Item No: 125
AC- 23/7/2020

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Civil Engineering

Second Year with Effect from AY 2020-21
Third Year with Effect from AY 2021-22
Final Year with Effect from AY 2022-23

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

Item No: -125
AC- 23/7/2020

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Second Year B.E. Civil Engineering**
2	Eligibility for Admission	**After Passing First Year Engineering as per the Ordinance 0.6242**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6242**
5	No. of Years / Semesters	**8 semesters**
6	Level	**U.G.**
7	Pattern	**Semester**
8	Status	**New**
9	To be implemented from Academic Year	**With effect from Academic Year: 2020-2021**

Date

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
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University of Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2020-21. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2021-22, 2022-23, respectively.

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Incorporation and Implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of ‘C ‘ scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme ‘A' and ‘B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD’s/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

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Preface

The engineering education in India is expanding and is set to increase manifold. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. To meet this challenge, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program Outcomes (POs) are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this, Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome based education (OBE) in the process of curriculum development from Rev-2012 onwards and continued to enhance the curriculum further based on OBE in Rev-2016 and Rev-2019 "C" scheme.

As Chairman and Members of Board of Studies in Civil Engineering, University of Mumbai, we are happy to state here that, the Program Educational Objectives (PEOs) for Undergraduate Program were finalized in a brain storming sessions, which was attended by more than 40 members from different affiliated Institutes of the University, who are either Heads of Departments or their senior representatives from the Department of Civil Engineering. The PEOs finalized for the undergraduate program in Civil Engineering are listed below;

1. To prepare the Learner with a sound foundation in mathematical, scientific and engineering fundamentals
2. To motivate the Learner in the art of self-learning and to use modern tools for solving real life problems
3. To prepare the Learner for a successful career in Indian and Multinational Organisations and for excelling in post-gradute studies
4. To motivate learners for life-longing learning
5. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the Learner's thought process

In addition to the above listed PEOs, every institute is encouraged to add a few (2-3) more PEOs suiting their institute vision and mission

Apart from the PEOs, for each course of the program, objectives and expected outcomes from a learner's point of view are also included in the curriculum to support the philosophy of OBE. We strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stakeholders.

Board of Studies in Civil Engineering, University of Mumbai

1. Dr. S. K. Ukarande:	Chairman
2. Dr. K. K. Sangle:	Member
3. Dr. S. B. Charhate:	Member
4. Dr. A. R. Kambekar:	Member
5. Dr. R. B. Magar:	Member
6. Dr. Seema Jagtap:	Member

Program Structure for Second Year Engineering
Semester III & IV
UNIVERSITY OF MUMBAI
(With Effect from **2020-2021**)

Semester - III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC301	Engineering Mathematics-III	3	-	1	3	-	1	4
CEC302	Mechanics of Solids	4			4			4
CEC303	Engineering Geology	3			3			3
CEC304	Architectural Planning & Design of Buildings	2	-	-	2	-	-	2
CEC305	Fluid Mechanics- I	3	-	-	3	-	-	3
CEL301	Mechanics of Solids	-	2	-	-	1	-	1
CEL302	Engineering Geology	-	2	-	-	1	-	1
CEL303	Architectural Planning & Design of Buildings	-	2	-	-	1	-	1
CEL304	Fluid Mechanics- I	-	2	-	-	1	-	1
CEL305	Skill Based Lab Course-I		3		-	1.5		1.5
CEM301	Mini Project – 1 A	-	3[$]	-	-	1.5	-	1.5
Total		**15**	**14**	**1**	**15**	**7**	**1**	**23**

Examination Scheme									
Course Code	**Course Name**	**Internal Assessment**			**End Sem Exam**	**Exam Duration (Hrs.)-**	**Term Work**	**Prac. /Oral**	**Total**
		Test I	Test II	Avg.					
CEC301	Engineering Mathematics-III	20	20	20	80	3	25	-	125
CEC302	Mechanics of Solids	20	20	20	80	3	-	-	100
CEC303	Engineering Geology	20	20	20	80	3	-	-	100
CEC304	Architectural Planning & Design of Buildings	20	20	20	80	3	-	-	100
CEC305	Fluid Mechanics- I	20	20	20	80	3	-	-	100
CEL301	Mechanics of Solids	-	-	-	-	-	25	25	50
CEL302	Engineering Geology	-	-	-	-	-	25	25	50
CEL303	Architectural Planning & Design of Buildings	-	-	-	-	-	25	25	50
CEL304	Fluid Mechanics- I	-	-	-	-	-	25	25	50
CEL305	Skill Based Lab Course-I	-	-	-	-	-	50	-	50
CEM301	Mini Project – 1 A	-	-	-	-	-	25	25	50
	Total			**100**	**400**	**-**	**200**	**125**	**825**

Semester – IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC401	Engineering Mathematics - IV	3	--	1	3	-	1	4
CEC402	Structural Analysis	4	--	-	4	-	-	4
CEC403	Surveying	3	--	-	3	-	-	3
CEC404	Building Materials &Concrete Technology	3	--	-	3	-	-	3
CEC405	Fluid Mechanics-II	3	-	-	3	-	-	3
CEL 401	Structural Analysis	--	2	-	-	1	-	1
CEL 402	Surveying	--	3	-	-	1.5	-	1.5
CEL 403	Building Material Concrete Technology	--	2	-	-	1	-	1
CEL 404	Fluid Mechanics-II	--	2			1		1
CEL 405	Skill Based lab Course-II	--	2	-	-	1	-	1
CEM401	Mini Project – 1 B	--	3[$]	-	-	1.5	-	1.5
Total		**16**	**14**	**1**	**16**	**7**	**1**	**24**

Examination Scheme									
Course Code	**Course Name**	**Internal Assessment**			**End Sem Exam**	**Exam Duration (Hrs.)-**	**Term Work**	**Prac. /Oral**	**Total**
		Test I	Test II	Avg.					
CEC 401	Engineering Mathematics - IV	20	20	20	80	3	25	-	125
CEC 402	Structural Analysis	20	20	20	80	3	-	-	100
CEC 403	Surveying	20	20	20	80	3			100
CEC 404	Building Materials & Concrete Technology	20	20	20	80	3	-	-	100
CEC 405	Fluid Mechanics-II	20	20	20	80	3	-	-	100
CEL 401	Structural Analysis						25	25	50
CEL 402	Surveying						50	25	75
CEL 403	Building Materials & Concrete Technology	-	-	-	-	-	25	25	50
CEL 404	Fluid Mechanics-II	-	-	-	-	-	25	25	50
CEL 405	Skill Based lab Course-II	-	-	-	-	-	50	-	50
CEM401	Mini Project – 1 B	-	-	-	-	-	25	25	50
	Total			**100**	**400**	**-**	**225**	**125**	**850**

Semester- III

Course Code	Course Name	Credits
CEC 301	Engineering Mathematics-III	04

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	01	03	-	01	04

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem. Exam	Duration of End Sem. Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 hrs	25	-	-	125

Pre-requisite: Engineering Mathematics-I,

Engineering Mathematics-II,

Course Objectives:

1. To familiarize with the Laplace Transform, Inverse Laplace Transform of various functions, its applications.
2. To acquaint with the concept of Fourier Series, its complex form and enhance the problem solving skills.
3. To familiarize with the concept of complex variables, C-R equations with applications.
4. To study the application of the knowledge of matrices and numerical methods in complex engineering problems.

Course Outcomes: Learner will be able to….

1. Apply the concept of Laplace transform to solve the real integrals in engineering problems.
2. Apply the concept of inverse Laplace transform of various functions in engineering problems.
3. Expand the periodic function by using Fourier series for real life problems and complex engineering problems.
4. Find orthogonal trajectories and analytic function by using basic concepts of complex variable theory.
5. Apply Matrix algebra to solve the engineering problems.
6. Solve Partial differential equations by applying numerical solution and analytical methods for one dimensional heat and wave equations.

Module	Detailed Contents	Hrs.
01	**Module: Laplace Transform** 1.1 Definition of Laplace transform, Condition of Existence of Laplace transform, 1.2 Laplace Transform (L) of Standard Functions like e^{at}, $sin(at)$, $cos(at)$, $sinh(at)$, $cosh(at)$ and t^n , $where\ n \geq 0$. 1.3 Properties of Laplace Transform: Linearity, First Shifting theorem, Second Shifting Theorem, change of scale Property, multiplication by *t*, Division by *t*, Laplace Transform of derivatives and integrals (Properties without proof). 1.4 Evaluation of integrals by using Laplace Transformation. **Self-learning topics:** Heaviside's Unit Step function, Laplace Transform. of Periodic functions, Dirac Delta Function.	07 Hrs.
02	**Module: Inverse Laplace Transform** 2.1 Inverse Laplace Transform, Linearity property, use of standard formulae to find inverse Laplace Transform, finding Inverse Laplace transform using derivative 2.2 Partial fractions method & first shift property to find inverse Laplace transform. 2.3 Inverse Laplace transform using Convolution theorem (without proof) **Self-learning Topics:** Applications to solve initial and boundary value problems involving ordinary differential equations.	06 Hrs.
03	**Module: Fourier Series:** 3.1 Dirichlet's conditions, Definition of Fourier series and Parseval's Identity (without proof) 3.2 Fourier series of periodic function with period 2π and $2l$, 3.3 Fourier series of even and odd functions 3.4 Half range Sine and Cosine Series. **Self-learning Topics:** Complex form of Fourier Series, orthogonal and orthonormal set of functions, Fourier Transform.	07Hrs.
04	**Module: Complex Variables:** 4.1 Function *f*(z) of complex variable, limit, continuity and differentiability of *f*(z), Analytic function, necessary and sufficient conditions for *f*(z) to be analytic (without proof), 4.2 Cauchy-Riemann equations in cartesian coordinates (without proof) 4.3 Milne-Thomson method to determine analytic function *f*(z) when real part (u) or Imaginary part (v) or its combination (u+v or u-v) is given.	07Hrs.

	4.4 Harmonic function, Harmonic conjugate and orthogonal trajectories **Self-learning Topics:** Conformal mapping, linear, bilinear mapping, cross ratio, fixed points and standard transformations	
05	**Module: Matrices:** 5.1 Characteristic equation, Eigen values and Eigen vectors, Properties of Eigen values and Eigen vectors. (**No theorems/ proof**) 5.2 Cayley-Hamilton theorem (without proof): Application to find the inverse of the given square matrix and to determine the given higher degree polynomial matrix. 5.3 Functions of square matrix 5.4 Similarity of matrices, Diagonalization of matrices **Self-learning Topics:** Verification of Cayley Hamilton theorem, Minimal polynomial and Derogatory matrix & Quadratic Forms (Congruent transformation & Orthogonal Reduction)	06 Hrs.
06	**Module: Numerical methods for PDE** 6.1 Introduction of Partial Differential equations, method of separation of variables, Vibrations of string, Analytical method for one dimensional heat and wave equations. (only problems) 6.2 Crank Nicholson method 6.3 Bender Schmidt method **Self-learning Topics:** Analytical methods of solving two and three dimensional problems.	06 Hrs.
	Total	39

Term Work:

General Instructions:

1 Batch wise tutorials are to be conducted. The number of student'sperbatch should be as per University pattern for practicals.

2 Students must be encouraged to write at least 6 class tutorials on entire syllabus.

3 A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering Mathematics. This project should be graded for 10 marks depending on the performance of the students.

The distribution of Term Work marks will be as follows –

1	Attendance (Theory and Tutorial)	05 marks
2	Class Tutorials on entire syllabus	10 marks
3	Mini project	10 marks

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks
2 Question 1 will be compulsory and should cover maximum contents of the curriculum
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4 Only Four questions need to be solved.

References:

1 Engineering Mathematics, Dr. B. S. Grewal, KhannaPublication
2 Advanced Engineering Mathematics, Erwin Kreyszig, Wiley EasternLimited,
3 Advanced Engineering Mathematics, R. K. Jain and S.R.K. Iyengar, Narosapublication
4 Advanced Engineering Mathematics, H.K. Das, S. Chand Publication
5 Higher Engineering Mathematics B.V. Ramana, McGraw HillEducation
6 Complex Variables and Applications, Brown and Churchill, McGraw-Hilleducation,
7 Text book of Matrices, Shanti Narayan and P K Mittal, S. ChandPublication
8 Laplace transforms, Murray R. Spiegel, Schaum's OutlineSeries

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Semester- III									
Course Code			Course Name					Credits	
CEC 302			Mechanics of Solids					4	
Contact Hours				Credits Assigned					
Theory	Practical	Tutorial		Theory	Practical	Tutorial		Total	
4	-			4	-	--		4	
Theory						Term Work/Practical/Oral			Total
Internal Assessment			End Sem. Exam	Duration of End Sem Exam		TE	PR	OR	
Test-I	Test-II	Average							
20	20	20	80	3 Hours		-	--	--	100

Rationale

Civil Engineering structures are made using various engineering materials such as steel, concrete, timber, other metals or their composites. They are subjected to force systems resulting into axial forces, bending moments, shear forces, torsion and their combinations. Different materials respond differently to these by getting deformed and having induced stresses. Determination of stress, strain, and deflection suffered by structural elements when subjected to diverse loads is prerequisite for an economical and safe design.

In this course, learners will understand the internal response behavior of material under different force systems. The knowledge of 'Mechanics of Solids' will be foundation of essential theoretical background for the subjects of Structural Analysis and Structural Design.

Objectives

1) To learn stress - strain behavior and physical properties of materials and to compute the Stresses developed and deformation of Elastic members and thin cylinders subjected to internal pressure.
2) To learn to represent graphically the distribution of axial force, shear force and bending moment along the length of statically determinate beams and portal frames.
3) To compute area moment of inertia and to analyze the distribution of shear stress and the flexural (bending) stress across the cross section of structural members.
4) To study circular shafts under the action of twisting moment and to determine the direct and bending stresses in columns and study buckling behavior of centrally and eccentrically loaded columns.
5) To determine principal planes and stresses and strain energy computation in elastic members.
6) To learn the computation of slope and deflection of elastic beams and general theorems used in this computation.

Detailed Syllabus			
Module		**Course Modules / Contents**	**Periods**
1	**Module Name- Stresses and Strains in Elastic members, Spherical and Cylindrical shells**		**(9)**
	1.1	Types of Stresses and Strains, stress-strain curve, different types of Elastic moduli and relationships between them, Poisson's ratio, factor of safety. Bars of varying sections, composite sections, temperature stresses	**6**
	1.2	Thin cylindrical and spherical shells under Internal pressure: Determination of Hoop stress, Longitudinal stress, Shear stress and volumetric strain.	**3**
2	**Module Name- Axial force, shear force and bending moment diagrams for beams and portal frames**		**(9)**
	2.1	Concept of Axial Force, Shear Force and Bending Moment. a) A.F. S.F. and B M Diagrams for statically determinate S S and Cantilever **beams without internal hinges** and for single loading like point load, UDL, UVL or Couple moment. b) A.F. S.F. and B.M. Diagrams for statically determinate **beams with internal hinges** and combination of loading	**6**
	2.2	A.F. S.F. and B.M Diagrams for statically determinate **3-member Portal Frames with or without internal hinges .**	**3**
3	**Module Name- Area Moment of Inertia, Shear stresses and Bending stresses in beams**		**(9)**
	3.1	Area Moment of inertia, Parallel and Perpendicular axis theorem, polar moment of inertia. Radius of gyration. (Rectangular, Triangular, Circular, Semicircular section and their combination) Distribution of shear stress across plane sections Commonly used for structural purposes.	**5**
	3.2	Theory of pure bending, Flexure formula for straight beam, simple problems involving application of Flexure formula, section modulus, moment of resistance, flitch beams.	**4**
4	**Module Name- Torsion in Shafts, Columns**		**(10)**
	4.1	Torsion in solid and hollow circular shafts, shafts with varying cross sections, Shafts transmitting and receiving power at different points. Stresses in Shafts while transmitting power.	**4**
	4.2	Direct and bending stresses in Columns, Core of section.	**6**

		Buckling of Columns, Members subjected to axial loading, concept of buckling, effective length, different support conditions, Euler's and Rankine's formula. Concept of Eccentrically loaded columns.	
5	**Module Name- Principal planes and stresses, Strain Energy**		**(8)**
	5.1	General equation for transformation of stress, Principal planes and principal stresses, maximum Shear stress, stress determination by analytical and Graphical method (using Mohr's circle).	**4**
	5.2	Strain energy due to axial force and impact loads in columns, due to bending in beams, due to torsion of shaft.	**4**
6	**Module Name- Slope and Deflection in Beams , General Theorems**		**(7)**
	6.1	Concept of Slope and Deflection in Beams, Macaulay's Method for slope and deflection in S S and Cantilever beams subjected to point loads, UDL and couple moments.	**4**
	6.2	General Theorems: Betti and Maxwell's reciprocal Theorem,, Principle of Superposition, Principle of Virtual work, Castigliano's theorems.	**3**

Contribution to Outcome

On completion of this course, the students will be able to:

1) Evaluate stress - strain behavior of elastic members and thin cylinders subjected to internal pressure.
2) Draw variation of axial force, shear force and bending moment diagram for statically determinate beams and frames.
3) Calculate Moment of Inertia for cross sections and analyse the material response under the action of shear and the effect of flexure (bending).
4) Predict the angle of twist and shear stress developed in torsion and compute direct and bending stresses developed in the cross section of centrally and eccentrically loaded columns.
5) Locate principal planes in members and calculate principal stresses using analytical and graphical method and to calculate strain energy stored in members due to elastic deformation.
6) Evaluate slope and deflection of beams supported and loaded in different ways.

Internal Assessment (20 Marks):

One **Compulsory Class Test,** based on approximately 40% of contents and another on 40% from the remaining content be taken. Average of the two will be considered as IA Marks.

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture

Hours mentioned in the curriculum.

1) Question paper will comprise of total **six questions**, **each carrying 20 marks.**
2) **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3) **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4) Only **Four questions need to be solved**.

Recommended Books:

1. Strength of Materials: *S. Ramamrutham*, Dhanpatrai Publishers.
2. Strength of Materials: *R.K. Rajput*, S. Chand Publications.
3. Mechanics of Materials: Vol-I: *S.B. Junnarkar and H.J. Shah*, Charotar Publications.
4. Strength of Materials: *Subramanian*, Oxford University Press
5. Strength of Materials: *S.S. Rattan*, Tata Mc-Graw Hill, New Delhi
6. Strength of Materials (Mechanics of Materials): *R.S. Lehri and A.S. Lehri*, S.K. Kataria Publishers, New Delhi
7. Strength of Materials: *Dr. V.L. Shah*, Structures Publications, Pune

Reference Books:

8. Mechanics of Materials: *James, M. and Barry J.*; Cengage Learning.
9. Mechanics of Materials: *Andrew Pytel and Jaan Kiusalaas*, Cengage Learning.
10. Mechanics of Materials: *Timoshenko and Gere*, Tata McGraw Hill, New Delhi.
11. Mechanics of Materials: *James M. Gere*, Books/Cole.
12. Strength of Materials: *G.H. Ryder*, Mc-Millan.
13. Mechanics of Materials: *E.P. Popov*, Prentice Hall India (PHI) Pvt. Ltd.
14. Mechanics of Materials: *Pytel and Singer*, Mc-Graw Hill, New Delhi.
15. Strength of Materials: *William A. Nash and Nillanjan Mallick*, Mc-Graw Hill Book Co. (Schaum's Outline Series)

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Semester-III

Course Code	Course Name	Credits
CEC 303	Engineering Geology	3

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
3		-	3		-	3

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	3 hrs		-		100

Rationale

Engineering geology is an applied geology discipline that involves the collection, analysis, and Interpretation of geological data and information required for the safe development of civil works. The objective of this course is to focus on the core activities of engineering geologists – site characterization, geologic hazard identification and mitigation. Through lectures, labs, and case study examination student will learn to couple geologic expertise with the engineering properties of rock in the characterization of geologic sites for civil work projects.

Understanding of the foundation rocks and structures present in them is of utmost importance for the safety and stability of Civil engineering structures. The study also helps in the assessment of groundwater, oil and gas and mineral resource evaluation.

Objectives

1. To acquire basic knowledge of Geology and to understand its significance in various civil engineering projects.
2. To study minerals and rocks in order to understand their fundamental characteristics and engineering properties.
3. To study structural geology for characterization of site, analysis and report geologic data using standards in engineering practice.
4. To study methods of subsurface investigation, advantages and disadvantages caused due to geological conditions and assessment of site for the construction of civil structures.
5. To study rock mass characterization for the construction of tunnels and assessment of rock as source of ground water.
6. To study the control of geology over the natural hazards and their preventive measures.

Detailed Syllabus

Module		Course Modules / Contents	Periods
1	**Introduction & Physical Geology**		**5**
	1.1	Branches of geology useful to civil engineering, Importance of geological studies in various civil engineering Projects. Departments dealing with this subject in India and their scope of work- GSI, Granite Dimension Stone Cell, NIRM.	
	1.2	Internal structure of the Earth and use of seismic waves in understanding the interior of the earth. Theory of Plate Tectonics.	
	1.3	Weathering types, Erosion and Denudation. Factors affecting weathering and product of weathering (engineering consideration) Superficial deposits and its geological Importance.	
	1.4	Brief study of geological action of wind, glacier and river.	
2	**Mineralogy and Petrology**		**7**
	2.1	Identification of minerals with the help of physical properties, rock forming minerals, megascopic identification of primary and secondary minerals, study of common ore minerals.	
	2.2	Igneous Petrology - Mode of formation, Texture and structure, form of Igneous rocks, Classification of Igneous rocks, study of commonly occurring igneous rocks, Engineering aspect of Granite and Basalt.	
	2.3	Sedimentary Petrology - Mode of formation, Textures, characteristics of shallow water deposits like lamination, bedding, current bedding etc., classification, study of commonly occurring sedimentary rocks and their engineering application.	
	2.4	Metamorphic Petrology - Mode of formation, agents and types of metamorphism, structures and textures of metamorphic rocks, classification and study of commonly occurring metamorphic rocks and their engineering application.	
3	**Structural Geology and Stratigraphy**		**12**
	3.1	Dip and Strike. Outcrop and width of outcrop. Inliers and Outliers. Type of discontinuities in the rocks. **Fold:** Terminology, Classification on the basis of position of axial plane, Criteria for their recognition in field and engineering consideration. **Fault:** Terminology, Classification on the basis of movement of faulted block, Criteria for recognition in field, effects on outcrops and Engineering consideration.	

		Joints & Unconformity: Types and geological importance. Three point problems to determine attitude of the strata	
	3.2	Determination of thickness of the strata with the help of given data.	
	3.3	Geological Maps and their application for civil engineering works, Identification of symbols in maps.	
	3.4	General principles of Stratigraphy, geological time scale, Physiographic divisions of India and their characteristics. Stratigraphy of Deccan Volcanic Province.	
4	**Geological Investigation, study of dam and reservoir site:**		**7**
	4.1	Required geological consideration for selecting dam and reservoir site. Favorable & unfavorable conditions in different types of rocks in presence of various structural features, precautions to be taken to counteract unsuitable conditions.	
	4.2	Electrical resistivity and Seismic method of geological investigation. Rock Quality Designation and its importance to achieve safety and economy of the projects like dams and tunnels.	
	4.3	Borehole problems and their significance in determining subsurface geology of the area.	
5	**Tunnel Investigation and Ground Water Control**		**5**
	5.1	Importance of geological considerations while choosing tunnel sites and alignments of the tunnel, safe and unsafe geological and structural conditions.	
	5.2	Geo-mechanics classification (RMR) and its application.	
	5.3	Sources, zones, water table, unconfined, confined and Perched water tables. Factors controlling water bearing capacity of rocks, Pervious and Impervious rocks, Different types of rocks as source of ground water. Artesian well (flowing and non-flowing). Cone of Depression and its use in Civil engineering.	
6	**Geological Disasters and Control Measures**		**3**
	6.1	Landslides-Types, causes and preventive measures for landslides, Landslides in Deccan region.	
	6.2	Volcano- Central type and fissure type, products of volcano.	
	6.3	Earthquake- Terminology, Earthquake waves, construction and working of seismograph, Earthquake zones of India, elastic rebound theory, Preventive measures for structures constructed in Earthquake prone area.	

Contribution to Outcome

On completion of this course, the students will be able to:

1) Explain the concepts of Geology and its application for safe, stable and economic design of any civil engineering structure.
2) Interpret the lithological characters of the rock specimen and distinguish them on the basis of studied parameters.
3) Describe the structural elements of the rocks and implement the knowledge for collection and analysis of the geological data.
4) Interpret the geological conditions for the dam site and calculate RQD for the assessment of rock masses.
5) Analyze the given data and suggest rock mass rating for assessment of tunnelling conditions.
6) Interpret the causes of geological hazards and implement the knowledge for their prevention.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests** - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecturehours mentioned in the curriculum.

1) Question paper will comprise of total **six questions**, **each carrying 20 marks.**
2) **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3) **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4) Only **Four questions need to be solved**.

Recommended Books:

1) Text book of Engineering Geology: N. Chenna, Kesavulu, Mc-Millan.
2) Text book of Engineering and General Geology, 8th edition (2010): Parbin Singh, S K Kataria& Sons.
3) Text book of Engineering Geology: P. K. Mukerjee, Asia.
4) Text book of Engineering Geology: Dr. R. B. Gupte, Pune VidyarthiGriha
5) Prakashan, Pune.
6) Principles of Engineering Geology: K. M. Banger.

Reference Books:

7) A Principles of Physical Geology: Arthur Homes, Thomas Nelson Publications, London.
8) Structural Geology, 3rd edition (2010): Marland P. Billings, PHI Learning Pvt. Ltd. New Delhi
9) Earth Revealed, Physical Geology: David McGeeary and Charles C. Plummer
10) Principles of Geomorphology: William D. Thornbury, John Wiley Publications, New York.
11) Geology for Civil Engineering: A. C. McLean, C.D. Gribble, George Allen &UnwinLondon.
12) Engineering Geology: A Parthsarathy, V. Panchapakesan, R Nagarajan, Wiley India 2013.

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Semester - III

Course Code	Course Name	Credits
CEC304	Architectural Planning & Design of Buildings	02

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
02	-	-	02	-	-	02

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	---	-		100

Rationale

Drawing is the language of Civil Engineers to communicate. Drawing is one of the most essential documents as far as civil engineering is concerned. It provides guidance and instructions to architects, engineers and workmen at field, on how to construct structures according to the figures and dimensions shown in the drawing. Approved drawings are also essential for the estimation of cost and materials; as well as a very important contract document.

Objectives

1) To remember and recall the intricate details of building design and drawing.
2) To gain an understanding of the basic concepts of building design and drawing.
3) To learn how to apply professional ethics and act responsibly pertaining to the norms of building design and drawing practices, rules, regulation and byelaws, Building codes
4) To identify, analyze, research literate and solve complex building design and drawing problems.
5) To have new solutions for complex building design and drawing problems.
6) To effectively communicate ideas, related to building design and drawing, both orally as well as in written format like reports & drawings.

Course Outcomes

At the end of the course learners will be able to:

1) Remember and recall the intricate details of building design and drawing.
2) Understand the basic concepts of building design and drawing.
3) Learn how to apply professional ethics and act responsibly pertaining to the norms of building design and drawing practices.
4) Identify, analyze, research literate and solve complex building design and drawing problems.
5) Have new solutions for complex building design and drawing problems.
6) Effectively communicate ideas, related to building design and drawing, both orally as well as in written format like reports & drawings.

Detailed Syllabus		
Module	**Sub- Modules/ Contents**	**Periods**
1	**Principles and Codes of Practices for Planning and Designing of Buildings(Residential and Public buildings)**	**8**
1.1	Study of IS 962: 1989 – Code of Practice for Architectural and Building Drawings; How to develop Line plan into actual PLAN, ELEVATION, Section etc. including all the constructional details of various components in a BUILDING	
1.2	Principles of planning for Residential buildings	
1.3	Classification of buildings: Residential –Individual Bungalows & Apartments/Flats. Public – Education (Schools, Colleges etc.) &Health (Primary Health Center, Hospital) related buildings	
1.4	Study & drawing of SITE PLAN,FOUNDATION PLAN,ROOF PLAN of building; Study of building Bye – laws, Zoning Regulations and permissions required from commencement to completion of the building according to National Building Code (N.B.C.) of India and local Development Control (D.C.) rules	
1.5	Study of sun path diagram, wind rose diagram and sun shading devices	
1.6	Calculation of setback distances, carpet area, built-up area and floor spaceindex (FSI)	
1.7	Study of Principles of planning for public buildings: i) Building for education: schools, colleges, institutions etc. ii) Buildings for health: hospitals, primary health centers etc.	
2.	**Components and Services of a Building**	**3**
2.1	Staircase (dog -legged) planning, designing & drawing in details	
2.2	Foundations: stepped footing, isolated sloped footing and combined footing	
2.3	Openings: doors and windows	
2.4	Types of pitched roof and their suitability (plan and section)	
2.5	Building services: Water supply, sanitary and electrical layouts	
3.	**Perspective Drawings**	**4**
3.1	One-point perspective drawing	
3.2	Two-point perspective drawing	
4	**Town Planning, Architectural Planning & Built Environment**	**3**
4.1	Objectives and planning of TOWN PLANNING	
4.2	Master plan, Re-Development of buildings, Slum rehabilitation.	
4.3	Architectural Planning: introduction and principles	
4.4	Built Environment: introduction and principles	
5	**Green Buildings**	**2**
5.1	Introduction, uses ,objectives of Green Buildings and overview	
5.2	Study of Certification methods such as LEED, TERI, GRIHA, IGBC.	
6.	**Computer Aided Drawing (CAD)**	**6**
6.1	Details and learning methods of CAD in Civil Engineering structures	
6.2	Study and demonstration of any one of the professional CAD software's	
	Total	**26**

Theory Examination:

1) Only 4 questions (out of 6) need to be attempted.
2) Question no. 1 will be compulsory and based on the drawing work of any one building, may be residential or public building.. Some questions from the remaining may be on Theory portion.
3) 4. Any 3 out of the remaining 5 questions need to be attempted.
4) In question paper, weightage of each module maybe approximately proportional to the number of lecture hours assigned to it in the syllabus.

Internal Assessment:

There will be **Two** class tests (to be referred to as an '**Internal Assessment'**) to be conducted in the semester. The first internal assessment (IA-I) will be conducted in the mid of the semester based on the 50% of the syllabus. It will be of 20 marks. Similarly, the second internal assessment (IA-II) will be conducted at the end of the semester and it will be based on next 50% of the syllabus. It will be of 20 marks. Lastly, the average of the marks scored by the students in both the Internal Assessment will be considered. Duration of both the IA examination will be of one hour duration, respectively. Civil Engineering Drawing (including Architectural aspect) by *M. Chakraborti* (Monojit Chakraborti Publications, Kolkata)

Recommended Books

1) Planning and Designing Buildings by Y. S. Sane (Modern Publication House, Pune)
2) Building Drawing and Detailing by B.T.S. Prabhu, K.V. Paul and C. V. Vijayan (SPADES Publication, Calicut)
3) Building Planning by Gurucharan Singh (Standard Publishers & Distributors, New Delhi)

References:

1) IS 962: 1989 – Code of Practice for Architectural and Building Drawings.
2) National Building Code of India – 2005 (NBC 2005)
3) Development Control Regulations for Mumbai Metropolitan Region for 2016 – 2036 (https://mmrda.maharashtra.gov.in)
4) Development Control Regulations for Navi Mumbai Municipal Corporation – 1994 (https://www.nmmc.gov.in/development-control-regulations)
5) Development Plan and Control Regulation KDMC, https://mmrda.maharashtra.gov.in

Reference Codes:

1) National Building Code of India, 2005
2) IS 779-1978 Specification for Water Meter
3) IS 909-1975 Specification for Fire Hydrant
4) IS 1172-1983 Code of Basic Requirement for Water Supply, Drainage & Sanitation
5) IS 1742-1983 Code of Practice for Building Drainage

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Semester- III

Course Code	Course Name	Credits
CEC305	Fluid Mechanics - I	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 hrs	-	-	-	100

Rationale

The concept of fluid mechanics in civil engineering is essential to understand the processes and science offluids. The course deals with the basic concepts and principles in hydrostatics, hydro kinematics andhydrodynamics with their applications in fluid flow problems.

Objectives

The students will be able to learn:

1. The properties of fluids, units and dimensions
2. Pressure measurement, manometry, Hydrostatic forces acting on different surfaces, Principle of buoyancy and stability of floating body
3. Kinematic and Dynamic behavior through various laws of fluids like continuity, Euler's, Bernoulli's equations, energy and momentum equations.
4. Importance of fluid flow and various velocity measuring and discharge measuring devices used in pipes and channels.
5. The basic difference between incompressible and compressible flow, Propagation of pressure waves and stagnation points.

Detailed Syllabus

Module		Course Modules / Contents	Periods
1		**Properties of Fluids** Mass density, weight density, specific gravity, specific volume, viscosity, compressibility and elasticity, surface tension, capillarity, vapour pressure, types of fluids, and introduction to real life applications.	05
2		**Fluid Statics**	11
	2.1	**Pressure Measurement:** Pascal's law, hydrostatic law, pressure variation in fluids at rest. Pressure scale, Absolute, atmospheric, gauge pressure, measurement of pressure using manometers	
	2.2	**Hydrostatic force on surfaces:**	

		Total pressure and centre of pressure, total pressure on horizontal planesurface, vertical plane surface, Inclined plane surface, centre of pressure for vertical plane surface and for inclined plane surface, practical applications of total pressure and centre of pressure on dams, gates, and tanks.	
	2.3	**Buoyancy and floatation:** Archimedes principle, Meta-Centre, metacentric height, Stability of floating and submerged bodies, determination of metacentric height, Experimental and analytical methods, metacentric height for floating bodies containing liquid, Time period of Transverse oscillations of floating bodies.	
3	**Fluid Kinematics**		**05**
	Types of fluid flow, description of flow pattern, Lagrangian methods, Eulerian method, continuity equation, velocity and acceleration of fluid particles, streamline, streak line, path line,velocity potential and stream function, equipotential lines and flow net, uses of flow net, rotational and irrotational motions, circulation and vorticity		
4	**Fluid Dynamics**		**06**
	Control volume and control surface, Forces acting on fluid in motion, Navier Stokes Equation, Euler's Equation of motion, Integration of Euler's equations of motion, Bernoulli's Theorem and its derivation, Bernoulli's equation for compressible fluid and real fluid, practical applications of Bernoulli's Equation - Venturimeter, Orifice meter, nozzle meter, pitot tube, Rota meter.		
5	**Flow measurement**		**08**
	5.1	**Orifices and mouthpieces** Classification of orifices, flow through orifices, determination of hydraulic coefficients, flow through large rectangular orifice, flow through fully submerged and partially submerged orifice, time of emptying a tank through an orifice at its bottom. Classification of Mouthpieces, Flow through external cylindrical mouthpiece, convergent-divergent mouthpiece, Borda's mouthpieces.	
	5.2	**Notches and weirs** Classification of notches and weirs, discharge over a rectangular, triangular, trapezoidal notch/weir, velocity of approach, stepped notch, Cipolleti weir, broad crested weir, ogee weir, discharge over a submerged weir, ventilation of weirs.	
6	**6.1**	**Compressible flow**	**04**
		Basic equation of flow (elementary study), velocity of sound or pressure wave in a fluid, Mach number, propagation of pressure waves, area-velocity relationship, Stagnation properties.	
Total			**39**

Contribution to Outcome

Upon completion of the course, students shall have ability to:

1) Describe various properties of fluids and types of flow
2) Determine the pressure difference in pipe flows, application of Continuity equation and Bernoulli's theorem to determine velocity and discharge
3) Apply hydrostatic and dynamic solutions for fluid flow applications
4) Analyse the stability of floating bodies
5) Apply the working concepts of various devices to measure the flow through pipes and channels
6) Explain the compressible flow, propagation of pressure waves and stagnation properties

Internal Assessment (20 Marks):

Consisting Two Compulsory Class Tests:

First test based on approximately 40% of contents and second test based on remainingcontents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1) Question paper will comprise of total **six questions, each carrying 20 marks.**
2) **Question 1**will be compulsory and should **cover maximum contents of the curriculum**
3) **Remaining questions will be mixed in nature**(for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4) Only **Four questions need to be solved**.

Recommended Books:

1) Hydraulics and Fluid mechanics: Dr. P.M. Modi and Dr. S.M. Seth, Standard Book House, Delhi
2) Theory and Application of Fluid Mechanics: K. Subramanian, Tata McGraw hill publishing company, New Delhi.
3) Fluid Mechanics: Dr. A.K Jain, Khanna Publishers.
4) Fluid Mechanics and Hydraulics: Dr. S.K. Ukarande, Ane's Books Pvt.Ltd. (Revised Edition 2012), ISBN 97893 8116 2538
5) Fluid Mechanics and fluid pressure engineering: Dr. D.S. Kumar, F.K. Kataria and sons
6) Fluid Mechanics: R.K. Bansal Laxmi Publications (P) Ltd.

Reference Books:

1) Fluid Mechanics: Frank M. White, Tata McGraw Hill International Edition.
2) Fluid Mechanics: Streeter White Bedford, Tata McGraw International Edition.
3) Fluid Mechanics with Engineering Applications: R.L. Daugherty, J.B. Franzini, E.J. Fennimore, Tata McGraw Hill, New Delhi.
4) Hydraulics: James F. Cruise, Vijay P. Singh and Mohsen M. Sherif, CENGAGE Learning India (Pvt.) Ltd.
5) Introduction to Fluid Mechanics: Edward J. Shaughnessy, Jr, Ira M. Katz, James P. Schaffer. Oxford Higher Education.

Semester- III

Course Code	Course Name	Credits
CEL301	Mechanics of Solids- LAB	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Objectives

1) To learn stress - strain behavior and physical properties of materials and to compute the Stresses developed and deformation of Elastic members.
2) To compute the distribution of shear stress and the flexural (bending) stress across the cross section of structural members
3) To study circular shafts under the action of twisting moment.
4) To learn the computation of slope and deflection of elastic beams and general theorems used in this computation.

Outcomes

Learner will be able to…

1) Evaluate stress - strain behavior of materials and assess the structural behavior by the virtue of stresses developed and deformation of elastic members.
2) Analyze the material response under the action of shear and the effect of flexure (bending).
3) Predict the angle of twist and shear stress developed in torsion.
4) Evaluate slope and deflection of beams supported and loaded in different ways.

Term Work : Term work comprises of Laboratory work and assignments.

Laboratory work : (At least 6- Performances - Any one from each Module)

Mechanics of Solids (Practical performance)		
Schedule	**Name of Experiment**	**Duration (Hours)**
1st week	1) Using UTM find different Moduli of a material or 2) The Tension Test on M S rod or 3) The Tension Test on M S Flat	**2**
3rd week	1) The Compression Test on Concrete cube or 2) The Compression Test on Timber or 3) The Compression Test on Brick	**2**
5th week	1) Test of Bending Using a Strain Guage or 2) Test of Bending Using a other electronic devices or 3) Test of Shear Stress in Beams	**2**
7th week	1) Using TorsionTesting Machine, verify the torsion equation, find different Moduli of a material. or 2) Spring Stiffness Test using strain gauges or other electronic devices	**2**
9th week	1) Charpy impact testing and Energy concept. or 2) Izod impact testing and Energy concept.	**2**
11th week	1) Using U T M perform experiments and verify Slope and deflection equations, 3 points and 4 points loading. (Performance) or 2) Deflection of Simply supported Beams (Performance) or 3) Deflection of Cantilever Beams (Performance)	**2**
Total Duration = 12 Hours		

Assignment:

(At least 1 from each module as per the Course instructor's guidelines; it is to be assessed during Laboratory hours. In order to avoid Copying/ repetition, Course Instructor may give different assignments to different groups.)

Mechanics of Solids		
Schedule	**Assignment**	**Duration (Hours)**
2nd week	**Stresses and strains in Elastic members, Spherical and Cylindrical shells** • Prepare a model of Cylindrical vessel or • Prepare a model of spherical vessel or • Prepare a model of Cylindrical vessel with hemispherical ends or • Prepare a chart showing diagrammatic representation of stresses or • A set of 5 questions on a module designed by course instructor, or • A site visit to a relevant place or • A model / chart based on a module or • Design of a new experiment based on a module or • Write a Computer program in C++ or MSExcel on how to find a particular quantity from given data (Ex: Find output, Elongation 'δ' from the input values of P,L,A and E) • A chart about scientists and their contribution to the study of 'Mechanics of Solids' (Example given at the end of this document – Appendix I)	**2**

4th week	**Axial force, shear force and bending moment diagrams for beams and portal frames** • A set of 5 questions on a module designed by course instructor, or • A site visit to a relevant place or • A model / chart based on a module or • Design of a new experiment based on a module or • A chart about scientists and their contribution to the study of 'Mechanics of Structures' (Example given at the end of this document) or • Prepare a chart showing AFD, SFD & BMD for different symmetric and asymmetric loads on S S beams or • Prepare a chart showing AFD, SFD & BMD for different loads on Cantilever beams	**2**
6th week	**Area Moment of Inertia, Bending stresses and Shear stresses in beams** • Prepare a chart showing MI @ XX, YY &ZZ axes passing through the centroid. or • Prepare 3D models of different typical cross sections of beams and find their cross sectional area, Ixx, Iyy and Izz.. or • Prepare charts showing typical cross sections and variation of Bending stresses and shear stresses across the cross section. or • A set of 5 questions on a module designed by course instructor, or • A site visit to a relevant place or • A model / chart based on a module or • Design of a new experiment based on a module or • Write a Computer program in C++ or MS Excel on how to find a particular quantity from given data (Ex: Find output, Flexural stress 'f' from the input values of P,L,I and E) • A chart about scientists and their contribution to the study of 'Mechanics of Structures' (Example given at the end of this document)	**2**
8th week	**Torsion of Shafts, Columns** • Prepare 3D models of different solid and hollow circular cross sections of shafts and find their cross sectional area, Ixx, Iyy and Izz. or • A set of 5 questions on a module designed by course instructor, or • Write a Computer program in C++ or MS Excel on how to find a particular quantity from given data (Ex: Find output, Shear stress 'q' or angle 'Ɵ' from the input values of T,L,G and J) • A site visit to a relevant place or • A model / chart based on a module or • Design of a new experiment based on a module or • A chart about scientists and their contribution to the study of 'Mechanics of Solids' (Example given at the end of this document)	**2**
10th week	**Principal planes and stresses, Strain Energy** • Draw typical stress transformation cases of Mohr's circle using graph paper. or • A set of 5 questions on a module designed by course instructor, or • A site visit to a relevant place or • A model / chart based on a module or • Design of a new experiment based on a module or • A chart about scientists and their contribution to the study of 'Mechanics of solids' (Example given at the end of this document)	**2**

12th week	**Slope and Deflection in Beams ; General Theorems** • Prepare chart to explain General theorems for slope and deflection. or • A set of 5 questions on a module designed by course instructor, or • A site visit to a relevant place or • A model / chart based on a module or • Design of a new experiment based on a module or • A chart about scientists and their contribution to the study of 'Mechanics of Solids' (Example given at the end of this document)	**2**
Total Duration = 12 Hours		

Appendix -I:

A chart about scientists and their contribution to the study of 'Mechanics of solids' be made by students. Contributions of Scientists like GiordanoRiccati, Leonhard Euler, Saint Venant, Christian Otto Mohr, William J M Rankine, Carlo Castigliano, EnricoBetti, Robert Hooke, W. H. Macaulay, Augustin- Louis Cauchy, Simeon Poisson can be studied and presented.

Important Websites:

1) http://www.iitk.ac.in/mseold/mse_new/facilities/laboratories/Material Testing Lab / MSE313A.pdf
2) https://home.iitm.ac.in/kramesh/Strength of Materials Laboratory Manual.pdf
3) https://www.researchgate.net/publication/338139499_Me_8381-Strength_Of_Materials_Lab_Manual

Assessment:

To be done in 13th week

- **Term Work:**

Including Laboratory Work and Assignments both, Distribution of marks for Term Work shall be as follows:

Laboratory work- : 15 Marks
Assignments- : 10 Marks

The sum will be multiplied by a factor of attendance between
0.5 (for poor attendance) to 1 (very good attendance).

- **End Semester Oral Examination**

Oral examination will be based on entire syllabus

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Semester- III		
Course Code	**Course Name**	**Credits**
CEL302	**Engineering Geology Lab. Practice**	**1**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**2**	**-**	**-**	**1**	**-**	**1**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
-	-	-	-	3 hrs	25	-	25	50

Objectives

1. To acquire basic knowledge of Geological Lab practices and apply it for the safe development of Civil Engineering works.
2. To examine the mineral and rock sample and understand their fundamental properties for their evaluation as construction and foundation material.
3. To study the Geological maps and their sections in terms of selecting the sites for various civil engineering structures.
4. To study Borehole problems for determination of subsurface geology of the area.
5. To Study the drilling data and calculate RQD for assessment of rock masses for Civil Engineering purposes.

Outcomes

Learner will be able to…

1. Identify various rock forming minerals on the basis of physical properties.
2. Explain the characteristics of Igneous, Sedimentary and Metamorphic rocks and assess their suitability as construction material and foundation rock.
3. Interpret the rock characteristics and comment on their suitability as water bearing horizons.
4. Interpret the geological map and assess the suitability of the site for Civil Engineering works.
5. Solve the borehole problems and interpret it in order to understand subsurface Geology of the area.
6. Calculate RQD and evaluate the rock masses for Civil Engineering Works.

A) List of Experiments

Module	Detailed Contents	Lab Sessions/Hr
1	**Study of Physical Properties of Minerals:** Identification of common Rock forming minerals on the basis of physical Properties- **Silica Group:** Quartz and its varieties; Cryptocrystalline silica: Jasper and Agate; **Feldspar Group:** Orthoclase, Plagioclase; **Carbonate Group:** calcite; **Amphibole Group:** Asbestos, Actinolite and Hornblende; **Pyroxene Group:**Augite; **Mica Group:**Muscovite, Biotite and Talc; **Element Group:** Graphite.	**6**
2	Identification of Metallic minerals: Galena, Pyrite, Hematite, Magnetite.	**2**
3	**Identification of rocks:** **Igneous Rocks**-Granite and its varieties, Syenite, Diorite, Gabbro, Pegmatite. Porphyry, Dolerite, Rhyolite, Pumice, Trachyte, Basalt and its varieties, Volcanic Breccia, Volcanic Tuffs.	**4**
4	**Sedimentary Rocks-** Conglomerate, Breccia, Sandstone and its varieties, Shales, Limestones, Laterites.	**2**
5	**Metamorphic Rocks-** Schist and its varieties, Gneiss and its varieties, Slate, Marbles, Quartzite and Phyllite.	**2**
6	**Geological Maps:** a) Horizontal strata: Drawing the cross section and assessment of geological history of the area. b) Inclined Strata: Calculation of dip and strike in an inclined strata and assessment of geological history of the area. c) Assessment of the geological conditions for a proposed dam site in the given map. d) Assessment of the geological conditions for a proposed tunnel site in the given map. e) Assessment of the geological conditions for groundwater reserve in the given map.	**6**
7	Borehole problems to interpret subsurface geology	**2**
8	Calculation of RQD from the given data and assessment of rock quality.	**2**

B) Assessment:

- **Term Work**

Including Laboratory Work and Assignments both, Distribution of marks for Term Work Shall beas follows:

Laboratory work- : 10 Marks
Assignments- : 10 Marks
Attendance : 05 Marks

- **End Semester Oral Examination**

Oral examination will be based on the entire syllabus.

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Semester- III

Course Code	Course Name	Credits
CEL 303	Architectural Planning & Design of Buildings Lab	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

@ **For the course 'Building Design and Drawing, the oral examination shall be conducted in conjunction with the sketching examination.**

Rationale

Drawing is the language of Civil Engineers to communicate. Drawing is one of the most essential documents as far as civil engineering is concerned. It provides guidance and instructions to architects, engineers and workmen at field, on how to construct structures according to the figures and dimensions shown in the drawing. Approved drawings are also essential for the estimation of cost and materials; as well as a very important contract document.

Course Objectives

1) To remember and recall the intricate details of building design and drawing.
2) To gain an understanding of the basic concepts of building design and drawing.
3) To learn how to apply professional ethics and act responsibly pertaining to the norms of building design and drawing practices.
4) To identify, analyze, research literate and solve complex building design and drawing problems.
5) To have new solutions for complex building design and drawing problems.
6) To effectively communicate ideas, related to building design and drawing, both orally as well as in written format like reports & drawings.

Course Outcomes:

At the end of the course, learners will be able to:

1) Plan and design of residential and public building by implementing the principles of planning of buildings, Green building principles, byelaws, regulations and codes for planning

2) Preparing various working and detailed drawing of the buildings in CAD.
3) Preparing layouts of various building services.
4) Preparing perspective views for all types of buildings
5) Preparing the reports based on the drawings prepared, if required

Practical:

Students should make all the drawings during the Practical time allotted to them.

1) Drawings (Manually) should be drawn in the allotted Drawing hall only.
2) Drawings (CAD sheets) should be drawn on the Desktop/Laptop in Computational Lab.

After completing the work, Print out of those sheets should be submitted for gradation/Marks.

Assignments:

Two Assignments should be completed, covering all the modules in the syllabus.

1) Assignment-1 should be on 50% of the syllabus, to be completed before Internal Assessment-I exam.
2) Assignment-2 should be on the remaining 50% of the Syllabus, to be completed before Internal Assessment-II exam.

Site Visit:

Students should visit any Residential building/Public building physically and take Measurements inside of all rooms & over all outside of the building & can submit asmalldrawing sheet with the help of CAD. (**Optional** only)

Practical Examination (Oraland Sketching)

Practical examination will consist of sketching and oral examination based on the entire syllabus.

Term Work:

Drawings & Assignments:

1) Ground floor plan, first floor plan, elevation, section passing through at least one sanitary unit & staircase, Site plan, Foundation Plan and details of one FOOTING, Roof Plan ,schedule of opening and construction notes of a **residential building(bungalow or apartment)** to be constructed as a (G+1) R.C.C. framed structure **(only Manual Drawing)**
2) **One-Point** Perspective drawingfor any Residential structure(**only Manual drawing)**
3) Ground floor plan, first floor plan, elevation, section passing through at least one sanitary unit & staircase, schedule of opening and construction notes of a **public building(**Education/Health related **)** be constructed as a (G+1) R.C.C. framed structure (**only CAD drawing Sheet**)
4) **Two-Point** perspective drawing for any one public building (**only CAD drawing Sheet**)
5) Assignment No.- 1
6) Assignment No.- 2

Distribution of Term-work Marks:

The marks of term-work shall be judiciously awarded depending upon the quality of the term work. The final certification acceptance of term-work warrants the satisfactorily the appropriate completion of the required quality & quantity of work for the minimum passing marks to be obtained by the students. Broadly, the split of the marks for term work shall be as given below. However, there can be further bifurcation in the marks under any of the heads to account for any sub-head therein.

	Particulars	**Marks**
1	Drawing Sheet (Manual)	**7.5** Marks
2	Drawing Sheet (CAD Based)	**7.5** Marks
3	Assignments	**5** Marks
4	Attendance	**5** Marks
	Total	**25 Marks**

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to. 75% 80%: 03 Marks; 81% 90%: 04 Marks 91% onwards: 05 Marks **(Consider Practical attendance)**

Recommended Books:

- Building Drawing with an Integrated Approach to Built Environment by *M. G. Shah, C. M. Kale, S.Y. Patki*(Tata McGraw-Hill Education)
- Civil Engineering Drawing (including Architectural aspect) by *M. Chakraborti* (MonojitChakraborti Publications, Kolkata)
- Planning and Designing Buildings by *Y. S. Sane* (Modern Publication House, Pune)
- Building Drawing and Detailing by *B.T.S. Prabhu, K.V. Paul and C. V. Vijayan* (SPADES Publication, Calicut)
- Building Planning by *Gurucharan Singh* (Standard Publishers & Distributors, New Delhi)

References:

- IS 962: 1989 – Code of Practice for Architectural and Building Drawings.
- National Building Code of India – 2005 (NBC 2005)
- Development Control Regulations for Mumbai Metropolitan Region for 2016 – 2036 (https://mmrda.maharashtra.gov.in)
- Development Control Regulations for Navi Mumbai Municipal Corporation – 1994 (https://www.nmmc.gov.in/development-control-regulations)
- Development Plan and Control Regulation KDMC, https://mmrda.maharashtra.gov.in

Reference Codes:

- National Building Code of India, 2005
- IS 779-1978Specification for water meter
- IS 909-1975 Specification for fire hydrant
- IS 1172-1983 Code of basic requirement for water supply ,drainage & sanitation
- IS 1742-1983 code of practice for building drainage

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Semester- III

Course Code	Course Name	Credits
CEL304	Fluid Mechanics – I (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objectives:

The students will be able to learn:

1. The basic fluid mechanics concepts
2. Measuring pressure, velocity and discharge of fluid flow through pipes and channels

Course Outcomes:

At the end of the course, learner will be able to:

1. Calculate the metacentric height
2. Verify the Bernoulli's theorem
3. Determine the discharge coefficients
4. Measure fluid flow using various devices
5. Determine the hydraulic coefficients of an orifice

List of Experiments (Minimum Six)

Module	Detailed Contents	Lab Sessions/Hr
1	Determination of the Metacentric height of a floating body	02 hrs
2	Investigating the validity of the Bernoulli equation applied to a steady flow of water through a tapered duct	04 hrs
3	Determination of coefficient of discharge of Venturimeter.	02 hrs
4	Determination of coefficient of discharge of Orifice meter.	02 hrs
5	Determination of coefficient of discharge of Nozzle meter.	04 hrs
6	Determination of coefficient of discharge of Notches (Rectangular and Triangular notch).	02 hrs
7	Determination of coefficient of discharge of weirs (Broad Crested weir and Ogee weir).	04 hrs
8	To determine the value of coefficient of contraction, coefficient of velocity and coefficient of discharge for the given orifice	04 hrs
9	Determination of coefficient of discharge of mouthpiece.	02 hrs

Assessment:

Term Work

Including Laboratory Work and Assignments both, Distribution of marks for Term Work shall be as follows:

Laboratory work	:	15 Marks
Assignments	:	05 Marks
Attendance	:	05 Marks

End Semester Oral Examination

Oral examination will be based on entire syllabus.

Reference Books:

- Fluid Mechanics and Hydraulic Machines: R. K. Rajput, S. Chand and Company
- Hydraulics and Fluid mechanics: Dr.P.M. Modi and Dr. S.M. Seth, Standard Book House, Delhi
- Hydraulics Fluid Mechanics and Fluid Machines: S. Ramamrutham, DhanpatRai Publishing Company (P) Ltd-New Delhi
- Theory and Application of Fluid Mechanics: K. Subramanian, Tata McGraw hill publishing company, New Delhi.
- Fluid Mechanics and Hydraulics: Dr. S.K. Ukarande, Ane's Books Pvt. Ltd. (Revised Edition 2012), ISBN 97893 8116 2538
- Fluid Mechanics and fluid pressure engineering: Dr. D.S. Kumar, F.K. Kataria and sons
- Fluid Mechanics: R.K. Bansal Laxmi Publications (P) Ltd.

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Semester-III

Course Code	Course Name	Credits
CEL305	Skill Based Lab Course-I Computer Aided Drafting & Building Information Modelling	1.5

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	3	-	-	1.5	-	1.5

Theory					Term Work /Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	50	-	-	50

Objectives:

1. To enable the learners efficiently draft and label buildings components using the concepts of 2D and 3D drawing and detailing
2. To introduce the concepts of object-based modelling in 3-D environment to learners
3. To enable the learners to work on drawing and drafting softwares so that they can conveniently understand and design civil engineering components through the softwares.

Outcomes: Learner will be able to…

1. Transfer the plan from a drawing sheet to a 2-D drafting software
2. Visualize the various elements in the software like points, lines, polygons, etc. as objects of the real world and relate it with civil engineering components.
3. Apply civil engineering concepts to draft efficient civil engineering plans in accordance to various building bye laws and forms.
4. Conceptualize the space, logistic and statutory constraints in the real world to draw an efficient plan so that optimization is achieved
5. Attach and retrieve information pertaining to various civil engineering components through 3-D modelling software
6. Demonstrate a virtual walkthrough of buildings

C) **List of Experiments (Minimum Eight)**

Module	Detailed Contents	Lab Sessions/Hr
1	Listing out the various Computer Aided Drawing and Drafting (CADD) tools available for civil engineering projects in the market and highlighting the capabilities and advantages of each	03
2	Basic introduction to compatibilities, utilities and attributes of peculiar drafting softwares w.r.t their various commands, features, capabilities and functions.	03
3	Line plan of a residential structure using a CADD tool	03

4	Developed plan of a residential structure (minimum G+4) using a CADD tool	06
5	Developed plan of a public building using a CADD tool	06
6	Basic introduction to compatibilities, utilities and attributes of peculiar building information modelling (BIM) softwares w.r.t their various commands, features, capabilities and functions.	03
7	Creating families and basic models on BIM	06
8	Creating architectural plan on BIM of a G+1 bungalow	03
9	Demonstrating a walkthrough on BIM for clients and presenting it	03
10	Clash detection and removal	03

D) Assessment:

- **Term Work**

Including Laboratory Work comprising of minimum 6 software generated sheets and one walkthrough presentation on BIM, distribution of marks for Term Work shall be as follows:

Laboratory work : 30 Marks (comprising of minimum 6 software generated sheets)

Presentation : 10 Marks (showing 3-D walk through the building)

Attendance : 10 Marks

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Semester- III

Course Code	Course Name	Credits
CEM 301	Mini Project -1 A	1.5

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem. Exam	Duration of End Sem. Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Objectives

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will be able to…

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life long learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity;however, focus shall be on self-learning.

- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;

- Marks awarded by guide/supervisor based on log book : 10
- Marks awarded by review committee : 10
- Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
- First shall be for finalisation of problem
- Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
- First review is based on readiness of building working prototype to be conducted.
- Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
  - Identification of need/problem
  - Proposed final solution
  - Procurement of components/systems
  - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
  - First shall be for finalisation of problem and proposed solution
  - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1) Quality of survey/ need identification
2) Clarity of Problem definition based on need.
3) Innovativeness in solutions
4) Feasibility of proposed problem solutions and selection of best solution
5) Cost effectiveness
6) Societal impact
7) Innovativeness
8) Cost effectiveness and Societal impact
9) Full functioning of working model as per stated requirements
10) Effective use of skill sets
11) Effective use of standard engineering norms
12) Contribution of an individual's as member or leader
13) Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1) Quality of problem and Clarity
2) Innovativeness in solutions
3) Cost effectiveness and Societal impact
4) Full functioning of working model as per stated requirements
5) Effective use of skill sets
6) Effective use of standard engineering norms
7) Contribution of an individual's as member or leader
8) Clarity in written and oral communication

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Second Year Civil Engineering
UNIVERSITY OF MUMBAI
(With Effect from **2020-2021**)

Semester – IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC401	Engineering Mathematics - IV	3	--	1	3	-	1	4
CEC402	Structural Analysis	4	--	-	4	-	-	4
CEC403	Surveying	3	--	-	3	-	-	3
CEC404	Building Materials & Concrete Technology	3	--	-	3	-	-	3
CEC405	Fluid Mechanics-II	3	-	-	3	-	-	3
CEL 401	Structural Analysis	--	2	-	-	1	-	1
CEL 402	Surveying	--	3	-	-	1.5	-	1.5
CEL 403	Building Material Concrete Technology	--	2	-	-	1	-	1
CEL 404	Fluid Mechanics-II	--	2			1		1
CEL 405	Skill Based lab Course	--	2	-	-	1	-	1
CEM401	Mini Project – 1 B	--	3[$]	-	-	1.5	-	1.5
Total		**16**	**14**	**1**	**16**	**7**	**1**	**24**

Examination Scheme									
Course Code	**Course Name**	**Internal Assessment**			**End Sem Exam**	**Exam Duration (Hrs.)-**	**Term Work**	**Prac. /Oral**	**Total**
		Test I	Test II	Avg.					
CEC 401	Engineering Mathematics - IV	20	20	20	80	3	25	-	125
CEC 402	Structural Analysis	20	20	20	80	3	-	-	100
CEC 403	Surveying	20	20	20	80	3	-	-	100
CEC 404	Building Materials & Concrete Technology	20	20	20	80	3	-	-	100
CEC 405	Fluid Mechanics-II	20	20	20	80	3	-	-	100
CEL 401	Structural Analysis						25	25	50
CEL 402	Surveying						50	25	75
CEL 403	Building Materials & Concrete Technology	-	-	-	-	-	25	25	50
CEL 404	Fluid Mechanics-II	-	-	-	-	-	25	25	50
CEL 405	Skill Based lab Course	-	-	-	-	-	50	-	50
CEM401	Mini Project – 1 B	-	-	-	-	-	25	25	50
	Total			**100**	**400**	**-**	**225**	**125**	**850**

Semester- IV

Course Code	Course Name	Credits
CEC 401	Engineering Mathematics-IV	04

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	01	03	-	01	04

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 hrs	25	-	-	125

Pre-requisite:

- Engineering Mathematics-I,
- Engineering Mathematics-II,
- Engineering Mathematics-III,

Objectives:

1) To study the concept of Vector calculus & its applications in engineering.
2) To study Line and Contour integrals and expansion of complex valued function in a power series.
3) To familiarize with the concepts of statistics for data analysis.
4) To acquaint with the concepts of probability, random variables with their distributions and expectations.
5) To familiarize with the concepts of probability distributions and sampling theory with its applications.

Outcomes: Learner will be able to….

1) Apply the concept of Vector calculus to evaluate line integrals, surface integrals using Green's theorem, Stoke's theorem & Gauss Divergence theorem.
2) Use the concepts of Complex Integration for evaluating integrals, computing residues & evaluate various contour integrals.
3) Apply the concept of Correlation, Regression and curve fitting to the engineering problems in data science.
4) Illustrate understanding of the concepts of probability and expectation for getting the spread of the data and distribution of probabilities.
5) Apply the concept of probability distribution to engineering problems& Testing hypothesis of small samples using sampling theory
6) Apply the concepts of parametric and nonparametric tests for analysing practical problems.

Module	Detailed Contents	Hrs.
01	**Module : Vector Calculus** 1.1 Solenoidal and irrotational (conservative) vector fields. 1.2 Line integrals – definition and problems. 1.3 Green's theorem (without proof) in a plane, Stokes' theorem (without Proof), Gauss' Divergence theorem (without proof) and problems (only evaluation). **Self Learning Topics**: Identities connecting Gradient, Divergence and Curl, Angle between surfaces. Verifications of Green's theorem, Stoke's theorem & Gauss-Divergence theorem, related identities & deductions.	**07**
02	**Module: Complex Integration** 2.1 Line Integral, Cauchy's Integral theorem for simple connected and multiply connected regions (without proof), Cauchy's Integral formula (without proof). 2.2 Taylor's and Laurent's series (without proof). 2.3 Definition of Singularity, Zeroes, poles of *f(z)*, Residues, Cauchy's Residue Theorem (without proof) **Self-learning Topics:** Application of Residue Theorem to evaluate real integrations.	**07**
03	**Module: Statistical Techniques** 3.1 Karl Pearson's Coefficient of correlation (r) and related concepts with problems 3.2 Spearman's Rank correlation coefficient (R) (Repeated & non repeated ranks problems) 3.3 Lines of regression 3.4 Fitting of first and second degree curves. **Self-learning Topics:** Covariance, fitting of exponential curve.	**06**
04	**Module: Probability Theory:** 4.1 Conditional probability, Total Probability and Baye's Theorem. 4.2 Discrete and Continuous random variables, Probability mass and density function, Probability distribution for random variables, 4.3 Expectation, Variance, Co-variance, moments, Moment generating functions, (Four moments about the origin &about the mean). **Self- learning Topics:** Properties variance and covariance,	**06**
05	**Module: Probability Distribution and Sampling Theory-I** 5.1 Probability Distribution: Poisson and Normal distribution 5.2 Sampling distribution, Test of Hypothesis, Level of Significance, Critical region, One-tailed, and two-tailed test, Degree of freedom. 5.3 Students' t-distribution (Small sample). Test the significance of single sample mean and two independent sample means and paired t- test) **Self -learning Topics:** Test of significance of large samples, Proportion test, Survey based project.	**07**
06	**Module: Sampling theory-II** 6.1 Chi-square test: Test of goodness of fit and independence of attributes (Contingency table) including Yate's Correction. 6.2 Analysis of variance: F-test (significant difference between variances of two samples) **Self- learning Topics:** ANOVA**:** One way classification, Two-way classification (short-cut method).	**06**

Term Work:

General Instructions:

1) Batch wise tutorials are to be conducted. The number of students per batch should be as per University pattern for practical.
2) Students must be encouraged to write at least 6 class tutorials on entire syllabus.
3) A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering mathematics. This project should be graded for 10 marks depending on the performance of the students.

The distribution of Term Work marks will be as follows –

1	Attendance (Theory and Tutorial)	05 marks
2	Class Tutorials on entire syllabus	10 marks
3	Mini project	10 marks

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

- Question paper will comprise of total six questions, each carrying 20 marks
- Question 1 will be compulsory and should cover maximum contents of the curriculum
- Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
- Only Four questions need to be solved.

References:

1. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited,
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication,
4. Vector Analysis, Murray R. Spiegel, Schaum Series
5. Complex Variables and Applications, Brown and Churchill, McGraw-Hilleducation
6. Probability Statistics and Random Processes, T. Veerarajan, Mc. GrawHilleducation.

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Semester-IV									
Course Code			Course Name						Credits
CEC402			Structural Analysis						4
Contact Hours				Credits Assigned					
Theory	Practical		Tutorial	Theory	Practical		Tutorial		Total
4	-		-	4	-		-		4
Theory						Term Work/Practical/Oral			Total
Internal Assessment			End Sem. Exam	Duration of End Sem. Exam		TW	PR	OR	
Test-I	Test-II	Average							
20	20	20	80	3 hrs		-	-	-	100

Rationale

Different components of civil engineering structures are subjected to variousforce systems and their combinations. For designing the components, these are analyzed for their response. The structural systems are determinate or indeterminate in nature and so there are different analysis methods.These will be learnt in this course. Subject knowledge of Engineering Mechanics and Mechanics of solids is the prerequisite of this course.

Their application on solids and mechanisms, the action of force systems is studied and further extended in this subject. Learner will learn to apply these to the analysis of various members of structural systems such as beams, trusses, portal frames and arches. These analyses will further be used while designing of Steel and RCC structures.

Objectives

1. To analyze for axial force in the Coplanar, perfect trusses and analysis of 3- Hinged arches.
2. To study the concept of Influence Line Diagrams for Reactions, SF and B M in beams and axial forces in trusses and their application for rolling load systems.
3. To learn methods for evaluating rotation and displacement parameters in respect of frames andtrusses using various methods. To understand static and kinematic indeterminacy of structures.
4. To analyze the indeterminate structures using Flexibility methods and Using Clapeyron's Theorem..
5. To analyze the indeterminate structures such as beams & simple rigid jointed framesusing direct stiffness method.
6. To analyze the indeterminate structures using Moment Distribution as Stiffness method and Plastic analysis of structures.

Detailed Syllabus			
Module		**Course Modules / Contents**	Duration
1	**Trusses and 3 hinged Arches**		**(9)**
	1.1	**Trusses**: Analysis of Perfect Coplanar Trusses by Method of Joints (3) Analysis of Perfect Coplanar Trusses by Method of sections.(3)	**6**
	1.2	**Three hinged elastic arches,** Determination of normal thrust, radial shear and bending moment for Symmetrical & Unsymmetrical parabolic three hinged arches.(3)	**3**
2	**Influence line diagrams and rolling loads**		**(09)**
	2.1	Influence lines for Reactions, shear force and bending moment at a section of cantilever, simply supported, overhanging beams without internal hinges. (2) Rolling loads, Determination of S F and BM at a section, Value and criteria for maximum shear force and bending moment, absolute maximum shear force and bending moment under rolling loads (UDL and series of point loads) for simply supported girder. (4)	**6**
	2.2	I L D for Axial forces in members of Pin jointed trusses (3)	**3**
3	**Determinate and Indeterminate structures**		**(8)**
	3.1	Deflection of Statically determinate structures, methods based on energy principles and Castigliano's theorems to evaluate deflection in portal frames, bent up and arch type structures. Application of Unit Load Method for calculating slope and deflection of a point on rigid jointed frames and deflection of a point on Pin jointed truss.	**5**
	3.2	Static and kinematic indeterminacies: Types of structures occurring in practice, their classification, linear and non-linear behavior of materials, geometric non-linearity, static and kinematic determinacy and indeterminacy of structure.	**3**
4	**Analysis of indeterminate structures by Flexibility method**		**(9)**
	4.1	Analysis of fixed beam. Application of Clapeyron's theorem of three moments to fixed beam and continuous beam.	**4**
	4.2	Flexibility coefficients and their use in formulation of compatibility equations. Application of flexibility method to propped cantilevers, fixed beams & continuous beams, Simple rigid jointed frames.	**5**
5	**Analysis of indeterminate structures by Stiffness method**		**(8)**
	5.1	**Direct stiffness method:** Stiffness coefficients for prismatic members and their use for formulation of equilibrium equations.	**4**
	5.2	Application of Direct stiffness method to indeterminate beams & simple rigid jointed frames.	**4**
6	**Moment distribution method and Plastic Analysis of structures.**		**(9)**

	6.1	**Moment distribution method:** Application to indeterminate beams & simple rigid jointed frames & frame with inclined member but having only single translation degree of freedom including the effect of support settlement.	**5**
	6.2	**Plastic analysis of structures**: Introduction to plastic analysis, concept of plastic hinge, plastic moment carrying capacity, shape factor. Static and kinematic method of plastic analysis.Determination of collapse load for single and multiple span beams.	**4**

Contribution to Outcome

On completion of this course, the students will be able to:

1. Calculate axial forces in the Coplanartrusses by using Method of joints and method of sections and also calculate radial shear, normal thrust and bending moment in parabolic 3-Hinged arches.
2. Draw Influence Line Diagrams for axial forces in trusses, Reactions, SF and B M in beams and find their values when rolling loads are passing over them..
3. Evaluate rotation and displacement at a joint of frames and deflection at any joint of truss and will be able to compute static and kinematic indeterminacy of structure.
4. Apply Flexibility methods and make use of Clapeyron's Theorem to analyze the indeterminate structures.
5. Analyse the indeterminate structures such as beams & simple rigid jointed frames using direct stiffness method.
6. Analyse the indeterminate structures using Moment Distribution as Stiffness method and make plastic analysis.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1) Question paper will comprise of total **six questions**, **each carrying 20 marks.**
2) **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3) **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4) Only **Four questions need to be solved**.

Recommended Books:

1. Basic Structural Analysis: *C.S. Reddy*, Tata McGraw Hill New Delhi.
2. Mechanics of Structures: Vol-I: S. B. Junnarkar and H.J. Shah, Charotar Publishers, Anand.
3. Analysis of Structures: Vol. I and II, Vazirani and Ratwani

4. Strength of Materials: S. Ramamrutham, Dhanpatrai and Publishers, Delhi
5. Theory of Structures: S. Ramamrutham, Dhanpatrai and Sons, Delhi
6. Structural Analysis I: HemantPatil, YogeshPatil, Jignesh Patel, Synergy Knowledgeware, Mumbai.
7. Strength of Materials: Rajput, S. Chand Publications, Delhi
8. Structural Analysis: Bhavikatti, Vikas publisher house Pvt, ltd.
9. Structural Analysis: DevdasMenon, Narosa Publishing House.
10. Basic Structural Analysis: K.U. Muthu, Azmi Ibrahim, M. Vijyanand,
11. MagantiJanadharnand. I.K.International Publishing House Pvt. Ltd.
12. Comprehensive Structural Analysis: Vol-I and II by Vaidyanathan R. and Perumal R.LaxmiPublications.
13. Elementary Structural Analysis: Jindal
14. Structural Analysis: L.S. Negi and R.S. Jangid, Tata Mc-Graw Hill India
15. Fundamentals of Structural Analysis: Sujit Kumar Roy and SubrotaChakrabarty, S. Chand Publications.
16. Structural Analysis: T.S. Thandavamoorthy, Oxford University Press.
17. Structural Analysis: Manmohan Das, Bharghab Mohan Pentice Hall International. .

Reference Books:

1. Structural Analysis: *Hibbler*, Pentice Hall International.
2. Structural Analysis: *Chajes*, ElBS London.
3. Theory of Structures: *Timoshenko and Young*, Tata McGraw Hill New Delhi.
4. Structural Analysis: *Kassimali*, TWS Publications.
5. Element of Structural Analysis: *Norris and Wilbur*, McGraw Hill.
6. Structural Analysis: *Laursen H.I*, McGraw Hill Publishing Co.
7. Structural theorem and their application: *B.G. Neal*, Pergaman Press.
8. Fundamentals of Structural Analysis: *K.M. Leet*, C.M. Uang and A.M. Gilbert, Tata McGraw Hill, New Delhi.
9. Elementary theory of Structures: *Hseih*, Prentice Hall

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Semester- IV

Course Code	Course Name	Credits
CEC403	Surveying	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorials	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem. Exam	Duration of End Sem. Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 hrs	-	-	-	100

Rationale

As it is always said "well begun is half done". All civil engineering projects such as buildings, roads, bridges, railways, airports, dams, water treatment plants, sewage treatment plants begin with surveying. Knowledge of surveying is thus fundamental and very useful to all civil engineers. In this course, the students are well informed about the principles and methods of surveying. The students are made conversant with various instruments which are used in the field to take measurements for preparation of drawings. The course introduces the advancements in instruments and methods of surveying. The study deals with the methods of computing land areas and volume of earthworks. The course also covers horizontal and vertical curves.

Objectives

The students will be able to learn:

1. The basic principles and classification of surveying.
2. Various methods of measurements in surveying.
3. The appropriate techniques of surveying and skills of collecting field data for preparing drawings.
4. Advancements in instruments and methods of surveying.
5. The methods of computing areas and volumes using the site specific data for various purposes.
6. The setting out techniques of curves.

Detailed Syllabus

Module	Course Modules/ Contents		Periods
1	**Introduction**		5
	1.1	Definition, principles, objectives, fundamental classification-plane and geodetic.	
	1.2	Chaining, Ranging and offsetting: Definitions, Principles, Instruments required, Obstacles, conventional signs and symbols.	
	1.3	Bearings – Different types, compass – prismatic, surveyor, dip,declination and local attraction, compass traversing	
2	**Levelling and Contouring**		8
	2.1	Definitions, basic terms, types of instruments-dumpy level and Auto level, principal axes of dumpy level, temporary and permanent adjustments	
	2.2	Booking and reduction of levels, plane of collimation (HI) and rise-fall methods, computation of missing data, distance to the visible horizon,corrections due to curvature and refraction, reciprocal levelling, Numerical problems	
	2.3	Differential levelling, profile levelling, fly levelling, check levelling, precise levelling, sources of errors,difficulties in levelling work, corrections and precautions work in levelling	
	2.4	Contouring: terms, contour, contouring, contour interval, horizontal equivalent Direct and indirect methods of contouring, interpolation of contours, uses of Contours and characteristics of contour lines. Grade contour	
3	**Theodolite Surveying**		8
	3.1	Various parts and axes of transit, technical terms, temporary and permanent adjustments of a transit, measurement of horizontal and vertical angles, Methods of repetition and reiteration.	
	3.2	Different methods of running a theodolite traverse, Latitudes and departures,rectangular coordinates,traverse adjustments by Bowditch's, transit and Modified transit rules, Gales Traverse Table, Numerical Problems.	
	3.3	Miscellaneous use of theodolite for various works such as prolongation of a straight line,setting out an angle, bearing measurements.Omitted measurements, Problems in using theodolite traversing, errors in theodolite traversing.	
4	**Indirect and Advanced Methods of Measurement**		7
	4.1	Tacheometry-Principle, Objective, Suitability and different methods of tacheometry, Stadia formula, Radial contouring , numerical on stadia method only	
	4.2	Electronic Distance Measurement: Working Principles, types, applications in surveying	
		Total Station- Working Principles, applications in surveying	
	4.3	Introduction to GPS	
	Plane Table Surveying, Areas and Volumes		5

5	5.1	Definition, principle, accessories required for plane table surveying, merits and demerits, temporary adjustments, Different methods of plane table surveying	
	5.2	Areas: Area of an irregular figure by trapezoidal rule, average ordinate rule,Simpson's 1/3 rule, various coordinate methods.Planimeter: types including digital planimeter, area of zero circle, uses of planimeter.	
	5.3	Volumes: Computation of volume by trapezoidal and prismoidal formula,volume from spot levels, volume from contour plans.	
6	**Curves**		**6**
	6.1	Horizontal Curves-Definitions of different terms, necessity and types of curves.Methods of setting out Simple circular curves- linear methods and Angular methods (Numericals on simple circular curves only)	
	6.2	Vertical curves– Definitions, geometry and types. Tangent correction and chord gradient methods.	
		Total	**39**

Contribution to Outcomes

After completion of the course, the learner will be able to:

1. 1.Apply the principles of surveying and field procedures to conduct the various surveys
2. Use various methods for taking linear and angular measurements
3. Collect, record and analyse the field data for preparing drawings.
4. Explain the advancements in instruments and methods
5. 5.Calculate the area of land and volume of earthwork
6. Set out curves

Internal Assessment (20 marks):
Consisting **Two Compulsory Class Tests:**
First test based on approximately 40% of the contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum

1. The question paper will consist of **six questions, each carrying 20 marks.**
2. **Question 1** will be **compulsory**and should cover **maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature**(for example if Q.2 has part (a) from module 3 then part (b) will be from any other module other than module 3)
4. Only**Four questions need to be solved.**

Recommended Books:

1. Surveying and Levelling: R. Agor, Vol. -I, 11th Edition, Khanna Publishers (ISBN8174092358)

2. Surveying and Levelling:Kanetkar and Kulkarni, Vol. -I, 24th Edition, Pune Vidyarthi Griha, Pune. (ISBN 8185825114)
3. Surveying and Levelling:Dr. B.C. Punmia, Vol.-I, 16th Edition, Vol. -II 4th Edition, Laxmi Publications (ISBN9788170088530)
4. Surveying and Levelling: N NBasak, 2nd Edition, Tata McGraw Hill, New Delhi. (ISBN 9789332901537)

Reference Books:

1. Surveying: Volume -I: Dr K.R. Arora, Standard Book House.
2. Surveying and Levelling (2nd Edition): R. Subramanian; Oxford Higher Education.
3. Surveying and Levelling (Vol.-I): S.K. Duggal, Tata McGraw Hill
4. Textbook of Surveying, C Venkatramaiah, University Press, Hyderabad, Latest Edition
5. Fundamentals of Surveying, S.K. Roy, Prentice Hall India, New Delhi
6. Surveying for Engineers, John Uraine and Bill Price, Palgrave Macmillan
7. Surveying: Theory and Practice, James Anderson, Edward M. Mikhail, Tata Mcgraw Hill

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Semester - IV

Course Code	Course Name	Credits
CEC 404	Building Materials & Concrete Technology	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03		-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	---	100

Rationale

Materials are essential elements, constituent parts (or) substances which are used to raise a building, but materials could not be turned into structures without a method of construction. This course provides necessary knowledge about properties, uses of different types of building materials and the selection of materials, its mix proportioning, mixing, placing, compacting and curing. This course is intended for gaining useful knowledge with respect to facts, concepts, principles and procedures related to building materials and concrete technology so that student can effectively execute quality control during building construction work.

Objectives

1. To identify the good and significant materials to be used for the construction work and their associated quality, durability, warrantees, and availability.
2. To study the manufacturing process, properties and use of different types of building materials like stone, brick, glass, timber and the materials such as paints and varnishes used for the treatment of surfaces so as to achieve good knowledge about the building materials.
3. To acquire a thorough knowledge about the properties and significance of different materials used for the manufacturing of concrete.
4. To study the properties, test conducted and significance of concrete in terms of properties of fresh and hardened concrete.
5. To understand the concept and optimization of mix design of concrete for different exposure conditions.
6. To enable the students to understand the mechanized and precise procedure of concrete production in Ready Mix Plants. To understand the basic non-destructive tests conducted on concrete to check the in place strength and durability of concrete.

Detailed Syllabus

Module		Course Modules / Contents	Periods
1	**Introduction to building materials and concrete:**		**03**
	1.1	**Introduction to building materials:** Introduction, role of materials in construction, classification of materials, economical and durable materials.	
	1.2	**Introduction to concrete:** History of concrete, necessity, limitations, merits and demerits.	
2	**Building Materials:**		**09**
	2.1	**Stones:** Classification and properties of building stones, relation to their structural requirements, quarrying, dressing, seasoning and preservative treatments.	
	2.2	**Bricks and blocks:** Burnt clay bricks: raw materials, manufacturing processes, classification, properties, defects, tests as per BIS codes. Bricks for special use: refractory bricks. Concrete blocks, Paver block, Autoclaved Aerated Concrete (AAC) blocks, Cellular Light Weight Concrete (CLC) blocks and ceramic tiles: raw materials, manufacturing process and properties.	
	2.3	**Glass:** Properties, types, uses.	
	2.4	**Timber:** Types of natural wood and artificial wood, preservative treatments, defects in timber, wood products and wood composites.	
	2.5	Damp proofing, water proofing materials and Termite proofing.	
	2.6	**Mortar:** Types, ingredients, proportions and suitability.	
	2.7	**Paints, Enamels and Varnishes:** Composition. Painting on: plastered surfaces, wood surfaces, meta l surfaces. Effect of weather on: Enamels, distemper, white wash and colour wash, varnish, French polish, Wax Polish.	
	2.8	**Miscellaneous Materials:** Gypsum, Plaster of Paris, Heat and sound insulating materials.	
3	**Constituent of Concrete:**		**09**
	3.1	**Fine and Coarse Aggregates:** Classification, physical and mechanical propertiesand their influence on the properties of concrete, gradation, Alkali aggregate reaction. Properties of manufacturing sand.	
	3.2	**Cement (OPC):** Grades, Manufacturing, Chemical composition, Hydration of cement, Physical properties as per BIS code. Effects of chemical constituents on the properties of cement. Different types of cement**:** Chemical composition, properties as per relevant IS codes and their applications.	
	3.3	**Water:** Desiredquality of water for concrete.	
	3.4	**Lime:**Types and their usages.	
	3.5	**Admixtures:** Definition and purposes, types of mineral and	

		chemical admixtures. Test on admixtures: chemistry and compatibility with concrete.	
4	**Concrete:**		**06**
	4.1	Grades, manufacturing process, preparation of batch report, Duff Abram's W/C ratio law & its significance.	
	4.2	Properties of fresh and hardened concrete, factors affecting of workability, vibration of concrete, Types of vibrators: Internal, external, surface and table vibrators.	
	4.3	Durability: factors affecting durability, relation between durability and permeability, laboratory tests on durability such as Permeability test, Rapid chloride penetration test (RCPT).	
5	**Concrete Mix Design:**		**08**
	5.1	Definition and objectives, Types of mix as per IS:456, Mix design for compressive strength and flexural strength in accordance with IS 10262 and IS 456.	
	5.2	Methods of Curing of concrete, Methods of determining compressive Strength of accelerated-cured concrete test specimens as per IS 9013, Calculation of ingredients of concrete for batching as per concrete mix proportions for different grades.	
6	**Concreting Methods and Test**		**04**
	6.1	**Ready Mixed Concrete:** Advantages of RMC, Components and Lay-out of RMC plant. Distribution and Transport, Handling and Placing. Codes recommendations.	
	6.2	**Non-Destructive Testing:** Need, application and limitation, Schmidt Rebound hammer test, Ultrasonic Pulse Velocity test.	

Contribution to Outcome

On completion of this course, the students will be able to:

1. To develop and implement the conceptual knowledge of building materials in the construction industry.
2. Assess the properties of building stones and their classifications. Understand the concept of various methods of manufacturing of bricks and different types of concrete blocks.
3. To expose students to various quality control aspects of civil engineering materials by performing different lab tests on materials.
4. Identify the ingredients and properties of fresh and hardened concrete.
5. To interpret and design concrete mix for various grades for various exposure conditions.
6. To study the new technology for manufacturing, testing and quality of concrete.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be compulsory and should cover **maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module3)
4. Only **Four questions need to be solved.**

Recommended Books:

1. A Building Construction: S.*C. Rangwala,* Charotar Publications, Gujarat, India.
2. Building Construction: *S.P. Arora, Dr.S.P. Bindra,*DhanpatRai Publication, New Delhi.
3. Building Construction: *Dr. B.C. Punmia, A.K.Jain, A.R.Jain,*Laxmi Publication., New Delhi.
4. Concrete Technology Theory and Practice: *M.S. Shetty, S.*Chand Publication.
5. Concrete Technology: *M.L. Gambhir,* Tata McGraw Hill, NewDelhi.
6. Concrete Technology: *A.M. Neville & J. J. Brooks.,* ELBS-Longman.
7. Concrete Technology: *A.M. Neville & Isaac Pitman,* London.
8. Concrete Technology: *A. R. Shanthakumar,* Oxford University Press.
9. Materials of Construction: *D. N. Ghose,* Tata McGraw Hill, Delhi.
10. Building Materials: *S.K. Duggal,* New Age International Publishers.
11. Concrete Technology: *D. F. Orchardi,* Wiley, 1962.
12. Relevant codes: BIS, ACI & BS.

Reference Books/Reference Materials:

1. Engineering Materials: *S.R. Rangwala,*Charotar Publications.
2. Architectural Materials science: D. Anapetor, Mir Publishers.
3. Introduction to Engineering Materials: B. K. Agrawal, Tata McGraw Hill, NewDelhi.
4. Engineering Materials: P. Surendra Singh, Vani Education Books,New Delhi.
5. Building Materials (Products, Properties and Systems): M.L. Gambhir and NehaJamwal,McGraw Hill Publications.
6. Properties of concrete: Neville, Isaac Pitman, London.
7. NPTEL Lecture series on Building Materials and Concrete Technology.

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Semester- IV

Course Code	Course Name	Credits
CEC405	Fluid Mechanics - II	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 hrs	-	-	-	100

Rationale

The course introduces the fluid flow science, problems and their applications in varied conditions. The study deals with the characteristics of fluid flow in pipes namely compressible, laminar and turbulent with their applications in detail.

Objectives

The students will be able to learn:

1. The knowledge of closed conduit flows, determine various losses through pipes, Pipe network and Water hammer effect
2. Theory of Laminar flow and Turbulent flow,
3. Understand the concept of Boundary Layer theory, flow separation and forces around submerged bodies
4. Application of moment of momentum principle on pipe bends and sprinklers
5. The importance of dimensionless numbers, dimensional analysis and similarities.

Detailed Syllabus

Module		Course Modules / Contents	Periods
1	**Flow through pipes**		14
	1.1	**Flow through pipes:** Loss of head through pipes, Darcy-Weisbach equation, Major and minor losses. Hydraulic gradient line and Total energy gradient line, pipes in series,equivalent pipes, pipes in parallel, flow through laterals, flow through Branched pipes, three reservoir problem, siphon.	
	1.2	**Pipe network and water hammer:** Hardy cross method, water hammer in Pipes-Gradual closure and instantaneous closure of valve control measures	

	1.3	**Flow through nozzles:** Power transmitted through nozzle, condition for maximum power transmitted,diameter of nozzle for maximum transmission of power	
2	**Laminar Flow**		**05**
	Reynolds experiment, critical velocity, laminar flow through circular pipes, flow between two parallel plates: stationary and moving.		
3	**Turbulent Flow**		**04**
	Causes of turbulence, shear stress in turbulent flow, Reynolds's stresses, Prandtl's mixing length Theory, Hydro dynamically smooth and rough boundaries, velocity distribution in smooth and rough pipes, Karman-Prandtl's velocity distribution equation.		
4	**Boundary Layer Theory**		**07**
	Development of boundary layer over flat surfaces. Boundary layer thickness, energy thickness and momentum thickness, Boundary layer separation and control. Introduction to flow around submerged body, drag and lift, terminal velocity of body, Magnus Effect.		
5	**Dynamics of Fluid Flow**		**04**
	Momentum principle, Moment of momentum principle (applications: Pipe bends and sprinklers).		
6	**Dimensional Analysis**		**05**
	Dimensional homogeneity, Buckingham's π theorem, Rayleigh's method, dimensionless numbers and their significance, Model (or similarity) laws, application of model laws: Reynolds's model law, Froude's model law, Euler's Model law, Weber's Model law, Mach model law, scale effect in models.		
Total			**39**

Contribution to Outcome

Upon completion of the course, students shall have ability to:

1. Analyze flow through pipes, various losses through pipes, pipe network and power transmission through nozzle
2. Explain the concept of Laminar flow and velocity distribution through parallel plates and pipes
3. Explain the concept of Turbulent flow and velocity distribution in pipes
4. Describe boundary layer concept , boundary layer separation and flow around submerged bodies
5. Apply Moment of Momentum Principle

6. Explain the importance of dimensionless numbers, dimensional analysis and similarity behavior of model and prototype

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests:**

First test based on approximately 40% of contents and second test based on remainingcontents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks.**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

Recommended Books:

1. Hydraulics and Fluid mechanics: Dr P.M. Modi and Dr. S.M. Seth, Standard book House, Delhi
2. Theory and Application of Fluid Mechanics: K. Subramanya, Tata McGraw hill publishing company
3. Fluid Mechanics: Dr. A.K Jain, Khanna Publishers.
4. Fluid Mechanics and fluid pressure engineering: Dr. D.S. Kumar, F.K. Kataria and sons
5. Fluid Mechanics and Hydraulics: Dr. S. K. Ukarande, Ane Books Pvt. Ltd. (Revised Edition, 2012), ISBN97893 8116 2538
6. Fluid Mechanics: R.K. Bansal Laxmi Publications (P) Ltd.
7. Fluid Mechanics and Machinery: C.S.P.Ojha, R. Berndtsson and P.N. Chandramouli. Oxford HigherEducation.

Reference Books:

1. Fluid Mechanics: Frank M. White, Tata Mc-Graw-Hill International edition.
2. Fluid Mechanics: Streeter White Bed ford, Tata McGraw International edition.
3. Fluid Mechanics with engineering applications: R.L. Daugherty, J.B.Franzini, E.J.,Finnemore, TataMcGraw Hill New Delhi.
4. Hydraulics: James F. Cruise, Vijay P. Singh and Mohsen M. Sherif, CENGAGE Learning India Pvt. Ltd.,Delhi.

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Semester- IV

Course Code	Course Name	Credits
CEL401	Structural Analysis Tutorial	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Objectives:

1. To analyse for axial force in the Coplanar, perfect trusses and analysis of 3- Hinged arches.
2. To study the concept of Influence Line Diagrams and rolling loads.
3. To learn methods for evaluating rotation and displacement of frames and trusses.
4. To analyse the indeterminate structures using Flexibility methods and Stiffness methods.
5. To understand Plastic analysis.

Outcomes:

On completion of this course, the students will be able to:

1. Calculate axial forces in the Coplanar trusses by using Method of joints and method of sections and also calculate radial shear, normal thrust and bending moment in parabolic 3-Hinged arches.
2. Draw Influence Line Diagrams for axial forces in trusses, Reactions, SF and B M in beams and find their values when rolling loads are passing over them..
3. Evaluate rotation and displacement at a joint of frames and deflection at any joint of truss and will be able to compute static and kinematic indeterminacy of structure.
4. Analyse the indeterminate structures such as beams & simple rigid jointed frames using Flexibility methods and direct stiffness method.

List of Tutorials and Assignments		
Week (Activity)	**Content**	**Hours**
1st week (Tutorial)	Analysis of Trusses and Three hinged elastic arches (Numericals based on this Module will be solved in tutorial room.)	**2**

2nd week (Assignments)	1) Analysis of Trusses and Three hinged elastic arches 2) Solve set of questions given by the course instructor or 3) Write a report on use of arches in civil engineering or 4) Difference in behaviour of trusses and arches if used in bridges or 5) Write a report on limitations of trusses /arches or 6) Report Famous Truss structures / arch structures in world or 7) 6 Write a report on use of trusses in Civil Engineering	**2**
3rd week (Tutorial)	Influence line diagrams and rolling loads (Numericals based on this Module will be solved in tutorial room.)	**2**
4th week (Assignments)	Influence line diagrams and rolling loads 1) Solve set of questions given by the course instructor or 2) Write a report on use of arches in civil engineering or 3) Design an experiment for ILD of reactions of beam. or 4) Design an experiment for ILD of axial forces of a multi-bay truss. or 5) write a report on IRC and classes of rolling loads	**2**
5th week (Tutorial)	Determinate and Indeterminate structure (Numericals based on this Module will be solved in tutorial room.)	**2**
6 th week (Assignments)	Determinate and Indeterminate structure 1) Solve set of questions given by the course instructor or 2) Prepare a chart explaining static and kinematic indeterminacy or 3) Write a computer program in C++ or MS-excel or similar for ILD of reactions. or 4) Write a computer program in C++ or MS-excel or similar for ILD for axial forces in Truss members.	**2**
7th week (Tutorial)	Analysis of indeterminate structures by Flexibility method (Numerical based on this Module will be solved in tutorial room.)	**2**
8th week (Assignments)	Analysis of indeterminate structures by Flexibility method 1) Solve set of questions given by the course instructor or 2) Prepare a poster on Flexibility and Stiffness approach or 3) Solve a set of 4-5 questions given by the course instructor on Flexibility methods and validate the same using relevant Structural Analysis or design software.	**2**
9th week (Tutorial)	Analysis of indeterminate structures by Direct stiffness method (Numericals based on this Module will be solved in tutorial room).	**2**
10th week (Assignments)	Analysis of indeterminate structures by Direct stiffness method 1) Solve set of questions given by the course instructor or 2) Write a report on Stiffness methods in civil engineering or 3) Prepare a poster on Clapeyron's theorem for continuous beam.or 4) Solve a set of 4-5 questions given by the course instructor on Direct stiffness method and validate the same using relevant Structural Analysis or design software.	**2**

11th week (Tutorial)	Moment distribution method, Plastic analysis of structures (Numerical based on this Module will be solved in tutorial room.)	**2**
12th week (Assignments)	Moment distribution method, Plastic analysis of structures 1) Solve set of questions given by the course instructor or 2) Write a report on Plastic analysis of structures or 3) Solve a set of 4-5 questions given by the course instructor on Moment distribution method and validate the same using relevant Structural Analysis or design software.	**2**
13th week	Viva-Voce Examination	**2**

- **Assessment:**

Term Work: Term work will include Tutorial work and Assignments both, Distribution of marks for Term Work shall be as follows:

Tutorial work- : 15 Marks
Assignments- : 10 Marks
Total Term work : 25 Marks
Attendance : Apply multiplying Factor 0.5 to 1.0 to the above total.

End Semester Oral Examination

Oral examination will be based on entire syllabus.

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Semester- IV

Course Code	Course Name	Credits
CEL402	Surveying(Lab)	1.5

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	50	-	25	75

@ For the course "Surveying (Lab)" the oral examination shall be conducted in conjunction with the practical conduction.

Course Objectives:

The students will be able to learn:

1) Various surveying instruments, their least counts, various parts and suitable uses.
2) Methods of measurements in the field.
3) Skills for collecting, recording and analysing the field data.
4) Advanced instruments and methods.
5) First hand practical experience by receiving field exposure to collect site specific data.
6) Setting out techniques.

Course Outcomes:

At the end of the course, learner will be able to:

1) Operate and use the surveying instruments according to the accuracy and suitability.
2) Measure linear and angular dimensions in horizontal and vertical planes.
3) Collect, record and analyse the field data systematically.
4) Prepare plans of the existing features on the ground, sections and contours.
5) Compute the area of land and the volume of earthwork.
6) Set out curves and foundation plans.

List of practical's and projects:

Perform minimum **six** practical's out of 01 to 10 and all the projects are **mandatory**

Module	**Detailed Contents**	**Lab Sessions/Hr**
1	Chain and cross staff surveying.	03 hrs
2	Measuring bearings of a closed traverse with prismatic compass and computation of interior angles.	03 hrs
3	Simple and compound levelling	03 hrs
4	Measurement of horizontal and vertical angles.	03 hrs
5	Finding constants, heights and distances using tachometry.	03 hrs
6	Measurement of distances, bearings and area using total station.	03 hrs
7	Plane Table Surveying by intersection method.	03 hrs
8	Find an area of irregular figure using a conventional planimeter and verify it using a digital planimeter.	03 hrs
9	Setting out a simple curve by Rankine's method.	03 hrs
10	Setting out a simple foundation plan.	03 hrs
Projects		
A survey camp of three days is to be arranged to execute the following projects for undergoing the students through practical instructions in civil engineer's career with the actual field exposure at an ideal site location .		
1	**Project I:** Road project using Auto level for a minimum length of 500 m including fixing of alignment, profile levelling, cross-sectioning at 20m interval,, plotting of 'L' section and 'C' section. (Two full imperial sheets, the first sheet with key plan and 'L' section and the second sheet covering any three typical Cross-sections)	
2	**Project II:** Block Contouring project using Auto level for minimum 60 m × 60 m area and generating contours by MS Excel. (Take contour interval as 0.2 meter)	
3	**Project III:**Tachometric contouring project on a hilly area with at least two instrument stations about 60 m to 100 m apart and generating contours by taking contour intervals as 1 meter.	

Assessment:

Teamwork

Including above practical work, projects and assignments, distribution of marks for Term Work shall be as follows:

Practical Work-	:	15 marks
Assignments -	:	05 marks
Attendance-	:	05 marks
Projects-		
Field work	:	15marks
Office work (Drawings)	:	10marks
Total	**:**	**50marks**

- **End Semester Practical/ Oral Examination**

Practical Examination : 10 Marks

Oral Examination : 15 Marks.

Oral examination will be conducted after conduction of practical examination & it will be based on term work & Practical examination

Reference Books:

1) Surveying and Levelling *: R. Agor, Vol-I, 11th Edition,* Khanna Publishers (ISBN 8174092358)
2) Surveying and Levelling :*Kanetkar and Kulkarni,*Vol-I, 24th Edition, Pune VidyarthiGriha, Pune. (ISBN 8185825114)
3) Surveying and Levelling : *Dr. B.C. Punmia,* Vol.-I, 16th Edition, Vol -II 4th Edition, Laxmi Publications (ISBN9788170088530)
4) Surveying and Levelling: *N NBasak,* 2nd Edition, Tata McGraw Hill, New Delhi. (ISBN 9789332901537)
5) Surveying: Vol-I: Dr K.R. Arora, Standard Book House.
6) Surveying and Levelling (2nd Edition): R. Subramanian; Oxford Higher Education.
7) Surveying and Levelling (Vol.-I): S.K. Duggal, Tata Mc-Graw Hill

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Semester- IV

Course Code	Course Name	Credits
CEL 403	Building Materials & Concrete Technology (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Objectives:

1) To determine physical and mechanical properties of materials used in the manufacturing of concrete like cement and aggregates.
2) To test the physical attributes and mechanical strength of burnt clay bricks used in the construction of structures.
3) To determine the various properties of fresh and hardened concrete with and without the addition of admixtures.
4) To study the different basic non-destructive tests conducted in the laboratory or on site to determine the durability and strength of existing concrete structures.
5) To utilize the knowledge of mix design in the manufacturing of concrete, in the laboratory.
6) To test the physical attributes and mechanical strength of timber and tiles used in the construction of various components of the structure.
7) To understand the practical scenario of the commonly used building materials in terms of their availability, cost and significance through market surveys.

Outcomes: Learner will be able to…

1) Develop collaborative skills to work in a team/group
2) Test physical properties of cement, aggregates and concrete.
3) Test various other building materials like tiles, bricks and timber
4) Evaluate the effects of admixtures on physical properties of concrete.
5) Design the concrete mix.
6) To bridge the gap between theoretical and market/industrial practices by market surveys.

List of Experiments (first seven are compulsory)

Module	Detailed Contents	Lab Sessions/Hr
1	Physical properties of OPC: Physical test, Fineness, Standard consistency, Soundness, Setting time, Compressive strength.	**02/04**
2	Physical Properties of Fine and Course Aggregates: Specific gravity, bulk density, Moisture content, Water absorption, flakiness index, elongation index, Fineness modulus, Silt content and bulking of sand	**02/04**
3	Tests on burnt clay bricks	**01/02**
4	Effect of w/c ratio on workability (slump cone, compaction factor, V-B test, flow table) and strength of concrete	**02/04**
5	Study of admixtures and their effect on workability and strength of concrete.	**01/02**
6	Non-destructive testing of concrete: Rebound hammer and ultrasonic pulse velocity	**01/02**
7	Concrete mix design in the laboratory	**01/02**
8	Test on tiles(optional)	**01/02**
9	Compression test on timber (Parallel/ perpendicular to the grains). (optional)	**01/02**
10	Market survey on common building materials (optional)	**01/02**

Site Visit/ Industrial Visit:

The students shall visit the brick, paver blocks, concrete block, cement, glass and RMC industrial plants. They shall prepare a report of the visit and the same shall be evaluated by the concerned teacher.

Assessment:

The term work shall consist of:

- Report of experiments performed.
- Industrial visit report to at least **any one** of the above mentioned industrial plants.
- Although minimum numbers of market surveys and industrial visits are prescribed, the students shall be encouraged to perform more number of experiments and site/ industrial visits.

Distribution of the Term Work Marks:

The marks of the term work shall be judiciously awarded for the various components of the term work and depending upon the quality of the term work including industrial/ site visit report. The final certification and acceptance of term work warrants the satisfactory performance of laboratory work by the student, appropriate completion of the assignments. Broadly, the split of the marks for term work shall be as given below. However, there can be further bifurcation in the marks under any of the heads to account for any sub-head therein.

Individual Practical performance **:** 07 Marks

Assignments : 03 Marks

Reports of experiment **:** 05 Marks

Site Visit/Industrial visit	**:**	05 Marks
Attendance	**:**	05 Marks
Total	**:**	**25 marks**

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted tom75% - 80%: 03 Marks; 81% - 90%: 04 Marks; 91% onwards: 05 Marks.

End Semester Practical/Oral Examination

The oral examination shall be based on the entire syllabus and term work comprising of the report of the experiments/ practical conducted by the students and a detail report of the industrial/ site visit.

Recommended Books:

1) A Building Construction: S.*C. Rangwala*, Charotar Publications, Gujarat, India.
2) Building Construction: S.P. Arora, Dr.S.P. Bindra,DhanpatRai Publication, New Delhi.
3) Building Construction: Dr. B.C. Punmia, A.K.Jain, A.R.Jain,Laxmi Publication., New Delhi.
4) Concrete Technology Theory and Practice: M.S. Shetty, S.Chand Publication.
5) Concrete Technology: M.L. Gambhir, Tata McGraw Hill, NewDelhi.
6) Concrete Technology: A.M. Neville & J. J. Brooks., ELBS-Longman.
7) Concrete Technology: A.M. Neville & Isaac Pitman, London.
8) Concrete Technology: A. R. Shanthakumar, Oxford University Press.
9) Materials of Construction: D. N. Ghose, Tata McGraw Hill, Delhi.
10) Building Materials: S.K. Duggal, New Age International Publishers.
11) Concrete Technology: D. F. Orchardi, Wiley, 1962.
12) Relevant codes: BIS, ACI & BS.

Reference Books/Reference Materials:

1) Engineering Materials: *S.R. Rangwala*,Charotar Publications.
2) Architectural Materials science: D. Anapetor, Mir Publishers.
3) Introduction to Engineering Materials: B. K. Agrawal, Tata McGraw Hill, NewDelhi.
4) Engineering Materials: P. Surendra Singh,Vani Education Books, New Delhi.
5) Building Materials (Products, Properties and Systems): M.L. Gambhir and NehaJamwal, McGraw Hill Publications.
6) Properties of concrete: Neville, Isaac Pitman, London.
7) NPTEL Lecture series on Building Materials and Concrete Technology.

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Semester- IV

Course Code	Course Name	Credits
CEL404	Fluid Mechanics – II (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objectives:

The students will be able to learn:

1) to verify the basic fluid mechanics concepts experimentally
2) the fluid flow pattern in pipes
3) to estimate the losses in pipe flow
4) the velocity distribution in pipes

Course Outcomes:

At the end of the course, learner will be able to:

1) Verify the Reynold's experiment
2) Estimate the viscosity of fluid
3) Calculate the losses in pipes
4) Assess the flow pattern and velocity distribution in pipe flow
5) learn the water hammer phenomenon through demonstration
6) learn the wind tunnel testing through demonstration

List of Experiments (Minimum Six)

Module	Detailed Contents	Lab Sessions/Hr
1	Study of different types of flow using Reynold's apparatus	02 hrs
2	Determination of viscosity of fluid	02 hrs
3	Estimation of the head loss due to friction incurred by a fluid along a pipeline (To find the friction factor for the given pipes of different sizes)	04 hrs
4	To determine different losses in pipe fittings (Estimation of the minor losses)	04 hrs
5	Laminar flow through pipes	02 hrs
6	Velocity distribution in circular pipes	04 hrs
7	Turbulent flow through pipe	02 hrs
8	Study of Water Hammer phenomenon	04 hrs
9	Study of wind tunnel	02 hrs

Assessment:

- **Term Work**

Including Laboratory Work and Assignments both, Distribution of marks for Term Work shall be as follows:

Laboratory work-	:	15 Marks
Assignments-	:	05 Marks
Attendance	:	05 Marks

- **End Semester Oral Examination**

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Reference Books:

1) Fluid Mechanics and Hydraulic Machines: R. K. Rajput, S. Chand and Company
2) Hydraulics and Fluid mechanics: Dr. P.M. Modi and Dr. S.M. Seth, Standard Book House, Delhi
3) Hydraulics Fluid Mechanics and Fluid Machines: S. Ramamrutham, DhanpatRai Publishing Company (P) Ltd-New Delhi
4) Theory and Application of Fluid Mechanics: K. Subramanian, Tata McGraw hill publishing company, New Delhi.
5) Fluid Mechanics and Hydraulics: Dr. S.K. Ukarande, Ane's Books Pvt. Ltd. (Revised Edition 2012), ISBN 97893 8116 2538
6) Fluid Mechanics and fluid pressure engineering: Dr. D.S. Kumar, F.K. Kataria and sons
7) Fluid Mechanics: R.K. Bansal Laxmi Publications (P) Ltd.

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Semester- IV

Course Code	Course Name	Credits
CEL405	Skill Based Lab Course-II Total Station and Geographical Information System	1

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	2	-	-	1	-	1

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem. Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	50	-	-	50

Objectives:

1) To enable the learners, operate the Total Station and generate its output in terms of plans, elevations and 3D views
2) To enable the learners, operate the Global Navigation Satellite System (GNSS) receivers and retrieve the information
3) To enable the learners work on a Geographical Information System (GIS) platform for assimilating geographical data

Outcomes: Learner will be able to…

1) Operate a Total Station and traverse the field
2) Perform various operations like computing height of a structure, computing area of plot, subdividing area, demarcating boundaries, etc. Using Total Station
3) Set out foundation plan using Total Station
4) Compute the point, line and area features using Global Navigation Satellite System
5) Plot various existing features in a geographic area on a GIS platform
6) Add attribute and perform various statistical operations in GIS

List of Experiments (Minimum Eight)

Module	Detailed Contents	Lab Sessions/Hr
1	Introduction to concepts, fundamental features and working principal of Total Station (TS)	02
2	Temporary settings of a TS in field and perform basic functions on	02

	total station like traversing, area of open plot, height calculations, etc.	
3	Collect detailed features of a plot (comprising features such as 2-3 buildings, courtyards, security cabins, playgrounds, trees, gates, poles, roads, drainage lines, etc.) using TS	04
4	Transfer data collected through TS on a convenient computer aided drafting (CAD) software	02
5	Feeding a CAD plan in TS and setting out a foundation plan using TS	02
6	Introduction to fundamental features of Global Navigation Satellite System (GNSS) and collect point, line and polygon features through a GNSS receiver	02
7	Computing latitudes, longitudes, altitudes of points, length of roads, area of plots, etc. using a GNSS system	02
8	Basic introduction to compatibilities, utilities and attributes of peculiar Geographical Information System (GIS) softwares available in market w.r.t their various commands, features, capabilities and functions.	02
9	Collecting ground points through GNSS and TS for integrating it with spatial data obtained from a GIS platform like google earth, openstreetnetwork, etc. and developing a model on a GIS software	04
10	Add various layers in term of attributes and perform various statistical operations and queries in GIS	04

Assessment:

- **Term Work**

Including Laboratory Work comprising of minimum 8 software generated sheets distribution of marks for Term Work shall be as follows:

Laboratory work : 40 Marks (comprising of min 8 software generated sheets:
4 using TS and GNSS data in CADD tool and 4 using GIS tool)

Attendance : 10 Marks

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Semester- IV

Course Code	Course Name	Credits
CEM 401	Mini Project -1B	1.5

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Objectives

1) To acquaint with the process of identifying the needs and converting it into the problem.
2) To familiarize the process of solving the problem in a group.
3) To acquaint with the process of applying basic engineering fundamentalsto attempt solutions to the problems.
4) To inculcate the process of self-learning and research.

Outcome: Learner will be able to…

1) Identify problems based on societal /research needs.
2) Apply Knowledge and skill to solve societal problems in a group.
3) Develop interpersonal skills to work as member of a group or leader.
4) Draw the proper inferences from available results through theoretical/ experimental/simulations.
5) Analyse the impact of solutions in societal and environmental context for sustainable development.
6) Use standard norms of engineering practices
7) Excel in written and oral communication.
8) Demonstrate capabilities of self-learning in a group, which leads to life long learning.
9) Demonstrate project management principles during project work.

Guidelines for Mini Project

1) Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
2) Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
3) Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
4) A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.

5) Faculty supervisor may give inputs to students during mini project activity;however, focus shall be on self-learning.
6) Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
7) Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
8) The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
9) With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
10) However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05
    -

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
- First shall be for finalisation of problem
- Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
- First review is based on readiness of building working prototype to be conducted.

- Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems
    - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
    - First shall be for finalisation of problem and proposed solution
    - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1) Quality of survey/ need identification
2) Clarity of Problem definition based on need.
3) Innovativeness in solutions
4) Feasibility of proposed problem solutions and selection of best solution
5) Cost effectiveness
6) Societal impact
7) Innovativeness
8) Cost effectiveness and Societal impact
9) Full functioning of working model as per stated requirements
10) Effective use of skill sets
11) Effective use of standard engineering norms
12) Contribution of an individual's as member or leader
13) Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1) Quality of problem and Clarity
2) Innovativeness in solutions
3) Cost effectiveness and Societal impact
4) Full functioning of working model as per stated requirements
5) Effective use of skill sets
6) Effective use of standard engineering norms
7) Contribution of an individual's as member or leader
8) Clarity in written and oral communication

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AC-29/06/2021
Item No.-6.2

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Civil Engineering

Second Year with Effect from AY 2020-2021

Third Year with Effect from AY 2021-2022

Final Year with Effect from AY 2022-2023

(REV-2019 'C' Scheme) from Academic Year 2019-2020

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019-2020)

Syllabus for Approval

Title of the Course	**:**	Third Year in Bachelor of Civil Engineering
Eligibility for Admission	**:**	After Passing First Year Engineering as per the Ordinance 0.6242
Passing Marks	**:**	40%
Ordinances / Regulations (if any)	**:**	Ordinance 0.6242
No. of Years / Semesters	**:**	8 semesters
Level	**:**	Under Graduation
Pattern	**:**	Semester
Status	**:**	New
To be implemented from Academic Year	**:**	With effect from Academic Year: 2021-2022

Dr. S. K. Ukarande

Associate Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Dr Anuradha Muzumdar

Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Third Year of Engineering from the Academic year 2021-22. Subsequently this will be carried forward for Final Year Engineering in the academic years 2022-23.

Dr. S. K. Ukarande

Associate Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Dr Anuradha Muzumdar

Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Incorporation and Implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill-based activities and project-based activities. Self-learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self-learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S. K. Ukarande

Associate Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Dr Anuradha Muzumdar

Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Preface

The engineering education in India is expanding and is set to increase manifold. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. To meet this challenge, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program Outcomes (POs) are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this, Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome-based education (OBE) in the process of curriculum development from Rev-2012 onwards and continued to enhance the curriculum further based on OBE in Rev-2016 and Rev-2019 "C" scheme.

As Chairman and Members of Board of Studies in Civil Engineering, University of Mumbai, we are happy to state here that, the Program Educational Objectives (PEOs) for Undergraduate Program were finalized in a brain storming session, which was attended by more than 40 members from different affiliated Institutes of the University, who are either Heads of Departments or their senior representatives from the Department of Civil Engineering. The PEOs finalized for the undergraduate program in Civil Engineering are listed below;

1. To prepare the Learner with a sound foundation in mathematical, scientific and engineering fundamentals
2. To motivate the Learner in the art of self-learning and to use modern tools for solving real life problems
3. To prepare the Learner for a successful career in Indian and Multinational Organisations and for excelling in post-graduate studies
4. To motivate learners for life-long learning
5. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the Learner's thought process

In addition to the above listed PEOs, every institute is encouraged to add a few (2-3) more PEOs suiting their institute vision and mission

Apart from the PEOs, for each course of the program, objectives and expected outcomes from a learner's point of view are also included in the curriculum to support the philosophy of OBE. We strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stakeholders.

Board of Studies in Civil Engineering University of Mumbai			
Dr. S. K. Ukarande	Chairman	Dr. V. Jothiprakash	Member
Dr. D.D. Sarode	Member	Dr. K. K. Sangle	Member
Dr. S. B. Charhate	Member	Dr. D. G. Regulawar	Member
Dr. Milind Waikar	Member	Dr. A. R. Kambekar	Member
Dr. R.B. Magar	Member	Dr. Seema Jagtap	Member

Undergraduate Program Structure for Second year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2020-2021**)
Semester – III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC301	Engineering Mathematics – III	03	-	01	03	-	01	04
CEC302	Mechanics of Solids	04	-	-	04	-	-	04
CEC303	Engineering Geology	03	-	-	03	-	-	03
CEC304	Architectural Planning & Design of Buildings	02	-	-	02	-	-	02
CEC305	Fluid Mechanics – I	03	-	-	03	-	-	03
CEL301	Mechanics of Solids	-	02	-	-	01	-	01
CEL302	Engineering Geology	-	02	-	-	01	-	01
CEL303	Architectural Planning & Design of Buildings	-	02	-	-	01	-	01
CEL304	Fluid Mechanics – I	-	02	-	-	01	-	01
CEL305	Skill Based Lab Course – I	-	03	-	-	1.5	-	1.5
CEM301	Mini Project – 1A	-	03$	-	-	1.5	-	1.5
Total		**15**	**14**	**1**	**15**	**7**	**1**	**23**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract. /Oral	Total
		Test - I	Test – II	Avg.					
CEC301	Engineering Mathematics –III	20	20	20	80	03	25	-	125
CEC302	Mechanics of Solids	20	20	20	80	03	-	-	100
CEC303	Engineering Geology	20	20	20	80	03	-	-	100
CEC304	Architectural Planning & Design of Buildings	20	20	20	80	03	-	-	100
CEC305	Fluid Mechanics – I	20	20	20	80	03	-	-	100
CEL301	Mechanics of Solids	-	-	-	-	-	25	25	50
CEL302	Engineering Geology	-	-	-	-	-	25	25	50
CEL303	Architectural Planning & Design of Buildings	-	-	-	-	-	25	25	50
CEL304	Fluid Mechanics – I	-	-	-	-	-	25	25	50
CEL305	Skill Based Lab Course – I	-	-	-	-	-	50	-	50
CEM301	Mini Project – 1A	-	-	-	-	-	50	-	50
Total		**100**			**400**	**-**	**225**	**100**	**825**

$ indicates work load of Learner (Not Faculty), for Mini Project.

Undergraduate Program Structure for Second year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2020-2021**)
Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC401	Engineering Mathematics – IV	03	-	01	03	-	01	04
CEC402	Structural Analysis	04	-	-	04	-	-	04
CEC403	Surveying	03	-	-	03	-	-	03
CEC404	Building Materials & Concrete Technology	03	-	-	03	-	-	03
CEC405	Fluid Mechanics-II	03	-	-	03	-	-	03
CEL401	Structural Analysis	-	02	-	-	01	-	01
CEL402	Surveying	-	03	-	-	1.5	-	1.5
CEL403	Building Material Concrete Technology	-	02	-	-	01	-	01
CEL404	Fluid Mechanics-II	-	02	-	-	01	-	01
CEL405	Skill Based lab Course – II	-	02	-	-	01	-	01
CEM401	Mini Project – 1B	-	03$	-	-	1.5	-	1.5
Total		**16**	**14**	**01**	**16**	**07**	**01**	**24**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract. /Oral	Total
		Test - I	Test – II	Avg.					
CEC401	Engineering Mathematics-IV	20	20	20	80	03	25	-	125
CEC402	Structural Analysis	20	20	20	80	03	-	-	100
CEC403	Surveying	20	20	20	80	03	-	-	100
CEC404	Building Materials & Concrete Technology	20	20	20	80	03	-	-	100
CEC405	Fluid Mechanics-II	20	20	20	80	03	-	-	100
CEL401	Structural Analysis	-	-	-	-	-	25	25	50
CEL402	Surveying	-	-	-	-	-	50	25	75
CEL403	Building Material Concrete Technology	-	-	-	-	-	25	25	50
CEL404	Fluid Mechanics-II	-	-	-	-	-	25	25	50
CEL405	Skill Based lab Course - II	-	-	-	-	-	50	-	50
CEM401	Mini Project – 1B	-	-	-	-	-	25	25	50
Total		**100**			**400**	**-**	**225**	**125**	**850**

$ indicates work load of Learner (Not Faculty), for Mini Project.

Undergraduate Program Structure for Third year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2021-2022**)
Semester - V

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC501	Theory of Reinforced Concrete Structures	03	-	-	03	-	-	03
CEC502	Applied Hydraulics	03	-	-	03	-	-	03
CEC503	Geotechnical Engineering-I	03	-	-	03	-	-	03
CEC504	Transportation Engineering	04	-	-	04	-	-	04
CEDLO501X	Department Level Optional Course-1	03	-	-	03	-	-	03
CEL501	Theory of Reinforced Concrete Structures	-	02	-	-	01	-	01
CEL502	Applied Hydraulics	-	02	-	-	01	-	01
CEL503	Geotechnical Engineering-I	-	02	-	-	01	-	01
CEL504	Transportation Engineering	-	02	-	-	01	-	01
CEL505	Professional Communication and Ethics-II	-	02*+2	-	-	02	-	02
CEM501	Mini Project – 2A	-	04$	-	-	02	-	02
Total		**16**	**16**	**-**	**16**	**08**	**-**	**24**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract /Oral	Total
		Test - I	Test – II	Avg.					
CEC501	Theory of Reinforced Concrete Structures	20	20	20	80	03	-	-	100
CEC502	Applied Hydraulics	20	20	20	80	03	-	-	100
CEC503	Geotechnical Engineering-I	20	20	20	80	03	-	-	100
CEC504	Transportation Engineering	20	20	20	80	03	-	-	100
CEDLO501 X	Department Level Optional Course -1	20	20	20	80	03	-	-	100
CEL501	Theory of Reinforced Concrete Structures	-	-	-	-	-	25	25	50
CEL502	Applied Hydraulics	-	-	-	-	-	25	25	50
CEL503	Geotechnical Engineering-I	-	-	-	-	-	25	25	50
CEL504	Transportation Engineering	-	-	-	-	-	25	25	50
CEL505	Professional Communication and Ethics-II	-	-	-	-	-	25	25	50
CEM501	Mini Project – 2A	-	-	-	-	-	25	25	50
Total		**100**			**400**	**-**	**150**	**150**	**800**

*** Theory class to be conducted for full class**
$ indicates work load of Learner (Not Faculty), for Mini Project

Undergraduate Program Structure for Third year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2021-2022**)
Semester - V

Department Level Optional Course – 1

Sr. No.	Course Code CEDLO501X	Department Level Optional Course – 1
1	CEDLO5011	Modern Surveying Instruments and Techniques
2	CEDLO5012	Building Services & Repairs
3	CEDLO5013	Sustainable Building Materials
4	CEDLO5014	Advanced Structural Mechanics
5	CEDLO5015	Air and Noise Pollution & Control
6	CEDLO5016	Transportation Planning & Economics
7	CEDLO5017	Advanced Concrete Technology

Undergraduate Program Structure for Third year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2021-2022**)
Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC601	Design & Drawing of Steel Structures	03	-	-	03	-	-	03
CEC602	Water Resources Engineering	03	-	-	03	-	-	03
CEC603	Geotechnical Engineering-II	03	-	-	03	-	-	03
CEC604	Environmental Engineering	04	-	-	04	-	-	04
CEDLO601X	Department Level Optional Course -2	03	-	-	03	-	-	03
CEL601	Design & Drawing of Steel Structures	-	02	-	-	01	-	01
CEL602	Water Resources Engineering	-	02	-	-	01	-	01
CEL603	Geotechnical Engineering-II	-	02	-	-	01	-	01
CEL604	Environmental Engineering	-	02	-	-	01	-	01
CEL605	Skill Based Lab Course – III	-	03	-	-	1.5	-	1.5
CEM601	Mini Project – 2B	-	03$	-	-	1.5	-	1.5
Total		**16**	**14**	**-**	**16**	**07**	**-**	**23**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract. /Oral	Total
		Test – I	Test - II	Avg.					
CEC601	Design & Drawing of Steel Structures	20	20	20	80	04	-	-	100
CEC602	Water Resources Engineering	20	20	20	80	03	-	-	100
CEC603	Geotechnical Engineering-II	20	20	20	80	03	-	-	100
CEC604	Environmental Engineering	20	20	20	80	03	-	-	100
CEDLO601X	Department Level Optional Course -2	20	20	20	80	03	-	-	100
CEL601	Design & Drawing of Steel Structures	-	-	-	-	-	25	25	50
CEL602	Water Resources Engineering	-	-	-	-	-	25	25	50
CEL603	Geotechnical Engineering-II	-	-	-	-	-	25	25	50
CEL604	Environmental Engineering	-	-	-	-	-	25	25	50
CEL605	Skill Based Lab Course-III	-	-	-	-	-	25	25	50
CEM601	Mini Project – 2B	-	-	-	-	-	25	25	50
Total		**100**			**400**	**-**	**150**	**150**	**800**

$ indicates work load of Learner (Not Faculty), for Mini Project.

Undergraduate Program Structure for Third year Civil Engineering

University of Mumbai

(With Effect from A.Y. **2021-2022**)

Semester - VI

Department Level Optional Course – 2

Sr. No.	Course Code CEDLO601X	Department Level Optional Course – 2
1	CEDLO6011	Rock Mechanics
2	CEDLO6012	Biological Processes & Contaminant Removal
3	CEDLO6013	Construction Equipment & Techniques
4	CEDLO6014	Urban Infrastructure Planning
5	CEDLO6015	Open Channel Flow
6	CEDLO6016	Computational Structural Analysis
7	CEDLO6017	Traffic Engineering and Management
8	CEDLO6018	Introduction to Offshore Engineering

Program Structure for Third Year Engineering
Semester VII & VIII
UNIVERSITY OF MUMBAI
(With Effect from 2022-2023)
Semester - VII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC701	Design & Drawing of Reinforced Concrete Structures	03	-	-	03	-	-	03
CEC702	Quantity Survey, Estimation and Valuation	03	-	-	03	-	-	03
CEDLO701X	Department Level Optional Course – 3	03	-	-	03	-	-	03
CEDLO702X	Department Level Optional Course – 4	03	-	-	03	-	-	03
CEILO701X	Institute Level Optional Course – 1	03	-	-	03	-	-	03
CEL701	Design & Drawing of Reinforced Concrete Structures	-	02	-	-	01	-	01
CEL702	Quantity Survey, Estimation and Valuation	-	02	-	-	01	-	01
CEP701	Major Project – I	-	06$	-	-	03	-	03
Total		**15**	**10**	**-**	**15**	**05**	**-**	**20**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract /Oral	Total
		Test - I	Test – II	Avg.					
CEC701	Design & Drawing of Reinforced Concrete Structure	20	20	20	80	04	-	-	100
CEC702	Quantity Survey, Estimation and Valuation	20	20	20	80	04	-	-	100
CEDLO701X	Department Level Optional Course – 3	20	20	20	80	03	-	-	100
CEDLO702X	Department Level Optional Course – 4	20	20	20	80	03	-	-	100
CEILO701X	Institute Level Optional Course – 1	20	20	20	80	03	-	-	100
CEL701	Design & Drawing of Reinforced Concrete Structure	-	-	-	-	-	25	25	50
CEL702	Quantity Survey, Estimation and Valuation	-	-	-	-	-	25	25	50
CEP701	Major Project – I	-	-	-	-	-	50	-	50
Total		**100**			**400**	**-**	**100**	**50**	**650**

$ indicates work load of Learner (Not Faculty), for Major Project.

Undergraduate Program Structure for Final year Civil Engineering

University of Mumbai

(With Effect from A.Y. **2022-2023**)

Semester - VII

Department Level Optional Course – 3

Sr. No.	Course Code CEDLO701X	Department Level Optional Course – 3
1	CEDLO7011	Prestressed Concrete
2	CEDLO7012	Applied Hydrology and Flood Control
3	CEDLO7013	Appraisal and Implementation of Infra Projects
4	CEDLO7014	Analysis of Offshore Structures
5	CEDLO7015	Advanced Construction Technology
6	CEDLO7016	Pavement Materials Construction and Maintenance

Department Level Optional Course – 4

Sr. No.	Course Code CEDLO702X	Department Level Optional Course – 4
1	CEDLO7021	Foundation Analysis and Design
2	CEDLO7022	Solid hazardous waste management
3	CEDLO7023	Ground Improvement techniques
4	CEDLO7024	Green building constructions
5	CEDLO7025	Legal Aspects in constructions
6	CEDLO7026	Environmental impact assessment
7	CEDLO7027	Advanced Steel Structures

Institute Level Optional Course – I

Sr. No.	Course Code CEILO701X	Institute Level Optional Course – I
1	CEILO7011	
2	CEILO7012	

3	CEILO7013	

Undergraduate Program Structure for Final year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2022-2023**)
Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC801	Construction Management	03	-	-	03	-	-	03
CEDLO801X	Department Level Optional Course – 5	03	-	-	03	-	-	03
CEDLO802X	Department Level Optional Course – 6	03	-	-	03	-	-	03
CEILO801X	Institute Level Optional Course – 2	03	-	-	03	-	-	03
CEL801	Construction Management	-	02	-	-	01	-	01
CEP801	Major Project – II	-	12$	-	-	06	-	06
Total		**12**	**14**	**-**	**12**	**07**	**-**	**19**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract. /Oral	Total
		Test - I	Test – II	Avg.					
CEC801	Construction Management	20	20	20	80	03	-	-	100
CEDLO801X	Department Level Optional Course – 5	20	20	20	80	03	-	-	100
CEDLO802X	Department Level Optional Course – 6	20	20	20	80	03	-	-	100
CEILO801X	Institute Level Optional Course – 2	20	20	20	80	03	-	-	100
CEL801	Construction Management	-	-	-	-	-	25	25	50
CEP801	Major Project – II	-	-	-	-	-	50	100	150
Total		**80**			**320**	**-**	**75**	**125**	**600**

$ indicates work load of Learner (Not Faculty), for Major Project.

Undergraduate Program Structure for Final year Civil Engineering

University of Mumbai

(With Effect from A.Y. **2022-2023**)

Semester VIII

Department Level Optional Course – 5

Sr. No.	Course Code CEDLO801X	Department Level Optional Course – 5
1	CEDLO8011	Bridge Engineering
2	CEDLO8012	Design of Hydraulics Structures
4	CEDLO8013	Construction Safety
5	CEDLO8014	Pavement Design
6	CEDLO8015	Industrial Waste Treatment
7	CEDLO8016	Soil Dynamics

Department Level Optional Course – 6

Sr. No.	Course Code CEDLO802X	Department Level Optional Course – 6
1	CEDLO8021	Repairs, Rehabilitation and Retrofitting of structures
2	CEDLO8022	Physio-Chemical Properties of Waste And Sewage Water
3	CEDLO8023	Transportation System Engineering
4	CEDLO8024	Smart Building Materials
5	CEDLO8025	Structural Dynamics
6	CEDLO8026	Ground Water Engineering

Institute Level Optional Course-2

Sr. No.	Course Code CEILO801X	Institute Level Optional Course-2

1	CEILO8011	
2	CEILO8012	
3	CEILO8013	

Faculty may design and conduct practicals for elective subjects wherever possible, under the head ‘content beyond syllabus’.

Semester V

Semester-V

Course Code	Course Name	Credits
CEC501	Theory of Reinforced Concrete Structures	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Working Stress Method (WSM) makes use of the concept of modular ratio based on the higher factor of safety in evaluating the stresses in two different materials of the RCC i.e., steel and concrete. The Limit State Method (LSM) is based on the statistical probability which provides the rational solution to the design problems. The philosophy which lies behind, LSM uses multiple safety factors format which attempts to provide adequate safety at the ultimate load as well as adequate serviceability at service load by considering all possible limit states. The subject involves the application of working stress method and limit state method in the analysis and design of various elements of the civil engineering structures.

Objectives

1 To develop clear understanding of design philosophy amongst the students for the design of reinforced concrete structure using working stress method (WSM) and limit state method (LSM).

2 To study various clauses of IS: 456-2000 and their significance in the RCC design.

3 To apply various concepts of LSM in the analysis and design of beams, slabs and columns.

4 To study the concept of Serviceability and Durability for deflection and crack width calculation in RCC structures.

5 To develop the concept of design using design charts and curves for columns subjected to axial load and moment.

6 To study the concept of reinforced concrete footing design subjected to axial load and moment.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Working Stress Method:**		06
	1.1	Concept of reinforced concrete, Working Stress Method (WSM) of design for reinforced concrete, permissible stresses as per IS:456-2000; stress- strain curve of concrete and steel, characteristics of concrete and steel reinforcement.	
	1.2	Concept of balanced, under reinforced and over reinforced sections.	
	1.3	Analysis and design of singly reinforced and doubly reinforced rectangular beams for Flexure.	
2	**Limit State Method:**		03
	2.1	Introduction to limit state method of design as per IS:456-2000.	
	2.2	Concepts of probability and reliability, characteristic load, characteristic strength, partial safety factors for loads and materials, introduction to various limit states of collapse and serviceability.	
3	**Limit State of Collapse: Flexure, Shear, Bond and Torsion:**		12
	3.1	Design of singly and doubly reinforced Rectangular and Flanged sections for flexure, shear and bond.	
	3.2	Design of beams subjected to bending, shear and torsion.	
4	**Design of Slabs using Limit state method:**		04
	4.1	Design of simply supported one-way slabs as per IS:456-2000.	
	4.2	Design of simply supported two-way slabs as per IS:456-2000.	
5	**Limit State of Collapse – Compression:**		08
	5.1	Limit state of collapse: compression for short and slender column.	
	5.2	Introduction to Members subjected to combined axial and uniaxial as well as biaxial bending.	
	5.3	Development of interactive curves and their use in column design.	
6	**Design of Foundations:**		06
	6.1	Design of Isolated square and rectangular footings subjected to axial load and moment.	
	6.2	Introduction to basic concepts of combined rectangular pad footing, slab beam type footing and Raft foundation.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1. Understand the fundamentals of WSM and LSM.
2. Apply various clauses specified in IS: 456-2000 for designing structural members with safety and economy.
3. Understand the use of readymade design charts and curves from Special Publications of Bureau of Indian Standards.
4. Analyze and design various reinforced concrete elements such as beam, slab, column, footings using the concept of Limit State Method.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. **Use of IS:456-2000 shall be allowed in the examination.**
2. Question paper will comprise of total six questions, each carrying 20 marks.
3. Question 1 will be compulsory and should cover maximum contents of the curriculum.
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Four questions need to be solved in total.

Recommended Books:

1. Design of Reinforced Concrete Structures: Dayaratnam, P; Oxford and IBH.
2. Limit State Design of Reinforced Concrete: Jain A. K, Nemchand and Bros., Roorkee
3. Limit State Design of Reinforced Concrete: Shah and Karve, Structure Publications, Pune.
4. Ultimate Strength Design for Structural Concrete: Arthur, P. D. and Ramakrishnan, V., Wheeler and Co. Pvt. Ltd.
5. Reinforced Concrete: H.J. Shah, Charotar Publishers, Anand.
6. Fundamentals of Reinforced Concrete: Sinha & Roy, S. Chand and Co. Ltd.
7. Illustrated Reinforced Concrete Design: Dr. V. L. Shah and Dr. S. R. Karve, Structure Publications, Pune.
8. Reinforced Concrete Design: Wang, C. K., Salmon, C. G., and Pincheira, J. A, John Wiley (2007), 7th Edition.
9. Reinforced Concrete Fundamentals: Ferguson, P. M., Breen, J. E., and Jirsa, J. O., John Wiley & Sons (1988) 5th Edition.

Reference Books:

1. Design of RCC structural Elements (RCC Vol-I): Bhavikatti, S. S., New Age International Publications.
2. Reinforced Concrete: Syal and Goel; Wheeler Publishers.
3. Reinforced Concrete Design: Pillai, S.U. and Menon, Devdas, Tata Mc-Graw Hill Publishing House, New Delhi.
4. Reinforced Concrete Design by S.N. Sinha, Tata Mc-Graw Hill Publishing House, New Delhi
5. Theory of Reinforced concrete structures by N. Subramanian, Oxford University Press.
6. RCC Design (WSM and LSM): Punmia, B. C., Jain, A. K., and Jain, Arun, K., Laxmi Publications.
7. Limit State Design of Reinforced Concrete (as per IS: 456-2000): Punmia, B. C., Jain, A. K., and Jain, Arun, K., Laxmi Publications.
8. Relevant IS Codes: BIS Publications, New Delhi.

Semester-V

Course Code	Course Name	Credits
CEC502	Applied Hydraulics	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

The knowledge of this course is essential to understand facts, concepts of impact of jets, Miscellaneous Hydraulic Machinery. Further it helps to understand the design aspects, components, function and uses of centrifugal pump, turbines. It also helps to study the concept of uniform Flow Through Open Channels, Non-Uniform Flow Through Open Channels.

Objectives

The students will be able to learn:

1 To introduce the concept of impact of jets.

2 To study hydraulic machines like centrifugal pumps and turbines.

3 To study various Miscellaneous Hydraulic Machinery.

4 To study the uniform flow through open channels and design of most economical section.

5 To study the non-uniform flow through open channels.

Detailed Syllabus

Module	Course Module / Contents	Periods
1	**Impact of Jets** Impulse momentum principle, Jet striking flat plates, stationary and moving vertical, inclined plates, hinged plates, curved vanes, series of plates and vanes mounted on wheel, concept of velocity triangles.	07
2	**Hydraulic Turbines** General layout of hydro-electric plant, heads, efficiencies of turbine, classification, concept of velocity triangles working of Impulse Turbine (Pelton Wheel), Reaction Turbine, Francis Turbine, Kaplan Turbine, draft tube theory, specific speed, unit quantities, Characteristic curves, Cavitation.	08
3	**Centrifugal Pumps** Work done, heads, efficiencies, Minimum speed: series parallel operation, Multistage pumps, concept of velocity triangles, specific speed, model testing, priming, characteristic curves, NPSH, cavitation.	04
4	**Miscellaneous Hydraulic Machinery** Hydraulic Ram, Press, Accumulator, Intensifier, Crane and Lift.	03
5	**Uniform Flow Through Open Channels** Uniform Flow: Flow through open channel: Definition, types of channels, Prismatic, non-prismatic channels, Types of flows in channels, Uniform flow: steady flow and unsteady flow, laminar and turbulent flow, subcritical flow, supercritical flow, Chezy's formula, Manning's formula, hydraulically efficient channel cross-sections (most economical sections).	07
6	**Non-Uniform Flow Through Open Channels** Concept of Specific energy and specific energy curve, Dimensionless specific energy discharge curve, applications of specific energy and Momentum principle to open channel flow, specific force. Gradually varied flow, equation for gradually varied flow, back water curve and afflux, Introduction to surface profiles, Hydraulic jump and standing wave.	10
	Total	39

Contribution to Outcome

On completion of this course, the students will be able to:

1 Describe impact of jet on stationary, moving, hinged and series of plates also solve the numerical based on forces acting on it.
2 Distinguish various types of turbines, Characteristic curves and its components.
3 Analyze Centrifugal pumps by incorporating velocity triangle diagrams.
4 Know the working mechanism of various Hydraulic machines.
5 Identify the hydraulic behaviour of open channel flow and design the most economical section of channels.
6 Explain mathematical relationships for hydraulic jumps, surges, and critical, uniform, and gradually-varying flows.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only four questions need to be solved in total.

Recommended Books:

1 Hydraulics and Fluid mechanics: Dr. P.M. Modi and Dr. S.M. Seth, Standard Book House, Delhi.
2 Theory and Application of Fluid Mechanics: K. Subramanian, Tata McGraw hill publishing company, New Delhi.
3 Fluid Mechanics: Dr. A.K Jain, Khanna Publishers.
4 Fluid Mechanics and Hydraulics: Dr. S.K. Ukarande, Ane's Books Pvt. Ltd. (Revised Edition 2012), ISBN 97893 8116 2538.
5 Fluid Mechanics and fluid pressure engineering: Dr. D.S. Kumar, F.K. Kataria and sons.
6 Fluid Mechanics: R.K. Bansal Laxmi Publications (P) Ltd.
7 Flow through open channels, K.G. Ranga Raju. (1993) : New Delhi : Tata McGrawHill, c1993.
8 Flow Through Open Channels. Rajesh Srivastava (2007): Oxford University Press, 2007, pbk, 432 p, ISBN: 0195690385.

Reference Books:

1 Fluid Mechanics: Frank M. White, Tata Mc-Graw Hill International Edition.

2 Fluid Mechanics: Streeter White Bedford, Tata Mc-Graw International Edition.

3 Fluid Mechanics with Engineering Applications: R.L. Daugherty, J.B. Franzini, E.J. Finnemore, Tata Mc-Graw Hill, New Delhi.

4 Hydraulics: James F. Cruise, Vijay P. Singh and Mohsen M. Sherif, CENGAGE Learning India (Pvt.) Ltd.

5 Introduction to Fluid Mechanics: Edward J. Shaughnessy, Jr, Ira M. Katz, James P. Schaffer. Oxford Higher Education.

6 Open channel Hydraulics: Chow, V.T., McGraw Hill International, New York.

7 Open Channel Flow: Henderson F.M., McGraw Hill International, New York.

Semester-V

Course Code	Course Name	Credits
CEC503	Geotechnical Engineering-I	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Around all civil engineering structures are supported by soil and rock. Rock is rarely occurring and hence, mostly the supporting medium is soil. The stability of structure depends on the stability of supporting medium. Therefore, geotechnical analysis is required to be carried out. Geotechnical analysis depends on the basic understanding of physical properties of soil which are useful for determining the strength, compressibility, drainage characteristics etc. Soil mechanics is the basic tool for geotechnical engineering, which is the specialized section of civil engineering. Soil is also used as a construction material to build various civil structures, viz., dams, embankment etc. Thus, it is very essential to understand various concepts involved in this course of Geotechnical Engineering-I.

Objectives

1. To study origin and mode of formation of soil as well as functional relationships among different unit weights, volumetric ratios, and water content.
2. To study clay mineralogy and plasticity characteristics of soils.
3. To comprehend particle size distribution and classification of soils as per IS code.
4. To study permeability and seepage flow of water through the soil.
5. To understand the concept of total stress, neutral stress and effective stress in soil.
6. To understand compaction characteristics of soils as well as the techniques of soil exploration, assessing the subsoil conditions and engineering properties of various soil strata.

Detailed Syllabus			
Module	**Course Module / Contents**		**Periods**
1	**Introduction to Geotechnical Engineering, Basic Definitions & Relationships**		**07**
	1.1	Definitions and scope of Geotechnical Engineering: rocks, soil, origin & mode of formation and types of soil obtained, soil mechanics, rock mechanics, geotechnical engineering.	
	1.2	Soil phase systems, volumetric ratios: void ratio, porosity, degree of saturation, air voids, air content.	
	1.3	Weight-volume relationship: different unit weights, water content, specific gravity of soil solids, mass and absolute specific gravity.	
	1.4	Functional relationships among different unit weights, volumetric ratios, and water content.	
	1.5	Relative density, relative compaction.	
	1.6	Different methods to determine water content, specific gravity and unit weight of soil.	
2	**Clay Mineralogy and Plasticity Characteristics of Soils**		**06**
	2.1	Explanation about clay minerals, e.g., Montmorillonite, Illite and Kaolinite; formation of clay minerals and their role in plastic behavior of soil.	
	2.2	Definition of plasticity of soil, consistency of soil, definition & determination of liquid limit, plastic limit, shrinkage limit.	
	2.3	Definitions of shrinkage parameters, plasticity index, liquidity index, consistency index, flow index, toughness index, activity, sensitivity and thixotropy of soil. Importance of consistency limits.	
3	**Particle Size Distribution and Classification of Soils**		**06**
	3.1	Wet & dry sieve analysis, Sedimentation analysis: Stoke's law, Hydrometer method of analysis, Limitation of sedimentation analysis.	
	3.2	Particle size distribution curve/ gradation curve and its uses. Introduction to cohesive and cohesionless soil.	
	3.3	Necessity of soil classification, Indian standard particle size classification, Indian standard soil classification system as per IS: 1498 -1970, boundary classification.	
4	**Permeability of Soils & Seepage Analysis**		**08**
	4.1	Types of soil water, definition of hydraulic head, hydraulic gradient, Darcy's law, validity of Darcy's law, permeability of soil.	
	4.2	Determination of coefficient of permeability of soil in lab using constant head and variable head methods, factors affecting permeability of soil, effect of permeability on various properties of soil, determination of in-situ permeability with pumping out and pumping in tests.	

	4.3	Permeability of stratified soil deposits.	
	4.4	Definition of seepage and its importance for the analysis & design of hydraulic structures, graphical representation of seepage by flow net diagram, definition of flow line, equipotential line, flow channel, flow field, characteristics of flow net, use of flow net, phreatic line.	
	4.5	Factor of safety against piping failure.	
5	**Effective Stress Principle**		**05**
	5.1	Definition of geostatic stresses, total stress, neutral stress/ pore water pressure, effective stress.	
	5.2	Effect of water table fluctuations, surcharge, capillary action, seepage pressure on effective stress; quick sand condition.	
6	**Compaction of Soil & Soil Exploration**		**07**
	6.1	Theory of compaction, determination of optimum moisture content (OMC) & maximum dry density (MDD) in laboratory by conducting the light and heavy compaction tests.	
	6.2	Factors affecting the compaction, effect of compaction on properties of soil, soil structure, placement water content, relative compaction, Proctor needle method for compaction.	
	6.3	Necessity of soil exploration, methods of soil investigation, methods of boring, disturbed and undisturbed soil samples, soil sampling and samplers, number and spacing of bore holes, depth of bore holes.	
	6.4	Penetrometer tests: SPT, SCPT and DCPT.	
	6.5	Representation of data with borehole logs.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Explain the basic concepts of the physical and engineering properties of soil and derive the relationships among various unit weights & other parameters.

2 Comprehend clay mineralogy and plasticity behavior of clay.

3 Analyze grain size distribution of soil and classify the soil as per IS code.

4 Evaluate the coefficient of permeability of different types of soils and draw the flow net diagram to estimate seepage discharge.

5 Compute the effective stress and pore water pressure inside the soil mass under different geotechnical conditions.

6 Evaluate the compaction parameters in laboratory and field as well as understand the necessity and methods of soil exploration.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only four questions need to be solved in total.

Recommended Books:

1. Basic and Applied Soil Mechanics: Gopal Ranjan, A S R Rao; New Age International Publishers.
2. Soil Mechanics and Foundation Engineering: V. N. S. Murthy; CBS Publishers & Distributors
3. Soil Mechanics and Foundation Engineering: K. R. Arora; Standard Publishers and Distributors, New Delhi.
4. Soil Mechanics and Foundations: B. C. Punmia, Ashok Kumar Jain, Arun Kumar Jain; Laxmi Publications (P) LTD., New Delhi
5. Geotechnical Engineering: C. Venkatramaiah; New Age International Private Limited
6. Fundamentals of Soil Engineering: D. W. Taylor; John Wiley & Sons.

Reference Books:

1. An Introduction to Geotechnical Engineering: Robert D. Holtz, William D. Kovacs; Prentice-Hall, New Jersey
2. Soil Mechanics: R. F. Craig; Spon Press, Taylor and Fransis Group
3. Soil Mechanics: T. W. Lambe, R. V. Whitman; John Wiley & Sons
4. Relevant Indian Standard Specifications Codes, BIS Publications, New Delhi
5. Soil Mechanics in Engineering Practice: Karl Terzaghi, Ralph B Peck, Gholamreza Mesri; John Wiley & Sons

Semester-V

Course Code	Course Name	Credits
CEC504	Transportation Engineering	04

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
04	-	-	04	-	-	04

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

An efficient transportation system is essential for sustainable economic development of the country and plays a significant role in promoting national and global integration. An efficient Transportation system helps in increasing productivity and enhances competitiveness of the economy. Hence, the transport sector is considered as an important component of the economy and a common tool used for development. Three basic modes of transportation include land, water and air. The course deals with understanding of basics of different modes of transportation (Highways, railways, airways and waterways). The highways owing to its flexibility in catering door-to- door service is one of the important modes. This course deals with the investigation, planning, design, construction and maintenance of highways in addition to traffic planning, operation and control.

Objectives

1	To understand the technical aspects of Railways, Airways and Waterways.
2	To carry out Planning and design of geometric elements of Highways.
3	To study various traffic studies and to understand elements of Traffic Engineering for efficient planning and control.
4	To study Requirements of Highway materials and to design Rigid and flexible pavements using IRC codes.
5	To study methods of construction of Rigid and Flexible pavements, use of soil stabilization and drainage to highways.
6	To design the overlay on basis of pavement evaluation and failure identification on rigid and flexible pavements.

Detailed Syllabus			
Module	**Course Module / Contents**		**Periods**
1	**Introduction to Transportation Systems**		**10**
	1.1	Introduction to Transportation Engineering, Comparison of various modes of transportation (Roadways, Railways, Airways and Waterways).	
	1.2	Introduction to Railway Engineering: Cross sectional elements of railway track (Foundation, Ballast, Sleepers and Rail), Introduction to turnout, Super elevation design, Negative Super elevation, Construction and Maintenance of Railway track.	
	1.3	Introduction to Airport Engineering: Elements of Airport, Site selection of Airport, Design of Runway length, Taxiway and Exit Taxiway design.	
	1.4	Introduction to Waterways: Definition of Docks, Harbor and Ports. Elements and types of Docks, Harbor and Port.	
2	**Planning and Geometric Design of Highways**		**10**
	2.1	Classification of roads based on various criteria, Road development plans, agencies related to highway development, Highway alignment (basic requirement and factors governing), hill roads, Surveys for highway location.	
	2.2	Terrain Classification, Vehicular Characteristics, Cross section elements of highways (width of carriage way, shoulders, medians, width of road way, right of way, camber & its profile).	
	2.3	Design speed, sight distance, perception time, break reaction time, analysis of safe sight distance, analysis of overtaking sight distance, intersection sight distance.	
	2.4	Horizontal curves: design of super elevation, its provisions, minimum radius of horizontal curves, widening of pavement, transition curves.	
	2.5	Gradients: different types, maximum, minimum, ruling exceptional, grade compensation on curves.	
3	**Traffic Engineering**		**10**
	3.1	Introduction to various traffic studies such as speed study, volume study, parking study, accident study, O&D study etc. Speed study: methods to determine speed, types of speed (Spot speed, Design speed, Upper & lower limit speeds, Mean - Median and Modal speed); Traffic Volume study (flow): Definition, AADT, ADT, Design volume, methods of determining traffic volume. Traffic density: Definition, importance.	
	3.2	Introduction to Relationship between Speed, density and volume. Capacity: Q-K-V curve, Different types and factors affecting capacity, Concept of PCU and LOS.	
	3.3	Introduction to traffic control devices Traffic signs, signals (no design), road marking.	

	3.4	Different types of Intersections-At-grade and Grade Separated; Grade separated interchanges; rotary intersection.	
4	**Pavement Material and Design**		**12**
	4.1	Types of pavements, comparison of flexible and rigid pavements, Requirements of pavement materials, Soil: requirement of soils as subgrade material, CBR test. Aggregate: Requirements of aggregate as Pavement material, Tests on aggregate with specified values. Bitumen: Requirements of bitumen as pavement material test on bitumen with specified values, variants of bitumen (Modified bitumen) and its uses. Introduction to Bituminous mix design using Marshall Stability test.	
	4.2	Flexible pavement design: Concepts related to flexible pavement design such as tyre pressure, contact pressure, ESWL, VDF and LDF. IRC approach for design (IRC: 37- 2001, IRC: 37- 2012), also IRC SP 72-2007/2015 and IRC 77 2008.	
	4.3	Rigid pavement design: Modulus of subgrade reaction, equivalent radius of resisting section, radius of relative stiffness, stresses on rigid pavement, combine loading temperature stress.; Design of rigid pavements (IRC: 58- 2002; IRC: 58- 2011, IRC: 58- 2015. IRC: SP- 62-2004, IRC: SP- 62-2014)	
5	**Pavement Construction, Soil Stabilization and Drainage**		**05**
	5.1	Construction of different types of roads: water bound macadam (WBM) road, WMM, bituminous pavements, cement concrete pavement. And joint (As per IRC, MORTH specifications) jointed reinforced, continuously reinforced; fiber reinforced; roller compacted concrete pavements.	
	5.2	Soil Stabilization: Significance, Principle of soil stabilization, different methods of soil Stabilization, use of Geosynthetics in highways and allied structures.	
	5.3	Highway drainage: Necessity/ Significance, mode of ingress of water in highway structure, Different methods of drainage- surface and subsurface drainage inkling for the roads in hilly areas.	
6	**Pavement Evaluation, Failures and Maintenance**		**05**
	6.1	Evaluation of pavement, Structural and functional evaluation, methods of structural evaluation (working of Benkelman beam, FWD, LWD), methods of functional evaluation (working of Bump indicator, profilometric systems)	
	6.2	Distress / failure in Rigid and flexible pavement, reasons and measures.	
	6.3	Strengthening of existing pavement, Overlay and its types, design of overlay (Benkelman beam method)	
		Total	**52**

Contribution to Outcome

On completion of this course, the students will be able to:

1. Compare various modes of transportation and understand basic technical aspects of railways, airways and waterways.
2. Understand different road plans, requirements of alignments and Design horizontal and vertical geometrical elements of highways.
3. Carry out different traffic studies and analyze basic parameters of traffic engineering for efficient planning and control of traffic.
4. Design the flexible and rigid pavement as per relevant IRC codes.
5. Construct different types of pavements, use of soil stabilization and planning of highway drainage.
6. Carry out structural and functional evaluation of pavement, identify the failures and design the overlay.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only four questions need to be solved in total.

Recommended Books:

1. A Course of Railway Engineering: Saxena, S. C. and Arora, S. P.; Dhanpat Rai Sons, New Delhi.
2. Airport Planning Design: Khanna, S.K., Arora, M.G.and Jain, J.J.;Nemchand Bros., Roorkee.
3. Docks and Harbour Engineering: Bindra, S. P.; Dhanpat Rai and Sons,New Delhi.
4. Highway Engineering: Khanna, S.K. and Justo, C. E. G.; Nem Chand and Bros., Roorkee.
5. Principles, Practice and Design of Highway Engineering (Including Airport Engineering)" Sharma, S.K.; S. Chand and Company Pvt. Ltd., New Delhi.
6. Highway Material and Pavement Testing: Dr. S. K. Khanna, Dr. C. E. G. Justo and Dr. A. Veeraragavan. Nem Chand and Bros., Roorkee, India.

Reference Books:

1 Indian Railway Track: Agarwal, M. M., Suchdeva Press New Delhi.

2 Planning Design of Airport: Horonjeff Mckelrey, Tata Mc-Graw Hill India Publishing House, New Delhi.

3 Design and Construction of Ports and Marine Structures: Quinn, A. D., Tata Mc-Graw Hill India Publishing House.

4 Transportation Engineering and Planning: C.S. Papacostas and P.D. Prevedouros; Prentice Hall India Learning Pvt. Ltd., New Delhi.

5 Principles of Transportation Engineering: Chakrabory, Partha and Das, Animesh; Prentice Hall India Learning Pvt. Ltd., New Delhi.

6 Transportation Engineering: Khisty, C.J. and Lall, Kent, B.; Prentice Hall India Learning Pvt. Ltd., New Delhi.

7 Traffic Engineering and Transport Planning: Kadiyali, L.R., Khanna Publishers, Delhi.

8 Principles and Practice of Highway Engineering: Kadiyali, L. R.; Khanna Publsihers, Delhi.

9 Relevant specifications of MORTH and relevant IRC codes.

Semester-V

Course Code	Course Name	Credits
CEDLO5011	Department Level Optional Course - 1 Modern Surveying Instruments and Techniques	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Revolutionary changes have taken place in the last few years in surveying instruments and techniques that are used for measuring level differences, distances, angles, areas, volumes, etc. This has become possible due to the advent of electronics in the surveying instruments. With rapid advancements in the technology and availability of cheaper and innovative electronic components, these instruments have become affordable and user friendly.

This course outlines the advancements in instruments and techniques such as digital levels, electronic distance measuring instruments, electronic theodolites, total stations, GPS, GIS, Remote Sensing, drone survey, aerial photogrammetry and hydrographic survey. It also makes the learner industry-ready with respect to the applications of the modern tools in data capturing and further in mapping using appropriate software.

Objectives

1. Understand the working principles and methodologies of modern surveying instruments and compare with conventional instruments.
2. Exhibit the concepts of Global Positioning System, Geographical Information system and remote sensing techniques.
3. Demonstrate the importance of Aerial photogrammetry in surveying works,
4. Develop recent methods of maintaining land records,
5. Study the art of delineating the levels underwater bodies.
6. Highlight the modern techniques in the field of surveying and mapping using various softwares.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Introduction to Modern Surveying Instruments:**		06
	1.1	Principles governing modern instruments and comparison with the conventional instruments.	
	1.2	E.D.M. Electromagnetic spectrum, Electromagnetic distance measurement, Instruments – Digital planimeter, Auto Level, Laser Level, Electronic Digital Theodolite, Total Station, Scan station, Smart Station (Total station with GPS).	
2	**Geoinformatics**		12
	2.1	Global Positioning System- Global Positioning System – working principle and methods, Different Approaches to use GPS and their accuracies, Advantages of GPS in Navigation, Survey, Planning and Mapping.	
	2.2	Geographical Information System -Introduction, Definition, Objectives, Components (people, procedure, hardware, software & data) & functions (input, manipulation, management, query & analysis and visualization) of GIS. Coordinate systems and projections, Geo-referencing, GIS data – spatial (Raster & vector) & spatial data. Introduction to vector and raster data analysis such as network analysis, overlay analysis etc. for vector, DEM, Management of a spatial data.	
	2.3	Remote Sensing introduction, Definition, Necessity, Importance and use; Basic concepts in Remote Sensing, Basic Laws of electromagnetic radiation, Atmospheric effects on radiation, Interaction of EM energy with matter, Resolution in remote sensing, Satellite remote sensing, Problems confronting remote sensing system. Ideal and Real remote sensing systems.	
3	**Aerial Photogrammetry**		06
	3.1	Introduction, principle and uses of Aerial photographs, Definitions, of different terms, Scale of vertical and tilted photograph (simple problems), Ground Coordinates.	
	3.2	Relief Displacements, Ground control, Procedure of aerial survey, overlaps and mosaics, Stereoscopes	
4	**Cadastral Surveying**		04
	4.1	Cadastral Surveying: Contemporary Techniques of maintaining survey records, 7-12 Extracts, Form-8 (Namuna-8).	
	4.2	Role of Survey Department, Role of revenue department. Soft/digitized formats of land records, Comparison with conventional record keeping	
5	**Hydrographic Surveying**		04
	5.1	Hydrographic Surveying: Objects, Applications, establishing controls, Shore line survey, Sounding, sounding equipment, Methods of locating soundings – conventional and using GPS.	

	5.2	Reduction of soundings, Plotting of soundings, Nautical sextant and its use, Tides and tide gauges, determination of MSL.	
6	**Applications of Modern Survey Techniques and Map Preparation Using Software**		**07**
	6.1	Applications of Total Station, GIS, GPS, Remote sensing, LIDAR, Drones in Civil Engineering.	
	6.2	Introduction of GRAM++, Q-GIS, Map Info etc.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Compare modern surveying instruments with conventional instruments.

2 Elucidate the utility of geoinformatics in surveying data collection and analysis.

3 Explain the utility of Aerial photogrammetry in surveying works.

4 Highlight the improvement in land record keeping and governance using modern tools.

5 Describe the procedure of hydrographic surveying and mapping.

6 Apply modern surveying tools to solve complex problems and demonstrate essential skills for working on surveying software.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only four questions need to be solved in total.

Recommended Books:

1 Agor R, Advanced Surveying, Khanna Publishers, New Delhi (ISBN9788174909053).

2 Kanetkar, T.P. and Kulkarni, S.V., Surveying and Levelling Vol. II, Pune Vidhyarthi Gruh Publication (ISBN9782508807185).

3 Arora, K.R., Surveying Vol. III, Standard Book House. New Delhi (ISBN9788189401276).

4 Basudeb Bhatta, Remote Sensing and GIS, Third Edition, Oxford University Press, New Delhi. ISBN: 9780199496648

5 B. C. Punmia, Ashok K Jain, Arun K Jain, Advance Surveying, Laxmi Publications (ISBN 9788170088530)

6 R. Subramanian, Surveying and levelling, Oxford University Press, New Delhi (ISBN9780198085423)

7 P.Dong , Q.Chen, Lidar Remote Sensing and applications ,CRC Press (ISBN 9781138747241)

Reference Books:

1 Basudeb Bhatta, Remote Sensing and GIS, Third Edition, Oxford University Press, New Delhi. ISBN: 9780199496648

2 T.M Lillesand, R.W Kiefer, and J.W Chipman, Remote sensing and Image interpretation, 5th edition, John Wiley and Sons, India; ISBN: 978-1-118-34328-9

3 Kaplan E.D and Hegarty C.J., Understanding GPS: principles and applications, Artech House (ISBN978-1-63081-058-0)

4 Wolf P.R. and Dewitt B.A., Elements of Photogrammetry, McGraw Hill,(ISBN 978-0072924541)

5 DeMers M.N., Fundamentals of GIS, John Wiley (ISBN978-0470129067)

6 Gibson P.J., Introductory Remote Sensing: Principles and Concepts, Routledge (ISBN0 415 18962 4).

Semester-V

Course Code	Course Name	Credits
CEDLO5012	Department Level Optional Course - 1 Building Services and Repairs	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

The building services are based on engineering operations of buildings & the built environment. Building services are responsible for the environment in which we live & work. Building service systems are complex. They are typically a major source of cost & potential problems in building service conditions. Fundamental knowledge of how mechanical, electrical, plumbing & other systems work & interact is important to the construction professionals. This course provides an introduction to building service systems which include the study of design, interfaces & specifications of various building services in buildings. For an existing building, it is necessary to be in a good condition to perform the intended functions. Adequate maintenance extends the building life & ensures the safety of occupants. Most of the structures are getting old & are in the dire need of the repair and maintenance. Hence, there is a huge employment potential in conformity with the field of repair and maintenance. This course, therefore, finds its place in the curriculum such that the pupils can acquire the competency in this area. The course deals with the different building services, health monitoring of buildings, their maintenance, repair materials and repair methodologies.

Objectives

1 To understand the concepts of mechanical systems in buildings such as lifts, escalators, HVAC systems, pumps & their applications.

2 To understand design concepts of electrical system, safety and illumination fundamentals.

3 To get familiar with the plumbing system and services in buildings related to water supply, drainage, gas supply and firefighting installations.

4 To learn about causes of distress of concrete structures and learn various instrumental testing methods for Condition assessment & evaluation of structure and assess the extent of repairs.

5 To acquire the knowledge of repair materials and repair methodologies for rehabilitation of RCC structures.

6 To learn implementing repair process and to follow safety during construction work.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Building services: Mechanical systems.**		06
	1.1	Lifts/elevators, escalators, conveyors: their components, capacity and principles of working, common problems.(3L)	
	1.2	Motors, Generators, Pumps, HVAC Systems - Heating systems, Cooling Systems, Packaged HVAC, types, capacity, components and their principles of working, common problems.(3L)	
2	**Building services: Electrical systems & Illumination in Buildings**		07
	2.1	Electrical grids and supply system: Layout of substations Transformers & switch gears, Main & distribution boards, electrical systems in buildings, Single / Three phase supply, ISI specifications, electrical load, electrical layout plan in a building, Types of wires, wiring system & their choice, Solar energy, CCTV, LAN. Protective devices in electrical installation: Earthing for safety, Types of Earthing, fuses, circuit breakers, lightening arrester.(4L)	
	2.2	Principles of Illumination Design: Visual task, Factors affecting visual task, Luminous flux, candela, solid angle illumination, utilization factor. Modern theory of light &color: Synthesis of Light, Additive & Subtractive synthesis of colour, classification of lighting, artificial lights sources, spectral energy distribution, luminous efficiency, color temperature, colour rendering. Level of illumination: Lighting for stores, offices, school, hospitals and house lighting, elementary idea of special features required and minimum level of illumination required in buildings.(3L)	
3	**Building services: Plumbing Systems in Building**		06
	3.1	Water Distribution system: Material for service pipes, service connection, size of service pipe, Water meter, valves and storage tanks, water requirement for domestic use and firefighting.(2L)	

	3.2	Drainage system: Pipe and traps, system of plumbing, house drainage plans, Chambers- gradient and spacing, manholes, septic tanks and soak pit, Introduction to rain water harvesting system.(2L)	
	3.3	Other plumbing systems: Fire safety, fire-fighting installations, types and purpose, piped gas supply systems, AC ducting.(2L)	
4	**Deterioration of Concrete Structures & Condition assessment**		**06**
	4.1	Durability & Causes of deterioration of concrete structures: effects of climate, moisture, temperature, chemical, wear, erosion & loading on serviceability & durability. Design errors & construction errors, causes of seepage & leakage in concrete structures, formation of cracks including those due to corrosion.(2L)	
	4.2	Condition Survey, Evaluation & Damage Assessment: Structural audit and bye laws. Diagnostic methods & analysis. Destructive, semi-destructive and non-destructive methods: core test, carbonation test, chloride test, petrography, corrosion analysis, cover meter test, rebound hammer test, ultrasonic pulse velocity test, and crack measurement techniques, Concrete endoscopy & thermal imaging, pull- off test & pull-out test.(4L)	
5	**Repair Materials & Methodologies For Repairs**		**08**
	5.1	Repair analysis, Repair materials: and their desired properties, Polymer modified mortar/ concrete, micro concrete, bonding chemicals, protective materials and their properties for moisture barrier systems, water-proofing of concrete structures, Systems like integral, crystalline, coatings, membranes, joints sealants, crack repair fillers, corrosion resistant steels, Pre-packed zinc sacrificial anode, Snap-On zinc mesh anode CP system, corrosion inhibitors, rust solvents.(4L)	
	5.2	Repair methodologies: Crack and patch repair, Injection grouting, surface coatings, column jacketing, guniting, shotcrete, Ferroconcrete, FRP, Carbon fiber wrapping, methods of rebar corrosion protection, cathodic protection.(4L)	
6	**Repair Process Implementation and Safety During Repairs**		**06**
	6.1	Legal Documentation and Records: Estimates of repair work, procedure and flow chart for repairs, Bill of quantities, Tendering, Work order, Agreement and Contract, Measurement book, bills, security deposits, role of PMC.(3L)	
	6.2	Safety during Repairs: Causes of accidents, safety signs, barricading, insurance, Temporary Support structures such as, formwork, shuttering, centering, staging and scaffolding.(3L)	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Apply the knowledge of working & installation of mechanical utility services in buildings.
2 Understand the electrical supply lines, materials, safety devices and illumination systems used in buildings.
3 Investigate and learn operations and adopt appropriate materials in plumbing systems & integrate the same into the building projects.
4 Assess the structural health of the buildings & adopt repair strategy to the damaged structures.
5 Implement the right methods and materials for repairing the concrete structures and also decide the sequence of operations.
6 Create and understand proper documentation process and adopt practices for safety for protection of men and materials on the repair site.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only four questions need to be solved in total.

Recommended Books:

1 Heat Pumps and Electric Heating: *E. R. Ambrose*, John and Wiley and Sons, Inc., New York, 1968
2 Handbook for Building Engineers in Metric Systems, NBC, New Delhi, 1968.
3 Philips Lighting in Architectural Design, McGraw-Hill, New York, 1964.
4 The Lighting of Buildings: *R. G. Hopkinson and J. D. Kay*, Faber and Faber, London, 1969.
5 National Building Code.
6 Building Construction: *Dr. B. C. Punmia, Ashok K Jain*, A.K Jain
7 Construction Engineering and Management: *S. Seetharaman*, Umesh Publications, Delhi.
8 Water supply and Sanitory Installations: *A. C. Panchdhari*, New Age International Publication, Delhi

9 Concrete Repair and Maintenance: *Peter H. Emmons and Gajanan M. Sabnis*, Galgotia Publication
10 Repairs and Rehabilitation-Compilation from Indian Concrete Journal-ACC Publication.
Building Services and Repairs: Dr. A. S. Radke, Tech Knowledge Publications

Reference Books:

1 Guide to Concrete Repair and Protection, HB84-2006, A joint publication of Australia Concrete Repair Association, CSIRO and Standards Australia
2 CPWD hand book on Repairs and Rehabilitation of RCC buildings published by DG (Works), CPWD, Government of India (Nirman Bhawan), http://www.cpwd.gov.in/handbook.pdf.
3 Guide to Concrete Repair, *Glenn Smoak*, US Department of the Interior Bureau of Reclamation, Technical Service Center, http://books.google.co.in.
4 Management of Deteriorating Concrete Structures: *George Somerville*, Taylor and Francis publication
5 Concrete Building Pathology: *Susan Macdonald*, Blackwell Publishing.
6 Testing of Concrete in Structures: *John H. Bungey, Stephen G. Millard and Michael G. Grantham*, Taylor and Francis Publication.
7 Durability of concrete and Cement Composites: *Page, C.L.* and Page, *M.M.*, Woodhead Publishers
8 Fire Safety in Building: V. K. Jain, New Age International Publication, Delhi
9 MEP systems & Repairs of Buildings: A.S. Radke, Published by Synergy Knowledgeware.

Semester-V

Course Code	Course Name	Credits
CEDLO5013	Department Level Optional Course - 1 Sustainable Building Materials	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Meeting the needs of the present without compromising the ability of future generations to meet their needs is considered to be the simplest and effective sustainable development. The greatest threats to the sustainable development on earth are: population growth and urbanization, energy use and global warming, excessive waste generation and the subsequent pollution and limited supply of resources. Concrete is the primary construction material in the world. Construction industry consumes 40 percent of the total energy and about one half of world's major resources. Hence, it is imperative to regulate the use of materials and energy in this industry. The largest environmental impact of the concrete industry comes from the cement manufacturing process that leads to relatively high greenhouse gas emissions. Minimizing the quantity of cement in a concrete mix has many potential benefits. Thus, the use of industrial byproducts such as fly ash, silica fume as cementitious materials in concrete structures can lead to significant reduction CO2 emissions and consumption of energy and raw materials. Green and intelligent buildings also have been evolved for sustainability of the construction industry. This course provides knowledge of different sustainable building materials and technologies in construction industry.

Objectives

1 To have more awareness among students about sustainability.

2 To understand environmental issues due to building materials and the energy consumption in manufacturing building materials.

3 To study the alternative masonry unit and mortar for sustainable practices.

4 To know the importance of cement reduction and replacements for a sustainable development.

5 To understand the alternative building technologies which are followed in construction.

6 To have cognizance of alternative roofing systems in practice.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Sustainability**		07
	1.1	Introduction: Need and concept of sustainability, Social Environmental and economic sustainability concepts,	
	1.2	Sustainable development, Nexus between technology and Development, Challenges for sustainable development Fundamentals of sustainability.	
	1.3	Global Environmental issue: Resource degradation, ozone layer Depletion Climate change, Carbon cycle, Factors affecting Carbon credits and carbon trading, carbon foot Print, Carbon sequestration-carbon capture and storage (CCS).	
	1.4	Environment legislation in India-water act and air act	
2	**Energy In Building Materials**		06
	2.1	Embodied energy and life cycle energy, Calculation of embodied energy in wall, Environmental issues concerned to building materials, Global warming and construction industry.	
	2.2	Environment friendly and cost-effective building technologies. Requirements for building of different climatic regions.	
	2.3	Traditional building methods and vernacular architecture Green buildings, Intelligent buildings, green materials, green building ratings-IGBC & LEED.	
	2.4	Renewable and nonrenewable energy sources.	
3	**Elements of Structural Masonry**		06
	3.1	Characteristics of building blocks for walls, Stones and Laterite blocks, Bricks, Fly ash bricks and hollow clay blocks, Concrete Blocks, Stabilized blocks: mud blocks, steam cured blocks, Fal-G Blocks stone masonry block.	
	3.2	Masonry Mortars: Mortars, Cementitious materials: Lime, OPC, PPC, Masonry cement, Lime pozzolana (LP)cement. Sand: natural and manufactured, Classification of mortar as per BIS, Types of mortar, Properties and requirements of mortar, Selection of mortar.	
4	**Cementitious and Supplementary Cementitious Materials and their Characterization:**		06
	4.1	Lime, Lime pozzolana cements, Pozzolana: Surkhi, Fly ash, IS (3812) (Type C and F), GGBFS, Silica Fumes, Metakaolin,	

		RHA, Composite cements and its types, IS (16415:2015), Magnesia based cements, Calcium sulfo- cement, Alkali activated, cement (Type 1 and Type II), Geopolymers. Composition, Properties and uses.	
	4.2	Membrane curing: wax and resin based, self-curing compound: Polymer and polyethylene glycol, Water reducing admixtures, use of treated domestic effluent (TDE) for mixing and curing	
5	**Alternate Building Technologies**		**07**
	5.1	Fiber reinforced cement composites: Matrix materials, reinforcing Materials, Applications	
	5.2	Fiber reinforced polymer composites: Matrix materials, types of polymers used and applications	
	5.3	Ferrocement and ferroconcrete building components: Materials, Construction methods, Mechanical properties, Applications.	
	5.4	Nanotechnology for sustainable construction.	
6	**Alternate Building Materials and Roofing Systems**		**07**
	6.1	Building materials from agro and industrial waste: Typical agro- waste and biomass resources, Use of industrial waste: Fly ash, Blast furnace slag, Iron ore tailings, Gold mine tailings Granite and marble polishing fines, demolished building waste	
	6.2	Concepts in roofing alternatives, Types of roof, Roof as a structural system, Cost reduction through construction process efficiency	
	6.3	Filler slab roofs, Composite beam and panel roofs, construction Details and roof assembly.	
	6.4	Masonry domes and vaults: Relevance, analysis and design, Barrel vault.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Explain sustainable practices by utilizing engineering practices.

2 Able to understand different types of environmental problems and their sustainable solution.

3 Suggest appropriate type of masonry unit and mortar for civil engineering constructions.

4 Analyze different alternative building materials for construction.

5 To suggest suitable alternative building technologies for sustainable development.

6 To propose different roofing systems and use of waste materials in construction industry.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only four questions need to be solved in total.

Recommended Books:

1 Alternative Building Materials and Technologies by KS Jagadish, BV Venkatraman Reddy and KS Nanjunda Rao, New Age International publications.
2 Sustainability Engineering: Concepts, Design and Case studies by Allen D.T, and Shonnard D.R , Prentice Hall.
3 Sustainability Engineering: Concepts, Design and Case studies by Bradley A.S; Adebayo A.O, and Mario P., Cengage learning
4 Sustainability of construction materials by Jamal M Khatib, Woodhead publishing limited.
5 Renewable energy sources by Twidell J.W and Weir A.D, English Language Book Society (ELBS)

Reference Books:

1 ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy efficiency Publications—Rating system, TERI Publications – GRIHA Rating system.
2 Structural Masonry by Arnold W Hendry, Macmillan Publishers
3 Systems Analysis for Sustainable Engineering: Theory and Application by Ni bin Chang, Mc Graw Hill Professional
4 NPTEL course on sustainable materials and green building https://nptel.ac.in/courses/105/102/105102195
5 Relevant codes

Semester-V

Course Code	Course Name	Credits
CEDLO5014	Department Level Optional Course - 1 Advanced Structural Mechanics	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

The structures are subjected to various types of loading/ forces. These are axial force, shear force, bending moment, torsion etc. This course enables the students with the knowledge in conformity with analysis of behaviour of structural members under different types of loading. The course facilitates in imparting theoretical concepts and physical understanding, which in turn will help in solving structural mechanics problems, mostly involving beams & thin-walled structures under different loading conditions.

Objectives

1 To understand the concept of unsymmetrical bending, shear centre and spring & evaluate the stress due to unsymmetrical bending, shear centre for symmetrical & un- symmetrical thin-walled sections.

2 To study the concepts and behavior of beams curved in elevation & to evaluate the stress.

3 To study the concepts and behavior of beams curved in plan subjected to different types of loadings.

4 To understand the concept &behavior of beams resting on elastic foundation.

5 To understand the concept of different theories of failure in regards of materials.

6 To study the behavior of deep beams using different theories available for the analysis of different sections.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Unsymmetrical Bending, Shear Centre and Springs**		**07**
	1.1	Product of inertia, principal moment of inertia, flexural stresses due to bending in two planes for symmetrical sections, bending of unsymmetrical sections.	
	1.2	Shear Centre for symmetrical & unsymmetrical (about both axes) thin-walled open sections.	
	1.3	Helical springs, flat spiral springs, laminated springs.	
2	**Beams Curved in Elevation**		**07**
	2.1	Bending of beams with large initial curvature, loaded in their plane of curvature.	
	2.2	Application to analysis of hooks, circular closed rings, chain links with straight length & semi-circular ends.	
3	**Beams Curved In Plan**		**05**
	3.1	Analysis of Beams Curved in Plan such as cantilever circular arc, semicircular beams fixed at two ends and subjected to central concentrated load.	
	3.2	Simply supported semicircular beam subjected to UDL supported on three equally spaced columns, Analysis of circular ring beam.	
4	**Beams on Elastic Foundation**		**07**
	4.1	Analysis of beams of infinite length subjected to concentrated force/moment & semi-infinite length subjected to concentrated load/moment at one end.	
	4.2	Semi-infinite beam hinged at one end (origin) & subjected to UDL throughout.	
5	**Theories of Failure**		**07**
	5.1	Maximum principal stress theory, Maximum principal strain theory, Maximum shear stress theory.	
	5.2	Maximum total strain energy theory.	
6	**Analysis of Deep Beams**		**06**
	6.1	Determination of deflection.	
	6.2	Determination of shear correction factor for various sections: rectangular solid & hollow section, circular solid & hollow section & I-section	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Understand the concept of unsymmetrical bending, shear centre for thin-walled open sections and springs.
2 Analyze hooks, circular closed rings, chain links with straight length & semi-circular ends using the concept of beam curved in elevation.
3 Analyze the beam curved in plan for different support conditions.
4 Study the behavior of beam resting on elastic foundation with various loading conditions.
5 Understand the concept of different theories of failure in different sections.
6 Determine deflection of deep beams, shear correction factor for different sections like solid & hollow sections.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only four questions need to be solved in total.

Recommended Books:

1 Mechanics of Materials: Popov, E.P. Prentice Hall of India Pvt. Ltd.
2 Advanced Mechanics of Materials: Arthur P. Boresi and Omar M. Sidebottom, Wiley and Sons.
3 Strength of Material Part I and Part II: Timoshenko, McGraw Hill, New York.
4 Mechanics of Solids: Shames, I and Pitarresi, J. M., Preentice Hall, New Delhi.
5 Strength of Materials: Subramanian, Oxford University Press.
6 Advanced Mechanics of Solids, L.S. Srinath, Tata McGraw Hill,20
7 Strength of Materials: R. K. Rajput, S. Chand and Co. Ltd.

Reference Books:

1 Mechanics of Materials: Beer, F.P., E. Russell Jhonston and John T. DeWolf, TMH, New Delhi.
2 Beams on Elastic Foundation: Heteny M.
3 Mechanics of Materials: James Gere, M., Thomson Brooks.
4 Reinforced Concrete Deep Beams: F.K. KONG, Taylor & Francis Books, Inc.

Semester-V

Course Code	Course Name	Credits
CEDLO5015	Department Level Optional Course - 1 Air and Noise Pollution and Control	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Air pollution is caused by solid and liquid particles and certain gases that are suspended in the air. These particles and gases can come from car and truck exhaust, factories, dust, pollen, mold spores, volcanoes and wildfires, possibly causing diseases, death to humans, damage to living organisms. Noise pollution impacts millions of people on a daily basis. The most common health problem it causes is Noise Induced Hearing Loss (NIHL). Exposure to loud noise can also cause high blood pressure, heart disease, sleep disturbances, and stress. This subject is intended to make students aware about the noise and air pollution, various sources which contribute in degradation of air quality, assessing the air quality through air quality index, and various air and noise pollution control methods and equipment used by industries.

Objectives

The students will be able to learn:

1 Understanding of basic concepts of air and noise pollution.

2 Study of air pollution episodes. Reasoning of the entire episode, identification of the parameters, conditions, mechanisms.

3 Study of sampling types and methods for ambient air and stack.

4 Study of macro and micro meteorology for understanding the dispersion of pollutants.

5 Simple and complex modeling for point source, line source and area source.

6 Study of pollution control methods, mechanism and devices, laws.

Detailed Syllabus

Module	Course Module / Contents	Periods
1	Introduction to Air Pollution: Definition, Air pollutants and its classification and sources of generation. Emission Inventory. Indoor air pollution. Measurement of air pollution. Air pollution in India and other countries. Air Quality Index. Numerical on conversion of units of pollutants.	05
2	Environmental Effects of Air Pollution: Effects of air pollutants on human beings, plants, animals, properties and visibility. Exposure to air pollution. Numerical problems based on COH, CoHb	06
3	Measurement and Control technology of Air Pollutants: methods to measure ambient air pollution and stack emissions, high volume sampler, wind rose diagram. Control Technology: Control Devices Principles, operations and types, simple hoods and ducts. Settling chambers, cyclones, electrostatic precipitators (ESP), Filters, scrubbers, absorption towers and incinerators. Collection efficiencies for laminar and turbulent flows for settling chambers, particle cut size for cyclone, ESP Concept of frictional and overall efficiencies. Design criteria for filters, scrubbers, absorption towers and incinerators.	10
4	Meteorological process and air quality monitoring: Large scale wind circulation geotropic wind, gradient wind, cyclone, anticyclone, planetary boundary layer. Lapse rate, stability conditions, wind velocity profile, maximum mixing depth, topographic effects. Plum patterns, plum dispersion, Gaussian model for predicting concentration, downwind from a single source, diffusion coefficients, Turner's stability categories and graphs for dispersion estimates. Maximum ground level concentration, inversion effects, distance touching ground modification of Gaussian model to predict particulate dispersion, plume rise, modified Holland equation for small source.	10
5	Current Issues on Air Pollution and Global -Legal Aspects, air pollution laws, Indian standards- emission and air quality standards Greenhouse effect/ Global warming, Ozone Pollution, Acid Rain.	04
6	Noise Pollution: definition and introduction, the effects of noise, characteristics of sound and its measurement, levels of noise and problems, noise rating system, noise level standards, sources of noise and their noise levels, noise abatement and control.	04
	Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Identify air and noise pollution problems and interpret criteria for air and noise quality data.
2 Recognize various environmental transformation processes of pollutants under extreme weather condition.
3 Interpret meteorological data and develop capability to assessment of project proposal.
4 Knowledge to analyze quality of air in the form of air quality index and dispersion modeling.
5 Relate and analyze the pollution regulation on its scientific basis.
6 Justify the use of pollution control equipment and their design.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only four questions need to be solved in total.
5 There can be an internal choice in various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.

Recommended Books:

1 Air Pollution: Rao. M. N. and Rao, H. V. N., Tata McGraw Hill Publication, New Delhi.
2 Environmental Pollution Control Engineering: Rao C.S., New Age International Publishers.
3 Noise Pollution: Agarwal S.K., APH Publishing Corporation.
4 Noise Pollution and Control Strategy: Singal S.P., Alpha Science International LTD.
5 Sewage disposal and Air pollution engineering: Garg, S.K., Khanna pbl.

Reference Books:

1 Air Pollution: Part A- Analysis and Part B-Prevention and Control: Ledbetter, J. O., Make Dekker Inc., New York.

2 Air Pollution: Wark and Warner, Harper and Row, New York.

3 Air Pollution Vol.1: Tripathi, A. K., Ashish Publication House, New Delhi.

4 Air Pollution Handbook: Magill, P. L.et al., McGraw Hill publication.

5 Air and Noise Pollution Control: Volume 1: Wang,L.K. and Pereira, N.C., Humana

6 Textbook of Noise Pollution and its Control: Bhatia S. C., Atlantic Publishers and Distributors, New Delhi.

7 Industrial Air Pollution Handbook: Parker, A., Tata McGraw Hills Publication.

8 Air Pollution: Henry Capeskins, McGraw Hill publication.

9 Environmental Noise Pollution: Noise Mapping, Public Health, and Policy,Enda Murphy and Eoin King.

10 Air Pollution: Wark and Warner, Harper and Row, New York.

11 Government of India's Publication of laws related to air pollution, Maharashtra Pollution Control Board's (MPCB) Publication of standards. IndianStandards relevant to Air Pollution Monitoring, Definitions, Standards.

12 Air Pollution Control Theory: Martin Crawford, McGraw Hill publication.

Semester-V

Course Code	Course Name	Credits
CEDLO5016	Department Level Optional Course - 1 Transportation Planning and Economics	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

The ultimate aim of Transport planning is to generate alternatives for improving Transportation system to meet future demand and selecting the best alternative after proper evaluation. The Course concentrates on Transportation system planning, Public Transportation Planning, Parking planning, and economic analysis of Transportation projects. Basic purpose of transportation planning is focusing on what's the most efficient movement for people and goods around the world. Improving access to an area not only reduces congestion, but the accessibility attracts new residents and businesses ultimately helping economic development.

Objectives

1 To understand various urban development policies in India and to learn different planning surveys.

2 To analyze and plan future traffic flow using four stage modelling.

3 To understand the implementation of land use transport model in Urban area.

4 To carry out economic analyses for different transportation infrastructure projects.

5 To understand and plan Urban public Transportation system.

6 To plan and design Parking system for residential, commercial and other projects.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Urban Transportation Planning**		04
	1.1	Problems & factors in Transportation Planning, Development of Transportation Systems in India, Growth of Transport - Trends in Traffic - Imbalances in Transport System.	
	1.2	Urban growth mechanism – Urban morphology - Urbanization & travel demand - Urban development planning policy – NUTP - Urban transport projects - Urban transport problems in India	
	1.3	Urban travel patterns - Study area delineation- Zoning - Planning surveys - Urban activity system, Trip based and activity-based approach - Four stage travel demand modelling.	
2	**Four Stage Modelling**		10
	2.1	Trip generation analysis: trip classification, multiple regression analysis, category analysis	
	2.2	Trip distribution analysis: introduction, methods of trip distribution, uniform and average factor method, Fratar method, Furness method, the gravity model, opportunities model.	
	2.3	Modal split analysis: introduction, Modal split analysis modal split models.	
	2.4	Traffic Assignment: purpose of traffic assignment, Assignment techniques: All or nothing assignment, Multiple route assignment, Capacity restraint assignment, Diversion Curves.	
3	**Land Use Transport Modelling**		05
	3.1	Urban system components - Urban spatial structure – Accessibility - Location theory.	
	3.2	Land use models - Land use transport models, Lowry & Garin – Lowry models.	
4	**Transportation Economics**		10
	4.1	Economic evaluation of highway schemes, need for economic evaluation, cost and benefits of transportation projects	
	4.2	Basic principles of economic evaluation, Net present value method, benefit/cost ratio method, internal rate of return method. Vehicle operating costs.	
5	**Urban Public Transport Planning**		05
	5.1	Growth history – Urban growth & public transport needs - Modes of public transport and comparison - Public transport travel characteristics	
	5.2	Technology of bus, rail, rapid transit systems, and basic operating elements. Transit characteristics - Fleet size and capacity estimation.	
6	**Parking Planning and Design**		05

	6.1	Types of Parking's, Methods of surveys, Parking inventories, Parking Design	
	6.2	Planning of parking for residential and commercial buildings including shopping complex, malls and multiplex.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Understand various Urban transport related terms and policies along with methods to carry out planning surveys.

2 Carry out trip generation, trip distribution, modal split and traffic assignment for planning of urban transport system.

3 Apply land use transport models at Urban area.

4 Carry out economic analysis of different Transport related Infrastructure projects by analyzing costs and benefits related to projects using NPV, IRR and B/C ratio method.

5 Estimate capacity of different public transportation modes in Urban area and to plan and schedule the same based on fleet size.

6 Plan and design Parking facility at Urban area.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only four questions need to be solved in total.

Recommended Books:

1 Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi, 2002.

2 IRC: SP: 30-1993., Manual on Economic Evaluation of Highway Projects in India.

3 Sarkar P K., Maitri V.,Economics in Highway and Transportation Planning, Standard Publisher, New Delhi, 2010.

4 K.S. Ramegauda, Urban and Regional Planning, Mysore University Publication.

5 Ceder, A.,Public Transit Planning and Operation: Theory, Modeling and Practice, B-H Elsevier Ltd., MA, 2007.

6 IRC:SP:12-2015, Guidelines for Parking Facilities in Urban Roads

Reference Books:

1 Khisty C J., Lall B.Kent, Transportation Engineering – An Introduction, Prentice-Hall, NJ, 2005

2 Ortuzar, J. D., Willumsen, L.G., Modeling Transport, John Wiley & Sons, 1994

3 Papacostas C.S. and Prevedouros, P.D., Transportation Engineering & Planning, PHI, New Delhi,2002

4 Hutchinson B.G., Principles of Urban Transportation System Planning, Mc-Graw Hill, 1974.

Semester-V

Course Code	Course Name	Credits
CEDLO5017	Department Level Optional Course – 1 Advanced Concrete Technology	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Basic concept of concrete technology is essential for civil engineering students to execute the civil engineering projects as per the standard laid down time to time. Advancements in concrete technology is the backbone of infrastructure of civil engineering field. This course provides necessary knowledge about various concreting operations and testing operations during and after construction. This course is intended for gaining knowledge about the properties of materials, especially concrete and to maintain quality in construction projects. This course will also provide knowledge to the students about the criteria to be remembered during the selection of materials, its mix proportioning, mixing, placing, compacting, curing and finishing.

Objectives

1 To understand the various properties and tests of materials used in concrete along with the rheology of fresh concrete.

2 To study the different procedures for testing hardened concrete, its compositions and quality of in place concrete.

3 To understand the concept of durability and cracking in concrete. To also understand the significance and parameters of concreting under extreme environment and conditions.

4 To understand the concept and optimization of the mix design of concrete by various codes.

5 To study the various constituents, properties, significance and applications of special concrete.

6 To study the quality of concrete and check the acceptance criteria.

Detailed Syllabus			
Module	**Course Module / Contents**		**Periods**
1	**Constituents and Properties Of Concrete**		**08**
	1.1	Introduction of cement and water: Chemical composition of OPC, hydration, chemistry of cement, cement testing, water requirement for hydration, water quality for concrete and water quality test.	
	1.2	Aggregates: Types of aggregate (natural, synthetic, recycled), required characteristics of aggregates for concrete, introduction to gradation of aggregates, standard grading curve and gap grading.	
	1.3	Chemical admixture: Introduction to accelerators, retarders, plasticizers, super plasticizers, viscosity modifying admixtures, water proofers, miscellaneous admixtures.	
	1.4	Mineral admixture: Introduction, composition of mineral admixture, fly ash and its type, silica fume, ground granulated blast furnace slag and others. Effects of mineral admixture on fresh and hardened concrete properties.	
	1.5	Properties of fresh concrete: Introduction to properties of fresh concrete, w/c ratio, w/b ratio, gel space ratio, maturity concept, aggregate cement bond strength, pumping of concrete.	
	1.6	Rheological models of fresh concrete: Introduction, simple flow test, rheological models and test methods, factors affecting rheological properties of concrete and effect of rheological properties on different types of concrete.	
2	**Testing of Concrete**		**05**
	2.1	Introduction to testing of hardened concrete - compression, tension, and flexure. Methods of testing (destructive, semi destructive, non-destructive).	
	2.2	Properties of hardened concrete: Factors influencing strength, importance of end effects in compression testing, tensile strength of concrete (split and flexural), relationship between compressive and tensile strength.	
	2.3	Advanced non-destructive evaluation: Ground penetration radar, probe test penetration, pull out/off, break off method, stress wave propagation method, electrical / magnetic methods, infrared thermography, and core test.	
3	**Durability of Concrete**		**10**
	3.1	Introduction to durability and permeability: Transport mechanism of fluids and gases in concrete, role of w/c and admixture on durability. Design of durability using performance specification.	
	3.2	Corrosion and carbonation: Introduction to corrosion of reinforcement in concrete, factors influencing corrosion, damages preventive measures of corrosion, tests for existing structures and remedial measures of corrosion, introduction and measurement of depth of carbonation.	
	3.3	Concrete structures in special environment: Frost action, fire or	

		high temperature, chemical attack and aggressive environment (sulphate attack, chloride attack, acid attack in sewers, sea water attack), alkali aggregate reaction (alkali silica and carbonate reaction).	
	3.4	Concreting under extreme weather: Hot and cold weather concreting, underwater concreting.	
4	**Concrete Mixture Design**		**07**
	4.1	Design of concrete mixes by IS 10262 (latest edition) Method – with and without fly ash, super plasticizer, effect of pumping of concrete on mixture design.	
	4.2	Design of concrete mixes by American Concrete Institute (ACI) Method – Air and non-air entrained concrete.	
	4.3	Design of concrete mixes by Department of Environment (DoE) Method.	
	4.4	Design of concrete mixes by Road note 4 Method.	
	4.5	Design of high strength concrete mixes using ACI 211.4R - 93 Method.	
5	**Special Concretes**		**06**
	5.1	Light weight concrete and ultra-light weight concrete: Types and properties of light weight aggregates, factors influencing the strength and density of light weight aggregate concrete, properties of light weight aggregate concrete. Introduction to other light weight concrete – Cellular and foamed concrete. (01).	
	5.2	High performance concrete: Methods for achieving high performance concrete, requirements for high performance characteristics, material selection, advantages and applications.	
	5.3	Self-compacting concrete (SCC): Materials for SCC, comparison of traditional and SCC constituents, requirements for SCC, initial mix compositions, production and placing of SCC, fresh concrete tests for SCC.	
	5.4	Fiber Reinforced Concrete (FRC): Study of different fibers (metallic fiber, polymeric fibers, carbon fibers, glass fibers, naturally occurring fibers) in concrete with respect to volume fraction, orientation and aspect ratio, physical and mechanical properties - steel and polypropylene fiber reinforced concrete. Applications of steel and polypropylene fibers reinforced concrete.	
	5.5	Introduction to other special concrete – Vacuum concrete, waste material-based concrete, shotcrete, roller compacted, mass concrete.	
6	**Quality Control (QC)**		**03**
	6.1	Introduction: Statistical QC, quality factors, control charts.	
	6.2	Acceptance criteria according to Indian standards: Strength of concrete (site and laboratory)	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1. To use the various concrete materials and demonstrate the fresh properties of concrete.
2. To perform different testing methods of concrete.
3. To describe the durability of concrete and apply the knowledge of durability in extreme weather concreting.
4. To design the concrete mix for field application by different methods.
5. To explain the various properties of special concrete.
6. To discuss the quality of concrete and explain the acceptance criteria.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only four questions need to be solved in total.

Recommended Books:

1. Concrete Technology: A. R. Shanthakumar, Oxford University Press, New Delhi, 2007.
2. Concrete Technology Theory and Practice: Shetty M.S., S. Chand.
3. Properties of concrete: Neville, Isaac Pitman, London.
4. Concrete Technology: Gambhir M.L., Tata McGraw Hill, New Delhi.
5. Concrete Technology: Neville A.M. & Brooks. J. J., ELBS-Longman, Pearson Education Ltd.
6. Relevant I.S. codes: Bureau of Indian standard and ACI code.
7. Design of concrete mixes by N Krishna Raju (Latest Edition), CBS Publishers and Distributers Pvt. Ltd.

Reference Books:

1 Fibre Reinforced Cementitious Composites: Arnon Bentur and Sidney Mindess, Modern Concrete Technology Series, Tylor and Francis.

2 Concrete- Microstructures, Properties and Materials: P. Kumar Mehta and Paulo J. M. Monteiro, Indian Edition, Indian Concrete Institute, Chennai, 1999

3 Special Publication of ACI on Polymer concrete and FRC.

4 Concrete Technology: D.F. Orchardi, Wiley, 1962.

5 www.theconcreteportal.com

Semester-V

Course Code	Course Name	Credits
CEL501	Theory of Reinforced Concrete Structures (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objectives:

1. To develop a clear understanding of design philosophy amongst the students for the design of reinforced concrete structures using working stress method (WSM) and limit state method (LSM).
2. To study various clauses of IS: 456-2000 and their significance in the RCC design.
3. To apply various concepts of LSM in the analysis and design of beams, slabs and columns.
4. To study the concept of Serviceability and Durability for deflection and crack width calculation in RCC structures.
5. To develop the concept of design using design charts and curves for columns subjected to axial load and moment.
6. To study the concept of reinforced concrete footing design subjected to axial load and moment.

Course Outcomes:

At the end of the course, learner will be able to:

1. Understand the fundamentals of WSM and LSM.
2. Apply various clauses specified in IS: 456-2000 for designing structural members with safety and economy.
3. Understand the use of readymade design charts and curves from Special Publications of Bureau of Indian Standards.
4. Analyze and design various reinforced concrete elements such as beam, slab, column, footings using the concept of Limit State Method.

List of Tutorials and Assignments		
Week (Activity)	**Detailed Content**	**Hours**
1st Week (Tutorial)	Analysis and Design of Singly and Doubly Reinforced RCC beam using WSM (Numericals Based on this module will be solved in tutorial class)	02
2nd Week (Assignment)	Analysis and Design of Singly and Doubly reinforced RCC beam using WSM or any one activity from below: Solve set of Questions given by the course instructor. Write a report on provisions in IS 456 2000 related to the design of beams A comparative study consisting of advantages and disadvantages of WSM and LSM	02
3rd Week (Tutorial)	Analysis and Design of Singly and Doubly Reinforced RCC beam using LSM. (Numericals Based on this module will be solved in tutorial class)	02
4th Week (Assignment)	Analysis and Design of Singly and Doubly Reinforced RCC beam using LSM. Or any one activity from below: Solve set of Questions given by the course instructor. Study of IS 456 2000 provisions on Limit state of collapse: Flexure.	02
5th Week (Tutorial)	Analysis and Design of Flanged beams for Flexure using LSM. Design of RCC beams in shear, bond, and torsion. (Numericals Based on this module will be solved in tutorial class)	02
6th Week (Assignment)	Analysis and Design of Flanged beams for Flexure using LSM. Or any one activity from below: Design of RCC beams in shear, bond, and torsion. Solve set of Questions given by the course instructor. Study of IS 456 2000 provisions on Limit state of collapse- Shear, Bond and Torsion.	02
7th Week (Tutorial)	Design of Simply supported One-way and Two-way slabs as per IS: 456-2000 (Numericals Based on this module will be solved in tutorial class)	02
8th Week (Assignment)	Design of Simply supported One-way and Two-way slabs as per IS: 456-2000. Or any one activity from below: Solve set of Questions given by the course instructor. Study of IS: 456-2000 provisions on Design of RCC slabs.	02
9th Week (Tutorial)	Analysis and Design of Columns loaded Axially, Uni-axially, and Bi-axially, using LSM. (Numericals Based on this module will be solved in tutorial class)	02
10th Week (Assignment)	Analysis and Design of Columns loaded Axially, Uni-axially, and Bi-axially, using LSM. or any one activity from below: Solve set of Questions given by the course instructor. Studying the development of interactive curves and their use in column design.	02

	Study of IS: 456-2000 Provisions for Limit State of Collapse – Compression	
11th Week (Tutorial)	Design of Isolated square and rectangular footings subjected to axial load and moment. (Numericals Based on this module will be solved in tutorial class)	02
12th Week (Assignment)	Design of Isolated Square and rectangular footings subjected to axial load and moment. or any one activity from below: Solve set of Questions given by the course instructor. Study of IS: 456-2000 provisions related to design of RCC foundations. Report or presentation on Significance and Design of different types of RCC Foundations by various groups of students.	02
13th Week	Viva – Voce Examination	02

Assessment:

- **Term Work**

Including Laboratory Work and Assignments both, Distribution of marks for Term Work shall be as follows:

Laboratory Work	:	10 Marks
Assignments	:	10 Marks
Attendance	:	05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

- **End Semester Oral Examination**

Oral examination will be based on entire syllabus.

- **Recommended books:**

Design of Reinforced Concrete Structures: Dayaratnam, P; Oxford and IBH.

Limit State Design of Reinforced Concrete: Jain A. K, Nemchand and Bros., Roorkee

Limit State Design of Reinforced Concrete: Shah and Karve, Structure Publications, Pune.

Ultimate Strength Design for Structural Concrete: Arthur, P. D. and Ramakrishnan, V., Wheeler and Co. Pvt. Ltd.

Reinforced Concrete: H.J. Shah, Charotar Publishers, Anand.

Fundamentals of Reinforced Concrete: Sinha & Roy, S. Chand and Co. Ltd.

Illustrated Reinforced Concrete Design: Dr. V. L. Shah and Dr. S. R. Karve, Structure Publications, Pune.

Reinforced Concrete Design: Wang, C. K., Salmon, C. G., and Pincheira, J. A, John Wiley (2007), 7th Edition.

Reinforced Concrete Fundamentals: Ferguson, P. M., Breen, J. E., and Jirsa, J. O., John Wiley & Sons (1988) 5th Edition.

Semester-V

Course Code	Course Name	Credits
CEL502	Applied Hydraulics (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objectives:

1 To describe the concepts of fluid dynamics and its applications.

2 To exemplify the fundamentals of impulse momentum principle and explain the working of various hydraulic machines.

3 To classify the uniform and non-uniform flow in open channel.

Course Outcomes:

At the end of the course, learner will be able to:

1 Evaluate the efficiencies and discuss the working of various pumps and turbines.

2 Apply impulse momentum principle to hydraulic machines.

3 Determine the rate of flow through open channel.

4 Generate and evaluate Gradually varied flow (GVF) and Rapid varied Flow (RVF) in open channel flow.

5 Compute the Chezy's Constant through tilting flume.

List of Experiments (Minimum Six)		
Module	**Detailed Content**	**Lab Session / Hr.**
1	Impact of jet, flat plate, inclined plate, curved vanes.	02
2	Performance of Pelton turbine.	02
3	Performance of Francis Turbine.	02
4	Performance of Kaplan Turbine.	02
5	Performance of Centrifugal pumps.	02
6	Chezy's roughness factor.	02
7	Specific energy.	02
8	Hydraulic Jump.	02
9	Calibration of Broad crested weir/Venturi flume.	02

Assessment:

- **Term Work**

The term work shall comprise of the neatly written report based on the afore-mentioned experiments and assignments. The assignments shall comprise of the minimum 20 problems covering the entire syllabus divided properly module wise. The marks of the term work shall be judiciously awarded for the various components of the term work and depending upon the quality of the term work. The final certification and acceptance of term work warrants the satisfactory performance of laboratory work by the student, appropriate completion of the assignments. Distribution of marks for Term Work shall be as follows:

Laboratory Work	:	10 Marks
Assignments	:	10 Marks
Attendance	:	05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

- **End Semester Oral Examination**

Pair of Internal and External Examiner should conduct oral examination.

Reference Books:

1 Fluid Mechanics and Hydraulic Machines: R. K. Rajput, S. Chand and Company.

2 Hydraulics and Fluid mechanics: Dr. P.M. Modi and Dr. S.M. Seth, Standard Book House, Delhi.

3 Hydraulics Fluid Mechanics and Fluid Machines: S. Ramamrutham, Dhanpat Rai Publishing Company (P) Ltd-New Delhi.

4 Theory and Application of Fluid Mechanics: K. Subramanian, Tata McGraw hill publishing company, New Delhi.

5 Fluid Mechanics and Hydraulics: Dr. S.K. Ukarande, Ane's Books Pvt. Ltd. (Revised Edition 2012), ISBN 97893 8116 2538.

6 Fluid Mechanics and fluid pressure engineering: Dr. D.S. Kumar, F.K. Kataria and sons.

7 Fluid Mechanics: R.K. Bansal Laxmi Publications (P) Ltd.

Semester-V

Course Code	Course Name	Credits
CEL503	Geotechnical Engineering – I (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objectives:

1	Determination of moisture content, specific gravity of soil solids and in-situ field density of soils as well as field identification of fine-grained soils
2	To determine the grain size distribution of soils and consistency or Atterberg limits of fine-grained soils
3	To determine coefficient of permeability of soils in laboratory
4	To determine compaction characteristics of soils in laboratory
5	To determine the density index (relative density) of cohesionless soil
6	To determine field SPT 'N' value by Standard Penetration Test

Course Outcomes:

At the end of the course, learner will be able to:

1	Determine the physical and engineering properties of soil
2	Determine the plasticity characteristics of soil
3	Carry out sieve analysis of soil, plot grain size distribution curve and determine the IS classification of soil
4	Determine coefficient of permeability of soils
5	Determine the compaction characteristics of soils
6	Compute the field SPT 'N' value and prepare the bore log

List of Experiments (Minimum ten)		
Module	**Detailed Content**	**Lab Session / Hr.**
1	Determination of natural moisture content of soil using oven drying method Following other methods to find moisture content shall be explained briefly: a) Pycnometer method b) Sand bath method c) Alcohol method d) Torsional balance method e) Moisture meter f) Radio activity method	02
2	Specific gravity of soil grains by density bottle method or Pycnometer method	02
3	Field density using core cutter method	02
4	Field density using sand replacement method	02
5	Field identification of fine-grained soils	02
6	Grain size distribution of coarse-grained portions (gravel and sand) of soil by sieve analysis	02
7	Grain size distribution of fine portions (silt and clay) of the soil by Hydrometer analysis	02
8	Determination of liquid (Casagrande method), plastic and shrinkage limits	02
9	Determination of liquid limit by cone penetrometer method	02
10	Determination of co-efficient of permeability using constant head method	02
11	Determination of co-efficient of permeability using falling head method	02
12	Compaction test, IS light compaction test/ Standard Proctor test	02
13	Compaction test, IS heavy compaction test/ Modified Proctor test	02
14	Relative density (or, density index) test	02
15	Standard penetration test	02

Assessment:

- **Term Work**

a) The term work shall be comprised of the neatly written reports based on the experiments performed in the laboratory, assignments, attendance and case study.
b) The assignments shall be given covering the entire syllabus in such a way that the students would attempt at least two problems on each module/ sub-module.
c) Students (5 students max. in a group) should perform a case study on Forensic Investigation for Geotechnical Failures/or, Geo environmental Engineering and must submit a report or power

point presentation on the same. The questions related to this concept shall not be asked in the theory examination. However, it shall be treated as a part of term work submission.

Distribution of Term-work Marks

The marks of the term work shall be judiciously awarded depending upon the quality of the laboratory works, assignments, attendance and case study. The final certification acceptance of term work warrants the satisfactory and appropriate completion of laboratory work, assignments and case study with the minimum passing marks by the students. The following weightage of marks shall be given for different components of the term-work.:

Laboratory Work	:	12 Marks
Case study	:	03 Marks
Assignments	:	05 Marks
Attendance	:	05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

- **End Semester Oral Examination**

The oral examination shall be based upon the entire theory and laboratory syllabus.

Reference Books:

1 SCI/SCOPUS Indexed Refereed International Journals (For Case Studies)

2 Relevant Indian Standard Specifications Codes, BIS Publications, New Delhi.

3 Departmental Laboratory Manual

4 Standard Geotechnical Engineering Handbook

5 NPTEL Video lectures on Practical.

Semester-V

Course Code	Course Name	Credits
CEL504	Transportation Engineering (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objective:

1 To determine Penetration grade and Viscosity grade of bitumen.

2 To find the Softening point and Ductility value of bitumen.

3 To determine Impact, Abrasion and Crushing value of aggregate.

4 To carry out shape test on aggregates.

5 To carry out Classified volume study and plot speed profile at mid-block section.

Course Outcomes:

At the end of the course, learner will be able to:

1 Classify Bitumen on basis of Penetration and Viscosity grade.

2 Select Bitumen as per suitability on basis of Softening point and Ductility value.

3 Determine suitability of aggregate on basis of Impact value, Abrasion value and Crushing value.

4 Differentiate Elongated and Flaky aggregates on basis of Shape test.

5 Carry out Classified volume study at mid-block section of road.

6 Plot speed profile curve (S-Curve) at mid-block section.

List of Experiments (Minimum Eight)		
Module	**Detailed Content**	**Lab Session / Hr.**
1	Penetration Test on Bitumen.	02
2	Viscosity Test on Bitumen.	02
3	Softening Point Test on Bitumen	02
4	Ductility Test on Bitumen	02
5	Determination of Aggregate Impact Value	02
6	Determination of Aggregate Crushing Value	02
7	Determination of Abrasion Value of Road Aggregate	02
8	Shape Test of Aggregate	02
9	Classified Volume count at mid-block section	02
10	Speed profile study at mid-block section	02

Assessment:

- **Term Work**

Including Laboratory Work Survey project report and Assignments, Distribution of marks for Term Work shall be as follows:

Laboratory Work and Traffic Survey	:	10 Marks
Assignments	:	10 Marks
Attendance	:	05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

- **End Semester Oral Examination**

Oral exam will be based on experiments performed, traffic survey carried out and theory syllabus.

Reference Books:

1 Highway Engineering: Khanna, S.K. and Justo, C. E. G.;Nem Chand and Bros., Roorkee.

2 Principles, Practice and Design of Highway Engineering (Including Airport Engineering)" Sharma, S.K.; S. Chand and Company Pvt. Ltd., New Delhi.

3 Highway Material and Pavement Testing: Dr. S. K. Khanna, Dr. C. E. G. Justo and Dr. A. Veeraragavan. Nem Chand and Bros., Roorkee, India.

4 Traffic Engineering and Transport Planning: Kadiyali, L.R., Khanna Publishers, Delhi

5 Principles and Practice of Highway Engineering: Kadiyali, L. R.; Khanna Publsihers, Delhi.

6 Relevant specifications of MORTH and relevant IRC codes.

Semester-V

Course Code	Course Name	Credits
CEL505	Professional Communication and Ethics-II	02

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
---	02*+02	-	-	02	-	02

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Rationale

This curriculum is designed to build up a professional and ethical approach, effective oral and written communication with enhanced soft skills. Through practical sessions, it augments student's interactive competence and confidence to respond appropriately and creatively to the implied challenges of the global Industrial and Corporate requirements. It further inculcates the social responsibility of engineers as technical citizens.

Course Objectives

1 Discern and develop an effective style of writing important technical/business documents.

2 Investigate possible resources and plan a successful job campaign.

3 Understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement.

4 Develop creative and impactful presentation skills.

5 Analyze personal traits, interests, values, aptitudes and skills.

6 Understand the importance of integrity and develop a personal code of ethics.

Course Outcomes

Learner will be able to

1 Plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.

2 Strategize their personal and professional skills to build a professional image and meet the demands of the industry.

3 Emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.

4	Deliver persuasive and professional presentations.
5	Develop creative thinking and interpersonal skills required for effective professional communication.
6	Apply codes of ethical conduct, personal integrity and norms of organizational behaviour.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Advanced Technical Writing: Project/ Problem Based Learning (PBL)**		06
	1.1	**Purpose and Classification of Reports, Classification on the basis of:** Subject Matter (Technology, Accounting, Finance, Marketing, etc.); Time Interval (Periodic, One-time, Special); Function (Informational, Analytical, etc.); Physical Factors (Memorandum, Letter, Short & Long)	
	1.2	**Parts of a Long Formal Report** Prefatory Parts (Front Matter), Report Proper (Main Body), Appended Parts (Back Matter)	
	1.3	**Language and Style of Reports**: Tense, Person & Voice of Reports, Numbering Style of Chapters, Sections, Figures, Tables and Equations, Referencing Styles in APA & MLA Format, Proofreading through Plagiarism Checkers	
	1.4	**Definition, Purpose & Types of Proposals:** Solicited (in conformance with RFP) & Unsolicited Proposals, Types (Short and Long proposals)	
	1.5	**Parts of a Proposal** Elements: Scope and Limitations, Conclusion	
	1.6	**Technical Paper Writing**: Parts of a Technical Paper (Abstract, Introduction, Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References), Language and Formatting, Referencing in IEEE Format	
2	**Employment Skills**		06
	2.1	**Cover Letter & Resume:** Parts and Content of a Cover Letter, Difference between Bio-data, Resume & CV, Essential Parts of a Resume, Types of Resume (Chronological, Functional & Combination)	
	2.2	**Statement of Purpose:** Importance of SOP, Tips for Writing an Effective SOP	
	2.3	**Verbal Aptitude Test:** Modelled on CAT, GRE, GMAT exams	
	2.4	**Group Discussions:** Purpose of a GD, Parameters of Evaluating a GD, Types of GDs (Normal, Case-based & Role Plays), GD Etiquettes	
	2.5	**Personal Interviews:** Planning and Preparation, Types of Questions, Types of Interviews (Structured, Stress, Behavioral, Problem Solving & Case-based), Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	

3	**Business Meetings**		
	3.1	**Conducting Business Meetings:** Types of Meetings, Roles and Responsibilities of Chairperson, Secretary and Members, Meeting Etiquette	**02**
	3.2	**Documentation**: Notice, Agenda, Minutes	
4	**Technical/ Business Presentations**		
	4.1	**Effective Presentation Strategies**: Defining Purpose, Analysing Audience, Location and Event, Gathering, Selecting & Arranging Material, structuring a Presentation, Making Effective Slides, Types of Presentations Aids, Closing a Presentation, Platform Skills	**02**
	4.2	**Group Presentations**: Sharing Responsibility in a Team, Building the contents and visuals together, Transition Phases	
5	**Interpersonal Skills**		
	5.1	**Interpersonal Skills**: Emotional Intelligence, Leadership & Motivation, Conflict Management & Negotiation, Time Management, Assertiveness, Decision Making	**08**
	5.2	**Start-up Skills:** Financial Literacy, Risk Assessment, Data Analysis (e.g., Consumer Behaviour, Market Trends, etc.)	
6	**Corporate Ethics**		
	6.1	**Intellectual Property Rights:** Copyrights, Trademarks, Patents, Industrial Designs, Geographical Indications, Integrated Circuits, Trade Secrets (Undisclosed Information)	**02**
	6.2	**Case Studies:** Cases related to Business/ Corporate Ethics	
		Total	**26**

List of Assignments for Term Work

In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.

1 Cover Letter and Resume
2 Short Proposal
3 Meeting Documentation
4 Writing a Technical Paper/ Analysing a Published Technical Paper
5 Writing a SOP
6 IPR
7 Interpersonal Skills
8 Aptitude test (Verbal Ability)

Note:

- The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).
- The group size for the final report presentation should not be less than 5 students and not to exceed more than 7 students.
- There will be an end–semester presentation based on the book report.

Assessment:

- **Term Work**

Term work shall consist of minimum 8 experiments.

Assignments	:	10 Marks
Presentation Slides	:	05 Marks
Book Report (Hard Copy)	:	05 Marks
Attendance	:	05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

- **Internal Oral**

Oral Examination will be based on a GD & the Project/Book Report presentation

Group Discussion	:	10 Marks
Individual Presentation	:	10 Marks
Group Dynamics	:	05 Marks

Recommended Books:

1 Arms, V. M. (2005). Humanities for the engineering curriculum: With selected chapters from Olsen/ Huckin: Technical writing and professional communication, second edition. Boston, MA: McGraw-Hill.
2 Bovée, C. L., &Thill, J. V. (2021). Business communication today. Upper Saddle River, NJ: Pearson.
3 Butterfield, J. (2017). Verbal communication: Soft skills for a digital workplace. Boston, MA: Cengage Learning.
4 Masters, L. A., Wallace, H. R., & Harwood, L. (2011). Personal development for life and work. Mason: South-Western Cengage Learning.
5 Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). Organizational behaviour. Harlow, England: Pearson.
6 Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
7 Archana Ram (2018) Place Mentor, Tests of Aptitude for Placement Readiness. Oxford University Press
8 Sanjay Kumar & Pushp Lata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

Semester-V

Course Code	Course Name	Credits
CEM501	Mini Project -2A	2

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	04	-	-	2	-	2

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Rationale

From primitive habitats of early years to modern buildings, the civil engineering industry's growth has been needing based and society centric. Civil engineers deal with many challenges on daily basis that most people do not have any idea. Mumbai University proposed Mini projects in the syllabus so that the budding civil engineers can connect with the world outside their books and have the idea of future course. The Mini project should actually provide solution to a typical problem after a brainstorming and in a stipulated period. The competitions ahead will give students the experience of the civil engineering industry's real-world problems and make students brainstorm ideas, learn, and explore the civil engineering industry.

Course Objectives:

1	To recognize societal problems and convert them into a problem statement by understanding of facts and ideas in a group activity.
2	To deal with new problems and situations by applying acquired knowledge, facts, techniques and rules in a different way.
3	To examine and break information into parts, by analyzing motives or causes.
4	To learn evaluating information, validity of ideas and work based on a set of criteria.
5	To create solutions by compiling information together in a different way.
6	To design model by combining elements in a new pattern or proposing new solutions.

Course Outcomes:	
At the end of the course, learner will be able to:	
1	Identify problems based on societal /research needs and formulate a solution strategy.
2	Apply fundamentals to develop solutions to solve societal problems in a group
3	Analyze the specific need, formulate the problem and deduce the interdisciplinary approaches, software-based solutions and computer applications.
4	Develop systematic flow chart, evaluate inter disciplinary practices, devices, available software, estimate and recommend possible solutions.
5	Draw the proper inferences from available results through theoretical/ experimental/ simulations and assemble physical systems.
6	Create devises or design a computer program or develop computer application.

- **Guidelines for Mini Project -2A**

  Expected outcome is hardware based, "A Working Model."

  Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.

  Students should find 'List of Mini project – 2A problems' in University web portal www.mu.ac.in, and in consultation with faculty supervisor/ head of department/ internal committee of faculties select the title.

  Students shall submit implementation plan in the form of Gant/ PERT/ CPM chart, which will cover weekly activity of mini project.

  A log book to be prepared by each group, wherein group can record weekly work progress, guide/ supervisor can verify and record notes/ comments.

  Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.

  Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.

  Students shall convert the best solution into working model using various components of their domain areas and demonstrate.

  The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.

  With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that Students come out with original solution.

  However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/ modifications or a completely new project idea in even semester. This policy can be adopted on case-by-case basis.

List of approved problems for Mini Project -2A:	
H501:	Construction of Model showing New application of alternative materials and byproducts of different industries for Durability and sustainability.
H502:	Construction of Model/ device for Smart Traffic Management System Using Internet of Things
H503:	IOT based smart device for traffic signal monitoring system using vehicle Count.
H504:	Mini Project on Construction of Model showing New application of use of Fly Ash in Civil Engineering works.
H505:	Mini Project on specimen of Modified Concrete Pavements (using unconventional, recycled or waste product)
H506:	Novel device for Base isolation system for multistoried building
H507:	Mini project on specimen of light transmitting concrete.
H508:	Model of Novel Seismic isolation devices for bridge structures.
H509:	Novel Applications of Bamboo as a building material specimen.
H510:	Development of device using sensors for deflection of girders. Beams, slabs or bridges.
H511:	Development of device using sensors for detection of fracture in Railway tracks.
H512:	Mini project on specimen of Bubble deck slab.
H513:	Construction of specimen of GFRG panels as walls in buildings instead of conventional walls.
H514:	Construction of specimen of Agro waste reinforced panels as walls in buildings instead of conventional walls.
H515:	Construction of specimen of unconventional panels as walls in buildings instead of conventional walls.
H516:	Construction of specimen of Ferro cement Slab as a replacement to RCC slab.
H517:	Construction of specimen of No Fines Concrete or porous Concrete and its applications.
H518:	Construction of Model of Novel Soil Stability technique to prevent landslides.
H519:	Construction of Model of a dwelling unit (house) in rural area.
H520:	Typical design of Model for construction of toilets in rural India.
H521:	Construction of Model for Typical applications of Ferro concrete.
H522:	Construction of Model of road paths with locally sourced materials in villages.
H523:	Construction of Model showing Typical application of Prestressed concrete.
H524:	Construction of Model showing Typical application of fiber reinforced concrete.

(This is tentative list, this list will be continuously updated by contributions from faculty, industry and alumni.)

Guidelines for Assessment of Mini Project:

- **Term Work**

The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.

In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

Distribution of Term work marks for both semesters shall be as below:

Marks awarded by guide/supervisor based on log book	:	10 Marks
Marks awarded by review committee	:	10 Marks
Quality of Project report	:	5 Marks

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

- **One-year project:**

  Only if a project is very demanding it will be considered for 'One Year Project'. Subject to approval by the Head of the department.

  Outcome shall be a 'Hardware and a software based' solution

  There shall also a 'technical paper' to be presented in conference/published in journal (UGC approved) or student's competition.

  In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.

  First shall be for finalization of problem

  Second shall be on finalization of proposed solution of problem.

  In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.

  First review is based on readiness of building working prototype to be conducted.

  Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

- **Half-year project:**

  In this case in one semester students' group shall complete project in all aspects including

  Identification of need/problem

  Proposed final solution

  Procurement of components/systems

  Building prototype and testing

  Two reviews will be conducted for continuous assessment,

  First shall be for finalization of problem and proposed solution.

  Second shall be for implementation and testing of solution.

- **Assessment criteria of Mini Project:**

  Mini Project shall be assessed based on following criteria:

  Quality of survey/ need identification

  Clarity of Problem definition based on need.

  Innovativeness in solutions

  Feasibility of proposed problem solutions and selection of best solution

  Cost effectiveness

  Societal impact

  Innovativeness

  Cost effectiveness and Societal impact

  Full functioning of working model as per stated requirements

  Effective use of skill sets

  Effective use of standard engineering norms

  Contribution of an individual as member or leader

  Clarity in written and oral communication

  In one year, project, first semester evaluation may be based on first six criteria and remaining may be used for second semester evaluation of performance of students in mini project.
  In case of half year project all criteria in generic may be considered for evaluation of performance of students in mini project.

- **Guidelines for Assessment of Mini Project Practical/Oral Examination:**

  Report should be prepared as per the guidelines issued by the University of Mumbai.

  Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years and approved by head of Institution.
  Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

- **Mini Project shall be assessed based on following points:**

  Quality of problem and Clarity

  Innovativeness in solutions

  Cost effectiveness and Societal impact

  Full functioning of working model as per stated requirements

  Effective use of skill sets

  Effective use of standard engineering norms

  Contribution of an individuals as member or leader

  Clarity in written and oral communication

Semester VI

Semester-VI

Course Code	Course Name	Credits
CEC601	Design and Drawing of Steel Structures	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	4 Hours	-	-	-	100

Rationale

Steel structures are preferred due to their higher strength, speed of construction and aesthetic view. Civil Engineers must have knowledge of designing and detailing of steel structures to make structures safe and serviceable during its life span. I.S. code specifying the use of Limit State design philosophy for design of steel structures and its various components. This course is designed to provide basic knowledge of design and detailing of steel structures.

Objectives

1 To make students familiar with behavior of steel structure and their components under the action of various loads.
2 To train the students for effective use of IS codes, design tables and aids in analyzing and designing the steel structures by limit state method.
3 To help students design connections of steel members.
4 To equip students with aspects required for designing tension member, compression members and column bases.
5 To equip students with aspects required for designing of flexural members.
6 To aid students in designing steel trusses.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Introduction**		03
	1.1	Types of steel structures, Properties of Structural Steel, Indian Standard Specifications and Sections, Advantages and limitations of WSM, permissible stresses in WSM. Introduction to Limit State Design, partial safety factors for load and resistance, design load combinations, section classification such as plastic, compact, semi-compact and slender.	
2	**Design of Bolted And Welded Connections**		06
	2.1	Design of bolted and welded connections for axial force, beam to beam and beam to column connections. Framed, stiffened and unstiffened seat connections, bracket connections.	
3	**Design of Tension Members**		04
	3.1	Introduction, types of tension members, net area calculation.	
	3.2	Design strength due to yielding, rupture and block shear.	
	3.3	Design of tension members with welded and bolted end connection using single angle section & double angle section.	
4	**Design of Compression Members and Column Bases**		11
	4.1	Introduction, types of compression members, classification of cross sections, types of buckling, effective length of column and slenderness ratio, buckling curves, design of compression members as struts using single angle sections & double angle section.	
	4.2	Design of axially loaded column using rolled steel sections, design of built-up column, laced and battened Columns.	
	4.3	Design of slab bases & gusseted base.	
5	**Design of Flexural Members**		11
	5.1	Design strength in bending, effective length, Lateral torsion buckling behavior of unrestrained beams, design of single rolled section with or without flange plates, design strength of laterally supported beams, low and high shear, design strength of laterally unsupported beams, web buckling, web crippling, shear lag effect and deflection.	
	5.2	Design of welded plate girder: proportioning of web and flanges, flange plate curtailment	
6	**Design of Truss**		04
	6.1	Design of determinate truss. Calculation of dead load, live load and wind load acting on truss. Load combinations and calculation of internal forces. Design and detailing of members. Support detailing. Design of angle section purlin.	
		Total	39

Contribution to Outcome

On completion of this course, the students will be able to:

1 Use the knowledge of Limit State Design philosophy as applied to steel structures. IS 800 code clauses
2 Design bolted and welded connections.
3 Design members subjected to axial tension.
4 Design compression members, Built-up columns and column bases.
5 Design members subjected to bending moment, shear force etc.
6 Estimate design loads as per IS 875 for roof truss and design the Steel roof truss.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total Five questions. $\{(\mathbf{32} + (\mathbf{4} \times \mathbf{16})\}$
2 Question 1 will be compulsory carrying 32 marks and should be based on steel design project.
3 Remaining questions will be carrying 4×16 marks, mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any other module. Only three questions carrying 16 marks need to be solved.
4 Total Four questions need to be solved. (32+16+16+16)
5 In end semester examination, students will write answers in answer booklet and draw sketches on half imperial drawing sheet.
6 **Use of relevant IS codes shall be allowed in the examination**

Recommended Books:

1 Design of Steel Structure by N. Subramanian, Oxford University Press, New Delhi.
2 Limit state design of steel structures by S. K. Duggal, McGraw Hill Education (India) Pvt. Limited, New Delhi.
3 Design of steel structure by Limit State Method as per IS: 800 - 2007 by Bhavikatti S. S., I.K. International Publishing House, New Delhi.
4 Design of Steel Structures by K. S. Sai Ram, Pearson Education, New Delhi.
5 Limit state design of steel structures as per IS 800/2007. by S. Kanthimathinathan. I.K. International Publishing House, New Delhi.
6 Relevant Indian Specifications, Bureau of Indian Standards, New Delhi
7 Limit state design of steel structure by Dr. V.L. Shah and Gore, Structure publication Pvt. Pune.

Reference Books:

1 Design of Steel Structure by Allen Williams

2 Practical Design of Steel Structure by Karuna Moy Ghosh, Whittles Publishing

3 Structural design and drawing by D. Krishnamurthy, CBS Publishers, New Delhi.

4 Teaching Resources Material for steel structures by INSDAG Kolkata.

Semester-VI

Course Code	Course Name	Credits
CEC602	Water Resources Engineering	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

India is an agricultural country where majority of population lives in villages so agricultural industry is the backbone of Indian economy. Being a tropical country with large temporal and spatial variation of rainfall and availability of rainfall only for three to four months, irrigation is strongly needed in India. To satisfy this need, enhancing the irrigation facilities in the country is required. This course provides necessary knowledge and information about various irrigation methods as well as water requirements of crops, hydrologic processes, control level fixation of dams and reservoirs and hydraulics of wells. In addition to this, it provides necessary knowledge about analysis and design of gravity dams and earthen dams, different silt theories related to irrigation channels, detailed classification of canal head-works and its distribution system and finally discusses about different canal structures and cross drainage works.

Objectives

1 To study different irrigation engineering methods and water requirement of crops.

2 To study hydrological cycle, its elements and plotting of hydrographs.

3 To study and calculate discharge from aquifers.

4 To study control level fixation for reservoir, Dams i.e., gravity dam, its various components and analysis and suitable conditions of earthen dam and its seepage analysis.

5 To study importance of silt theories and its design considerations.

6 To study Canal headwork, its distribution system and design of canal structures.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Irrigation Methods and Water Requirement of Crops**		07
	1.1	National water policy. Introduction to irrigation and need of irrigation, Benefits of irrigation and ill effects of irrigation, types of Irrigation Projects: minor, medium and major irrigation projects and National water policy.	
	1.2	Methods of Irrigation Systems: Surface irrigation and different techniques of water distribution for surface irrigation, Subsurface irrigation, sprinkler irrigation and drip irrigation.	
	1.3	Water Requirement of Crops: Crops and crop seasons in India, delta and duty of crops, relationship between delta and duty of crops. Soil water relationship and its significance from irrigation considerations, root zone soil water, infiltration, consumptive use, frequency of irrigation.	
2	**Hydrology**		07
	2.1	Hydrologic cycle, Precipitation: Forms and Types of precipitations.	
	2.2	Measurement of rainfall by rain gauges and stream flow measurement. calculation of missing rainfall data and adequacy of rain gauge stations.	
	2.3	Runoff: Runoff- factors affecting runoff, computation of runoff, yield of the catchment runoff hydrograph, flood discharge and its calculations.	
	2.4	Hydrograph: Flood hydrograph- Its components and base-flow separation, Unit hydrograph, application of unit hydrograph, methods of deriving unit hydrograph, S-hydrograph and its application.	
3	**Ground Water and Well Hydraulics**		05
	3.1	Ground water resources and occurrence of ground water.	
	3.2	Well hydraulics: steady state flow conditions in wells.	
	3.3	Equilibrium equations for confined and unconfined aquifer.	
	3.4	Aquifer tests.	
	3.5	Difference between open well and tube well, Well Losses	
4	**Dams and Spillways**		09
	4.1	Reservoir, various zones of storage reservoir, control level fixation for a reservoir. Introduction to reservoir sedimentation and control measures.	
	4.2	Gravity Dams: Definition, typical cross section and components of gravity dam, forces acting on gravity dam, modes of failure	

		of gravity dam, structural stability analysis of gravity dam, elementary and practical profile of gravity dam, low and high gravity dam, galleries in gravity dam – Function of gallery and different cross-sections of gallery adopted in practice, joints in gravity dam. control of cracking in concrete dams.	
	4.3	Earthen Dam: Types of earthen dams and methods of construction of earthen dam, causes and failures of earthen dams, seepage line/phreatic line for different conditions and its location using graphical method, seepage control through embankment and through foundations.	
	4.4	Spillways: Introduction, types of spillways – its working and functionality.	
5	**Irrigation Channels (Silt Theories)**		**06**
	5.1	Kennedy's theory and method of channel designs silt supporting capacity according to Kennedy's theory.	
	5.2	Lacey's regime theory and application of Lacey's theory for designing channel cross-section.	
	5.3	Comparison between Kennedy's theory and Lacey's theory.	
	5.4	Drawbacks of Kennedy's theory and Lacey's theory.	
	5.5	Introduction to sediment transport in channels.	
6	**Canal Headwork-Distribution System and Canal Structures**		**05**
	6.1	Canal Headwork and Distribution System: Classification of canals, canal alignment, canal losses, canal lining, water logging and remedial measures for water logging.	
	6.2	Canal Structures Canal Falls and types of canal falls, canal escapes and types of canal escapes, canal regulators and types of canal regulators, canal outlets and types of canal outlets, cross drainage works and types of cross drainage work.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Describe National water Policy, Calculate Crop water requirement and Classify various types and methods of irrigation.

2 Estimate flood discharge and Runoff by traditional and modern usage tools for planning and management of water resources projects.

3 Apply knowledge on ground water, well hydraulics to estimate the safe yield and ground water potential

4 Analyze and design gravity dams and earthen dams with spillways for sustainable development

5 Compare different silt theories related to irrigation channel and design the same.

6 Classify and Explain various canal structures and suggest remedial measures for water logging to save fertile irrigation

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only four questions need to be solved in total.

Recommended Books:

1. Irrigation and Water Power Engineering: B.C. Punmia, PandeB.B.Lal, A.K Jain. Laxmi Publications Pvt, Ltd. New Delhi.
2. Irrigation Engineering and Hydraulic Structures: S.K. Ukarande, Ane Books Pvt. Ltd. ISBN-9789383656899.
3. Irrigation Water Resources and Water Power Engineering: P.N. Modi, Standard Book House, Delhi, ISBN 978-81-87401-29-0.
4. Irrigation Engineering and Hydraulics Structures: S. K. Garg, Khanna Publishers. Delhi.
5. Design of Irrigation Structures: S. K. Sharma, S. Chand and Co.
6. Theory and Design of Irrigation Structures: R. S. Varshney and R, C. Gupta, Nem Chand
7. Engineering for Dams, Vol. I to III: Crager, Justin and Hinds, John Wiley
8. Design of Small Dams: USBR.
9. Hydro Power Structures: R. S. Varshney, Nem Chand and Bross.
10. Concrete Dams: R. S. Varshney, Oxford and IBH Publishing Co.

Semester VI

Course Code	Course Name	Credits
CEC603	Geotechnical Engineering-II	3

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
3	--	--	3	--	--	3

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hrs.	--	--	--	100

Rationale

Basic knowledge of analysis and design of foundations is very important for all civil engineers, more so for geotechnical and structural engineers. Soil testing (both field and lab tests) and its analysis are not only compulsory prerequisites for the analysis, design and construction of any major structure but also holds lucrative consultancy work and job opportunities in the field of civil engineering. Immense research opportunities are also available in this field.

Objectives

1 Students will gain knowledge of consolidation theory.

2 Students will evaluate the shear strength characteristics of the soil. Moreover, they would apply the knowledge for solving the related problems.

3 Students will analyze stability of slopes.

4 Students will analyze and evaluate lateral earth pressure.

5 Students will analyze and design shallow foundation.

6 Students will analyze and design deep foundation.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Module Name- Consolidation of soils**		**06**
	1.1	Compressibility & settlement, comparison between compaction & consolidation, concept of excess pore water pressure, initial, primary secondary consolidation, spring analogy for primary consolidation, consolidation test results, coefficient of compressibility, coefficient of volume change, compression, expansion, recompression indices, normally and over consolidated soils.	
	1.2	Terzhaghi's theory of consolidation (no proof)- assumptions, coefficient of vertical consolidation, distribution of hydrostatic excess pore water pressure with depth & time, time factor, relationship between time factor and degree of consolidation, determination of coefficient of vertical consolidation, pre-consolidation pressure.	
	1.3	Final settlements of a soil deposit in the field, time settlement curve, field consolidation curve.	
2	**Module Name- Shear strength**		**05**
	2.1	Introduction, frictional cohesive strength, state of stresses in soil mass, principal stresses, determination of stresses on an inclined plane by using analytical and Mohr's circle method, important characteristics of Mohr's circle.	
	2.2	Coulomb theory, Mohr-Coulomb theory- shear strength parameters; Mohr-Coulomb failure envelope- relation between major and minor principal stresses, total & effective stress analysis.	
	2.3	Different types of drainage conditions UU, CU and CD: Direct shear test, Triaxial compression test, Unconfined compression test, Vane shear test; comparison between direct & triaxial tests, interpretation of test results of direct shear & triaxial shear tests stress-strain curves.	
	2.4	Determination of shear strength of soil- pull out test and Introduction to liquefaction of Soils.	
3	**Module Name- Stability of Slopes**		**06**
	3.1	Introduction: Types of slopes, types of slope failures, factors of safety.	
	3.2	Stability analysis of infinite slopes in i) cohesionless soil and ii) cohesive soil under a) dry condition, b) submerged condition and c) steady seepage condition along the slope.	

	3.3	Stability analysis of finite slopes: i) Taylor's stability number ii) friction circle method iii) Swedish circle.	
4	**Module Name - Lateral Earth Pressure Theories**		**08**
	4.1	Introduction to Lateral Earth Pressure Theories: Concept of lateral earth pressure based on vertical and horizontal stresses, different types of lateral earth pressure	
	4.2	Rankine's earth pressure theory: i) assumptions, ii) active and passive states in cohesionless soil: effect of submergence, effect of uniform surcharge, effect of inclined surcharge iii) active and passive states in cohesive soil	
	4.3	Coulomb's wedge theory: i) assumptions, ii) active and passive states in cohesionless soil, iii) active and passive states in cohesive soil	
	4.4	Rehbann's Graphical Method (no proof)	
	4.5	Culmann's Graphical Method (no proof)	
5	**Module Name- Shallow Foundations**		**08**
	5.1	Introduction: types of shallow foundations, definitions of different bearing Capacities	
	5.2	Theoretical methods of determining bearing capacity of shallow foundations: i) Terzaghi's theory: assumptions, zones of failure, modes of failure, ultimate bearing capacity equations for general and local shear failure, factors influencing bearing capacity: shape of footing and water table, limitations of Terzaghi's theory ii) Vesic's theory: bearing capacity equation I.S. Code Method: bearing capacity equation	
	5.3	Field methods of determining bearing capacity of shallow foundations: i) standard penetration test and ii) plate load test	
6	**Module Name- Pile Foundations**		**06**
	6.1	Introduction to pile foundations: necessity of pile foundations, types of pile foundation.	
	6.2	Theoretical methods of determining load carrying capacity of pile foundations: i) static formulae and ii) dynamic formulae	
	6.3	Field method of determining load carrying capacity of pile foundations: pile load test	
	6.4	Group action of piles, settlement of pile groups, negative skin friction	
		Total Hours	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Evaluate the consolidation parameters for the soil.

2 Calculate the shear strength parameters for the soil.

3 Calculate the factors of safety of different types of slopes under various soil condition, analyze the stability of slopes.

4 Calculate lateral earth pressure under various soil condition.

5 Calculate bearing capacity of shallow foundations using theoretical and field methods.

6 Calculate load carrying capacity of individual as well as group of pile foundation using theoretical and field methods and pile settlement.

Internal Assessment (20 Marks):

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Average of the two will be considered as IA marks.

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total **six questions, each carrying 20 marks.**

2 **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum.**

3 **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only **Four questions need to be solved.**

Recommended Books:

1 Soil Mechanics and Foundation: Dr. B.C. Punmia, Ashok Kumar Jain, Arun Kumar Jain; Laxmi Publications

2 Soil Mechanics and Foundation Engineering: K.R. Arora; Standard publishers and Distributors

3 Soil Mechanics and Foundation Engineering: V.N.S Murthy; Saitech Publications

4 Geotechnical Engineering: C. Venkatramaiah; New age International

5 Theoretical Soil Mechanic: K. Terzaghi; John Wiley and Sons

6 Fundamentals of Soil Engineering: D. W. Taylor; John Wiley and sons

7 Relevant Indian Standard Specification Code: BIS Publications, New Delhi

8 Soil Mechanics in Theory and Practice: Alam Singh; Asia Publishing House

9 Geotechnical Engineering: Purushothama Raj; Tata McGraw Hill Publications

10 Basic and Applied Soil Mechanic: Gopal Ranjan and A.S. Rao; New Age International

Semester-VI

Course Code	Course Name	Credits
CEC604	Environmental Engineering	04

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
04	-	-	04	-	-	04

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Every civil engineer must be acquainted with the principles of public health engineering, purification of water, sewage collection, design of water and sewage treatment and develop rational approaches towards sustainable waste management via appropriate treatment and reuse. The course deals with the overall features and study of treatment of water, building drainage, rain water harvesting, sewage treatment processes and solid waste management. The course also lays emphasis on the knowledge of Air and Noise pollution.

Objectives

1 To demonstrate the necessary knowledge and concepts in the fields of water supply and quality of water.

2 To impart necessary skill for the design and operation of various units of water treatment facilities.

3 To recognize the necessary knowledge of good plumbing system, building drainage and rainwater harvesting.

4 To demonstrate the necessary knowledge on domestic sewage and Sewerage system.

5 To develop a flow Content for sewage treatment and design its units.

6 To impart the basic understanding of Air pollution, noise pollution and solid waste so as to control its adversity on ambient environment.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Water Supply and Quality Of Water**		04
	1.1	Water supply: Water supply systems, water resources, types of intake structures, distribution systems of water and distribution layouts.	
	1.2	Quality of water: Introduction to pure water: potable, wholesome, palatable, distilled, polluted and contaminated water, drinking water standards and characteristics of water, water borne diseases.	
2	**Water Treatment**		15
	2.1	WTP: Typical layout of WTP, Aeration, Types of Aeration systems, sedimentation, types of settling, tube settlers, design of sedimentation tank.	
	2.2	Coagulation and flocculation: Principle of coagulation, flocculation, Clari flocculator, coagulants aids.	
	2.3	Filtration: rapid sand filters, operation, cleaning and back-washing, Entire design of rapid gravity filter with under drainage system. Pressure filter: Construction and operation	
	2.4	Disinfection: Different methods of disinfection, chlorination and chemistry of chlorination, chlorine demand, free and combined chlorine, various forms of chlorine, types of chlorination. Numerical to calculate quantity of required chlorine doses.	
	2.5	Advanced and Miscellaneous Treatments: Water softening by lime soda process and by base exchange method, Reverse Osmosis, Activated carbon, Membrane filtration, Removal of Iron and Manganese.	
3	**Building Water Supply, Drainage and Rainwater Harvesting**		04
	3.1	Building water supply: Water demands, Per capita Supply, Service connection from main, Water meter.	
	3.2	Building drainage: basic principles, traps-types, location and function, Systems of Plumbing, anti siphonic and vent pipes.	
	3.3	Rainwater harvesting: Need for rainwater harvesting, Annual potential, Roof-top rain water harvesting. Numerical on annual rainwater harvesting potential.	

4	**Domestic Sewage and Sewerage System:**		**08**
	4.1	Sewage: Introduction to domestic sewage, and storm water, System of sanitation, Physical and chemical characteristics, decomposition of sewage, BOD, COD, numerical on BOD. MPCB norms for disposal of sewage effluent.	
	4.2	Sewerage system: Systems of sewerage and their layouts: Separate, Combined and partially combined system, merits and demerits, self-cleaning velocity and non-scouring velocity, Sewer- Shape, hydraulic design of sewers, Laying and testing of sewers, manhole-location, necessity, types and drop manhole, ventilation	
5	**Sewage Treatment**		**15**
	5.1	Treatment processes: Objective, methods of treatment, flow sheets showing Preliminary, Primary, Secondary and Tertiary treatment. Primary treatment: Screening, Grit removal, Oil and Grease removal, settling tank.	
		Secondary Treatment Methods: Trickling filter- Principle, Process description and Design of trickling filter. Activated sludge process (ASP) - Principle, Process description, Recirculation of sludge, (numerical), Sludge volume index.	
	5.2	Introduction to Biological Treatment: Aerated lagoons, Oxidation ponds, oxidation ditches.	
		Self-purification of natural waterbodiess: Oxygen economy, Disposal of treated effluent. Disposal of Raw and treated sewage on land and water, DO sag curve.	
	5.3	Rural and Low-cost sanitation: Septic Tank and Soak Pit – Operation, suitability and Design	
6	**Air Pollution, Noise Pollution and Municipal Solid Waste Management**		**06**
	6.1	Air pollution: Composition of air, Quantification of air pollutants, Air quality standards, Effect of air pollution on Environment, Introduction to Air pollution control devices.	
	6.2	Noise pollution: Basic concept and measurement, Effects of noise, and control methods, and numerical on sound level.	
	6.3	Municipal Solid Waste Management: Sources, storage, treatment, disposal,5R Principles.	
		Total	**52**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Analyse the quality of water and make outline of water Supply scheme.
2 Design the various units of water treatment plant and apply the advanced, miscellaneous treatments whenever necessary.
3 Build service connection of water supply from main and building drainage system at construction site along with rain water harvesting layout.
4 Analyse and plan sewerage system along with test for sewer line.
5 Design the units of sewage treatment plant. Also, able to apply the knowledge of low-cost treatment and stream sanitation.
6 Understand air pollution, noise pollution and functional elements of solid waste management.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only Four questions need to be solved.

Site Visit:

The students will visit to sewage treatment plant/ water treatment plant in the nearby vicinity or in the city and prepare detailed report thereof. This report will form a part of the term work

Recommended Books:

1 Water Supply Engineering: S. K. Garg, Khanna Publication.
2 Water Supply Engineering: P.N. Modi, Rajsons Publication.
3 Water Supply and Sanitary Engineering: S.K. Hussain, Oxford & IBH Publication, New Delhi
4 Environmental Engineering: *B. C. Punmia*, Laxmi Publications, New Delhi.
5 Solid waste management in developing countries: A.D. Bhide and B.B. Sundaresan
6 Environmental Engineering Vol II- Sewage Disposal and Air Pollution Engineering: *S. K. Garg*, Khanna Publishers New Delhi
7 Wastewater Treatment- Concepts and Design Approach: G. L. Karia and R. A. Christian
8 Integrated solid waste management, Tchobanoglous. Theissen and Vigil, McGraw Hill Publication.

Reference Books:

1 Manual on Wastewater Treatment 3rd Ed. Pub: CPH and Env. Engg. Organization, Ministry of Urban Development, Govt. of India, New Delhi, 1991.

2 Plumbing Engineering, Theory and Practice: *Patil S. M.,* Seema Publication, Mumbai.

3 Manual on Municipal Solid Waste Management: Ministry of urban development, New Delhi.

4 Water Supply and Sewerage:*E.W. Steel.*

5 Manual on Water Supply and Treatment, (latest Ed.): Ministry of Urban Development, New Delhi.

6 Water supply and pollution control: J.W. Clark, W. Veisman, M.J. Hammer, International textbook company.

7 CPHEEO Manual on Water Supply and Treatment.

8 CPHEEO Manual on Sewage and Treatment.

9 Environmental Engineering: Peavy,H.S., RoweD.R., TchobanoglousG.; 1991, Tata-Mcgraw Hill.

Semester-VI

Course Code	Course Name	Credits
CEDLO6011	Department Level Optional Course -2 Rock Mechanics	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

The Civil Engineering structures are built on or through rocks. The design of structures depends on the rock mass properties and the interaction between the rock and the structure. This demands the study of deformation resulting from the strain of rocks in response to various stresses working on them. The mechanisms and character of the deformation of rocks can be investigated through laboratory experiments. The course will give an idea of in- situ testing of the rock and observation of geological conditions that can affect the way a rock behaves when subjected to loads and stresses.

Objectives

1 To provide basic knowledge of Rock -Mechanics to understand design aspects of various structures on or through rocks.

2 To study the various classification schemes of rock masses and their application.

3 To study the physical properties of rocks and various lab test conducted on them to determine the strength.

4 To determine properties and behavior of various types of rock under different loading conditions.

5 To study bearing capacity, stress distribution and factor of safety within the rock.

6 To study the stability of rock slopes and design aspects of openings in/on the rocks.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Structural Geology and Data Interpretation**		05
	1.1	Introduction to Rock Mechanics and Importance	
	1.2	Geological classification of rocks	
	1.3	Description of discontinuities and their effect on rocks	
	1.4	Stereographic Analysis of structural Geology	
2	**Engineering Classification of Rocks and Rock Masses:**		06
	2.1	Classification of intact rocks. Rock mass classifications: Rock Quality Designation (RQD), Rock Structural Rating (RSR), Rock Mass Quality (Q system).	
	2.2	Strength and Modulus from classifications, classification based on Strength and Modulus.	
	2.3	Geo-mechanics (RMR)} and Geo-engineering classification	
	2.4	Deere and Miller's Engineering Classification	
3	**Laboratory Testing of Rocks: Field and Laboratory Tests on Rocks**		07
	3.1	Determination of physical properties of rocks	
	3.2	Uniaxial Compressive Strength Test	
	3.3	Tensile Strength Test	
	3.4	Direct Shear Test and Triaxial Test	
	3.5	Slake Durability Test	
	3.6	Schmidt Rebound Hardness, Swelling Pressure and Free-Swell, Void Index, Hydraulic fracture, Flat Jack Test	
4	**Strength, Modulus and Stress-Strain Responses of Rocks:**		07
	4.1	Factors influencing rock responses, Strength criteria for isotropic intact rocks, Modulus of isotropic intact rocks.	
	4.2	Uni-axial Compressive Strength of intact anisotropic rocks, Strength due to induced anisotropy in rocks, Compressive Strength and Modulus from SPT.	
	4.3	Stress- strain models (constitutive models, elastic stress-strain model, elastic-plastic stress-strain model, Visco-elastic Model.	
5	**Bearing Capacity of Rocks:**		06
	5.1	Estimation of bearing capacity (foundation on intact rock, heavily fractured rock), UBC with Hoek-Brown criterion, foundation on slope	
	5.2	Stress distribution in rocks, Factor of safety, strengthening measures (concrete shear keys, bored concrete piles, tensioned	

		cable anchors, concrete block at toe),	
	5.3	Settlement in rocks (from joint factor, for horizontal joints, from field tests).	
6	**Stability of Rock Slopes & Opening in Rocks**		**08**
	6.1	Modes of failure, rotational failure, plane failure, wedge method of analysis, buckling failure, toppling failure, application of stereographic projection, Remedial measures.	
	6.2	Rock Bolting and Grouting: Methods to improve rock mass responses, grouting in rocks, objectives, contact grouting, consolidation grouting, process of grouting, grout requirement, types of grout, stage grouting, grout curtain. Rock Bolting Rock anchors.	
	6.3	Tunneling: Ground conditions in tunneling, Computing structural discontinuities in rock masses, requirement of lining in tunnels, pressure tunnels and tunnels for other purposes, application of stereographic projection.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Explain basic concepts of Rock -Mechanics and apply it to design aspects of various Civil Engineering structures on or through the rocks.

2 Classify the rock masses and evaluate them for various Civil Engineering works.

3 Explain the laboratory testing of rocks and determine the physical properties and strength of intact rocks and rock masses.

4 Explain the stress-strain responses of the rocks and influencing factors.

5 Determine the bearing capacity and factor of safety of rocks.

6 Determine the stability of slopes and underground excavations.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).

Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Introduction to Rock Mechanics: Goodman, RE (1989), Canada, Jhon Wiley & Sons.

2 Rock Slope Engineering, Hoek, E and Bray, JW (1977), The Institution of Mining and Metallurgy, London.

3 Rock Mechanics and Design of Structures on Rock: *Obert, Leon and W. I. Duvall*.

4 Engineering Rock Mass Classification, Singh, B and Goel RK (20011), Oxford, UK, Elsevier Inc.

Reference Books:

1 Rock Mechanics in Engineering Practice: *K. G. Stagg and O. C. Zienkiewicz*, John Willey and Sons, New York.

2 Rock Mechanics – Vol. I and II: *Jumukis*, Trans Tech Publication, USA.

3 Fundamentals of Rock Mechanics: Jaeger, JG, Cook, NGW and Zimmerman, RW (2007) 4 th Ed., Singapore, Blackwell Publishing

4 Rock Mechanics and Design of Structures on Rock: Obert, Leon and W. I. Duvall.

Semester-VI

Course Code	Course Name	Credits
CEDLO6012	Department Level Optional Course - 1 Biological Process and Contamination Removal	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Biological treatment processes are widely used in both developed and developing countries to control and accelerate the natural process of organic matter decomposition. The process is often used to treat biodegradable waste materials released from domestic, commercial and industrial sources before they are disposed of. However, it is also observed to further treat the wastewater for contamination removal in order to remove and treat toxic materials. The course deals with the overall features and study of biological treatments of wastewater and contamination removal. The course lays emphasis on complete updates of these processes and knowledge related to design of treatment units.

Objectives

1 To understand quality, quantity, characteristics and treatment process of wastewater generated from various sources

2 To understand the biological process and treatment of wastewater.

3 To provide students the necessary knowledge and concepts of advancements/ emerging techniques of Microbial Growth Kinetics, Utilization of soluble substrate and biotechnological remedies

4 To study and design the aerobic decomposition and its application in Aerobic Suspended Growth Biological Treatment Systems.

5 To study and design the anerobic decomposition and its application in wastewater treatment.

6 To develop rational approaches towards natural and biotechnological methods for contamination removal.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Waste Water Generation, Collection and Conveyance**		08
	1.1	Introduction: Domestic waste water, Industrial Wastewater and Stormwater, Conservancy and Water carriage system, Systems of sewerage, Quantity and Quality of Wastewater.	
	1.2	Need for Analysis, Characteristics of wastewater: Analysis of wastewater, Characteristics of wastewater and sampling, Composition, Biochemical characteristics, aerobic decomposition, anaerobic decomposition,	
	1.3	Waste Water Treatment and Flow diagram: Treatment processes: Objective, methods of treatment, flow sheets showing Preliminary, Primary, Secondary and Tertiary treatment. Waste Water Treatment Plant and Effluent Treatment Plants. Various combinations and options. Low-cost treatment plant.	
2	**Introduction to Biological Treatment:**		03
	2.1	Overview of biological wastewater treatment, objectives of the treatment, role of microorganisms, types of biological processes for wastewater treatment, suspended and attached growth systems.	
3	**Microbial Growth Kinetics**		06
	3.1	Microbial Growth Kinetics terminology, rate of utilization of soluble substrates, rate of biomass growth with soluble substrate, rate of oxygen uptake, effects of temperature, total volatile suspended solids and active biomass, net biomass yield and observed yield.	
	3.2	Biotechnological remedies - Bio-fertilizers, Physical, chemical and Microbiological factors of composting, Health risk – Pathogens, Odor management, Microbial cell/enzyme technology, Adapted microorganisms, Biological removal of Nutrients.	
4	**Aerobic Decomposition:**		08
	4.1	Aerobic Suspended Growth Biological Treatment Systems: Aerobic biological oxidation, process description, environmental factors, Modifications of ASP: Complete Mix activated sludge, Extended Aeration system, Oxidation Ditch systems, Oxygen activated sludge, Oxidation ponds, Stabilization ponds, Aerobic attached Growth Biological Treatment-Trickling Filter.	
	4.2	Design of ASP, Trickling Filter, Oxidation Pond, Oxidation Ditch and Aerated lagoons.	

5	**Anaerobic Decomposition:**		**08**
	5.1	Anaerobic Decomposition: Mechanism of anaerobic fermentation – a multistep process, Microbiology and Biochemistry of Anaerobic processes, Substrate inhibition, Stuck reactors, Standard rate, High rate and Multistage anoxic digesters. Introduction to UASB.	
	5.2	Design of anaerobic treatment units: Anaerobic Lagoons	
6	**Natural and Biotechnological Methods of Contamination Removal:**		**06**
	6.1	Natural Treatment Systems: Development of natural treatment systems, Rapid infiltration systems, Overland Flow systems, constructed wetlands, Floating aquatic plant treatment systems. Introduction to engineering Fundamentals of Biotechnology. Heavy Metal Removal using advance treatment methods – Membrane filtration, Reverse Osmosis and Ion exchange.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Determine and analyze the characteristics of wastewater and decide the treatment for wastewater.
2 Understand biological treatment process and necessity of contamination removal
3 Understand and apply the concepts of advancements/emerging techniques of Microbial Growth Kinetics, Utilization of soluble substrate and biotechnological remedies.
4 Summarize the concept of aerobic decomposition and its application in Aerobic Suspended Growth Biological Treatment Systems
5 Summarize the concept of the anaerobic decomposition and its application in wastewater treatment.
6 To derive the knowledge and develop rational approaches towards natural and biotechnological Methods for contamination removal

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Wastewater Engineering Treatment, Disposal, Refuse: Metcalf and Eddy, T.M.H. Edition, New Delhi, 1995.

2 Environmental Engineering Vol II- Sewage Disposal and Air Pollution Engineering: S. K. Garg, Khanna Publishers New Delhi.

3 Water supply and sanitary Engineering: Hussain S. K., Oxford and IBH Publication, New Delhi.

4 Wastewater Treatment for Pollution Control and Reuse by Soli. J Arceivala (Author), Shyam. R Asolekar.

5 Environmental Engineering: B. C. Punmia, Laxmi Publications, New Delhi.

6 Water Supply and Sewerage: E.W. Steel.

7 Introduction to Environmental Engineering, Vesilind, PWS Publishing Company 2000.

8 Introduction to Environmental Engineering: P. Aarne Vesilind, Susan M. Morgan, Thompson.

9 Wastewater Treatment- Concepts and Design Approach: G. L. Karia and R. A. Christian.

10 Basic Principles of Wastewater Treatment Book by Marcos Von Sperling.

Reference Books:

1 Manual on Wastewater Treatment 3rd Ed. Pub: CPH and Env. Engg. Organization, Ministry of Urban Development, Govt. of India, New Delhi, 1991.

2 CPHEEO Manual on Sewage and Treatment.

3 Relevant Indian standard specifications and BIS publications.

4 Handbook of Water and Wastewater Treatment Plant Operations Book by Frank R. Spellman

Semester-VI

Course Code	Course Name	Credits
CEDLO6013	Department Level Optional Course-2 Construction Equipment & Techniques	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Machines have revolutionized every sphere of human being's life. Engineering constructions also have seen a drastic reformation due to introduction of various construction equipment and techniques. This course provides an extensive overview of advanced equipment used in construction industry and also discusses certain methods/techniques used to construct facilities using these equipments. It makes the student aware of the equipment/techniques required while constructing different kinds of civil engineering structures. Student will be introduced to some emerging technologies in the field of Civil engineering which will make them more industry ready.

Objectives

1 To understand the characteristics and complexities involved in large civil engineering projects so that the equipment/technique requirements of a project can be listed out.
2 To know the various conventional techniques/equipments used in civil engineering projects.
3 To get acquainted with the modern equipments/techniques which have replaced the conventional ones.
4 To select the appropriate equipment/techniques in construction for large and heavy engineering projects on the basis of suitability, availability, productivity, output, initial and operation cost, savings in time and other resources, etc.
5 To understand the characteristics and complexities involved in large civil engineering projects so that the equipment/technique requirements of a project can be listed out.
6 To know the various conventional techniques/equipments used in civil engineering projects.

Detailed Syllabus			
Module	**Course Module / Contents**		**Periods**
1	**Introduction**		**06**
	1.1	Equipment v/s Labour, Standard and Special equipments, Types of costs related to equipments including related numerical, Equipment life and Replacement decisions including related numerical, Cycle time, Balancing of equipments and related numerical.	
	1.2	Different categories of construction equipments used conventionally with reference to available types and their output, working mechanism, factors affecting their performance and criteria for selecting a particular equipment: Earthmoving and other hauling equipment, Pavers for road construction. Numbering and Record maintaining of Earthmoving and other hauling equipment's; Pile driving equipment; Applications of Air compressor. Dewatering techniques for trenches; Stone crushing equipment.	
2	**Underground & Underwater Tunnelling**		**09**
	2.1	Various purposes for which tunnelling may be carried out, Basic terms related to tunnelling. Conventional methods of carrying out tunnelling in different types of soils/rocks. Methods for dewatering tunnels.	
	2.2	Detailed Procedure for underwater tunneling. Modern methods of tunnelling and detailed study of following equipments/ techniques in this regard. Use of drones, construction robots for aerial surveys. Use of GPS and remote sensing for setting out tunnel alignment. Jumbo – used for drilling and blasting, Blasting Techniques for quarrying stones for construction purpose. Diaphragm wall construction and other ground stabilization methods. Vertical shaft sinking machine (VSM). Tunnel Boring machine (TBM), Micro tunneling. New Austrian tunnelling method (NATM). Cut & cover method, Top to bottom construction. Tunnel lining trolley. Tunnelling for Metro projects. Difference in Tunnelling for Roads and Metros.	
3	**Modern Formwork Systems and Working Techniques in Limited Space**		**06**
	3.1	Difference in conventional and modern systems of formwork Mivan, Doka shuttering along with their advantages and disadvantages. Modular shuttering, Slip and jump form.	
	3.2	High rise construction: Concrete making on mass scale, pumping and placing booms. Tower cranes and the benefits they offer for high rise construction. Range diagram.	

	3.3	Prefabricated housing systems, Difficulties faced in the installation and operation of all these systems. Emergency housing for disaster management.	
	3.4	Working skills/tricks required for managing a site in urban/restricted space environment. Techniques for controlled demolition of buildings.	
4	**Equipments For Laying of Utility Lines, Bridge Construction & Installation of Structural Steel Members.**		**06**
	4.1	Use of ground penetrating radar (GPR) for locating underground utilities. Laying of pipes using pipeline insertion system. Installation and operation of underground power transmission lines as well as overhead transmission towers.	
	4.2	Incremental launching method and balanced cantilever method of bridge/flyover construction with reference to the recent infrastructure developed in the local and global context.	
	4.3	Equipments/techniques used for connecting structural steel components of bridge decks, terminals, malls, stadiums, car sheds, etc.	
5	**Equipments/ Techniques for Setting Up of Power Generation/Supply Structures.**		**06**
	5.1	Hydropower station. Tidal power plants. Desalinization plants. Thermal power station. Solar power station. Atomic power generation. Installation and operation of wind mills. Construction of a fuel station.	
6	**Equipments/ Techniques for Construction of Transporting Facilities**		**06**
	6.1	Construction of railway lines using track laying machine. Methods, techniques and equipments involved in the construction of Metro, mono and maglev trains. Connecting link between underground and overhead metro systems. 5D BIM integration in Metro projects.	
	6.2	Equipments required for construction and operation of an airport and sea port. Application of Drones, GIS, GPS and BIM for monitoring project progress/working of Airports and Seaports. Piling Equipment's for Jetty Construction.	
	6.3	Light Detection and Ranging (Lidar) Technique for Railways/ Highways/ Bullet train alignments.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Understand the use/applications of various conventional construction equipments and select the best out of them for a particular site requirement.
2 Know modern methods/equipments used for underground as well as underwater tunnelling.
3 Compare conventional and modern methods of formwork and get acquainted with techniques used on sites with restricted space.
4 Understand the techniques involved and the equipments required thereof for laying of utility lines, bridge construction and installation of structural steel members.
5 Gain knowledge about the setting up of different kinds of the power generating structures.
6 Get acquainted with the equipments/ techniques for construction of transporting facilities.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only Four questions need to be solved.

Recommended Books:

1 Construction Equipment & Planning. Purifoy, R.L & Ledbetter McGraw Hill
2 Construction Equipment & its Management. Sharma, S. C. Khanna Publishers
3 Tunnel Engineering HandbookThomas R. Kuesel, Elwyn H. King, John O. Bickel Springer
4 Practical tunnel construction Gary B. Hemphill Wiley Publishers
5 Success with drones in Civil Engineering Brett Hoffstadt Kindle
6 Construction Technology for Tall BuildingsMichael Yit Lin Chew World Scientific
7 The prefabricated home Colin DaviesReaktion Books
8 Literature/specifications/downloadable videos available on Doka and Mivaan shuttering websites.
9 Accelerated Bridge Construction: Best Practices and Techniques Mohiuddin Ali Khan BH Elsevier

Reference Books:

1 Design and Construction of Nuclear Power Plants Rüdiger Meiswinkel, Julian Meyer, Jürgen Schnell Wiley Publishers

2 Energy and Power generation handbook K.R Rao ASME Press

3 Magnetic Levitation Hyung-Suk Han Dong-Sung Kim Springer

4 Metro Rail Projects in India M Ramachandran Oxford

5 BIM Handbook Eastman,Teicholz,Sacks,Liston John Wiley and Sons

6 IRC:43-2015 Recommended Practice for Plants, Tools and Equipment Required for Construction and Maintenance of Concrete Roads (First Revision).

7 IRC-2018 Pocket book for Road Construction Equipment.

8 IRC: SP-97- 2013 Guidelines on Compaction Equipment for Roads Works

Semester-VI

Course Code	Course Name	Credits
CEDLO6014	Department Level Optional Course -2 Urban Infrastructure Planning	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Indian cities are currently expanding at a rapid rate, and are therefore facing immense pressure for the improvement of their services and infrastructure. Without coordination and planning for the anticipated spatial growth and densification, the infrastructure services are neglected. Such growth areas can become under-serviced places of the cities, one from which many problems of the city stem: water, sanitation and waste problems, uncontrolled pests, and crime due to poor access to water and sanitation services. To address the emerging issues of urban centre, there is a pressing need to train urban infrastructure specialists who can comprehensively plan for city's growing infrastructure needs and formulate projects for efficient infrastructure service delivery for existing areas. There are ample urban infrastructure challenges and opportunities in terms of planning; effective policy, program and project formulation for well-trained young urban infrastructure professionals with specific domain knowledge

Objectives

1 Describe an infrastructure system using accurate terminology;
2 Demonstrate an understanding of the main concepts and principles of infrastructure planning;
3 Identify the key features of a sustainable infrastructure system and explain how they promote sustainable development;
4 Apply analytical tools for infrastructure planning;
5 Critically evaluate infrastructure cases/projects/proposals through the lens of sustainability;
6 Identify the gaps between theoretical principles of sustainable infrastructure and their application in practices

Detailed Syllabus			
Module	**Course Module / Contents**		**Periods**
1	**Introduction to Planning**		**04**
	1.1	Origins and growth of cities, effects of cultural influence on physical form; Human settlements as an expression of civilizations; Basic elements of the city; Concepts of space, time, scale of cities.	
	1.2	Contribution of housing to micro and macro economy, contribution to national wealth and GDP, housing taxation, national budgets, fiscal concessions; need of affordable housing for urban poor, concept of RERA	
2	**Urban Economics**		**06**
	2.1	General introduction to principles of economics and public finance. Importance of economics in Urban Development and Planning	
	2.2	Industrial location policies, any other economic activity base policies and their impact on urban development, Role of land economics in preparation of Urban Development plans. Relevant case studies of Urban Land Economics.	
	2.3	Economic growth and development, quality of life; Human development index, poverty and income distribution, employment and livelihood; Economic principles in land use planning; Policies and strategies in economic planning, balanced versus unbalanced growth, public sector dominance; changing economic policies, implications on land.	
3	**Infrastructure Planning**		**12**
	3.1	Role of Infrastructure in Development, Elements of Infrastructure (physical, social, utilities and services); Basic definitions, concepts, significance and importance; Data required for provision and planning of urban networks and services; Resource analysis, provision of infrastructure, and land requirements; Principles of resource distribution in space; Types, hierarchical distribution of facilities, Access to facilities, provision and location criteria, Norms and standards, etc.	
	3.2	Zoning, Various growth patterns of town, Housing layouts and road networks in town, Urban aesthetics and landscaping, MRTP and Land Acquisition Acts	
		Planning and Management of Water, Sanitation and Storm Water; Water – sources of water, treatment and storage, transportation and distribution, quality, networks, distribution losses, water harvesting, recycling and reuse, norms and standards of provision, institutional arrangements, planning	

		provisions and management issues; Sanitation – points of generation, collection, treatment, disposal, norms and standards, grey water disposal, institutional arrangements, planning provisions and management issues. Storm water – rainfall data interpretation, points of water stagnation, system of natural drains, surface topography and soil characteristics, ground water replenishment, storm water collection and disposal, norms and standards, institutional arrangements, planning provisions and management issues;	
	3.3	Solid Waste Disposal and Management Basic principles, generation, characteristics, collection, disposal, management	
	3.4	Fire and Electrification, and Social Infrastructure Planning for fire protection, services and space standards, location criteria; Planning for Education, health, civic, cultural infrastructure and facilities for transport and other miscellaneous infrastructure services	
	3.5	Planning for Education, health, civic, cultural infrastructure and facilities for transport and other miscellaneous infrastructure services	
4	**Traffic and Transportation Planning**		**07**
	4.1	Evaluation of urban structure: Transport system, infrastructure and management, transport systems and their types, design and operating characteristics, urban road hierarchy, planning, and management criteria for road and junction improvements, arterial improvement techniques.	
	4.2	Traffic management, mass transit system: Problems and prospects. Review of existing traffic management schemes in Indian cities. Case study of various metro rail project envisaged for Mumbai, Navi Mumbai & Pune.	
	4.3	Economic evaluation: pricing and funding of transport services and systems, economic appraisal of highway and transport projects. Techniques for estimating direct and indirect road user costs and benefit value of time	
	4.4	Intelligent transport system (ITS) its types and applications	
5	**Urban Management and Governance**		**06**
	5.1	Introduction to Development Management and Urban Governance- Concept, approaches, components, interface with national goals and political economic system. Urban Development Management Strategies, Tools and Techniques; organizations involved Land and Real Estate Development Economic concepts of land, Land Pricing / valuation; Urban reforms and acts and policies. Overview of Urban Governance Definition, concepts, components, government and governance, hierarchy and structure, forms of governance, process of inclusion and exclusion.	

	5.2	Information System and Urban Reforms Spatial and Non - spatial information systems; Use of GIS in overlaying infrastructure facilities, use of remote sensing in identifying and mapping urban structures.	
	5.3	Present organizations and involved in urban governance with focus on MCGM, TMC and CIDCO. Urban Local Governance and Participatory Processes System, structure, functions, powers, process and resource, performance, interface with NGO's, other agencies.	
6	**Environmentally Safe and Disaster Resilient Infrastructure**		**04**
	6.1	Frame work, statement prediction and assessment of impacts of air, water, noise, cultural and socio-economic environment. Methods of impact analysis, public participation. Environmental protection international and national agencies and legislation, Environment Impact Assessment. Urban Heat Island Effect, Effect of uncontrolled growth of town	
	6.2	Disaster response planning, roles and responsibilities of various agencies Emergency operation support and management Planning for Disaster Prone Areas, Planning requisites for disaster prone areas and preventive measures, Vulnerability analysis	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Explain the concepts related to planning of modern cities, GDP contribution, RERA, affordable housing

2 Elaborate the economics involved in urban infrastructure planning

3 Envisage the various elements required for infrastructure development of a city and describe the concepts, significance and importance of each

4 Evaluate technical, social and economic feasibility of transportation projects within cities

5 Demonstrate modern tool usage for urban management and governance

6 Design environmentally safe and disaster resilient infrastructure

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).

Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only Four questions need to be solved.

Recommended Books:

1 The Urban and Regional Planning Reader, edited by Eugenie L. Birch, Published by Routledge, 2008; ISBN 978-0-415-319
2 Housing: The Essential Foundations, edited by Dr. Paul Balchin, Paul Balchin, Maureen Rhoden, Edition Routledge, DOI https://doi.org/10.4324/9780203010426, eBook ISBN 9780203010426
3 New Urban Housing by Hilary French, Publisher: Yale University Press, ISBN0300115784 (ISBN13: 9780300115789)
4 Sociology: A Brief Introduction, by Richard T. Schaefer, Publisher: McGraw-Hill Education, ISBN 10:1259425584, ISBN 13: 9781259425585
5 Sociology: Principles of Sociology with an Introduction to Social Thoughts, by Rao C.N. Shankar, S. Chand Publication
6 Projects: Preparation, Appraisal, Budgeting and Implementation by Prasanna Chandra, Tata McGraw-Hill; ISBN0074516280 (ISBN13: 9780074516287)
7 Introduction to Transportation Planning, by B. Bruton, Michael J. Bruton; Published by Hutchinson Radius; ISBN0091580412 (ISBN13: 9780091580414)

Reference Books:

1 Modern Economics by H.L. Ahuja, 19th Revised Edition, Published by S.Chand (G/L) & Company Ltd
2 Economics, An Introductory Analysis by Paul A. Samuelson, William D. Nordhaus, Published July 27th 2004 by Irwin/McGraw-Hill (first published 1948), ISBN0072872055 (ISBN13: 9780072872057)
3 Modelling Transport, by de Dios Ortuzar and Luis G. Willumsen, 4th Edition, Wiley Publication
4 Principles of Urban Transport Systems Planning, by B.G. Hutchinson, Publisher: Scripta Book Co.; ISBN0070315396 (ISBN13: 9780070315396)
5 Traffic Engineering and Transport Planning, L. R. Kadiyali, Khanna Publishers, 1983
6 Remote Sensing and GIS, by Basudeb Bhatta, second Edition, Oxford University press
7 NEPA and Environmental Planning: Tools, Techniques, and Approaches for Practitioners; Charles H. Eccleston; CRC Press
8 Planning for Disaster: How Natural and Manmade Disasters Shape the Built Environment, by William Ramroth; Publisher: Kaplan Business; Original edition; ISBN-13: 978-1419593734.

Semester-VI

Course Code	Course Name	Credits
CEDLO6015	Department Level Optional Course -2 Open Channel Flow	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Civil engineers deal with the analysis and design of irrigation systems which include dams, weirs, barrages, canals, drains and other supporting systems, for which good knowledge of dynamics of open channel flow is very much essential. Hence this course is designed to study different types of flow like uniform flow, non- uniform flow, spatially varied flow, and unsteady flow occurring in open channels. Competencies developed by this course would therefore be useful for students to handle and solve the practical problems/ issues in the field of Water resource management, Water shed Management etc. It is expected that the students will be better equipped to address various engineering problems related to hydrology and hydraulics.

Objectives

1 Understand the nature of flow, explain the basic concepts of uniform flow and to design the best hydraulic sections in open channel.
2 Apply the Energy concepts of fluid in open channel and demonstrate various flow measurement devices in open channels.
3 Develop Dynamic equation to compute the flow profiles for Gradually varied flow and classify water profiles in prismatic channels with different slope conditions.
4 Illustrate the causes of Rapidly varied flow, predict the formation of hydraulic jump and its applications.
5 Determine different types of spatially varied flow with varying discharges and characteristics of water surface profiles.
6 Study and analyze the temporal flow variations in open channel and the formation of surges.

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Uniform Flow**		07
	1.1	Flow through open channel, Types of channels, open and covered channels, Classification of flow in channel, Geometrical properties, velocity distribution in a channel section	
	1.2	Uniform flow in open channels, Discharge through open channel, Manning's and Chezy's Equation, Determination of roughness coefficients,	
	1.3	Determination of Conveyance of a channel, Hydraulic mean depth, Normal depth and Normal velocity, computation of uniform flow	
	1.4	Most economical sections of prismatic channels, condition for maximum velocity in a circular channel, condition for maximum discharge in a circular channel	
2	**Energy-Depth Relationships**		07
	2.1	Specific energy, Specific energy curve, Depth- Discharge diagram, critical depth, critical slope, critical flow, alternate depths	
	2.2	Condition for maximum discharge for a given value of Specific energy	
	2.3	Momentum in open channel flow- Specific force, specific force diagram, Dimensionless specific force diagram,	
	2.4	Critical flow and its computation, Application of specific energy and discharge diagrams to channel transitions	
	2.5	Metering Flumes- Venturi flume, Standing wave flume, Parshall flume, Determination of mean velocity of flow, Measurement of discharge in Rivers	
3	**Non-Uniform Flow: Gradually Varied Flow**		07
	3.1	Dynamic equation of Gradually Varied Flow (GVF) in rectangular and wide rectangular channels	
	3.2	Types of slopes- channel bottom slopes and water surface slopes, classification of channel bottom slopes and surface profiles	
	3.3	Characteristics of surface profiles, Backwater curve and drawdown curve	
	3.4	Computation of GVF-Direct Step and Standard step method, Numerical methods, Graphical Integration method	

4	**Non-Uniform Flow: Rapidly Varied Flow**		**07**
	4.1	Rapidly varied flow (RVF), Hydraulic Jump, Momentum equation for the jump	
	4.2	Hydraulic jump in a rectangular channel, Froude Number before and after jump, Classification of jumps, Characteristics of jump in a rectangular channel	
	4.3	Jumps in non-rectangular channel, applications of jump, location of jump, surges in open channel	
	4.4	Use of RVF for flow measurement purpose-Sharp crested weir, Broad crested weir, Ogee spillway, sluice gate	
5	**Spatially Varied Flow**		**06**
	5.1	Importance of Spatially Varied Flow (SVF), Causes, Continuity, Momentum and Energy Equation	
	5.2	Water surface profiles, Applications, Differential Equation for SVF with increasing and decreasing discharge–	
	5.3	Relevant case studies	
6	**Unsteady Flow**		**05**
	6.1	Basic concepts of Gradually varied unsteady flow, Rapidly varied unsteady flow	
	6.2	Positive and negative surges	
	6.3	Relevant case studies	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Describe the basic nature of flow in open channels, analyze the behaviour of flow and apply basic theories to design the optimum channel sections.

2 Demonstrate the energy concepts in open channel and its practical applications.

3 Apply dynamic equation for Gradually varied flow (GVF) and evaluate water profiles at different conditions in prismatic channels.

4 Differentiate between GVF and Rapidly Varied Flow (RVF), analyze hydraulic jump in open channel and its importance.

5 Explain the spatially varied flow and classify water profiles.

6 Discuss the temporal variations of flow in GVF and RVF in open channel.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only Four questions need to be solved.

Recommended Books:

1 Flow in Open channels: K. Subramanya, Tata Mc Graw -Hill Publishing Co. Ltd., New Delhi
2 Flow through Open channels: Rajesh Srivastava, Oxford University Press
3 Flow through Open channels: K. G. Ranga Raju, Tata Mc Graw -Hill Publishing Co. Ltd., New Delhi
4 Fluid Mechanics and Hydraulics: Dr S.K. Ukarande, Ane's Books Pvt. Ltd., (Revised Version 2012)
5 Hydraulics & Fluid Mechanics: Modi P.N. & Seth S.M, Standard book house, New Delhi

Reference Books:

1 Open channel Hydraulics: Chow, V.T., McGraw Hill International, New York
2 Open Channel Flow: Henderson F.M., McGraw Hill International
3 Open Channel Flow: M. Hanif Chaudhry, Prentice Hall of India.
4 Open channel Hydraulics: French, R.H., McGraw Hill International

Semester-VI

Course Code	Course Name	Credits
CEDLO6016	Department Level Optional Course - 1 Computational Structural Analysis	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

This subject deals with the conceptual applications of principles of mechanics of rigid and deformable bodies in Structural Engineering.

Objectives

1 To understand basic concepts of Matrix Methods of Structural Analysis and application of approximation techniques (Numerical Methods) in analysis of Structural Member

2 To analyze the behavior of structural members viz beams/plane trusses/ continuous beams/ portal frames

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Basic concepts of structural analysis and methods of solving simultaneous equations**		**04**
	1.1	Introduction, Types of framed structures	
	1.2	Static and Kinematic Indeterminacy, Equilibrium equations	
	1.3	Compatibility conditions, principle of superposition, Energy principles, Equivalent joint loads	
	1.4	Methods of solving linear simultaneous equations- Gauss elimination method, Cholesky method and Gauss- Seidel method.	

2	**Fundamentals of Flexibility and Stiffness Methods**		**07**
	2.1	Concepts of stiffness and flexibility	
	2.2	Local and Global coordinates	
	2.3	Development of element flexibility and element stiffness matrices for truss, beam and grid elements	
	2.4	Force- transformation matrix	
	2.5	Development of global flexibility matrix for continuous beams, plane trusses and Rigid plane frames	
	2.6	Displacement- transformation matrix, Development of global stiffness matrix for continuous beams, plane trusses and rigid plane frames.	
3	**Analysis Using Flexibility Method (Including Secondary Effects)**		**07**
	3.1	Continuous beams, plane trusses and rigid plane frames	
4	**Analysis Using Stiffness Method (Including Secondary Effects)**		**07**
	4.1	Continuous beams, plane trusses and rigid plane frames	
5	**Direct stiffness Method**		**07**
	5.1	Stiffness matrix for truss element in local and global coordinates	
	5.2	Analysis of plane trusses	
	5.3	Stiffness matrix for beam element	
	5.4	Analysis of continuous beams and orthogonal frames.	
6	**Finite Element Method**		**07**
	6.1	Historical Background – Mathematical Modeling of field problems in Engineering	
	6.2	Governing Equations – Discrete and continuous models	
	6.3	Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value	
	6.4	Basic concepts of the Finite Element Method.	
	6.5	One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors- Assembly of Matrices – Solution of problems from solid mechanics.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1. Formulate force displacement relation by flexibility and stiffness method
2. Analyze the plane trusses, continuous beams and portal frames by transformation approach
3. Analyze the structures by direct stiffness method
4. Explain the basics of finite element formulation.
5. Apply finite element formulations to solve one dimensional Problems

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Recommended Books:

1. Matrix Methods of Structural Analysis, S. S Bhavikatti, WILEY
2. Matrix Analysis of Framed Structures, Weaver, W., and Gere, J.M., CBS Publishers and distributors pvt. Ltd., 2004.
3. Computational Structural Mechanics, Rajasekaran, S., and Sankarasubramanian, G., PHI, New Dehi, 2001.
4. Introductions to Matrix Methods of Structural Analysis, Martin, H, C., McGraw-Hill, New York, 1966.
5. Structural Analysis A Matrix Approach, G. S. Pandit, S. P. Gupta, TATA McGraw Hill
6. Matrix Computer Analysis of Structures, Rubinstein, M.F., Prentice-Hall

Reference Books:

1. Introductory Methods of Numerical Analysis, S S. Sastry, ASIN : 8120345924, Publisher-Prentice Hall India Learning Private Limited.
2. Introduction to the Finite Element Method, Desai Abel, CBS Publishers and distributors
3. Introduction to Finite Elements in Engineering, Chandrupatala, Belugundu, Pearson Education Publisher : Pearson; 4th edition (20 December 2011)
4. Numerical Methods for Engineers, Steven Chapra, Tata McGraw Hill

Semester-VI

Course Code	Course Name	Credits
CEDLO6017	Department Level Optional Course -2 Traffic Engineering and Management	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Traffic Engineering Management follows the Transportation Planning and is the specialized branch of the Highway Engineering, which introduces the concepts of characterizing traffic, various modeling approaches, and design of facilities to control and manage traffic. A key feature of the course is that it is well connected with the current design and analysis practice stipulated in national standards, and manuals. Therefore, it deals with the application of scientific principles, tools, techniques and findings for safe, rapid, economical and efficient movement of people and vehicles.

Objectives

1 To understand the concepts of traffic characteristics, traffic surveys to be conducted for planning any transportation network or judging the adequacy of the existing one

2 The application of various statistical tools to the analysis of the large data base emerging out of extensive traffic surveys and transportation and traffic planning.

3 To understand the concept of various features of the intersection infrastructures, their necessity, pros and cons, design or planning principles and subsequently, to design / plan the features such as channelization, island, speed change lanes and parking facility.

4 To understand the concept of highway capacity and such other components such as Passenger Car Unit and Level of Service affecting the Capacity; and Speed- Flow- Density Relationship and various theories describing these relationships.

5 To understand the importance of Highway Safety and implementation of Traffic System Management (TSM) Measures and subsequent to study the various Traffic Control Devices and aspects of Highway Lighting.

6 To explore the future of traffic engineering in the form of Intelligent Transportation system

Detailed Syllabus			
Module	**Course Module / Contents**		**Periods**
1	**Traffic Characteristics and Surveys**		**03**
	1.1	Scope, Traffic Elements - Characteristics-vehicle, road user and road - Traffic studies-speed & delay, traffic volume, O & D, parking and accidents - Sample size, study methodology - Data analysis & inferences.	
2	**Application of Statistics in Traffic Engineering**		**05**
	2.1	Various probability distributions & their applications - Parameter estimation - Hypothesis testing - Random variables	
	2.2	Estimation and analysis of simple regression models - Correlation coefficients - Analysis of correlation coefficients	
	2.3	Application of queuing theory as applied to traffic flow problems for study state conditions	
3	**Intersection Design**		**10**
	3.1	Types of intersections - Conflict diagrams –Control hierarchy-Design of rotaries (Indo-HCM 2017) & at-grade intersections – Signal design as per IRC:93- Grade separated intersections & their warrants, coordination of signals, types of area traffic control	
4	**Traffic Flow Theory**		**10**
	4.1	Measurement, microscopic and macroscopic Study of Traffic Stream Characteristic -Flow, Speed and Density; pace – Time diagram, Headways, Speeds, Gaps and Lags; gap acceptance. Fundamental Equation of Traffic Flow, Speed-Flow-Density Relationships, Shock Wave Theory Passenger's car units, Factors affecting PCU and methods to determine PCU, level of service, factor affecting capacity and level of service. Capacity and level of service suggested for different road facilities as discussed in Indo-HCM 2017, review of flow density speed studies, Light hill and Whitham's theory, fundamentals of traffic stimulation modeling.	
5	**Traffic Management and Road safety Audit**		**07**
	5.1	Various measures for traffic systems management and travel demand management-Congestion management -cost effective Management, their scope, relative merits and demerits. (Pedestrians and Cyclist Management) (IRC SP:55-2014)	
	5.2	Highway Lighting: Important definitions, law of illumination, discernment by artificial lighting, mounting height, spacing, lantern arrangements, types of lamps, lighting of some important highway structures.	
	5.3	Accidents: Accident cause, recording system, analysis and	

		preventive measures, accident cost, alternative methodologies for calculation.	
	5.4	Road Safety Audit: Global & Local perspective – Road safety issues – Road safety programmers – Types of RSA, planning, design, construction & operation stage audits – Methodology – Road safety audit measures, road safety audit process as per IRC: SP-88-2010	
6	**Intelligent Transportation System**		**04**
	6.1	Overview of ITS implementations in developed countries, ITS in developing countries. Study of IRC: SP-110-2017	
	6.2	Historical Background, Benefits of ITS – Introduction to Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), Traffic control and monitoring aspects.	
	6.3	Application of ITS: Advanced Traffic Management Systems (ATMS) Advanced Vehicle Control Systems (AVCS), Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS), Automated Highway Systems	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 Understand different characteristics of the road users and vehicles from their consideration and view point in the traffic engineering and transportation planning.
2 Conduct different traffic surveys, analyzing the data collected as a part of such studies and interpreting it with the help of the different statistical models.
3 Explain the concepts of PCU and LOS, their implication in determination of the capacity using Speed-Flow-Density relationships.
4 Discuss the aspects associated with road safety, its audit and different TSM measures.
5 Discuss transportation planning and ascertain the financial viability of any transportation network in the inception stage itself.
6 Improve the effectiveness and efficiency of transportation systems through advanced technologies in Information systems and communication.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi, 2002.

2 Srinivasa Kumar .R ,Introduction to Traffic Engineering,The Orient Blackswan;south Asian Edition,2018.

3 Chakroborty P., Das N., Principles of Transportation Engineering, PHI,New Delhi,2003

4 Khanna S.K., Justo C.E.G., Highway Engineering, Nem Chand & Bros., Roorkee, 2001

5 Khisty C J,LallB.Kent; Transportation Engineering-An Introduction, Prentice-Hall,NJ, 2005

6 May, A.D., Traffic Flow Fundamentals, Prentice – Hall, Inc., New Jersey,1990.

7 O'Flaherty C A, Highways- Traffic Planning & Engineering, Edward Arnold, UK

8 Drew, D.R., Traffic Flow Theory and Control, McGraw-Hill, New York.

9 Benjamin J. R., Cornell C. A., Probability Statistics and Decision for Civil Engineers, McGraw-Hill, 1970.

10 Asad J. Khattak , Intelligent Transportation Systems: Planning, Operations, and Evaluation, CRC Press

Reference Books:

1 Transportation Engineering and Planning Papacostas, C. S., Prevedouros, P. D., PHIL earning Pvt. Ltd.

2 Transportation Engineering: Khisty, C.J. and Lall, K.B.; PHI Learning Pvt.Ltd.

3 Introduction to Urban Transport Systems, Planning: Hutchinson, B.G.;McGraw-Hill.

4 Economics of Transportation: Fair and Williams, Harper and Brothers, Publishers, NewYork.

5 Highway Capacity Manual, Transportation Research Board, National Research Council, WashingtonD.C.

6 Relevant IRC Codes amended time to time.

Semester-VI

Course Code	Course Name	Credits
CEDLO6018	Department Level Optional Course -2 Introduction to Offshore Engineering	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Offshore Engineering discipline deals with the design and construction of structures intended to work in the ocean environment. The majority of offshore structures are used in the Oil and Gas industry. Offshore construction is the installation of structures and facilities in a marine environment. Civil Engineering graduates will be able to work in the specialized field of ocean and coastal environment.

Objectives

1 To understand the complexities in offshore construction and obtaining resources from the ocean.
2 To addresses the general engineering concepts that are fundamental to offshore engineering.
3 To understand types of sites and platform structures, key engineering systems and ocean environmental monitoring

Detailed Syllabus

Module	Course Module / Contents		Periods
1	**Introduction:**		05
	1.1	History and current state of the art of offshore structures, Definition of Offshore Structures, Met ocean Engineering: wind, wave and current loads on offshore structures	
2	**Environment & Construction:**		06
	2.1	Offshore environment, Construction and launching, offshore project management,	
3	**Ocean Construction:**		06

	3.1	Types of Platforms: Jackets, Tension Leg Platforms (TLP), Semisubmersibles, Jack-ups, Concrete Gravity, deep water construction in ocean, offshore site investigations	
4	**Offshore Pipelines:**		**06**
	4.1	Hydrostatic, hydrodynamic analysis and structural design	
5	**Buoys and Mooring systems:**		**08**
	5.1	Buoys and Mooring systems Mooring configurations, advantages and disadvantages	
6	**Design Criteria:**		**08**
	6.1	Introduction to probabilistic design, extreme load & strength & fatigue, basics of anchoring and mooring system, riser system, Scaling laws & Model testing, Challenges in Deepwater testing: deep-water installations, constructions challenges.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1 To know various offshore construction methodologies

2 To addresses the general engineering concepts during construction stages.

3 To handle complexities and key engineering systems in ocean environment

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests –
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test).
Average of marks will be considered for IAE.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Subrata K. Chakrabarti (2005): Handbook of offshore engineering Volume–I & II, Elsevier, The Boulevard Langford Lane, Kidlington, Oxford OX5 l GB, UK.

2 Deo M C (2013):Waves and Structures, http://www.civil.iitb.ac.in/~mcdeo/waves.html

3 American Petroleum Institute, Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Load and Resistance Factor Design, 1st Edition, 1993. (TP690.A642 RP2A-LRFD)

4 American Petroleum Institute, Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st ed., 2000. (TP690.A642 RP2A-WSD).

Semester-VI

Course Code	Course Name	Credits
CEL601	Design and Drawing of Steel Structures (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objectives:

1 To estimate the design loads on steel structures as per IS 875

2 To analyze the member forces by any suitable method.

3 To design the members for axial, flexure and shear forces.

4 To prepare the detailed design report and fabrication drawings by manual or CAD software.

Course Outcomes:

At the end of the course, learner will be able to:

1 Calculate dead, live and wind loads on the structure.

2 Analyze the structure by analytical/graphical method.

3 Use steel table for selecting appropriate section.

4 Design the members for various load combinations.

5 Design the bolted and welded connection.

6 Read and Prepare the detailed fabrication drawing and design report.

The Project shall be given to a group of students consisting of not more than10 students.		
List of the Projects		
Schedule	**Detailed Content**	**Lab Session / Hr.**
Project 1	**Design and drawing of steel roof truss for industrial shed should consist of the following items.**	
1st Week	Introduction, problem statement, Calculation of panel point DL, LL, and WL on truss.	02
2nd Week	Analysis of truss by graphical method/ any software and calculation of design loads in members	02
3rd Week	Design of purlins, Principal rafter, Main Tie, Design of remaining members of truss. etc.	02
4th Week	Design of bolted /welded connections and design of sliding and hinged supports including anchor bolts	02
5th Week	To generate/draw fabrication drawings on full imperial size drawing sheet and design report on A4 size pages.	02
6th Week	To generate fabrication drawings and design report including estimation of steel required.	02
Project 2	**Design and drawing of floor beam system for steel building G+1 should consist of the following items**	
7th Week	Introduction, problem statement and to draw grid floor plan.	02
8th Week	Calculation of DL, LL on slab, beams etc. and to analyze frame for BM and SF.	02
9th Week	Calculation of design loads on columns and footing.	02
10th Week	Design of beams, columns and footings.	02
11th Week	Design of beam end and beam-column connections.	02
12th Week	To generate/draw fabrication drawings on Full imperial size drawing sheet and design report on A4 size pages.	02
13th Week	To generate fabrication drawings and design report including estimation of steel required.	02

Assessment:

- **Term Work**

Shall consist of design report and fabrication drawings for the above projects and Site visit report related to this course. Distribution of marks for Term Work shall be as follows:

Project 1+Project 2+ Site visit report : 20 Marks

Attendance : 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

- **End Semester Oral Examination**

Oral Examination will be based on Sketching Examination, Term Work and Entire syllabus

Recommended Books:

1 Design of Steel Structure by N. Subramanian, Oxford University Press, New Delhi.

2 Limit state design of steel structures by S. K. Duggal, McGraw Hill Education (India) Pvt. Limited, New Delhi.

3 Design of steel structure by Limit State Method as per IS: 800 - 2007 by Bhavikatti S. S., I.K. International Publishing House, New Delhi.

4 Design of Steel Structures by K. S. Sai Ram, Pearson Education, New Delhi.

5 Limit state design of steel structures as per IS 800/2007. by S. Kanthimathinathan. I.K. International Publishing House, New Delhi.

6 Relevant Indian Specifications, Bureau of Indian Standards, New Delhi.

Reference Books:

1 Design of Steel Structure by Allen Williams

2 Practical Design of Steel Structure by Karuna Moy Ghosh, Whittles Publishing

3 Structural design and drawing by D. Krishnamurthy, CBS Publishers, New Delhi.

4 Teaching Resources Material for steel structures by INSDAG Kolkata.

Semester-VI

Course Code	Course Name	Credits
CEL602	Water Resources Engineering (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objectives:

1 To study different irrigation engineering methods and water requirement of crops.

2 To study hydrological cycle, its elements and plotting of hydrographs.

3 To study and calculate discharge from aquifers.

4 To study control level fixation for reservoir, Dams i.e gravity dam, its various components and analysis and suitable conditions of earthen dam and its seepage analysis.

5 To study importance of silt theories and its design considerations.

6 To study Canal headwork, its distribution system and design of canal structures.

Course Outcomes:

At the end of the course, learner will be able to:

1 Classify various techniques of water distribution and compute water requirement of crops.

2 Discuss in detail about hydrological process and interpret plotting of hydrographs.

3 Apply their knowledge on well hydraulics and compute discharge from an aquifer.

4 Classify and describe various hydraulic structures such as dams and carry out its analysis for structural stability.

5 Compare different silt theories related to irrigation channel and design the same.

6 Identify and classify different canal head works - its distribution system and canal structures.

List of Experiments (Minimum Five)		
Module	**Detailed Content**	**Lab Session / Hr.**
Assignment		
1	Assignment no 1: Irrigation projects in India and Numerical based Water requirement of crops.	02
2	Assignment no 2: Numerical based on missing data, hydrographs.	02
3	Assignment no 3: Numerical based on yield of aquifer.	02
4	Assignment no 4: Numerical based on stability of gravity dam, seepage line (earthen dam)	02
5	Assignment no 5: Numerical based on Silt Theories	02
6	Assignment no 6: Case study on different canals in India and abroad.	02
Model Preparation (if possible, prepare any one model from below suggested topic)		
1	Prepare a model for any one water distribution technique referring to introductory chapter.	06
2	Prepare model for Dam (Gravity or Earthen Dam).	

Assessment:

- **Term Work**

Comprises of Assignments which has to be submitted by each student individually and preparation of model can be worked out in group of 6 members each.

Distribution of marks for Term Work shall be as follows:

Assignments : 20 Marks

Attendance : 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

- **End Semester Oral Examination**

Pair of Internal and External Examiner should conduct oral examination.

Reference Books:

1 Irrigation and Water Power Engineering: B.C. Punmia, PandeB.B.Lal, A.K Jain. Laxmi Publications Pvt, Ltd. New Delhi.

2 Irrigation Engineering and Hydraulic Structures: S.K. Ukarande, Ane Books Pvt. Ltd. ISBN-9789383656899.

3 Irrigation Water Resources and Water Power Engineering: P.N. Modi, Standard Book House, Delhi, ISBN 978-81-87401-29-0.

4 Irrigation Engineering and Hydraulics Structures: S. K. Garg, Khanna Publishers. Delhi.

5 Design of Irrigation Structures: S. K. Sharma, S. Chand and Co.

6 Theory and Design of Irrigation Structures: R. S. Varshney and R, C. Gupta, Nem Chand

7 Engineering for Dams, Vol. I to III: Crager, Justin and Hinds, John Wiley

9 Design of Small Dams: USBR.

10 Hydro Power Structures: R. S. Varshney, Nem Chand and Bross.

11 Concrete Dams: R. S. Varshney, Oxford and IBH Publishing Co.

Semester-VI

Course Code	Course Name	Credits
CEL603	Geotechnical Engineering-II Lab	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objective:

1 To study consolidation characteristics of soil.

2 To study and examine shear strength parameters of soil.

3 To Study and determine the strength of sub-grade soil.

4 To Study and determine swelling pressure of soil.

5 To gain the knowledge of stress distribution in soil.

6 To gain the knowledge of various geotechnical software.

Course Outcomes:

At the end of the course Students will be able to

1 Determine consolidation parameters such as coefficient of compressibility, coefficient of volume change, coefficient of consolidation.

2 Determine cohesion and angle of shearing resistance for various soil types.

3 Determine the CBR value of soil for pavement design.

4 Determine swelling pressure of soil.

5 Understand the concept of stress distribution in soils due to vertically applied load.

6 Solve design problems using geotechnical software.

List of Experiments (Minimum Five)

Module	Detailed Content	Lab Session Hrs.
1	Determination of pre-consolidation pressure and coefficient of consolidation from one dimensional consolidation test	02

2	Determination of shear strength parameters using direct shear test	02
3	Determination of shear strength parameters using unconsolidated undrained tri-axial compression test	02
4	Determination of undrained cohesion using unconfined compression test	02
5	Determination of shear strength of soft clays by vane shear test	02
6	Determination of CBR value using CBR test	02
7	Determination of swelling pressure of clays	02

Assignment:

a) Term Work Assessment
Assignments should contain at least 15 numerical problems covering the entire syllabus.

b) One assignment shall be given on either vertical stress distribution in soils or a design problem using geotechnical engineering software. The teacher is expected to impart the knowledge to the students about the concept of stress distribution of soils or design problem using software. The questions related to stress distribution in soils or design problem using software shall **NOT** be asked in the theory examination. However, it shall be treated as a part of term work submission. It shall preferably cover the following points:

- Vertical stress distribution in soils: Estimation of vertical stress in soil due to surface load using Boussinesq equation.

OR

- Design problem using software: Introduction to any geotechnical software like Geo 5, PLAXIS, FLAC, MIDAS GTS-NX etc.

Distribution of Term Work Marks

Including Laboratory Work and Assignments both, Distribution of marks for Term Work shall be as follows:

Laboratory Work	:	15 Marks
Assignments	:	05 Marks
Attendance	:	05 Marks

- End Semester Oral Examination : 25 marks

Reference Books:

1 Engineering Soil Testing: Shamsher Prakash, P.K. Jain; Nem Chand & Bros

2 Soil Testing for Engineers: William T. Lambe; John Wiley and Sons, Inc.

3 Soil Mechanics Laboratory Manual: Brij Mohan DAS; Oxford University Press Inc.

4 Soil Mechanics in Engineering Practice: Karl Terzaghi, Ralph B. Peck, Gholamreza Mesri; John Wiley and Sons, Inc.

5 Soil Mechanics and Foundations: Dr. B. C. Punmia, Ashok Kumar Jain, Arun Kumar; Laxmi Publications

6 Soil Mechanics in Theory and Practice: Alam Singh; Asia Publishing House

7 Soil Mechanics and Foundation Engineering: V. N.S. Murthy; Saitech Publications

8 Relevant Indian Standard Specifications Code: BIS Publications; New Delhi

Semester-VI

Course Code	Course Name	Credits
CEL604	Environmental Engineering (Lab)	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	02	-	-	01	-	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objectives:

1 To analyse engineering skill related to water and wastewater sample.

2 To apply decision related to treatment of water and wastewater based on standards.

3 To understand the fundamental characteristics of municipal solid waste.

4 To acquire knowledge on the severity of air pollution and suggest remedies and preventive measures.

5 To understand the basic concepts of noise and its measurement.

Course Outcomes:

At the end of the course, learner will be able to:

1 Impart the knowledge on quality or characteristic of water and wastewater sample.

2 Interpret the required treatment for water and wastewater based on standards and norms.

3 Impart the knowledge on quality of solid waste.

4 Measure the concentration of particulate matters, dust and dispersed pollutants in air.

5 Inspect the levels of noise and interpret the results.

List of Experiments (Any eight to be performed)		
Module	**Detailed Content**	**Lab Session / Hr.**
1	Determination of pH of water/ sewage sample /solid waste.	02
2	Determination of Turbidity in water sample.	02
3	Determination of Total Solids, suspended solids, dissolved solids, volatile solids.	02
4	Determination of chlorides.	02
5	Determination of Optimum dose of coagulant by using Jar Test.	02
6	Determination of Dissolved Oxygen.	02
7	Determination of Residual chlorine	02
8	Determination of air quality using High Volume air Sampler.	02
9	Determination of Level equivalent of Noise	02
10	Determination of Bio Chemical Oxygen Demand of sewage sample	02
11	Determination of Chemical Oxygen Demand of sewage sample.	02
12	Determination of moisture content of solid waste.	02

Assessment:

- **Term Work**

Including Laboratory Work and Assignments both, Distribution of marks for Term Work shall be as follows:

Laboratory Work	:	15 Marks
Assignments	:	05 Marks
Attendance	:	05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

- **End Semester Oral Examination**

Oral exam will be based on experiments performed, site visit and theory syllabus.

Reference Books:

1 Water Supply Engineering: S. K. Garg, Khanna Publication.
2 Environmental Engineering Vol II: Garg, S. K., Khanna Publishers New Delhi.
3 Water Supply Engineering: P.N. Modi, Rajsons Publication.
4 Environmental Engineering: *B. C. Punmia*, Laxmi Publications, New Delhi.
5 Solid waste management in developing countries: A.D. Bhide and B.B. Sundaresan.
6 CPHEEO Manual on Water Supply and Treatment.
7 CPHEEO Manual on Sewage and Treatment.

Semester-VI

Course Code	Course Name	Credits
CEL605	Skill Based Lab Course-III	1.5

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Course Objectives:

1. To Provide hands on training on analysis, modelling and design of R. C. C. Framed structure and Steel structure.
2. To prepare the database and perform its statistical analysis using relevant software.
3. To understand and apply the basic functions of excel for data analysis, preparation of programs and generation of reports having mathematical and pictorial representation.
4. To design reliable and sustainable transportation systems.
5. To evaluate the demand of water for given population and create the proper distribution system.
6. To Apply the basic knowledge of various computer languages to create the programme pertaining to civil engineering domain.

Course Outcomes:

At the end of the course, learner will be able to:

1. To understand the functions involved various softwares related to civil engineering field.
2. To perform different functions of the software related to analysing modelling and designing the structure, creation of database and its analysis.
3. To describe and represent the data obtained from site, experimental work in various formats as per industrial requirements
4. To import road geometric design into the software as well as relate with the design standards applied into the software.
5. To design the effective distribution network system for the distribution of water resources.
6. To apply the knowledge to create the programme in excel and various computer languages for solving problems pertaining to civil engineering field.

List of Experiments (Minimum Eight)		
Module	**Detailed Content**	**Lab Session / Hr.**
Analysis, Modelling and Design of structure using professional software		**15**
1	Introduction to structural engineering software. Study of basic commands and tools.	03
2	Analysis of determinate and in-determinate structure. Extraction of shear force and bending moment diagram for given structure manually as well using software	03
3	Developing a model of simple plan of a building (square or rectangular)	03
4	Analysis of frames – R. C. C. framed structure	03
5	Analysis of frames – Steel structure	03
Preparation and analysis of database using open-source software		**03**
6	Introduction to statistical software – Basic function required for preparing database, statistical analysis of the data and its representation	03
Excel		**15**
7	Introduction to Excel – Basic function required for preparing database, statistical analysis of the data and its graphical representation a. Creation of database of result obtained from Traffic volume survey and its analysis b. Creating database of results obtained from laboratory experiments and its analysis	03
8	Preparation of programme using various functions in excel or any other relevant exercise in civil engineering field 1. Mix design of concrete 2. Design of pavement 3. Design of structural members	03
9	Preparation of checklist for various items of work in building construction for quality control, Preparation of various reports like Daily progress report, Daily Labour report, Weekly progress report, Weekly Labour report, Geotechnical reports, Audit reports	03
10	Use of transportation engineering related software for creation of contour, creation of cross section, setting horizontal and vertical alignment and calculation of cut and fill	03
11	Use of open-source software for designing and simulation of water distribution network	03
Programming using open-source software C or C++ or java or python		**06**
12	Introduction to programming software, Basics commands and tools for development of programme related to civil engineering field	03
13	Programming for Civil Engineers with content related to any domains of Civil Engineering problem solving using programming software.	03

Assessment:

- **Term Work**

Including Laboratory Work comprising of minimum 5 software generated reports/sheets/program outputs along with minimum 5 assignments or reports, distribution of marks for Term Work shall be as follows:

Laboratory Work	:	10 Marks (comprising of min. 5 software generated sheets/program outputs)
Assignments	:	10 Marks (comprising of min. 5 Reports)
Attendance	:	05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

End Semester Oral Examination

Oral exam will be based on Laboratory Work performed.

Reference Books:

1 Software manuals

2 IS 456, IS 800

3 Refereed Journal papers on Software applications

4 Manual on Water Supply and Treatment, C. P. H. E. E. O., Ministry of Urban Development, Government of India, New Delhi

5 The 'C' Programming Language, B.W Kernighan & D.M Ritchie, Prentice Hall of India

6 Statistics for Managers, Using Microsoft Excel, 8th Edition, David M., Levine, Pearson India Education service Pvt ltd.

Recommended Books:

1 Excel with Microsoft Excel: Comprehensive & Easy Guide to Learn Advanced MS Excel Paperback – 1 January 2019 by Naveen Mishra (Author); Publisher:Penman Books; Publication date: 1 January 2019; ISBN-10: 9389024153; ISBN-13: 978-9389024159

2 Structural Modeling, Analysis & Design Using Staad Pro Software Paperback – 15 October 2015 by Vignesh Kumar M (Author); Publisher: LAP Lambert Academic Publishing; Genre: Business & Economics; ISBN: 9783848447671, 9783848447671

3 Discovering Statistics Using SPSS for Windows: Advanced Techniques for the Beginner; By Andy P. Field; Publisher:Sage Publications; ISBN:9780761957553, 0761957553

4 Quality Management in Construction Projects; By Abdul Razzak Rumane; Copyright Year 2018; ISBN 9780367890032; Published December 10, 2019 by CRC Press

5 Introduction to Machine Learning with Python: A Guide for Data Scientists Paperback – 7 October 2016; by Andreas C. Mueller (Author), Sarah Guido (Author); ISBN-10: 1449369413; ISBN-13: 978-1449369415, 1st Edition; Publisher O 'Reilly

Semester-VI

Course Code	Course Name	Credits
CEM601	Mini Project -2B	1.5

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	03	-	-	1.5	-	1.5

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	-	25	50

Rationale

Civil engineers deal with many challenges on daily basis. The civil engineering industry's growth has been need based and society centric. Computers and IT systems have touched almost every part of our lives and inter-disciplinary approach is way of life ahead. Mumbai University proposed Mini projects in the syllabus so that the budding civil engineers can connect with the world outside their textbooks and have the idea of future course. The Mini project should actually provide solution to a typical problem after a brainstorming and in a stipulated period. The solutions based on software, development of computer application, or IT systems based on artificial intelligence or IOT are expected from civil engineering students. The competitions ahead will give students the experience of the civil engineering industry's real-world problems and make students brainstorm ideas, learn, and explore the civil engineering industry.

Course Objectives:

1 To recognize societal problems and convert them into a problem statement by understanding of facts and ideas in a group activity. (BTL-2)

2 To deal with new problems and situations by applying acquired knowledge, facts, techniques and rules in a different way. (BTL-3)

3 To examine and break information into parts, by analyzing motives or causes. (BTL-4)

4 To learn evaluating information, validity of ideas and work based on a set of criteria. (BTL-5)

5 To create solutions by compiling information together in a novel way. (BTL-6)

6 To design software based model, application or IT system by combining elements in a new pattern or proposing new solutions. (BTL-6)

Course Outcomes:

At the end of the course, learner will be able to:

1 Identify problems based on societal /research needs and formulate a solution strategy.

2 Apply fundamentals to develop solutions to solve societal problems in a group.

3 Analyze the specific need, formulate the problem and deduce the interdisciplinary approaches, software-based solutions and computer applications.

4 Develop systematic flow chart, evaluate inter disciplinary practices, devices, available software, estimate and recommend possible solutions.

5 Draw the proper inferences from available results through theoretical/experimental/simulations and assemble physical systems.

6 Create devises or design a computer program or develop computer application.

- **Guidelines for Mini Project -2**B

  Expected outcome is Software based, "**A Computerized Model/ A software/ A computer program, an IOT application or A Computer or Mobile based application** ".

  Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.

  Students should find 'List of Mini project- 2B problems' in University web portal www.mu.ac.in, and in consultation with faculty supervisor/head of department/internal committee of faculties select the title.

  Students shall submit implementation plan in the form of Gant/PERT/CPM chart, which will cover weekly activity of mini project.

  A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.

  Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.

  Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.

  Students shall convert the best solution into A Computerized Model/ a software/ A computer program, an IOT application or A Computer or Mobile based application using various components of their domain areas and demonstrate.

  The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.

  With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it ispreferable that Students come out with original solution.

  However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a

completely new project idea in even semester. This policy can be adopted on case-by-case basis.

List of approved problems for Mini Project -2B:	
S501:	Development for Mobile App for Smart Traffic Management System Using Internet of Things
S502:	Development for Mobile App for IoT based smart traffic signal monitoring system using vehicle Count.
S503:	Development of (AI Based) software or mobile App. To identify quantity of (bricks, pipes, bars etc.) from photograph.
S504:	Development of (AI Based) software or mobile App. To identify size of cracks in distressed structure from coin aimed photograph.
S505:	Development of (AI Based) software or mobile App. To identify size of cracks in distressed structure.
S506:	Development of (AI Based) software or mobile App. For Assessment of Irrigation Water Quality Index.
S507:	Development of (AI Based) software or mobile App. For Ground Water Quality monitoring in industrial zone.
S508:	Development of (AI Based) software or mobile App Advanced Earthquake Resistant Techniques
S509:	Development of Remote Monitoring System For Civil Engineering projects.
S510:	Application of Geographic Information system using Quantum GIS software.
S511:	Development of (AI Based) software or mobile App for Building Information Modelling using ArchiCAD/ Revit architecture software.
S512:	Development of (AI Based) software or mobile App Digitization of Slump cone Test.
S513:	Development of (AI Based) software or mobile App Digitization of other mechanical Tests.
S514:	Development of (AI Based) software or mobile App Civil Engineering quantity calculator.
S515:	Development of (AI Based) software or mobile App Digitization of Non-destructive testing of concrete-various methods.
S516:	Development of (AI Based) software or mobile App Mapping of area using Total Station and plotting the same on 3-d drafting.
S517:	Preparation of Excel VBA sheet for solving Survey, Soil Mechanics, Structural Analysis problems.
S518:	Development of (AI Based) software or mobile App Smart street lights and fault location monitoring in the cloud over IoT
S519:	Development of (AI Based) software or mobile App IOT based smart irrigation system
S520:	Development of (AI Based) software or mobile App Smart cities: Traffic data monitoring over IoT for easy transportation/alternative route selection
S521:	Development of (AI Based) software or mobile App Dam gate level monitoring for water resource analysis and dam gate control over IoT.
S522:	Development of (AI Based) software or mobile App Smart colony: RFID based gate security system, street lights, and water pump automation.
S523:	Development of (AI Based) software or mobile App Agriculture automation using GSM (soil moisture level control and motor control)

(This is tentative list, this list will be continuously updated by contributions from faculty, industry and alumni.)

Guidelines for Assessment of Mini Project:

- **Term Work**

The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.

In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

Distribution of Term work marks for both semesters shall be as below:

Marks awarded by guide/supervisor based on log book	:	10 Marks
Marks awarded by review committee	:	10 Marks
Quality of Project report	:	5 Marks

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

- **Assessment criteria of Mini Project:**

Mini Project shall be assessed based on following criteria:

Quality of survey/ need identification

Clarity of Problem definition based on need.

Innovativeness in solutions

Feasibility of proposed problem solutions and selection of best solution

Cost effectiveness

Societal impact

Innovativeness

Cost effectiveness and Societal impact

Full functioning of working model as per stated requirements

Effective use of skill sets

Effective use of standard engineering norms

Contribution of an individuals as member or leader

Clarity in written and oral communication

In one year, project, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.

In case of half year project all criteria in generic may be considered for evaluation of performance of students in mini project.

- **Guidelines for Assessment of Mini Project Practical/Oral Examination:**

  Report should be prepared as per the guidelines issued by the University of Mumbai.

  Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years and approved by head of Institution.

  Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

- **Mini Project shall be assessed based on following points:**

  Quality of problem and Clarity

  Innovativeness in solutions

  Cost effectiveness and Societal impact

  Full functioning of working model as per stated requirements

  Effective use of skill sets

  Effective use of standard engineering norms

  Contribution of an individuals as member or leader

  Clarity in written and oral communication

AC-11/7/2022
Item No.-6.16

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Civil Engineering

Second Year with Effect from AY 2020-2021

Third Year with Effect from AY 2021-2022

Final Year with Effect from AY 2022-2023

(REV-2019 'C' Scheme) from Academic Year 2019-2020

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019-2020)

Syllabus for Approval

Title of the Course	**:**	B.E (Civil Engineering)
Eligibility for Admission	**:**	After Passing Third Year Engineering as per the Ordinance 6244
Passing Marks	**:**	40%
Ordinances / Regulations (if any)	**:**	Ordinance: O.6244
No. of Years / Semesters	**:**	4 years / 8 semesters
Level	**:**	UG
Pattern	**:**	Semester
Status	**:**	Revised 2019
To be implemented from Academic Year	**:**	With effect from Academic Year: 2022-2023

Dr. S. K. Ukarande

Associate Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Dr. Anuradha Muzumdar

Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Science and Technology (in particular Engineering) of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. Choice based Credit and grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 13 weeks and remaining 2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Final Year of Engineering from the Academic year 2022-23.

Dr. S. K. Ukarande

Associate Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Dr. Anuradha Muzumdar

Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Incorporation and Implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill-based activities and project-based activities. Self-learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self-learning to learner. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S. K. Ukarande

Associate Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Dr. Anuradha Muzumdar

Dean
Faculty of Science and Technology,
University of Mumbai, Mumbai

Preface

The engineering education in India is expanding and is set to increase manifold. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. To meet this challenge, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program Outcomes (POs) are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this, Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome-based education (OBE) in the process of curriculum development from Rev-2012 onwards and continued to enhance the curriculum further based on OBE in Rev-2016 and Rev-2019 "C" scheme.

As Chairman and Members of Board of Studies in Civil Engineering, University of Mumbai, we are happy to state here that, the Program Educational Objectives (PEOs) for Undergraduate Program were finalized in a brain storming session, which was attended by more than 40 members from different affiliated Institutes of the University, who are either Heads of Departments or their senior representatives from the Department of Civil Engineering. The PEOs finalized for the undergraduate program in Civil Engineering are listed below;

1. To prepare the Learner with a sound foundation in mathematical, scientific and engineering fundamentals
2. To motivate the Learner in the art of self-learning and to use modern tools for solving real life problems
3. To prepare the Learner for a successful career in Indian and Multinational Organisations and for excelling in post-graduate studies
4. To motivate learners for life-long learning
5. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the Learner's thought process

In addition to the above listed PEOs, every institute is encouraged to add a few (2-3) more PEOs suiting their institute vision and mission

Apart from the PEOs, for each course of the program, objectives and expected outcomes from a learner's point of view are also included in the curriculum to support the philosophy of OBE. We strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stakeholders.

Board of Studies in Civil Engineering University of Mumbai			
Dr. S. K. Ukarande	Chairman	Dr. V. Jothiprakash	Member
Dr. D.D. Sarode	Member	Dr. K. K. Sangle	Member
Dr. S. B. Charhate	Member	Dr. D. G. Regulawar	Member
Dr. Milind Waikar	Member	Dr. A. R. Kambekar	Member
Dr. R.B. Magar	Member	Dr. Seema Jagtap	Member

Undergraduate Program Structure for Second year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2020-2021**)
Semester – III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC301	Engineering Mathematics – III	03	-	01	03	-	01	04
CEC302	Mechanics of Solids	04	-	-	04	-	-	04
CEC303	Engineering Geology	03	-	-	03	-	-	03
CEC304	Architectural Planning & Design of Buildings	02	-	-	02	-	-	02
CEC305	Fluid Mechanics – I	03	-	-	03	-	-	03
CEL301	Mechanics of Solids	-	02	-	-	01	-	01
CEL302	Engineering Geology	-	02	-	-	01	-	01
CEL303	Architectural Planning & Design of Buildings	-	02	-	-	01	-	01
CEL304	Fluid Mechanics – I	-	02	-	-	01	-	01
CEL305	Skill Based Lab Course – I	-	03	-	-	1.5	-	1.5
CEM301	Mini Project – 1A	-	03$	-	-	1.5	-	1.5
Total		**15**	**14**	**1**	**15**	**7**	**1**	**23**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract. /Oral	Total
		Test - I	Test – II	Avg.					
CEC301	Engineering Mathematics –III	20	20	20	80	03	25	-	125
CEC302	Mechanics of Solids	20	20	20	80	03	-	-	100
CEC303	Engineering Geology	20	20	20	80	03	-	-	100
CEC304	Architectural Planning & Design of Buildings	20	20	20	80	03	-	-	100
CEC305	Fluid Mechanics – I	20	20	20	80	03	-	-	100
CEL301	Mechanics of Solids	-	-	-	-	-	25	25	50
CEL302	Engineering Geology	-	-	-	-	-	25	25	50
CEL303	Architectural Planning & Design of Buildings	-	-	-	-	-	25	25	50
CEL304	Fluid Mechanics – I	-	-	-	-	-	25	25	50
CEL305	Skill Based Lab Course – I	-	-	-	-	-	50	-	50
CEM301	Mini Project – 1A	-	-	-	-	-	25	25	50
Total		**100**			**400**	**-**	**200**	**125**	**825**

$ indicates work load of Learner (Not Faculty), for Mini Project.
Faculty Load: 1 hour per week per four groups.

Undergraduate Program Structure for Second year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2020-2021**)
Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC401	Engineering Mathematics – IV	03	-	01	03	-	01	04
CEC402	Structural Analysis	04	-	-	04	-	-	04
CEC403	Surveying	03	-	-	03	-	-	03
CEC404	Building Materials & Concrete Technology	03	-	-	03	-	-	03
CEC405	Fluid Mechanics-II	03	-	-	03	-	-	03
CEL401	Structural Analysis	-	02	-	-	01	-	01
CEL402	Surveying	-	03	-	-	1.5	-	1.5
CEL403	Building Material Concrete Technology	-	02	-	-	01	-	01
CEL404	Fluid Mechanics-II	-	02	-	-	01	-	01
CEL405	Skill Based lab Course – II	-	02	-	-	01	-	01
CEM401	Mini Project – 1B	-	03$	-	-	1.5	-	1.5
Total		**16**	**14**	**01**	**16**	**07**	**01**	**24**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract. /Oral	Total
		Test - I	Test – II	Avg.					
CEC401	Engineering Mathematics-IV	20	20	20	80	03	25	-	125
CEC402	Structural Analysis	20	20	20	80	03	-	-	100
CEC403	Surveying	20	20	20	80	03	-	-	100
CEC404	Building Materials & Concrete Technology	20	20	20	80	03	-	-	100
CEC405	Fluid Mechanics-II	20	20	20	80	03	-	-	100
CEL401	Structural Analysis	-	-	-	-	-	25	25	50
CEL402	Surveying	-	-	-	-	-	50	25	75
CEL403	Building Material Concrete Technology	-	-	-	-	-	25	25	50
CEL404	Fluid Mechanics-II	-	-	-	-	-	25	25	50
CEL405	Skill Based lab Course - II	-	-	-	-	-	50	-	50
CEM401	Mini Project – 1B	-	-	-	-	-	25	25	50
Total		**100**			**400**	**-**	**225**	**125**	**850**

$ indicates work load of Learner (Not Faculty), for Mini Project.
Faculty Load: 1 hour per week per four groups.

Undergraduate Program Structure for Third year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2021-2022**)
Semester - V

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC501	Theory of Reinforced Concrete Structures	03	-	-	03	-	-	03
CEC502	Applied Hydraulics	03	-	-	03	-	-	03
CEC503	Geotechnical Engineering-I	03	-	-	03	-	-	03
CEC504	Transportation Engineering	04	-	-	04	-	-	04
CEDLO501X	Department Level Optional Course-1	03	-	-	03	-	-	03
CEL501	Theory of Reinforced Concrete Structures	-	02	-	-	01	-	01
CEL502	Applied Hydraulics	-	02	-	-	01	-	01
CEL503	Geotechnical Engineering-I	-	02	-	-	01	-	01
CEL504	Transportation Engineering	-	02	-	-	01	-	01
CEL505	Professional Communication and Ethics-II	-	02*+2	-	-	02	-	02
CEM501	Mini Project – 2A	-	04$	-	-	02	-	02
Total		**16**	**16**	**-**	**16**	**08**	**-**	**24**

Examination Scheme

Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract /Oral	Total
		Test - I	Test – II	Avg.					
CEC501	Theory of Reinforced Concrete Structures	20	20	20	80	03	-	-	100
CEC502	Applied Hydraulics	20	20	20	80	03	-	-	100
CEC503	Geotechnical Engineering-I	20	20	20	80	03	-	-	100
CEC504	Transportation Engineering	20	20	20	80	03	-	-	100
CEDLO501X	Department Level Optional Course -1	20	20	20	80	03	-	-	100
CEL501	Theory of Reinforced Concrete Structures	-	-	-	-	-	25	25	50
CEL502	Applied Hydraulics	-	-	-	-	-	25	25	50
CEL503	Geotechnical Engineering-I	-	-	-	-	-	25	25	50
CEL504	Transportation Engineering	-	-	-	-	-	25	25	50
CEL505	Professional Communication and Ethics-II	-	-	-	-	-	25	25	50
CEM501	Mini Project – 2A	-	-	-	-	-	25	25	50
Total		**100**			**400**	**-**	**150**	**150**	**800**

*** Theory class to be conducted for full class**
$ indicates work load of Learner (Not Faculty), for Mini Project.
Faculty Load: 1 hour per week per four groups.

Undergraduate Program Structure for Third year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2021-2022**)
Semester - V

Department Level Optional Course – 1

Sr. No.	Course Code CEDLO501X	Department Level Optional Course – 1
1	CEDLO5011	Modern Surveying Instruments and Techniques
2	CEDLO5012	Building Services & Repairs
3	CEDLO5013	Sustainable Building Materials
4	CEDLO5014	Advanced Structural Mechanics
5	CEDLO5015	Air and Noise Pollution & Control
6	CEDLO5016	Transportation Planning & Economics
7	CEDLO5017	Advanced Concrete Technology

Undergraduate Program Structure for Third year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2021-2022**)
Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC601	Design & Drawing of Steel Structures	03	-	-	03	-	-	03
CEC602	Water Resources Engineering	03	-	-	03	-	-	03
CEC603	Geotechnical Engineering-II	03	-	-	03	-	-	03
CEC604	Environmental Engineering	04	-	-	04	-	-	04
CEDLO601X	Department Level Optional Course -2	03	-	-	03	-	-	03
CEL601	Design & Drawing of Steel Structures	-	02	-	-	01	-	01
CEL602	Water Resources Engineering	-	02	-	-	01	-	01
CEL603	Geotechnical Engineering-II	-	02	-	-	01	-	01
CEL604	Environmental Engineering	-	02	-	-	01	-	01
CEL605	Skill Based Lab Course – III	-	03	-	-	1.5	-	1.5
CEM601	Mini Project – 2B	-	03$	-	-	1.5	-	1.5
Total		**16**	**14**	**-**	**16**	**07**	**-**	**23**

Examination Scheme

Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract. /Oral	Total
		Test – I	Test - II	Avg.					
CEC601	Design & Drawing of Steel Structures	20	20	20	80	04	-	-	100
CEC602	Water Resources Engineering	20	20	20	80	03	-	-	100
CEC603	Geotechnical Engineering-II	20	20	20	80	03	-	-	100
CEC604	Environmental Engineering	20	20	20	80	03	-	-	100
CEDLO601X	Department Level Optional Course -2	20	20	20	80	03	-	-	100
CEL601	Design & Drawing of Steel Structures	-	-	-	-	-	25	25	50
CEL602	Water Resources Engineering	-	-	-	-	-	25	25	50
CEL603	Geotechnical Engineering-II	-	-	-	-	-	25	25	50
CEL604	Environmental Engineering	-	-	-	-	-	25	25	50
CEL605	Skill Based Lab Course-III	-	-	-	-	-	25	25	50
CEM601	Mini Project – 2B	-	-	-	-	-	25	25	50
Total		**100**			**400**	**-**	**150**	**150**	**800**

$ indicates work load of Learner (Not Faculty), for Mini Project
$ indicates work load of Learner (Not Faculty), for Mini Project.
Faculty Load: 1 hour per week per four groups.

Undergraduate Program Structure for Third year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2021-2022**)
Semester VI

Department Level Optional Course – 2

Sr. No.	Course Code CEDLO601X	Department Level Optional Course – 2
1	CEDLO6011	Rock Mechanics
2	CEDLO6012	Biological Processes & Contaminant Removal
3	CEDLO6013	Construction Equipment & Techniques
4	CEDLO6014	Urban Infrastructure Planning
5	CEDLO6015	Open Channel Flow
6	CEDLO6016	Computational Structural Analysis
7	CEDLO6017	Traffic Engineering and Management
8	CEDLO6018	Introduction to Offshore Engineering

Undergraduate Program Structure for Final year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2022-2023**)
Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC701	Design & Drawing of Reinforced Concrete Structures	03	-	-	03	-	-	03
CEC702	Quantity Survey, Estimation and Valuation	03	-	-	03	-	-	03
CEDLO701X	Department Level Optional Course – 3	03	-	-	03	-	-	03
CEDLO702X	Department Level Optional Course – 4	03	-	-	03	-	-	03
CEILO701X	Institute Level Optional Course – I	03	-	-	03	-	-	03
CEL701	Design & Drawing of Reinforced Concrete Structures	-	02	-	-	01	-	01
CEL702	Quantity Survey, Estimation and Valuation	-	02	-	-	01	-	01
CEP701	Major Project-Part I	-	06*	-	-	03	-	03
Total		**15**	**10**	**-**	**15**	**05**	**-**	**20**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract /Oral	Total
		Test - I	Test – II	Avg.					
CEC701	Design & Drawing of Reinforced Concrete Structure	20	20	20	80	04	-	-	100
CEC702	Quantity Survey, Estimation and Valuation	20	20	20	80	04	-	-	100
CEDLO701X	Department Level Optional Course – 3	20	20	20	80	03	-	-	100
CEDLO702X	Department Level Optional Course – 4	20	20	20	80	03	-	-	100
CEILO701X	Institute Level Optional Course – I	20	20	20	80	03	-	-	100
CEL701	Design & Drawing of Reinforced Concrete Structure	-	-	-	-	-	25	25	50
CEL702	Quantity Survey, Estimation and Valuation	-	-	-	-	-	25	25	50
CEP701	Major Project-Part I	-	-	-	-	-	25	25	50
Total		**100**			**400**	**-**	**75**	**75**	**650**

*** Faculty load- In Semester VII - 1/2 hour per week per project group**

Undergraduate Program Structure for Final year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2022-2023**)
Semester VII

Department Level Optional Course – 3

Sr. No.	Course Code CEDLO701X	Department Level Optional Course – 3
1	CEDLO7011	Pre-stressed Concrete
2	CEDLO7012	Applied Hydrology and Flood Control
3	CEDLO7013	Appraisal and Implementation of Infra Projects
4	CEDLO7014	Analysis of Offshore Structures
5	CEDLO7015	Advanced Construction Technology
6	CEDLO7016	Pavement Materials Construction and Maintenance

Department Level Optional Course – 4

Sr. No.	Course Code CEDLO702X	Department Level Optional Course – 4
1	CEDLO7021	Foundation Analysis and Design
2	CEDLO7022	Solid and Hazardous Waste Management
3	CEDLO7023	Ground Improvement techniques
4	CEDLO7024	Green building constructions
5	CEDLO7025	Legal Aspects in constructions
6	CEDLO7026	Environmental impact assessment
7	CEDLO7027	Advanced Design of Steel Structures

Institute Level Optional Course – I

Sr. No.	Course Code CEILO701X	Institute Level Optional Course – I
1	ILO7011	Product Life-cycle Management
2	ILO7012	Reliability Engineering
3	ILO7013	Management Information Systems
4	ILO7014	Design of Experiments
5	ILO7015	Operations Research
6	ILO7016	Cyber Security and Laws
7	ILO7017	Disaster Management and Mitigation Measures
8	ILO7018	Energy Audit and Management
9	ILO7019	Development Engineering

Undergraduate Program Structure for Final year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2022-2023**)
Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credit Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
CEC801	Construction Management	03	-	-	03	-	-	03
CEDLO801X	Department Level Optional Course – 5	03	-	-	03	-	-	03
CEDLO802X	Department Level Optional Course – 6	03	-	-	03	-	-	03
CEILO801X	Institute Level Optional Course – II	03	-	-	03	-	-	03
CEL801	Construction Management	-	02	-	-	01	-	01
CEP801	Major Project – Part II	-	12$	-	-	06	-	06
Total		**12**	**14**	**-**	**12**	**07**	**-**	**19**

Examination Scheme									
Course Code	Course Name	Internal Assessment			End Sem Exam	Exam Duration (Hrs.)	Term Work	Pract. /Oral	Total
		Test - I	Test – II	Avg.					
CEC801	Construction Management	20	20	20	80	03	-	-	100
CEDLO801X	Department Level Optional Course – 5	20	20	20	80	03	-	-	100
CEDLO802X	Department Level Optional Course – 6	20	20	20	80	03	-	-	100
CEILO801X	Institute Level Optional Course – II	20	20	20	80	03	-	-	100
CEL801	Construction Management	-	-	-	-	-	25	25	50
CEP801	Major Project – Part II	-	-	-	-	-	50	100	150
Total		**80**			**320**	**-**	**75**	**125**	**600**

$: Faculty load- In Semester VIII - 1 hour per week per project group

Undergraduate Program Structure for Final year Civil Engineering
University of Mumbai
(With Effect from A.Y. **2022-2023**)
Semester VIII
Department Level Optional Course – 5

Sr. No.	Course Code CEDLO801X	Department Level Optional Course – 5
1	CEDLO8011	Bridge Engineering
2	CEDLO8012	Design of Hydraulic Structures
4	CEDLO8013	Construction Safety
5	CEDLO8014	Pavement Design
6	CEDLO8015	Industrial Waste Treatment
7	CEDLO8016	Soil Dynamics

Department Level Optional Course – 6

Sr. No.	Course Code CEDLO802X	Department Level Optional Course – 6
1	CEDLO8021	Repairs, Rehabilitation and Retrofitting of structures
2	CEDLO8022	Physico-Chemical Treatment of Water and Waste Water
3	CEDLO8023	Transportation System Engineering
4	CEDLO8024	Smart Building Materials
5	CEDLO8025	Structural Dynamics
6	CEDLO8026	Ground Water Engineering

Institute Level Optional Course – II

Sr. No.	Course Code CEILO801X	Institute Level Optional Course – II
1	ILO8011	Project Management
2	ILO8012	Finance Management
3	ILO8013	Entrepreneurship Development and Management
4	ILO8014	Human Resources Management
5	ILO8015	Professional Ethics and Corporate Social Responsibility (CSR)
6	ILO8016	Research Methodology
7	ILO8017	Intellectual Property Rights and Patenting
8	ILO8018	Digital Business Management
9	ILO8019	Environmental Management

Faculty may design and conduct practical for elective subjects wherever possible, under the head ‘content beyond syllabus’.

Semester VII

Semester VII

Course Code	Course Name	Credits
CEC701	Design and Drawing of Reinforced Concrete Structures	3

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
3	--	--	3	--	--	3

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	04 Hrs.	--	--	--	100

Rationale

Reinforced concrete construction is widely used for residential, commercial and industrial structures. IS code has specified the use of Limit State Method (LSM) design philosophy for design of structures. During previous semester students have studied design of basic elements by LSM. This course covers complete design of G+3 RCC framed building in addition to other structures like water tank and retaining wall. Pre-stressed Concrete structures are another class of structures used for bridge girders, long span slabs etc. Civil Engineers must have knowledge of designing and detailing of RCC and PSC structures to make structures safe and serviceable during its life span. The knowledge about response of structures during an earthquake is prerequisite for Civil Engineers. The course introduces Prestressed concrete and Earthquake Resistant Design of structures with drawing and detailing as per IS Code specifications.

Objectives

1. To explain the LSM design procedure of G+3 RCC framed building by application of IS code clauses including loading calculations, analysis and design of individual elements with detailing of reinforcements.
2. To explain the concepts in the design of water tanks.
3. To explain the concepts in the design of retaining walls.
4. To introduce the basics of structural dynamics, structural behavior under the dynamic load and the effect of damping.
5. To introduce earthquake resistant design approach.
6. To develop the practice of design using charts and tables from SP:16 published by BIS.
7. To introduce concept of Pre-stressed Concrete.

Detailed Syllabus

Module	Contents		Periods
I	**Comprehensive Design of Building**		**11**
	1.1	Analysis and design of residential/commercial/industrial (G+ 3) RCC framed building.	
	1.2	Load transfer mechanism, arrangement of beams, slabs and columns.	
	1.3	Design of Staircase (Dog legged and Open well type), Slabs (One way and Two way with continuity), Beams (Simply supported, Cantilever, Continuous), Columns (Axially loaded and Eccentrically loaded), Footings (Isolated and Combined).	
II	**Design of Retaining Wall**		**06**
	2.1	Design of Cantilever retaining wall	
	2.2	Design of Counterfort retaining wall	
III	**Design of Water Tank**		**07**
	3.1	Classification of Water Tank, Permissible Stresses, and Design of circular and rectangular water tanks resting on ground and underground. Codal provisions as per IS 3370:2020. Use of IS coefficient method and approximate method.	
	3.2	Introduction to design of elevated water tank, frame and shaft type of staging.	
IV	**Introduction to Structural Dynamics**		**06**
	4.1	Definition of basic terms used in structural dynamics. Static and dynamic loads, types of dynamic load.	
	4.2	Introduction to single degree of freedom system (SDOF), evaluation of dynamics response of SDOF system. Approximate method for determination of time period of vibration.	
V	**Earthquake Resistant Design of Structures**		**06**
	5.1	Earthquake motion and response of structure.	
	5.2	Design load calculation by seismic coefficient method.	
	5.3	Ductile design and detailing as per IS: 13920.	
VI	**Introduction to Pre-stressed Concrete**		**03**
	6.1	Prestressed Concrete: basic principles of prestressed concrete, materials used, systems of prestressing.	
	6.2	Losses in prestress.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1. Design G+3 RCC framed building using IS code recommendations.
2. Design different types of retaining walls with detailing of reinforcement
3. Design different types of water tanks with detailing of reinforcement.
4. Apply the basic concepts of structural dynamics
5. Evaluate the response of structure during an earthquake and calculate design forces.
6. Explain principles of Pre-stressed Concrete and its losses.

Internal Assessment 20 Marks

Consisting of two class tests - first test based on approximately 40% of content and second test based on remaining content (approximately 40% but excluding content covered in first test). Average of marks will be considered for IA.

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. **Use of relevant IS codes shall be allowed in the examination.**
2. Question paper will comprise of total six questions, each carrying 20 marks.
3. Question 1 will be compulsory based on entire syllabus.
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Four questions need to be solved in total.

Recommended Books:

1. Design of Reinforced Concrete Structures*: Dayaratnam, P;* Oxford and IBH.
2. Reinforced Concrete - Limit State Design: Ashok K. Jain, Nemchand & bro.
3. Limit State Design of Reinforced Concrete: Shah and Karve, Structure Publications, Pune.
4. Design of Prestressed Concrete Structures: Lin T.Y. and Ned Burns; John Wiley.
5. Reinforced Concrete: H.J. Shah, Charotar Publishers, Anand.
6. Prestressed concrete : Krishna Raju, Tata Mc-Graw Hill Publishing House, New Delhi
7. Illustrated Reinforced Concrete Design: Dr. V. L. Shah and Dr. S. R. Karve, Structure Publications, Pune.
8. Reinforced Concrete Design: Wang, C. K., Salmon, C. G., and Pincheira, J. A, John Wiley (2007), 7th Edition.

9. Reinforced Concrete Fundamentals: Ferguson, P. M., Breen, J. E., and Jirsa, J. O., John Wiley & Sons (1988) 5th Edition.
10. Earthquake resistant design of structures: Pankaj Agarwal, Manish Shrikhande, PHI, New Delhi.

Reference Books:

1. Design of RCC structural Elements (RCC Vol-I): Bhavikatti, S. S., New Age International Publications.
2. Reinforced Concrete: Syal and Goel, Wheeler Publishers.
3. Reinforced Concrete Design: Pillai, S.U. and Menon Devdas, Tata Mc-Graw Hill Publishing House, New Delhi.
4. Reinforced Concrete Design by S.N. Sinha, Tata Mc-Graw Hill Publishing House, New Delhi.
5. Theory of Reinforced concrete structures by N. Subramanian, Oxford University Press.
6. Pre-stressed concrete: N. Rajgopalan, Narosa Publishers.
7. Relevant IS Codes: BIS Publications, New Delhi.

Semester VII		
Course Code	**Course Name**	**Credits**
CEC702	**Quantity Survey, Estimation & Valuation**	**03**

Teaching Scheme						
Contact Hours			**Credits Assigned**			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
03	--	--	03	--	--	03

Evaluation Scheme								
Theory					**Term Work/ Practical/Oral**			**Total**
Internal Assessment			**End Sem Exam**	**Duration of End Sem Exam**	**TW**	**PR**	**OR**	
Test 1	**Test 2**	**Average**						
20	20	20	80	04 Hrs.	--	--	--	100

Rationale

Any structure, i.e., building, bridge, dam etc. consists of various building materials. Due to rise in the cost of materials, the structure has to be designed so that it is safe, serviceable and economical. Without proper design and estimation, it may lead to the increase in cost of construction and it further affects the economical aspect of the structure. A prior knowledge ofvarious building materials is required for the construction and it controls the cost of the structure, save wastage of labor-hours and eventually helps in giving the correct amount required and quantity of various materials required. It also helps in scheduling of men, materialsand machine to be used in the project at stages. The scope of the subject includes estimating, costing, analysis of rates, specification, valuation, tender and contracts etc.

Objectives

1. To emphasize the importance of relevant IS: 1200 - 1964 codes and understand Measurement systems for various items of civil engineering structures
2. To draft the specifications for various items of work & determine unit rates of items of works & to prepare the rate analysis for various items of work using DSR for reference.
3. To study the various methods of detailed and approximate estimates.
4. To calculate the quantity of earthwork using various methods.
5. To study the process of tendering and its various stages, various types of contracts, its suitability and validity as per the Indian Contract Act of 1872 and draft various clauses and conditions of a contract.
6. To explain the concept of valuation & to determine the present fair value of any constructed building at stated time.

Detailed Syllabus			
Module	**Sub-Modules/ Contents**		**Hrs.**
I.	**Introduction**		**03**
	1.1	Importance of Course	
	1.2	Measurement systems for specific items of civil engineering structures	
	1.3	Units of measurement of various items of works	
	1.4	IS1200: - Introduction, deduction rules for Masonry & Plastering work	
II.	**Specifications & Rate Analysis**		**06**
	2.1	Types & importance of specifications, rules to be followed for drafting the specifications of important items of work etc.	
	2.2	Rate analysis, its importance & necessity, Factors affecting rate analysis, Task work, sources of materials, Study of IS 7272 regarding labor output, District Schedule of Rates (DSR) Rate analysis of important items of construction works.	
III.	**Estimates**		**12**
	3.1	**Approximate Estimate** Definition & Purposes of approximate estimates, Methods for preparing approximate estimates & numerical based on methods, Various terms such as administrative approval, technical sanction, Contingencies, Work charged establishments etc.	
	3.2	**Detailed Estimate** Definition & purposes of detailed estimate, Data required for preparation of detailed estimate. Introduction of detailed estimate of load bearing structure. Methods of taking out quantities such as long wall & short wall method, Centre line method for R.C.C. framed structure, Bar Bending Schedule & its necessity, preparation of bar bending schedule of various structuralelements as per code IS2502.	
IV.	**Estimation of Earthwork for Roads & Canals**		**04**
	4.1	Methods of computation of volume of earthwork such as mean area method, mid-sectional area method, Prismoidal formula, Trapezoidal formula etc. & numerical based on methods. Introduction of Mass Haul diagram, Terms like lead & lift etc.	
V.	**Tenders & Contracts**		**06**
	5.1	**Tenders** Definition & types of tenders, Tender notice & its inclusions, Pre-qualification of contractors, Pre-bid meeting, Procedure for submission & opening of tender, acceptance & rejection of tender, Tender validity period, E-Tendering	
	5.2	**Contracts** Definition, basic forms such as Valid, void & voidable contract. General types of contracts with their suitability, conditions of contract	

VI.	**Valuation**		**08**
	6.1	Difference between cost, price & value. Types of value, Valuation & its purposes. Various terms such as depreciation, sinking fund, capitalized value, years purchase etc. Methods for calculating depreciation of building such as Straight-line method, Sinking fund method Freehold Properties, Leasehold Properties, Easement rights	
	6.2	Methods of valuation such as Rental method, land & building method, Belting method etc. Numerical based on valuation	

Contribution to Outcomes

On completion of the course, the learners will be able to:

1. **Apply** the measurement systems to various civil engineering items of work.
2. **Draft** the specifications for various items of work & determine unit rates of items of works
3. **Estimate** approximate cost of the structures by using various methods & **prepare** detailed estimates of various civil engineering structures, including bar bending schedule, by referring drawings.
4. **Assess** the quantities of earthwork & **construct** mass haul diagrams.
5. **Draft** tender notice & **demonstrate** the significance of the tender as well as contract process.
6. **Determine** the present fair value of any constructed building at stated time.

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests – First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test). Average of marks will be considered for IA.

End Semester Examination: **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1) Question paper will comprise of **six** questions; each carrying 20 marks.
2) The **first** question will be **compulsory** based on computation of quantities of various items of work by referring drawings.
3) The remaining **five** questions will be based on all the modules of entire syllabus. For this,the modules shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module or contents thereof.

4) The students will have to attempt any **three** questions out of remaining five questions.
   Total **four** questions need to be attempted.
5) There can be an internal choice in various sub-questions/ questions in order to accommodate the questions on all the topics / sub-topics.

Recommended Books:

1) Estimating, Costing, Specifications and Valuation: *Chakraborty, M.,* Kolkata.
2) Building and Engineering Contracts: *Patil, B. S.*, University Press, Hyderabad.
3) Estimating and costing: *Datta, B. N.,* UBS Publications
4) Relevant Indian Standard Specifications, BIS Publications
5) Professional Practice: Dr. Roshan H. Namavati
6) World Bank approved contract documents

Semester VII

Course Code	Course Name	Credits
CEDLO7011	Department Level Optional Course-3: Pre-stressed Concrete	3

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
3	--	--	3	--	--	3

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hrs	--	--	--	100

Rationale

The course is aimed to make the learners aware about highly mechanized technology in civil engineering construction and to develop the basic understanding of prestressed concrete which is used in a wide range of civil structures like high rise buildings, residential slabs and bridges etc. Prestressed Concrete improves performance/efficiency of the section. It reduces cross sectional dimensions that results in material saving when compared with simple reinforced concrete sections.

Objectives

1. To make the learner to understand difference between PSC and RCC section in terms of material and method / technique used for construction.
2. To make the learner to understand the principle of prestressing, analysis of prestressed concrete sections and losses in prestress.
3. To make the candidate able to understand and implement the guidelines of Indian Standard code for analysis and design sections using limit state philosophy.

Detailed Syllabus

Module	Sub-Modules/ Contents		Hrs.
I	**Introduction of Pre-stressed Concrete**		02
	1.1	Basic concept and general principle	
	1.2	Materials used and their properties, need of high strength concrete and steel	
	1.3	Techniques and systems of prestressing	
	1.4	Advantages of Prestressed Concrete	

II	**Analysis of Pre-stressed Concrete Beams**		10
	2.1	Loading stages, permissible stresses in concrete in compression and tension at transfer and service stages as per limit state of serviceability, maximum compression and limit state of serviceability cracking, permissible stresses in steel, stress method of analysis	
	2.2	Load balancing method of analysis, cable profile	
	2.3	Kern points, pressure line, efficiency of section, internal resisting couple method of analysis,	
III	**Losses in Prestress**		06
	3.1	Loss of stresses in steel due to elastic deformation of concrete, creep in concrete, shrinkage in concrete, relaxation in steel, anchorage slip and friction	
IV	**Analysis of Pre-stressed Concrete Beams in Limit State of Serviceability Deflection**		04
	4.1	Deflection at transfer, short time and longtime deflection of uncracked beams, permissible limits	
V	**Analysis and Design of Pre-stressed Concrete Beams in Limit State of Collapse**		10
	5.1	Shear - Principal tension, permissible limit, analysis and design of beams in shear (sections uncracked in flexure)	
	5.2	Flexure - General philosophy of design, assumptions, analysis and design of beams in flexure	
VI	**Design of Pre-stressed Concrete Beams in Limit State of Serviceability, Maximum Compression and Cracking**		07
	6.1	Suitability of section modulus	
	6.2	Optimum pre-stressing force and corresponding eccentricity	
	6.3	Safe cable zone	

Contribution to Outcome

On completion of this course, the students will be able to:

1 Explain the concept of pre-stressing, its casting techniques and applications.

2 Describe difference between RCC and PSC elements and their behavior.

3 Estimate the loss of stresses in pre-stressing steel.

4 Analyze and design the pre-stressed concrete element using relevant IS Code.

Site Visit:

The learners shall visit a construction site of pre-stressed concrete and submit a report.

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Average of marks will be considered for IA.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Recommended Books/Code:

1. Prestressed Concrete*: N. Krishna Raju*, Tata McGraw-Hill Publishing Company Limited, New Delhi
2. Fundamentals of Prestressed Concrete: *N.C Sinha* and *S.K. Roy*, S. Chand Publishing
3. Prestressed Concrete: *N. Rajagopalan*, Narosa Publishing House
4. Prestressed Concrete Structures: *P. Dayaratnam*, Oxford and IBH Publishing Co. Pvt. Ltd.
5. Prestressed Concrete*: S. Ramamrutham*, Dhanpat Rai Publishing Company Pvt. Ltd, New Delhi
6. IS code: IS:1343-2012

Reference Books:

1. Design of Prestressed Concrete Structures: T. Y. Lin and N.H. Burns, Wiley India Pvt. Ltd.
2. Design of Prestressed Concrete: *Arthur H. Nilson*, Wiley

Semester VII

Course Code	Course Name	Credits
CEDLO7012	Department Level Optional Course-3: Applied Hydrology & Flood Control	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorials	Total
3	--	--	3	--	--	3

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	3 hrs	-	-	-	100

Rationale

This course deals with the various processes involved in hydrological cycle and provides in depth understanding of the theories and concepts of surface, subsurface and ground water hydrology. It focuses on types and forms of precipitations. It also explains the application of hydrographs, unit hydrographs and further describes various techniques of estimating stream flows. It further describes the various techniques of estimating streamline flows. It also describes the importance of floods, flood routing and ground water hydrology.

Objectives

1. To explain the various processes involved in the hydrological cycle.
2. To measure rainfall, computation of average rainfall, various water losses etc.
3. To differentiate the various stream flow measurement and its importance.
4. To interpret the hydrograph and unit hydrographs, applications of unit hydrograph concept.
5. To evaluate various flood control methods, estimate design flood, and flood routing
6. To describe the concepts of ground water movement, steady and unsteady flow towards fullypenetrating wells and well yields.

Detailed Syllabus

Module	Sub-Modules/ Contents	Hrs.
I	**1.1 Introduction:** Hydrological cycle, scope of hydrology, water budget equation, data sources.	8
	1.2 Precipitation: Measurement of precipitation, network of rain gauges and their adequacy in a catchment, methods of computing average rainfall, hyetograph and mass curve of rainfall, adjustment of missing data, station year method and double mass curve analysis, Depth-Area -Duration relationship, Intensity-Duration - Frequency relationship, Probable Maximum Precipitation.	
II	**2.1 Abstractions from Precipitation:** Evaporation and transpiration, evapo-transpiration, interception, depression storage, infiltration and infiltration indices, determination of water losses.	6
	2.2 Stream Flow Measurement: Measurement stream-flow by direct and indirect methods, measurement of stage and velocity, area-velocity method, stage-discharge relationships, current meter method, pitot tube method, slope-area method, rating curve method, dilution technique, electro-magnetic method, ultrasonic method.	
III	**3.1 Runoff:** Catchment, watershed and drainage basins, Factors affecting runoff, rainfall-runoff relationship, runoff estimation, droughts	6
IV	**4.1 Hydrograph Analysis:** Characteristics, base flow separation, unit hydrograph, S-hydrograph, complex hydrograph, synthetic hydrograph, dimensionless unit hydrograph, Instantaneous unit hydrograph.	7
V	**5.1 Floods:** Estimation, envelope curves, flood frequency studies, probability and stochastic methods, estimation of design flood, flood control methods, Limitations, risk-reliability and safety factor. Flood routing: Hydrologic and hydraulic routings.	6
VI	**6.1 Ground Water Hydrology**: Yield, transmissibility, Darcy's law, Dupuitt's theory of unconfined flow, steady flow towards fully penetrating wells (confined and unconfined). Unsteady flow towards wells: Jacob's curve and other methods, use of well Function, pumping tests for aquifer characteristics, methods of recharge.	6
	Total	**39**

Contribution to Outcomes

On completion of the course, the learners will be able to:

1. Explain hydrologic cycle and various methods of Measurement of rainfall.
2. Calculate optimum number of rain gauge stations for average rainfall and missing rainfall over catchment
3. Describe various methods of measurement of stream flow and to calculate abstraction losses over the catchment
4. Develop rainfall runoff relationship and calculating runoff over catchment
5. Perform hydrologic and hydraulic routing
6. Calculate the discharge of well for confined and unconfined aquifer

Internal Assessment **20 Marks**

Consisting of two Compulsory Class Tests – First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test). Average of marks will be considered for IA

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only four questions need to be solved in total

Recommended books:

1. Irrigation Engineering and Hydraulic Structures: S.K. Ukarande, Ane Books Pvt. Ltd. ISBN-978-93-83656-89-9
2. Irrigation and Water Power Engineering: B.C. Punmia, Pande B.B.Lal, A.K Jain. Laxmi Publications Pvt, Ltd. New Delhi

3. Irrigation Water Resources and Water Power Engineering: P.N. Modi, Standard Book House,Delhi, ISBN 978-81-87401-29-0.
4. Irrigation Engineering and Hydraulics Structures: S. K. Garg, Khanna Publishers. Delhi.
5. Engineering Hydrology: *K. Subramanya*, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
6. Hydrology: *H. M. Raghunath*, New Age International Publishers, New Delhi
7. Elementary Hydrology: *V. P. Singh*, Prentice Hall
8. Engineering Hydrology: Principles and practice*: V. M. Ponce*, Prentice Hall

Semester VII		
Course Code	**Name of the Course**	**Credits**
CEDLO7013	**Department Level Optional Course 3: Appraisal & Implementation of Infrastructure Projects**	**03**

Teaching Scheme						
Contact Hours			**Credits Assigned**			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
03	--	--	03	--	--	03

Evaluation Scheme								
Theory					**TW/ Pract/Oral**			**Total**
Internal Assessment			**End Sem Exam**	**Duration of End Sem Exam**	**TW**	**PR**	**OR**	
Test 1	**Test 2**	**Average**						
20	20	20	80	03 Hrs.	-	-	-	100

Rationale

For any Civil Engineering project, a range of alternative schemes meeting project goals are feasible. Thus to identify the most suitable out of it, project evaluation has to be carried out in terms of financial viability, environmental impact, utility to the society, engineering feasibility, profitability, etc. This course is intended to make students aware of this evaluation (appraisal) criterion for any Civil engineering project. Students will understand the importance of feasibility studies and get acquainted to the process of preparing a project report, both being crucial role players while deciding the viability of a project. The professional construction engineering practice will be rendered meaningful if students learn about ways to raise project funds, their effective planning and optimum utilisation. This course is devised to help students in understanding financial and economic aspects of a project.

Objectives

1. To know the procedure of feasibility studies for any infrastructure project.
2. To learn the procedure of appraisals required for deciding the worthiness of any project.
3. To learn the procedure of forecasting demand and know the uncertainties involved.
4. To know the components and importance of technical & managerial appraisal.
5. To get acquainted with decision making tools like Break even analysis, SWOT analysis etc.
6. To get acquainted with different methods of project finance and implementation.

Detailed Syllabus			
Module	**Sub-Modules/ Contents**		**Hrs**
I.	**Construction Projects and Report Preparation**		**03**
	1.1	Classification of construction projects. Project Formulation and phases involved in it.	
	1.2	Feasibility studies, SWOT analysis. Preparation of Project report.	
II.	**Project Appraisal**		**06**
	2.1	Importance and phases in a project development cycle for major infrastructure projects.	
	2.2	Importance of Appraisal, its need and steps involved in it.	
III.	**Market Appraisal**		**09**
	3.1	Importance and methods of carrying out demand analysis. Sources to gather project related information and ways to carry out market survey.	
	3.2	Methods to forecast demands. Uncertainties involved in demand forecasting.	
IV.	**Technical and Managerial Appraisal**		**06**
	4.1	Method to study the technical appraisal/viability of a project in terms of its location, type of land and intended use of building, technology requirements of the project, Size and complexity of tools and plants, raw materials to be used and their impact on the vicinity, energy requirements, water supply and disposal of effluents if any.	
	4.2	Study of managerial requirements of a project, Desirable organisational structure and hierarchy to manage as well as implement the project, Method of assessment of entrepreneurs.	
V.	**Financial analysis and Economic Appraisal**		**09**
	5.1	Various costs related to a project, Methods to determine the profitability of a project, Break even analysis.	
	5.2	Economic appraisal: Urgency, Payback period, Avg. Rate of return, Net Present Value, Internal rate of return, Benefit cost ratio, Cost of Capital etc.	
VI.	**Project Financing and Implementation**		**06**
	6.1	Types and Sources of finance in local, National and International context. Issues related to project financing.	
	6.2	Agencies involved in the implementation of a project. Methods of implementation like Built, operate and Transfer and its other variants like B.O.O, B.O.O.T, B.L.T, EPC ,etc.	
		Total	**39**

Contribution to Outcomes

On successful completion of the course, the learners will be able to:

1) **classify** the projects and **describe** the phases involved in project formulation.
2) **prepare** a detailed project report on the basis of various feasibility studies and SWOT analysis.
3) **devise** a project's development cycle and get acquainted with the different appraisals in the process of deciding the worthiness of a project.
4) **exhibit** and **apply** the managerial skills and knowledge of financial aspects required during the implementation of projects.
5) **identify** various sources for project finance.
6) **know** the various agencies involved in project implementation as well as **select** the method of project implementation which is best suited for a particular project.

Theory Examination:

- Question paper will comprise of **six** questions; each carrying 20 marks.
- The **first** question will be **compulsory** which will have the short questions having weightage of 4-5 marks covering the entire syllabus.
- The remaining **five** questions will be based on all the modules of entire syllabus. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module or contents thereof.
- There can be an **internal** choice in various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
- The students will have to attempt any **three** questions out of remaining five questions.
- Total **four** questions need to be attempted.

Recommended Books:

1) Project Preparation, Appraisal, Budgeting, and Implementation: Prasanna Chandra (Tata McGraw Hill).
2) Infrastructure Development & Financing in India - N. Mani (New Century Publications).
3) Infrastructure & economic development - Anu Kapil (Deep &Deep Publications).
4) Construction Management: Planning and finance - Cormican D.(Construction press, London).
5) Engineering Economics – Kumar (Wiley, India).
6) Real Estate, Finance and investment - Bruggeman.Fishr (McGraw Hill).
7) The cost management toolbox; A Managers guide to controlling costs and boosting profits. - Oliver, Lianabel (Tata McGraw Hill).

Semester- VII

Course Code	Course Name	Credits
CEDLO 7014	Department Level Optional Course 3: Analysis of Offshore Structures	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem. Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 hrs	--	--	--	100

Rationale

Offshore Engineering discipline deals with the design and construction of structures intended to work in the ocean environment. The majority of offshore structures are used in the Oil and Gas industry. offshore construction is the installation of structures and facilities in a marine environment. Civil Engineering graduates will be able to study analysis and design in the specialized field of ocean and coastal environment.

Objectives

The objectives of this course are

1. to explain the types and materials used in offshore structures.
2. to provide an understanding of the structural response of offshore structures based on both component and system
3. to address the general engineering analysis and design concepts of offshore structures

Detailed Syllabus		
Module	**Course Modules / Contents**	**Hrs.**
I	**Types of offshore structures** Types of offshore structures, planning and design aspects, Overview of functional, environmental and accidental loads for marine structures, with emphasis on wind - and wave induced loads.	**05**
II	**Materials and their behaviour** Hydrodynamic interaction, Effects and dynamic response, Materials and their behaviour under static and dynamic loads, allowable stresses, various design methods and codes, design consideration, design loads.	**06**
III	**Analysis of offshore structures** Basics of Hydrodynamics, Structural dynamics, Advanced structural analysis techniques, Statistics of extremes: Airy Wave Theory, Higher order wave theories, Irregular Sea States, Short- and long-term statistics of wind; static wind load, Aerodynamic admittance function and gust factor.	**06**
IV	**Estimation of wave forces** The Morison's equation, wave force, lift force on members, wave slam, maximum force and moments using linear theory, Vertical Piles, Horizontal Bracings, Diagonal Front Face Bracings, Diagonal Side Face Bracings, wave forces on large diameter members, Froude-Krylov Theory, Diffraction Theory, Drift force, Spectral and statistical analysis of wave forces.	**06**
V	**Vibrations** Mass-spring system, Free Vibrations with Damping, Forced Vibrations, Forced Damped Vibrations, Torsional Vibrations, Elements of single d.o.f. system, Dynamics of multi d.o.f. systems, Eigen values and vectors; Iterative and transformation methods; Mode superposition, Fourier series and spectral method of response of single d.o.f. systems, Vibration of bars, beams, Behavior of concrete gravity platform as a rigid body on soil as a continuum	**10**
VI	**Corrosion and allowances** Corrosion and other allowances, consideration of stress concentration, Ingredient materials and protective measure, Behavior of concrete gravity platform as a rigid body on soil as a continuum	**06**
	Total	**39**

Contribution to Outcome

Upon completion of the course, students shall have ability to:

1. Explain the types and materials used in offshore structures
2. Evaluate of the structural response of offshore structures based on both component and system.
3. Apply general engineering and design concepts to offshore structures
4. Apply Morison's equations to calculate wave force, lift force, etc.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests:**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Average of marks will be considered for IAE

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks.**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

Recommended Books:

1. Subrata K. Chakrabarti (2005): Handbook of offshore engineering Volume–I & II, Elsevier, The Boulevard Langford Lane, Kidlington, Oxford OX5 l GB, UK.
2. Deo M C (2013): Waves and Structures, http://www.civil.iitb.ac.in/~mcdeo/waves.html
3. American Petroleum Institute, Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Load and Resistance Factor Design, 1st Edition, 1993. (TP690.A642 RP2A-LRFD)
4. American Petroleum Institute, Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design, 21st ed., 2000. (TP690.A642 RP2A-WSD).
5. Brebbia C.A. and Walker, "Dynamic Analysis of offshore structures", Newness butterworth, London, 1978.
6. Sarpakaya T. and Isaacson M., "Mechanics of Wave Forces on Offshore Structures", Van Nostrand Rainhold, NewYork, 1981.

7. Hallam M.G., Heaf N.J. and Wootton, L.R., "Dynamics of Marine Structures", CIRIA Publicartions, Underwater Engg. Group, London, 1978.
8. Graff W.J., "Introduction to Offshore Structures", Gulf Publishing Co., Houston, Texas, 1981.
9. Clough R.W. and Penzien J., "Dynamics of Structures", IInd Edition, McGraw hill, 1992.
10. Simiu E. and Scanlan R.H., “wind effects on Structures", Wiley,New York, 1978.
11. Codes of Practices (latest versions) such as API R-2A, bureau Veritas etc.
12. Rules for the design, construction and inspection of fixed offshore structures, 1977. Defnorske Veritas
13. Energy Department, U.K., Guidance of Design and Construction of Offshore Installation, 1974.
14. O.C. Zienkiewicz, R., Wlewis and K.G. Stagg, Numerical Methods in Offshore Engineering, Wiley Interscience Publication, 1978.

Semester VII

Course Code	Course Name	Credits
CEDLO7015	Department Level Optional Course-3 Advanced Construction Technology	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	--	--	--	100

Rationale

In today's times the construction activities are undergoing lots of changes/developments due to internal and globalized market demands of quality and faster completion of project works using modern techniques, use of modern and waste materials, and through mechanized construction. Today, we require high-capacity machines with better output and greater efficiency to make construction process less stressful. This course has been designed so that civil engineers would be able to use advanced construction technology. Student will be introduced to some emerging technologies in the field of Civil engineering which will make them more industry ready.

Objectives

1. To study and understand the latest construction techniques applied to engineering construction for sub structure.
2. To summarize the students about various techniques of super structure construction.
3. To give an experience in the implementation of new technology concepts which are applied in field of advanced construction in special structures.
4. To know the different methods of some advanced construction techniques and ground improvement techniques.
5. To present the new technology related to dredging system and its concepts related advanced construction technology.
6. To study different methods of rehabilitation and strengthening in construction to successfully achieve the structural design.

Detailed Syllabus			
Module	**Sub-Modules/ Contents**		**Hrs.**
I	**Sub Structure Construction**		06
	1.1	Box jacking, Pipe jacking, Underwater drilling, blasting, and concreting. Underwater construction of diaphragm walls and basement	
	1.2	Driving well and caisson, sinking cofferdam, cable anchoring, and grouting. Driving diaphragm walls, sheet piles	
	1.3	Laying operations for built-up offshore system, Shoring for deep cutting, large reservoir construction, and well points. Dewatering for underground open excavation.	
II	**Super Structure Construction for building**		06
	2.1	Vacuum dewatering of concrete flooring, Concrete paving technology	
	2.2	Techniques of construction for continuous concreting operation in tall buildings of various shapes and varying sections, Erection techniques of tall structures, large span structures, launching techniques for heavy decks, in-situ prestressing in high rise structures, post-tensioning of the slab, aerial transporting, Handling, and erecting lightweight components on tall structures	
III	**Construction of Special Structures**		06
	3.1	Erection of lattice towers - Rigging of transmission line structures, Construction sequence in cooling towers, Silos, chimneys, skyscrapers. Construction sequence and methods in domes, Support structure for heavy equipment and machinery in heavy industries, Erection of articulated structures and space decks.	
	3.2	Roof truss: erection problems Building / Industrial component, Equipment and tackles used for erecting these. Plate girder Launching a portion of bridge girder, large span lattice girder. Erection of chimney**,** Erection of overhead tank.	
IV	**Advancement in Construction techniques**		08
	4.1	Building construction techniques: Zero energy building, green building, pre-engineering building, Solar Paints, Building Integrated Photovoltaic (BIPV), Earthquake Resisting Controls-Isolation and Dissipation.	
	4.2	Coastal construction techniques: Sound Proofing walls, water-resistant roofs, high-performance doors and windows, air and moisture barriers.	
	4.3	Road construction techniques: 3D Printing, Road Printer, smart roads	
	4.4	Ground improvement techniques: Advanced piling techniques - Stone Column, Vibro Floatation, Grouting, Geotextile application, Micro Piles, and Soil Nailing. Vertical drains-Sand Drains, Pre-Fabricated Vertical Drains. Thermal Methods- soil heating and soil freezing.	
V	**Dredging**		06
	5.1	Dredging System, Mechanism, Hydraulic dredger in waves, dredging equipment, Water & Booster System, dredging in the navigation system, Agitation dredging system, silt dredging system, water injection system, Pneumatic dredging system, Amphibious & scrapper dredging system.	

	5.2	Advantages & Disadvantages of Various Dredging Systems, Production Cycle for Dredgers, Application, Capacity of dredgers, & its economical use, dredging economics	
VI	**Rehabilitation and Strengthening Techniques**		07
	6.1	Seismic retrofitting, strengthening of beams, strengthening of columns, strengthening of the slab, strengthening of a masonry wall, Protection methods of structures, Mud jacking and grouting for foundation, Micro piling and underpinning for strengthening floor and shallow profile, Subgrade waterproofing, Soil Stabilization techniques	
	6.2	Repair of steel structures, bridge, building, towers etc., monuments and historical structures. Prevention of water leakage in structures; Underwater repair; Durability of repairing material. Maintenance of underground railways.	
		Total	39

Contribution to Outcome

On completion of this course, the students will be able to:

1. Evaluate the procedure of construction techniques for sub structure of major civil engineering projects.
2. Get a thorough knowledge of various stages of construction of super structure of major civil engineering projects.
3. Gain an experience in the implementation of new construction technology on engineering concepts which are applied in field Advanced construction technology in special structures.
4. Get a diverse knowledge of the different methods of advancement in construction techniques and ground improvement techniques.
5. Learn various dredging systems for major civil engineering projects.
6. Explain the theoretical and practical aspects of rehabilitation and strengthening techniques in civil engineering along with the design and management applications.

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in first test)

Average of marks will be considered for IA.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Roy Chudley and Roger Greeno , Construction Technology , Prentice Hall, 2005.

2 Dr. B.C. Punamia (2008); “Building Construction” Laxmi Publications (P) Ltd.ISBN13: 978-8131804285. 666p.

3 S. S. Bhavekatti (2012); “Building Construction” Vikas Publishing House Pvt Ltd. ISBN-13: 978-9325960794. 356p.

4 Peter. H. Emmons, “Concrete repair and maintenance illustrated”, Galgotia Publications Pvt. Ltd., 2001.

5 S. P. Arora and S. P. Bindra (2010); “Textbook of Building Construction”, Dhanpat Rai & Sons publication, ISBN-13: 978-8189928803. 688p

6 Sushil Kumar (2010); “Building Construction” Standard Publishes-Distributors. ISBN-13: 978-8180141683. 796p.

7 S.C. Rangwala, Building Construction, Charotar Publication Pvt Ltd. Anand

Reference Books:

1 Sankar, S.K. and Saraswati, S., Construction Technology, Oxford University Press, New Delhi, 2008.

2 Peurifoy, Construction Planning, Equipment and methods –-Tata McGraw Hill Publication

3 Mahesh Varma , Construction Equipment Planning and Applications –

4 R. Chudley (revised by R. Greeno), Building Construction Handbook, Addison Wesley, Longman Group, England, 3rd ed.

5 S.S. Ataev, Construction Technology, Mir Publishers, Moscow

6 Robertwade Brown, "Practical foundation engineering hand book", McGraw Hill Publications.

7 Patrick Powers. J., Construction Dewatering: New Methods and Applications, John Wiley & Sons

8 Jerry Irvine, Advanced Construction Techniques, CA Rocketr

Semester VII

Course Code	Course Name	Credits
CEDLO7016	Department Level Optional Course-3: Pavement Materials, Construction and Maintenance	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Rationale

Highway and airways mode of transportation contributes to the economical, industrial, social and cultural development of any country. For the design and construction of highway and airfield, it is imperative to know the properties of the materials such as soil, aggregates and bitumen used in the construction of pavements. The various tests are required to be conducted to evaluate the properties of these materials for the scientific design of the pavements and economic utilization of the different materials. The course also deals with the soil survey, stresses in soil and various ways and means of improving the soil and implementing techniques of improvement. The course also deals with the various surface and sub-surface drainage.

Objectives

1. To give the students hands on experience on various material properties and testing procedures of pavement materials as per IRC standards. To study the soil classification for highway engineering purpose as per different classification system.
2. To understand the concept of stresses in soil. To enable the student to identify the basic deficiencies of various soil deposits and to arrive upon the various ways and means of improving the soil and implementing the techniques of improvement.
3. To understand the requirements of aggregates as per IRC code.
4. To learn bituminous types and mix designs.
5. To understand the different types of distresses in pavement, evaluation of the existing pavements using different methods and rehabilitation of the distressed pavements. To study the construction of the concrete roads and low volume roads
6. To learn basic principles of super pave technology of bituminous mixes

Detailed Syllabus			
Module	**Sub-Modules/ Contents**		**Hrs.**
I	Soil		05
	1.1	Soil-Classification methods	
	1.2	Tests on Soil: CBR test, effect of lateral confinement on CBR and E value of Subgrade soil, Consistency, Engineering Properties and Modulus of sub-grade reaction of soil, estimation of modulus of subgrade reaction, Static and cyclic plate load test, correction for plate size, correction for worst moisture content.	
	1.3	Soil classification as per HRB.	
II	Stresses in Soil		08
	2.1	Theories of elastic and plastic behavior of soils, Cyclic triaxial test on subgrade soils, resilient deformation, resilient strain, resilient modulus.	
	2.2	Stabilized Soils: Method of sampling and Preparation of Stabilized Soils for testing, Relation for Moisture content and Dry Density of Stabilized mixes, UCS of Stabilized soil, test for: soil bituminous, soil lime and soil fly ash mixes. (IRC: SP:89 (Part II)-2018)	
III	Aggregates		04
	3.1	Classification, requirements, Blending of aggregates, Importance of aggregate shape factor in mix design	
	3.2	Grading requirements for aggregate, selection of bases and sub-base material (including stabilized materials),	
IV	Bitumen, Tar and Bituminous Mix Design		09
	4.1	Binders: Requirements, criteria for selection of different binders, Temperature susceptibility, Bituminous emulsion and Cutbacks, fillers, extenders Polymers, Crum rubber, and rubber modified bitumen and anti-Stripping agents on pavement performance.	
	4.2	Bituminous Mix Design: selection of different grade of bitumen, skid qualities, types of bituminous surfaces, bituminous mix design, Marshall Stability test, design aspect of paving concrete. Experimental characteristics of road aggregate.	
V	Evaluation and strengthening		09
	5.1	Flexible and rigid pavement distresses, condition and evaluation surveys, present serviceability index, roughness measurement, Benkelman beam deflections, skid resistance and measurement	
	5.2	Highway construction: Construction of WBM roads, Bituminous pavements, cement concrete roads, Reinforced concrete pavements construction.	
	5.3	Quality control (QC) and Quality assurance (QA) during construction of various pavements.	
	5.4	Low-Cost Roads (Rural Areas) (IRC-SP-20-2002) Classification of low-cost roads, construction of low-cost roads.	

VI	Introduction to Super pave Technology		04
	6.1	Methods of selection of suitable ingredient for super pave method, Gyratory compaction, rolling thin film oven, pressure aging vessel, rotational viscometer, dynamic shear rheometer, bending beam rheometer, direct tension test.	
	6.2	Use of super pave perform and grade binder specifications. Comparison between Marshal Mix method and Super pave method.	

Contribution to Outcome

On completion of this course, the students will be able to:

1 Explain the soil classification in accordance with various soil classify the system and evaluate the ability of the soil as a subgrade material in terms of standard engineering parameters.

2 Describe the stress distribution in subgrade soil and the various ground improvement methods.

3 Evaluate the requirements and desirable properties of the aggregate to be used in the construction of pavements.

4 Compare the characterization of different surface paving (Bitumen) materials as per IRC code.

5 Explain the various causes leading to failure of pavement and remedies for the same and the construction of the concrete roads and low volume roads

6 Apply basic principles of mix design of cement concrete and bituminous mixes.

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I) Average of marks will be considered for IA.

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Highway Engineering: *Khanna, S.K., Justo, C,E.G. and Veeraragavan, A.*,Nem Chand and Brothers, Roorkee (10th Revised Edition, 2014)

2 Principles and Practices of Highway Engineering; *Dr. L. R. Kadiyali and Dr. N. B.Lal*, Khanna Publishers, New Delhi.

3 Highway Engineering, *Sharma, S.K.,* S. Chand Technical Publishers, New Delhi (3rd Revised Edition, 2013).

4 Principles of Transportation and Highway Engineering: *Rao, G.V.,* Tata Mc-Graw Hill Publications, New Delhi

Reference Books:

1 Principles of Pavement Design, Second Edition, 1975: *Yoder, E.J.*, John Wiley and Sons, Inc., New York.

2 Concrete Roads: *HMSO*, Road Research Laboratory, London.

Semester VII

Course Code	Course Name	Credits
CEDLO7021	Department Level Optional Course-4 Foundation Analysis and Design	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Practical	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hrs.	--	--	--	100

Rationale

Foundation design is an important aspect of the vast field of civil engineering in general and geotechnical engineering in particular. A foundation designer has many diverse and important encounters with foundation design problems. The knowledge of foundation design is essential in design problems related to buildings, bridges, highways. tunnels, canals, or dams. The suitability of various types of foundations i.e. shallow foundation, pile foundation, well foundation etc. depends upon the bearing capacity of the soil, the pattern of stress distribution in the soil beneath the loaded area, the probable settlement of the foundation, effect of ground water, effect of vibrations, the magnitude of loads and ground water conditions etc. This course provides some important geotechnical aspects of the analysis and design of foundations.

Objectives

1 To estimate the vertical stresses in soil and to study the various practical applications.

2 To understand the design concepts for shallow foundations including strip and raft foundations and to understand applications of geocells.

3 To study the load carrying capacity and design of pile foundation.

4 To understand different types of well foundations and concept of floating foundations.

5 To analyze cantilever sheet piles including anchored sheet piles and to understand braced cuts system

6 To learn different types of machine foundations and understand the design philosophy.

Detailed Syllabus

Module	Sub-Modules/ Contents		Hrs.
I	**Estimation of Stresses in Soils**		04
	1.1	Boussinesque and Westergaard's theories	
	1.2	Newmark Chart	
	1.3	Practical applications.	
II	**Shallow Foundation**		06
	2.1	Determination of bearing capacity of shallow foundation by IS Code method	
	2.2	Settlement analysis of shallow foundation by IS code method	
	2.3	Geotechnical design of shallow foundation on rock and weathered rock	
	2.4	Geotechnical design of raft foundation.	
	2.5	Improvement in the bearing capacity of footings using geocells	
III	**Pile Foundation**		07
	3.1	Introduction, necessity of piles, types of pile foundations.	
	3.2	Load carrying capacity of single and group piles	
	3.3	Pile load test as per IS 2911 (Part I & Part II)	
	3.4	Geotechnical Design of single pile and pile cap as per IS 2911 and IRC 78	
IV	**Floating Foundation and Well Foundation**		06
	4.1	Introduction to floating foundation, floatation, bottom elastic heave	
	4.2	Design of floating foundation on piles	
	4.3	Introduction to well foundation, forces acting on well foundation.	
V	**Sheet piles and Braced cuts**		08
	5.1	Cantilever sheet piles including anchored sheet piles in cohesionless and cohesive soils, lateral earth pressure diagram, computation of embedment depth	
	5.2	Difference in open cut and retaining wall theories, apparent earth pressure diagram	
	5.3	Design of reinforced soil retaining walls	
	5.4	Estimation of strut loads in braced cuts placed in cohesionless and cohesive soils.	
VI	**Machine Foundations**		08
	6.1	Introduction, Dynamic soil properties as per IS 5249	
	6.2	Types of machine vibrations	
	6.3	Basic principles of machines foundation	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1. Analyze vertical stress condition in soils.
2. Design a suitable foundation system.
3. Evaluate the safe allowable bearing capacity of shallow foundation and load carrying capacity of pile foundation under different soil conditions.
4. Explain concept of floating foundation.
5. Design different types of sheet piles.
6. Explain basic principles of machines foundation.

Internal Assessment 20 marks.

Consisting of Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Average of marks will be considered for IA.

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1. Terzaghi K. and Peck R. B., "Soil Mechanics in Engineering Practice", Wiley and Sons, 1996.
2. Alamsingh, "Soil Mechanics and Foundation Engineering", Vol I & Vol II, Standard book House, 2013.
3. Holtz, R.D. & Kovacs, W.D., "An introduction to geotechnical engineering", Prentice Hall, 1981.
4. Taylor D.W., "Fundamentals of soil mechanics, Asia publications Bombay, 1967.
5. Das B. M., "Shallow Foundation- Bearing Capacity & Settlement" Taylor & Francis, 2009.
6. Das B. M., "Principles of Foundation engineering", PWS Publishing Company, 2012.
7. Winterkorn H. and Fang F. Y., "Foundation Engineering Handbook", CBS Publishers & Distributors, New Delhi, 1990.
8. Robert M. Koerner, "Design with Geosynthetics", Pearson Prentice Hall, 2005.
9. G.V. Rao & G.V.S.S. Raju, "Engineering With Geosynthetics", Tata McGraw-Hill Pub Co Ltd, 1990.

Reference Books:

1. Bowles J. E., Foundation Analysis and Design, McGraw-Hill Book Co, 2001.
2. Shamsher P. and Sharma H., Pile Foundations in Engineering Practice, Wiley and Sons, 1990.
3. Ranjan, Gopal & Rao, A.S.R., "Basic and applied soil mechanics", New Age International Pvt. Ltd., 2004
4. Kramer S. L. Geotechnical Earthquake Engineering, Prentice Hall, 1996
5. Swami Saran, Soil Dynamics and Machine Foundation (2nd Ed,), Galgotia Publication Pvt Ltd.
6. Duncan C. Wyllie, "Foundations on Rock" CRC Press; 2nd edition 2019.
7. N.V. Nayak, "Foundation Design Manual" Dhanpat Rai Publications, 2018.

Semester VII

Course Code	Course Name	Credits
CEDLO7022	Department Optional Course-4 Solid and Hazardous Waste Management	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Rationale

Management of solid and Hazardous waste is a challenge for all developed and developing nations. Measures like proper collection, segregation, treatment, and solid waste disposal needs more attention in today's world. To achieve sustainable development proper solid waste management should be subjected to various types of waste treatments for obtaining value added products. Robust implementation of planned facilities for reuse, recycling, maximum resource recovery from various waste facilities, combined with safe residual waste disposal through sanitary landfills, incineration and novel methods of composting is initiated.

Objectives

1. To describe functional elements of solid waste management and its need.
2. To explain the segregation and transportation of municipal solid waste.
3. To recognize waste disposal methods and energy recovery techniques.
4. To comprehend the necessary knowledge and concepts of landfill for disposal.
5. To demonstrate hazardous waste management through its safe handling and disposal.
6. To identify assorted types of solid waste.

Detailed Syllabus

Module	Sub-Modules/ Contents		Hrs.
I	**Municipal Solid Waste Management**		06
	1.1	Sources, Types, Quantities, Composition, sampling of wastes, Properties of wastes, Numericals related to moisture content, density and Energy content, Problems and issues of solid waste management - Need for solid waste management- Awareness programme, Legal issues related to solid waste disposal	
	1.2	Functional Elements of SWM- waste generation (factors affecting), storage, collection, transfer and transport, processing, recovery and disposal in the management of solid waste.7R concept	
II	**Waste Segregation, Storage, Collection and Transport**		06
	2.1	Segregation - wet and dry method, Volume reduction at source, Recycling and Reuse of waste, Methods of collection - House to House collection, On site storage of municipal solid waste, Hauled container and stationary container system, Collection routes; Optimization of transportation routes, Numericals on container and collection systems.	
	2.2	Transfer station -Significance, Site selection, Types, Material Recovery facility	
III	**Waste processing techniques and Energy Recovery**		06
	3.1	Waste transformation- Biological and Thermal Biological Conversion Technologies – Composting, Factors affecting for composting, Various Composting Methods as Indore and Bangalore, Vermi, Mechanical and In vessel composting, Numericals on aerobic and anaerobic composting	
	3.2	Thermal conversion technologies – Incineration, Pyrolysis, Gasification, Refuse derived fuel	
IV	**Landfills for Disposal of Waste**		07
	4.1	Landfill Classification-Sanitary, Secure and Bioreactor, Design criteria for landfill site selection, operation and maintenance, Landfill methods -Trench, Area, Slope	
	4.2	Leachate generation, Characteristics and it's control methods. Landfill gas management and landfill closure	
	4.3	IoT in solid waste management	
V	**Hazardous Waste Management**		07
	5.1	Sources, Characteristics and classification of hazardous wastes, Storage, Handling, Collection, Transportation and Minimization, Need for Hazardous Waste Management	

	5.2	Treatment and Disposal Hazardous Site remediation – onsite and offsite Techniques. Hazardous waste management using secure landfill, Disposal practices in Indian Industries, Hazardous Waste Management Rules 2016.	
VI	**Assorted Solid Wastes**		
	6.1	**Biomedical waste** Need for Biomedical Waste Management, Sources, Classification, Storage and Segregation- Color coding, Collection and Transportation, Treatment and Disposal. Latest Biomedical waste management rules. **Electronic Waste** Types, Component separation, Collection, Recycling and Recovery, E-waste management techniques and Latest E- waste management rules	07
	6.2	**Plastic Waste** Problems related to plastic wastes, Plastic waste management- Recycling & recovery, Energy production, Plastic waste management- Rules and Regulation **Construction and Demolition waste** Composition, Recycling and reduction, Proper Management	

Contribution to Outcome

After the completion of the course the learner should be able to:

1. Acquire the knowledge of functional elements of solid waste management.
2. Illustrate solid waste collection system, route optimization techniques, transfer station and processing of solid waste.
3. Develop the ability to plan waste minimization and processing of solid waste.
4. Explain approaches to treat the solid waste in the most effective manner for sustainable development.
5. Discuss safe methods of handling, management and disposal of hazardous waste.
6. Summarize waste management techniques used for assorted solid waste

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Average of marks will be considered for IA.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1. Integrated Solid Waste Management: Techobanglous, Thisen and Vigil, McGraw Hill International.
2. Hazardous Waste Management: Lagrega, Buckingham and Evans, McGraw Hill International.
3. Solid Waste Management in Developing Countries: A.D. Bhide, Nagpur publications.
4. Environmental Pollution Control Engineering: C.S. Rao, Wiley Eastern, Manual of solid waste of management, CPHEEO.
5. E-Waste: Implications, Regulations, and Management in India and Current Global Best Practices, Rakesh Johri, The Energy and Resources Institute.
6. Biomedical Waste Management in India: Jugal Kishore and G. K. Ingle, Century Publications
7. Advances in Construction and Demolition Waste Recycling Management, Processing and Environmental Assessment, Fernando Pacheco-Torgal, Yining Ding, Francesco Colangelo, Rabin Tuladhar, Alexander Koutamanis.
8. Plastics Waste Management, Disposal Recycling and reuse, Marcel Dekker, Inc. New York, 1993- Nabil Mustafa.
9. CPHEEO, “Manual on Municipal Solid Waste Management” Central Public Health and Environmental Engineering Organization, Government of India, New Delhi , 2000.
10. MSW Rules 2016,” Swachh Bharat Mission and Smart Cities Program of India.
11. Hazardous and other Wastes Management Rules,2016

Semester VII

Course Code	Course Name	Credits
CEDLO7023	Department Level Optional Course-4: Ground Improvement Techniques	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorials	Total
03	--	--	03	--	--	03

Theory					Term Work/ Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test 1	Test 2	Average						
20	20	20	80	3 Hrs.	--	--	--	100

Rationale

A geotechnical engineer often needs to design new structures or repair the structures on or in problematic soils in engineering practices. The types of soil at construction sites are not always totally favorable for supporting civil engineering structure such as buildings, bridges, highways, tunnels, retaining walls, dams, offshore structures and many more. Soil needs to be treated using ground improvement techniques to enhance the soil strength. Specific types of soil improvement techniques are required for different problematic soils and situations, such as expansive and collapsible soils, liquefiable soils, karst deposits, foundation on dumps and sanitary landfills, earthquake prone areas, etc. This course will deal with different ground improvement techniques, their principles, effectiveness, design issues and areas of applications.

Objectives

- To enable students to identify problematic soils, associated issues and need for ground improvement.
- To make the students understand shallow and deep compaction techniques, importance of pre-compression and vertical drains.
- To make the students understand different soil stabilization techniques.
- To make the students learn the concepts, purpose and effects of grouting.
- To make the students understand application of stone column technique.
- To provide students the concept of reinforced earth, soil nailing and ground anchors.

Detailed Syllabus

Module	Sub-Modules/ Contents	Hrs.
I	**Introduction**	07
	Different types of problematic soils and concerns (inadequate mechanical properties, swelling and shrinkage - expansive soils, collapsible soils, marshy and soft soils, organic/ peaty soils, loose sandy or gravelly deposits, liquefiable soils, karst deposits, foundation on dumps and sanitary landfills, old mine pits, etc.); Need for ground improvement; Control of ground improvement works; Ground improvement techniques for different soil types (principles, applicability to various soil conditions, material requirements, equipments required, results likely to be achieved and limitations); Grain size ranges for different treatment methods; Classification of ground modification techniques; Factors affecting the selection of ground improvement techniques; Benefits/objectives of ground improvement techniques, Emerging trends in ground improvement techniques (Types and brief discussion on constructive use of waste materials, low cost technologies with soil and additives, Geosynthetics, biotechnical stabilization, etc.) **Note:** Refer IS 13094 (1992): "Selection of ground improvement techniques for foundation in weak soils – Guidelines"	
II	**Compaction and Consolidation**	07
	Shallow compaction: laboratory and field methods of compaction, compaction curve, advantages of compaction, effect of compaction; Deep compaction: objectives, brief discussion on dynamic compaction (types of dynamic compaction, evaluation of improvement), dynamic consolidation, dynamic replacement, Vibro-compaction or, Vibro-floatation, Vibro replacement, blasting; Precompression and vertical drains: Precompression or preloading (principle, settlement without and with Precompression), accelerated consolidation by sand drains, free strain and equal strain cases, design of sand drain layout; Brief discussion on prefabricated vertical drains (PVDs), advantages of PVDs over sand drains	
III	**Stabilization of Soil**	05
	Methods of stabilization; mechanical stabilization; lime, cement, fly-ash, bitumen, chemicals and polymer stabilization; Electrokinetic stabilization	

IV	**Grouting**	**06**
	Grouting technology, grout materials, choice of a grout material, classification, general relationship between permeability and groutability; Particulate grouts: characteristics of grout materials, characteristics of grout slurries; Non-particulate grouts: types of chemical grouts, salient features of chemical grouts, grout properties (mechanical properties, chemical properties, economic factors), penetrability and performance aspect of coarse and fine grouts, limits of groutability based on grain size distribution; Various applications of grouting. **Note:** Refer IS 14343:1996 "Choice of Grouting Materials for Alluvial Grouting – Guidelines"	
V	**Stone Columns**	**07**
	Some important features of stone column treatment: influence of soil type, influence of construction methodology, treatment depth, area of treatment; Basic design parameters: stone column diameter, pattern, spacing, equivalent diameter, replacement ratio, stress concentration factor; Failure mechanisms; Design considerations; Estimation of load capacity of a stone column (unit cell concept); Settlement analysis by the reduced stress method; Granular blanket; Field loading tests; Installation techniques of stone columns: non-displacement method, displacement method, vibro-replacement method; Vibrofloat and rammed stone columns; Methods of improving the effectiveness of stone column **Note:** Refer IS 15284-1 (2003): "Design and construction for ground improvement - Guidelines, Part 1: Stone columns"	
VI	**Reinforced Earth and Anchors**	**07**
	Theory of reinforced earth concept; Design principles of reinforced earth through Mohr circle analysis; Necessity of reinforced earth; Materials; Introduction to Geosynthetics: scope and definitions, multiple functions of Geosynthetics (Separation, Filtration, Drainage, Reinforcement, Protection (Cushion), Barrier/Containment/Waterproofing, Erosion Control), areas of applications; Introduction to soil nailing and ground anchors; Capacity of shallow horizontal strip anchor by using Mononobe-Okabe method.	
Total		**39**

Contribution to Outcome

After successful completion of the course, students will be able to:

1. Identify the problems associated with the existing ground conditions and recognize the need for ground improvement.
2. Explain shallow and deep compaction techniques, pre-compression and vertical drains as well as estimate maximum dry density and consolidation settlement.
3. Evaluate soil stabilization and select the effective soil stabilization technique.
4. Apply knowledge of grouting as per IS 14343:1996.
5. Design stone column as per IS 15284-1 (2003).
6. Describe reinforced earth mechanism, multiple functions of Geosynthetics and evaluate capacity of anchors.

Theory examination:

1. The question paper will comprise of **six** questions; each carrying 20 marks.
2. The first question will be **compulsory** and will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The remaining five questions will be based on all the modules of the entire syllabus. For this, the modules shall be divided proportionately and further, the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. The students will have to attempt any **three** questions out of remaining five questions.
5. Total four questions need to be attempted.

Recommended Books:

1. P. P. Raj (2016). “Ground Improvement Techniques”, Second edition, Laxmi Publications (P) LTD.
2. M. R. Hausmann (1990). “Engineering Principles of Ground Modification”, McGraw-Hill Inc.,US.
3. IS15284 (Part 1): Design and Construction for Ground Improvement–Guidelines: (Stone Column), Bureau of Indian Standards, New Delhi, (2003).
4. Nihar Ranjan Patra (2012). “Ground Improvement Techniques”, Vikas Publishing.
5. S. L. Kramer (2013). “Geotechnical Earthquake Engineering”, Pearson.
6. B. M. Das (1990). “Earth Anchors”, Elsevier.

Reference Books and IS Codes:

1. IS 13094 (1992): "Selection of ground improvement techniques for foundation in weak soils – Guidelines"
2. IS 14343:1996 "Choice of Grouting Materials for Alluvial Grouting – Guidelines"
3. IS 15284-1 (2003): "Design and construction for ground improvement - Guidelines, Part 1: Stone columns"
4. R.M. Koerner (1984). "Constructional and Geotechnical Methods in Foundation Engineering (McGraw-Hill series in construction engineering and project management), McGraw-Hill Inc.,US.
5. FHWA Report No. Rd 83/026, (1983) Design and Construction of Stone Columns, Vol I.
6. B. M. Das (2011). "Principles of Foundation Engineering", 7th edition, Cengage Learning.
7. R.M.Koerner (1999). "Designing with Geosynthetics", 4th Edition, Prentice Hall, Jersey.

Semester – VII								
Course Code			**Course Name**					**Credits**
CEDLO7024			**Department Level Optional Course-4: Green Building Constructions**					**03**
Contact Hours			**Credits Assigned**					
Theory	**Practical**	**Tutorial**	**Theory**		**Practical**		**Tutorial**	**Total**
03	--	--	03		--		--	03
Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			**End Sem Exam**	**Duration of End Sem Exam**	**TW**	**PR**	**OR**	
Test–I	**Test–II**	**Average**						
20	20	20	80	3 hours	--	--	--	100

Rationale

Globally, buildings are responsible for a huge share of energy, electricity, water and materials consumption. As of 2018, buildings account for 28% of global emissions or 9.7 billion tonnes of CO_2. The United Nations' 2020 global status report and other sources detail that around 35 - 40% of globally generated energy was used by buildings; which also contributed to 33% of worldwide emissions. If new technologies in construction are not adopted during this time of rapid growth, emissions could double by 2050, according to the United Nations Environment Program. Green building construction practices aim to reduce the environmental impact of building as the building sector has the greatest potential to deliver significant cuts in emissions at little or no cost. As civil engineering graduates, it is of utmost importance to have a deep understanding of the concepts and technologies involved in the sustainable development with respect to the construction industry. It is also further desirable for the graduates to have an in-depth knowledge of the green rating systems as well as green auditing & green retrofitting – which will have tremendous scope in the future.

Objectives

1. To outline the environmental impact of buildings
2. To explain the concepts of sustainable development and green building
3. To summarize the features of green buildings
4. To explain green building rating systems
5. To describe green audit
6. To explain green retrofitting

Detailed Syllabus			
Module	**Sub-Modules/ Contents**		**Hrs.**
I	**Introduction**		**3**
	1.1.	Environmental impact of buildings, concept of sustainable development, concept of green buildings, necessity of green buildings, benefits of green buildings	
	1.2.	Overview of features of green building – design and construction efficiency, water efficiency, energy efficiency, materials efficiency, indoor environmental quality, waste reduction, operations and maintenance	
	1.3.	Examples of green buildings	
II	**Site Selection, Planning and Design**		**8**
	2.1.	Site preservation	
	2.2.	Passive architecture	
	2.3.	Soil erosion control	
	2.4.	Natural topography and on-site vegetation	
	2.5.	Preservation of transportation of trees on-site	
	2.6.	Heat island reduction	
	2.7.	Optimization in structural design	
	2.8.	Innovation in design process	
III	**Water Conservation and Energy Efficiency**		**10**
	3.1.	Rainwater harvesting	
	3.2.	Water efficient plumbing fixtures	
	3.3.	Irrigation systems	
	3.4.	Wastewater treatment and reuse	
	3.5.	Water metering	
	3.6.	Wastewater reuse during construction	
	3.7.	Minimum and enhanced energy efficiency	
	3.8.	Commissioning plan for building equipment and systems and post-installation	
	3.9.	On-site and off-site renewable energy	
	3.10	Energy Metering and Management	
IV	**Green building materials and indoor environmental quality**		**10**
	4.1.	Sustainable building materials	
	4.2.	Use of certified green building materials, products & equipment	
	4.3.	Segregation of waste, organic waste management and handling of waste materials	
	4.4.	Fresh air ventilation	
	4.5.	CO_2 monitoring	
	4.6.	Day lighting	
	4.7.	Minimizing of indoor and outdoor pollutants	
	4.8.	Low-emitting materials	
	4.9.	Occupant well-being facilities	
	4.10	Indoor air quality testing, after construction and before occupancy	

	4.11	Indoor air quality management	
V	**Green building rating systems**		**4**
	5.1.	Introduction to green building rating systems	
	5.2.	Overview of various green building rating systems	
	5.3.	Indian Green Building Council (IGBC) rating system – overview, benefits of new green buildings, overview of certification process and project checklist	
VI	**Green audit and green retrofitting**		**4**
	6.1.	Green audit: pre-audit, on-site audit and post-audit report	
	6.2.	Case study of any one green building audit	
	6.3.	Green retrofit – overview, components of green retrofit: integrated design, occupant behaviour, lighting retrofits, HVAC retrofits, window retrofits, green roof retrofits	

Contribution to Outcomes

On completion of this course, students will be able to:

1. Explain environmental impact of buildings, discuss the concepts of sustainable development & green buildings and overview the features of green buildings
2. Describe site selection, planning and designing of green buildings
3. Explain water conservation and energy efficiency in green buildings
4. Identify green building materials and indoor environmental quality
5. Apply green building rating systems
6. Describe green audit and green retrofitting

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only four questions need to be solved.

Recommended Books:

1. Green Building: Principles and Practices by Dr. Adv. Harshul Savla (Notion Press)
2. The Idea of Green Building by A. K. Jain (Khanna Publishers)
3. Green Building Guidance: The Ultimate Guide for IGBC Accredited Professional Examination by Karthik Karuppu (Notion Press)
4. Green Building Materials & Implementation by Dr. V. Murugesh (Notion Press)
5. Green Building Fundamentals by G. Harihara Iyer (Notion Press)

Reference Books/Links:

1. Indian Green Building Council (IGBC) web-site: https://igbc.in/igbc/
2. Leadership in Energy & Environmental Design (LEED) web-site: https://www.usgbc.org/leed
3. Green Building: Principles & Practices in Residential Construction by Abe Kruger and Carl Seville (Delmar Cengage Learning)
4. Green Building through Integrated Design by Jerry Yudelson (McGraw Hill)
5. Green Building Handbook: Volume 1: A Gude to Building Products and their Impact on the Environment by Tom Wooley, Sam Kimmins, Rob Harrison and Paul Harrison (Routledge Publishers)

Semester VII

Course Code	Course Name	Credits
CEDLO7025	Department Level Optional Course- 4: Legal Aspects in Construction	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	--	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Practical	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hours	-	-	-	100

Rationale

Construction industry is one of the most regulated industries in the World and subjected to various laws, rules, and regulation and ethical standards. A civil Engineering graduate must be able to understand and interpret these laws and navigate through these environments with utmost certainty and responsibilities.

The syllabus of this course has been designed to give preliminary introduction to Civil Engineering about legal aspects in construction industry. Along with this, the course intends to help students understand various aspects of contracts, tenders and roles & responsibilities of various involved individual and parties.

Objectives

1 To explain needs of various laws and legislation related to Construction Industry.

2 To summarize application of various Contracts and their forms (Documents)

3 To describe application of various Tenders and their forms (Documents)

4 To understand needs & Methods of arbitration and dispute resolution mechanism

5 To explain needs health, safety and labour laws associated with Construction Industry

6 To describe needs of Environmental protection and ethics in Construction Industry

Detailed Syllabus

Module	Sub-Modules/ Contents		Hrs.
I	**Introduction to Legal Aspects in Construction Industry**		6
	1.1	Need of laws in the construction industry. Role of Builders, Engineers, Architects and Contractors.	
	1.2	Need for legislation. Important Laws related to construction industry: Indian Contract Act 1872, Labour laws, The Building and Other Construction Workers Act, 1996, The Environment (Protection) Act, 1986.	
II	**Contracting in Construction**		8
	2.1	Contract: Definition, Purpose and Sanctity of Contract, Classification of Construction Contracts and their advantages and disadvantages: Lump-Sum Contract, Unit Price Contract, Cost-Plus Contract and Target Contract. Types of Documents (Forms) in a Construction Contract.	
	2.2	Contract Management: Indian Contract Act- 1872, Breach of Contract and Professional ethics to be followed by Contracting Parties.	
III	**Tendering in Construction**		6
	3.1	Tender: Definitions. Requisites of a Valid Tender Types of Tendering: Open Tendering, Selective Tendering and Negotiated Tendering.	
	3.2	Tender Documents, Scrutinization process, Award, acceptance, Bidding models & bidding strategies. E-Tendering process of PWD.	
IV	**Arbitration and Dispute Resolution**		6
	4.1	Claims & disputes, Standard methods of resolving disputes.	
	4.2	Dispute Resolution Board (DRB) – Necessity, formation, Functioning, Advantages etc	
	4.3	Arbitration & conciliation Act -1996 – Arbitration agreement, Arbitration process, duties & powers of an arbitrator, rules of preparing evidence, Publication of an award.	
V	**Health, Safety and Labour Laws**		6
	5.1	Safety rules on construction sites. Roles and responsibilities of owner, contractor and engineers on site.	
	5.2	Important laws: BOWC Act 1996	
	5.3	Minimum Wage Act, 1948	
	5.4	GST Tax Act 2017	
VI	**Environmental Protection and Ethics**		7
	6.1	Impact of construction industry in global warning and climate change. Environmental impact assessment report and case study of any recent infrastructure project.	

	6.2	Paris agreement 2020 and Indian's Climate target as per Paris agreement.	
	6.3	Ethical responsibilities of Civil Engineers, contractors and other parties in construction.	

Contribution to Outcome

On completion of this course, the students will be able to:

1 Explain needs of various laws and legislation related to Construction Industry.

2 Describe application of various Contracts and their forms (Documents)

3 Describe application of various Tenders and their forms (Documents)

4 Evaluate needs & Methods of arbitration and dispute resolution mechanism

5 Explain health, safety and labour laws associated with Construction Industry

6 Apply needs of Environmental protection and ethics in Construction Industry

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Manual for Procurement of Works 2019 GoI, Ministry of Finance

2 PWD manual for E-tendering 2018 PWD, India

3 Construction contracts and claims - Simon M.S., McGraw Hill, New York

4 Construction contracts Management- NICMAR Publication India

5 Estimation and contracts B.S. Patil

Reference Books:

1 Construction contracts and claims - Simon M.S., McGraw Hill, New York

2 Construction contracts Management- NICMAR Publication India

Semester VII

Course Code	Course Name	Credits
CEDLO7026	Department Level Optional Course-4: Environmental Impact Assessment	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	03 hours	--	--	--	100

Rationale

Environmental impact assessment is the formal process used to predict the environmental consequences (positive or negative) of a plan, policy, program, or project prior to the decision to move forward with the proposed action. An impact assessment may propose measures to adjust impacts to acceptable levels or to investigate new technological solutions. This subject covers the study of environmental assessment process, environmental auditing and provisions of various environmental acts of India.

Objectives

1 Students will learn about sustainable development

2 Students will learn different steps within environmental impact assessment

3 Students will learn how to use of EIA for various projects

4 Students will learn the need to assess and evaluate the impact on environment.

5 Students will learn about Environmental Audit

6 Students will learn Major principles of environmental impact assessment

Detailed Syllabus

Module	Sub-Modules/ Contents	Hrs.
I	**Environmental impact assessment**	5
	What is it, Environmental attitudes, Brief history of EIA, Significance of EIA, Role of EIA in planning and decision-making process, objectives of EIA.	

II	**Environmental assessment process** Assessment methodology, Socioeconomic impact assessment, Air quality impact analysis, Noise impact analysis, Energy impact analysis, Water quality impact analysis, Vegetation and wild life impact analysis, Cumulative impact assessment, Ecological impact assessment, Risk assessment.	8
III	**Environmental Impact Assessment Process** Basic concept behind EIS, Stages in EIS production: Screening, scoping, prediction, evaluation, reducing impact, monitoring, conclusions, typical EIS outline	5
IV	**Rapid EIA** Rapid EIA, when it is carried out, advantages and disadvantages	6
V	**Environmental Auditing** Definition, aims and objectives, audit principles, incentives to undertake audit, partial environmental audits, stages of implementing environmental audits, scope of audit	7
VI	**Provisions of various environmental acts of India** various environmental acts of India, Case studies	8

Contribution to Outcome

On completion of this course, the students will be able to:

1. Demonstrate the understanding of concept of Sustainable Development and justify the methods of achieving Sustainable Development.
2. Overview of assessing risks posing threats to the environment
3. List and evaluate different risks associated with given project
4. Conduct Environmental Audit
5. Explain the importance of stakeholders in the EIA process
6. Conduct different case studies/examples of EIA in practice

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Recommended Books:

1 Corporate Environmental Management: Welford R, University Press

2 Environmental Assessment: *Jain R K*, Mc-Graw Hill

3 Environmental Impact Assessment: *Harry W Conter*, Mc-Graw Hill

4 Environmental Impact Assessment – Handbook: *John G Rau* and *D C Wooren*, Mc-GrawHill.

5 Introduction to Environmental Impact Assessment, A Chadwick, Taylor & Francis , 2007

6 Environmental Impact Assessment, Barthwal, R. R. New Age International Publications

7 Environmental Impact Assessment, Larry Canter, McGraw-Hill Publications

Reference Books:

1 Strategic Environmental Assessment,R.Therirvel, E. Wilson, S. Hompson, D. Heaney, D.Pritchard, Earthscan, London , 1992

2 A Practical Guide to Environmental Impact Assessment, Paul, A Erickson,Academic Press , 1994

3 Handbook of Environment Impact Assessment by Judith Petts; McGraw Hill publications

4 Environmental Impact Assessment: Theory & Practice, Wathern, P, Publishers-Rutledge, London, 1992.

Subject Code	Subject Name	Credits
CEDLO7027	Department Level Optional Course-4: Advanced Design of Steel Structures	03

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorials	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test	Test	Average						
20	20	20	80	--	--	--	--	100

Rationale

The civil engineering structures are subjected to different types of loading and their combination. Many of the structure are made of steel , these structure are design by working stress method and limit state method . The design method of different component are given in the syllabus are based on limit state method and working state method.

Objectives

- To understand the design philosophies of Working stress and Limit state methods and
- design of moment resistant connections.
- To explain the design concept of gantry girder
- To understand the analysis and design concept of round tubular structures
- To describe the design concept of different type of steel water tank
- To explain the design concept of lattice tower
- To describe the design concept of steel chimney.

Detailed Syllabus		
Module	**Sub-Modules/ Contents**	**Hrs.**
I	**Introduction to Steel Structure and Moment Resistant Beam End Connections:**	**07**
	Introduction to type of steel, mechanical properties of Structural steel, advantages of steel as structural material, design philosophies of Working Stress Method (WSM), Limit state method and design of simple riveted connection. Design of moment resistant bolted and welded beam end connections by limit state method	
II	**Gantry Girder:**	**06**
	Loads acting on gantry girder, Analysis of gantry girder, design of gantry girder by limit state method.	
III	**Round Tubular Structural Members:**	**06**
	Properties of steel tubes, design of tension member and compression members, design of welded connections, design of flexural members, analysis and design of tubular trusses including purlins and supports	
IV	**Elevated Steel Tanks and Stacks:**	**08**
	Loads acting on tanks including wind and earthquake, design of circular tanks with hemispherical and conical bottom, supporting ring beam, staging for circular tanks including design of columns and foundation,	
V	**Lattice Tower:**	**06**
	Different configuration of lattice towers, loads acting on lattice towers, Analysis of lattice tower,	
VI	**Steel Chimney:**	**06**
	Forces acting on chimney, design of self-supporting welded and bolted chimney and components including design of foundation.	

Contribution to Outcomes

On completion of this course, the students will be able to

1. Analyze and design Moment Connection.
2. Analyze and design gantry girder by limit state method.
3. Analysis and design of tubular truss using IS code.
4. Analysis and design of Elevated water tank using IS code.
5. Analyze and design Lattice Tower using IS code.
6. Analyze and design Steel Chimney using IS code.

1 Theory Examination:-

1. Question paper will comprise of six question; each carrying 20 marks.
2. The first question will be compulsory.
3. The remaining five questions will be based on all the modules of the entire syllabus. For this, the modules shall be divided proportionately and further, the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. The students will have to attempt any three questions out of remaining five questions.
5. Total four questions need to be attempted

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Average of marks will be considered for IA.

Term Work (this may be included in content beyond syllabus / optional)

The Term work shall consist of a Design report and detailed drawings on any two projects as indicated below:

1. Roofing system including details of supports using tubular section
2. Design of elevated circular tank with conical bottom steel tank.
3. Design of lattice tower or steel chimney.

The drawing should be drawn in pencil only on minimum of A-1 (imperial) size drawing sheets.

Recommended Books:

1 Design of Steel Structures : N Subramanian, Oxford- University Press

2 Design of Steel Structures: Punamia, A. K. Jain & Arun Kumar Jain . Laxmi Publication

3 Design of Steel Structures: Dayaratnam, Wheeler Publication, New Delhi.

4 Design of steel structures: Krishnamachar B.S, & Ajitha Sinha D.

Reference Books:

1. Design of Steel Structures: Mac. Ginely T.
2. Design of Steel Structures: Kazimi S. M. & Jindal R. S., Prentice Hall of India.
3. Design of Steel Structures: Breslar, Lin and Scalzi, John Willey, New York.
4. Design of Steel Structures: Arya and Ajmani, New chand & Bros.
5. Relevant IS codes, BIS Publication, New Delhi
6. Steel structures, Controlling behavior through design: R. Englekirk, Wiley
7. LRFD Steel Design : William T. Segui, PWS Publishing
8. Design of Steel Structures: Edwin H. Gaylord, Charles N. Gaylord and James. Stallmeyer, McGraw-Hill

Semester VII		
Course Code	**Course Name**	**Credits**
ILOC7011	**Institute Level Optional Course – I : Product Life-cycle Management**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- To familiarize the students with the need, benefits and components of PLM
- To acquaint students with Product Data Management & PLM strategies
- To give insights into new product development program and guidelines for designing and developing a product
- To familiarize the students with Virtual Product Development

Module	Sub-Modules/ Contents	Hrs.
I	**Introduction to Product Life-cycle Management (PLM):** Product Life-cycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies:** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy, Change management for PLM	10
II	**Product Design:** Product Design and Development Process, Engineering Design, Organization and Decomposition in Product Design, Typologies of Design Process Models, Reference Model, Product Design in the Context of the Product Development Process, Relation with the Development Process Planning Phase, Relation with the Post design Planning Phase, Methodological Evolution in Product Design, Concurrent Engineering, Characteristic Features of Concurrent Engineering, Concurrent Engineering and Life Cycle Approach, New Product Development (NPD) and Strategies, Product Configuration and Variant Management, The	09

	Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	
III	**Product Data Management (PDM):** Product and Product Data, PDM systems and importance, Components of PDM, Reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation	05
IV	**Virtual Product Development Tools:** For components, machines, and manufacturing plants, 3D CAD systems and realistic rendering techniques, Digital mock-up, Model building, Model analysis, Modeling and simulations in Product Design, Examples/Case studies	05
V	**Integration of Environmental Aspects in Product Design:** Sustainable Development, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	05
VI	**Life Cycle Assessment and Life Cycle Cost Analysis:** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis	05

Contribution to Outcomes:

Students will be able to

- Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
- Illustrate various approaches and techniques for designing and developing products.
- Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
- Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six questioncarrying20 marks
- Question no. 1 is compulsory. Any 3 out of remaining 5 need to be solved
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. John Stark, “Product Lifecycle Management: Paradigm for 21st Century Product Realisation”, Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, Antonino Risitano, “Product Design for the environment-A life cycle approach”, Taylor & Francis 2006, ISBN: 0849327229
3. Saaksvuori Antti, Immonen Anselmie, “Product Life Cycle Management”, Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, “Product Life-cycle Management: Driving the next generation of lean thinking”, Tata McGraw Hill, 2006, ISBN: 0070636265

Semester VII		
Course Code	**Course Name**	**Credits**
ILOC7012	**Institute Level Optional Course – I : Reliability Engineering**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives

- To familiarize the students with various aspects of probability theory
- To acquaint the students with reliability and its concepts
- To introduce the students to methods of estimating the system reliability of simple and complex systems
- To understand the various aspects of Maintainability, Availability and FMEA procedure

Module	Sub-Modules/ Contents	Hrs.
I	**Probability theory:** Probability: Standard definitions and concepts; Conditional Probability, Baye's Theorem. **Probability Distributions:** Central tendency and Dispersion; Binomial, Normal, Poisson, Weibull, Exponential, relations between them and their significance. **Measures of Dispersion:** Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Variance, Skewness and Kurtosis.	08
II	**Reliability Concepts:** Reliability definitions, Importance of Reliability, Quality Assurance and Reliability, Bath Tub Curve. **Failure Data Analysis:** Hazard rate, failure density, Failure Rate, Mean Time To Failure (MTTF), MTBF, Reliability Functions. **Reliability Hazard Models:** Constant Failure Rate, Linearly increasing, Time Dependent Failure Rate, Weibull Model. Distribution functions and reliability analysis.	08
III	**System Reliability:** System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.	05
IV	**Reliability Improvement:** Redundancy Techniques: Element redundancy, Unit redundancy, Standby redundancies. Markov analysis. System Reliability Analysis – Enumeration method, Cut-set method, Success Path method, Decomposition method.	08

V	**Maintainability and Availability:** System downtime, Design for Maintainability: Maintenance requirements, Design methods: Fault Isolation and self-diagnostics, Parts standardization and Interchangeability, Modularization and Accessibility, Repair Vs Replacement. Availability – qualitative aspects.	05
VI	**Failure Mode, Effects and Criticality Analysis:** Failure mode effects analysis, severity/criticality analysis, FMECA examples. Fault tree construction, basic symbols, development of functional reliability block diagram, Fau1t tree analysis and Event tree Analysis	05

Outcomes

Students will be able to…

- Explain and apply the concept of Probability to engineering problems
- Apply various reliability concepts to calculate different reliability parameters
- Estimate the system reliability of simple and complex systems
- Carry out failure mode effect and criticality analysis

Assessment:
Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:
In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six question carrying20 marks
- Question no. 1 is compulsory. Any 3 out of remaining 5 need to be solved
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. L.S. Srinath, “Reliability Engineering”, Affiliated East-Wast Press (P) Ltd., 1985.
2. Charles E. Ebeling, “Reliability and Maintainability Engineering”, Tata McGraw Hill.
3. B.S. Dhillion, C. Singh, “Engineering Reliability”, John Wiley & Sons, 1980.
4. P.D.T. Conor, “Practical Reliability Engg.”, John Wiley & Sons, 1985.
5. K.C. Kapur, L.R. Lamberson, “Reliability in Engineering Design”, John Wiley & Sons.
6. Murray R. Spiegel, “Probability and Statistics”, Tata McGraw-Hill Publishing Co. Ltd.

Semester VII		
Course Code	**Course Name**	**Credits**
ILOC7013	**Institute Level Optional Course – I : Management Information System**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			Total Marks
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- The course is blend of Management and Technical field.
- Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built
- Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage
- Identify the basic steps in systems development

Module	Sub-Modules/ Contents	Hrs.
I	**Introduction To Information Systems (IS):** Computer Based Information Systems, Impact of IT on organizations, Imporance of IS to Society. Organizational Strategy, Competitive Advantages and IS.	4
II	**Data and Knowledge Management**: Database Approach, Big Data, Data warehouse and Data Marts, Knowledge Management. Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	7
III	**Ethical issues and Privacy**: Information Security. Threat to IS, and Security Controls	7
IV	**Social Computing (SC):** Web 2.0 and 3.0, SC in business-shopping, Marketing, Operational and Analytic CRM, E-business and E-commerce – B2B B2C. Mobile commerce.	7
V	**Computer Networks Wired and Wireless technology**, Pervasive computing, Cloud computing model.	6
VI	**Information System within Organization**: Transaction Processing Systems, Functional Area Information System, ERP and ERP support of Business Process. **Acquiring Information Systems and Applications**: Various System development life cycle models.	8

Contribution to Outcomes

Students will be able to:

- Explain how information systems Transform Business
- Identify the impact information systems have on an organization
- Describe IT infrastructure and its components and its current trends
- Evaluate the principal tools and technologies for accessing information from databases to improve business performance and decision making
- Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Assessment:

Internal:

Assessment consists of two tests out of which; one should be compulsory class test and the other is either a class test or assignment on live problems or course project.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six question carrying20 marks
- Question no. 1 is compulsory. Any 3 out of remaining 5 need to be solved
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Kelly Rainer, Brad Prince,Management Information Systems, Wiley
2. K.C. Laudon and J.P. Laudon, Management Information Systems: Managing the Digital Firm, 10th Ed., Prentice Hall, 2007.
3. D. Boddy, A. Boonstra, Managing Information Systems: Strategy and Organization, Prentice Hall, 2008

Semester VII		
Course Code	**Course Name**	**Credits**
ILOC7014	**Institute Level Optional Course – I: Design of Experiments**	**03**

Teaching Scheme						
Contact Hours			**Credits Assigned**			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- To understand the issues and principles of Design of Experiments (DOE)
- To list the guidelines for designing experiments
- To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Module	Sub-Modules/ Contents	Hrs.
I	**Introduction** 1.1 Strategy of Experimentation 1.2 Typical Applications of Experimental Design 1.3 Guidelines for Designing Experiments 1.4 Response Surface Methodology	06
II	**Fitting Regression Models** 2.1 Linear Regression Models 2.2 Estimation of the Parameters in Linear Regression Models 2.3 Hypothesis Testing in Multiple Regression 2.4 Confidence Intervals in Multiple Regression 2.5 Prediction of new response observation 2.6 Regression model diagnostics 2.7 Testing for lack of fit	08
III	**Two-Level Factorial Designs** 3.1 The 2^2 Design 3.2 The 2^3 Design 3.3 The General2^k Design 3.4 A Single Replicate of the 2^k Design 3.5 The Addition of Center Points to the 2^k Design, 3.6 Blocking in the 2^k Factorial Design 3.7 Split-Plot Designs	07

IV	**Two-Level Fractional Factorial Designs** 4.1 The One-Half Fraction of the 2^k Design 4.2 The One-Quarter Fraction of the 2^k Design 4.3 The General 2^{k-p} Fractional Factorial Design 4.4 Resolution III Designs 4.5 Resolution IV and V Designs 4.6 Fractional Factorial Split-Plot Designs	07
V	**Response Surface Methods and Designs** 5.1 Introduction to Response Surface Methodology 5.2 The Method of Steepest Ascent 5.3 Analysis of a Second-Order Response Surface 5.4 Experimental Designs for Fitting Response Surfaces	07
VI	**Taguchi Approach** 6.1 Crossed Array Designs and Signal-to-Noise Ratios 6.2 Analysis Methods 6.3 Robust design examples	04

Contribution to Outcomes

Students will be able to

- Plan data collection, to turn data into information and to make decisions that lead to appropriate action
- Apply the methods taught to real life situations
- Plan, analyze, and interpret the results of experiments

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six question carrying20 marks
- Question no. 1 is compulsory. Any 3 out of remaining 5 need to be solved
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3rd edition, John Wiley & Sons, New York, 2001
2. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001

3. George E P Box, J Stuart Hunter, William G Hunter, Statics for Experimenters: Design, Innovation and Discovery, 2nd Ed. Wiley
4. W J Dimond, Peactical Experiment Designs for Engineers and Scintists, John Wiley and Sons Inc. ISBN: 0-471-39054-2
5. Design and Analysis of Experiments (Springer text in Statistics), Springer by A.M. Dean, and

Semester VII		
Course Code	**Course Name**	**Credits**
ILOC7015	**Institute Level Optional Course – I : Operations Research**	**03**

Teaching Scheme						
Contact Hours			**Credits Assigned**			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- Formulate a real-world problem as a mathematical programming model.
- Understand the mathematical tools that are needed to solve optimization problems.
- Use mathematical software to solve the proposed models.

Module	Sub-Modules/ Contents	Hrs.
I	**Introduction to Operations Research**: Introduction, , Structure of the Mathematical Model, Limitations of Operations Research **Linear Programming**: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Graphical method, Simplex Method Penalty Cost Method or Big M-method, Two Phase Method, Revised simplex method, **Duality**, Primal – Dual construction, Symmetric and Asymmetric Dual, Weak Duality Theorem, Complimentary Slackness Theorem, Main Duality Theorem, Dual Simplex Method, Sensitivity Analysis **Transportation Problem**: Formulation, solution, unbalanced Transportation problem. Finding basic feasible solutions – Northwest corner rule, least cost method and Vogel's approximation method. Optimality test: the stepping stone method and MODI method. **Assignment Problem**: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Processing of n Jobs Through Two Machines and m Machines, Graphical Method of Two Jobs m Machines Problem Routing Problem, Travelling Salesman Problem	14

	Integer Programming Problem: Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	
II	**Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	05
III	**Simulation**: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages of Simulation, Limitations of Simulation	05
IV	**Dynamic programming**. Characteristics of dynamic programming. Dynamic programming approach for Priority Management employment smoothening, capital budgeting, Stage Coach/Shortest Path, cargo loading and Reliability problems.	05
V	**Game Theory**. Competitive games, rectangular game, saddle point, minimax (maximin) method of optimal strategies, value of the game. Solution of games with saddle points, dominance principle. Rectangular games without saddle point – mixed strategy for 2 X 2 games.	05
VI	**Inventory Models**: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	05

Outcomes:

Students will be able to

- Explain the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
- Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
- Solve specialized linear programming problems like the transportation and assignment problems, solve network models like the shortest path, minimum spanning tree, and maximum flow problems.
- Describe the applications of integer programming and a queuing model and compute important performance measures

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six question carrying 20 marks
- Question no. 1 is compulsory. Any 3 out of remaining 5 need to be solved
- Remaining question (Q.2 to Q.6) will be selected from all the modules.

- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Taha, H.A. "Operations Research - An Introduction", Prentice Hall, (7th Edition), 2002.
2. Ravindran, A, Phillips, D. T and Solberg, J. J. "Operations Research: Principles and Practice", John Willey and Sons, 2nd Edition, 2009.
3. Hiller, F. S. and Liebermann, G. J. "Introduction to Operations Research", Tata McGraw Hill, 2002.
4. Operations Research, S. D. Sharma, KedarNath Ram Nath-Meerut.
5. Operations Research, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.

Semester VII		
Course Code	**Course Name**	**Credits**
ILOC7016	**Institute Level Optional Course – I : Cyber Security and Laws**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- To understand and identify different types cyber crime and cyber law
- To recognized Indian IT Act 2008 and its latest amendments
- To learn various types of security standards compliances

Module	Sub-Modules/ Contents	Hrs.
I	**Introduction to Cyber crime:** Cyber crime definition and origins of the world, Cyber crime and information security, Classifications of cyber crime, Cyber crime and the Indian ITA 2000, A global Perspective on cyber crimes.	4
II	**Cyber offenses & Cyber crime:** How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cyber crimes, Botnets, Attack vector, Cloud computing, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Security Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication Service Security, Attacks on Mobile/Cell Phones, Mobile Devices:Security Implications for Organizations, Organizational Measures for Handling Mobile, Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops	9
III	**Tools and Methods Used in Cyber line** Phishing, Password Cracking, Key loggers and Spy-wares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
IV	**The Concept of Cyberspace** E-Commerce , The Contract Aspects in Cyber Law ,The Security Aspect of Cyber Law ,The Intellectual Property Aspect in Cyber Law, The Evidence Aspect in Cyber Law , The Criminal Aspect in Cyber Law, Global Trends in Cyber Law , Legal Framework for Electronic Data Interchange Law Relating to Electronic Banking , The Need for an Indian Cyber Law	8

V	**Indian IT Act.** Cyber Crime and Criminal Justice: Penalties, Adjudication and Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments	6
VI	**Information Security Standard compliances** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	6

Outcomes

Students will be able to:

- Explain the concept of cybercrime and its effect on outside world
- Interpret and apply IT law in various legal issues
- Distinguish different aspects of cyber law
- Apply Information Security Standards compliance during software design and development

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six questioncarrying20 marks
- Question no. 1 is compulsory. Any 3 out of remaining 5 need to be solved
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Nina Godbole, Sunit Belapure, Cyber Security, Wiley India, New Delhi
2. The Indian Cyber Law by Suresh T. Vishwanathan; Bharat Law House New Delhi
3. The Information technology Act, 2000; Bare Act- Professional Book Publishers, New Delhi.
4. Cyber Law & Cyber Crimes By Advocate Prashant Mali; Snow White Publications, Mumbai
5. Nina Godbole, Information Systems Security, Wiley India, New Delhi
6. Kennetch J. Knapp, Cyber Security &Global Information Assurance Information Science Publishing.
7. William Stallings, Cryptography and Network Security, Pearson Publication
8. Websites for more information is available on : The Information Technology ACT, 2008- TIFR : https://www.tifrh.res.in
9. Website for more information , A Compliance Primer for IT professional : https://www.sans.org/reading-room/whitepapers/compliance/compliance-primer-professionals-33538

Semester VII		
Course Code	**Course Name**	**Credits**
ILOC7017	**Institute Level Optional Course – I : Disaster Management and Mitigation Measures**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			Total Marks
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives

- To understand physics and various types of disaster occurring around the world
- To identify extent and damaging capacity of a disaster
- To study and understand the means of losses and methods to overcome /minimize it.
- To describe role of individual and various organization during and after disaster
- To explain application of GIS in the field of disaster management
- To understand the emergency government response structures before, during and after disaster

Module	Sub-Modules/ Contents	Hrs.
I	**Introduction** **1.1** Definition of Disaster, hazard, global and Indian scenario, general perspective, importance of study in human life, Direct and indirect effects of disasters, long term effects of disasters. Introduction to global warming and climate change.	03
II	**Natural Disaster and Manmade disasters:** 2.1 Natural Disaster: Meaning and nature of natural disaster, Flood, Flash flood, drought, cloud burst, Earthquake, Landslides, Avalanches, Volcanic eruptions, Mudflow, Cyclone, Storm, Storm Surge, climate change, global warming, sea level rise, ozone depletion **2.2** Manmade Disasters: Chemical, Industrial, Nuclear and Fire Hazards. Role of growing population and subsequent industrialization, urbanization and changing lifestyle of human beings in frequent occurrences of manmade disasters.	09
III	**Disaster Management, Policy and Administration** 3.1 Disaster management: meaning, concept, importance, objective of disaster management policy, disaster risks in India, Paradigm shift in disaster management. 3.2 Policy and administration: Importance and principles of disaster management policies, command and co-ordination of in disaster management, rescue operations-how to start with and how to proceed in due course of time, study of flowchart showing the entire process.	06

IV	**Institutional Framework for Disaster Management in India:** 4.1 Importance of public awareness, Preparation and execution of emergency management programme.Scope and responsibilities of National Institute of Disaster Management (NIDM) and National disaster management authority (NDMA) in India.Methods and measures to avoid disasters, Management of casualties, set up of emergency facilities, importance of effective communication amongst different agencies in such situations. 4.2 Use of Internet and software for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	06
V	**Financing Relief Measures:** 5.1 Ways to raise finance for relief expenditure, role of government agencies and NGO's in this process, Legal aspects related to finance raising as well as overall management of disasters. Various NGO's and the works they have carried out in the past on the occurrence of various disasters, Ways to approach these teams. 5.2 International relief aid agencies and their role in extreme events.	09
VI	**Preventive and Mitigation Measures:** 6.1 Pre-disaster, during disaster and post-disaster measures in some events in general 6.2 Structural mapping: Risk mapping, assessment and analysis, sea walls and embankments, Bio shield, shelters, early warning and communication 6.3 Non Structural Mitigation: Community based disaster preparedness, risk transfer and risk financing, capacity development and training, awareness and education, contingency plans. 6.4 Do's and Don'ts in case of disasters and effective implementation of relief aids.	06

Contribution to Outcome

Students will be able to…

- Get to know natural as well as manmade disaster and their extent and possible effects on the economy.
- Plan of national importance structures based upon the previous history.
- Get acquainted with government policies, acts and various organizational structure associated with an emergency.
- Get to know the simple do's and don'ts in such extreme events and act accordingly.

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six question carrying20 marks
- Question no. 1 is compulsory. Any 3 out of remaining 5 need to be solved
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. 'Disaster Management' by Harsh K.Gupta, Universities Press Publications.
2. 'Disaster Management: An Appraisal of Institutional Mechanisms in India' by O.S.Dagur, published by Centre for land warfare studies, New Delhi, 2011.
3. 'Introduction to International Disaster Management' by Damon Copolla, Butterworth Heinemann Elseveir Publications.
4. 'Disaster Management Handbook' by Jack Pinkowski, CRC Press Taylor and Francis group.
5. 'Disaster management & rehabilitation' by Rajdeep Dasgupta, Mittal Publications, New Delhi.
6. 'Natural Hazards and Disaster Management, Vulnerability and Mitigation – R B Singh, Rawat Publications
7. Concepts and Techniques of GIS –C.P.Lo Albert, K.W. Yonng – Prentice Hall (India) Publications.

(Learners are expected to refer reports published at national and International level and updated information available on authentic web sites)

Semester VII		
Course Code	**Course Name**	**Credits**
ILOC7018	**Institute Level Optional Course – I : Energy Audit and Management**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			Total Marks
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Avg						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
- To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
- To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Module	Sub-Modules/ Contents	Hrs.
I	**Energy Scenario:** Present Energy Scenario, Energy Pricing, Energy Sector Reforms, Energy Security, Energy Conservation and its Importance, Energy Conservation Act-2001 and its Features. Basics of Energy and its various forms, Material and Energy balance	04
II	**Energy Audit Principles:** Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution. Elements of monitoring& targeting; Energy audit Instruments; Data and information-analysis. Financial analysis techniques: Simple payback period, NPV, Return on investment (ROI), Internal rate of return (IRR)	08
III	**Energy Management and Energy Conservation in Electrical System:** Electricity billing, Electrical load management and maximum demand Control; Power factor improvement, Energy efficient equipments and appliances, star ratings.	10

	Energy efficiency measures in lighting system, Lighting control: Occupancy sensors, daylight integration, and use of intelligent controllers. Energy conservation opportunities in: water pumps, industrial drives, induction motors, motor retrofitting, soft starters, variable speed drives.	
IV	**Energy Management and Energy Conservation in Thermal Systems:** Review of different thermal loads; Energy conservation opportunities in: Steam distribution system, Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system. General fuel economy measures in Boilers and furnaces, Waste heat recovery, use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	10
V	**Energy Performance Assessment:** On site Performance evaluation techniques, Case studies based on: Motors and variable speed drive, pumps, HVAC system calculations; Lighting System: Installed Load Efficacy Ratio (ILER) method, Financial Analysis.	04
VI	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

Outcomes:

Students will be able to:

- To identify and describe present state of energy security and its importance.
- To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
- To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
- To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
- To analyze the data collected during performance evaluation and recommend energy saving measures

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six questioncarrying20 marks
- Question no. 1 is compulsory. Any 3 out of remaining 5 need to be solved
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Handbook of Electrical Installation Practice, Geofry Stokes, Blackwell Science
2. Designing with light: Lighting Handbook, By Anil Valia, Lighting System
3. Energy Management Handbook, By W.C. Turner, John Wiley and Sons
4. Handbook on Energy Audits and Management, edited by A. K. Tyagi, Tata Energy Research Institute (TERI).
5. Energy Management Principles, C.B.Smith, Pergamon Press
6. Energy Conservation Guidebook, Dale R. Patrick, S. Fardo, Ray E. Richardson, Fairmont Press
7. Handbook of Energy Audits, Albert Thumann, W. J. Younger, T. Niehus, CRC Press
8. www.energymanagertraining.com
9. www.bee-india.nic.in

Semester VII		
Course Code	**Course Name**	**Credits**
ILOC7019	**Institute Level Optional Course – I : Development Engineering**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Avg						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

1. To understand the characteristics of rural Society and the Scope, Nature and Constraints of rural Development
2. To study Implications of 73rd CAA on Planning, Development and Governance of Rural Areas
3. An exploration of human values, which go into making a 'good' human being, a 'good' professional, a 'good' society and a 'good life' in the context of work life and the personal life of modern Indian professionals
4. To understand the Nature and Type of Human Values relevant to Planning Institutions

Module	Detailed Contents	Hrs.
I	Introduction to Rural Development Meaning, nature and scope of development; Nature of rural society in India; Hierarchy of settlements; Social, economic and ecological constraints for rural development Roots of Rural Development in India Rural reconstruction and Sarvodaya programme before independence; Impact of voluntary effort and Sarvodaya Movement on rural development; Constitutional direction, directive principles; Panchayati Raj - beginning of planning and community development; National extension services.	**08**
II	Post-Independence rural Development Balwant Rai Mehta Committee - three tier system of rural local Government; Need and scope for people's participation and Panchayati Raj; Ashok Mehta Committee- linkage between Panchayati Raj, participation and rural development.	**04**
III	Rural Development Initiatives in Five Year Plans Five Year Plans and Rural Development; Planning process at National, State, Regional and District levels; Planning, development, implementing and monitoring organizations and agencies; Urban and rural interface - integrated approach and local plans; Development initiatives and their convergence; Special component plan and sub-plan for the weaker section; Micro-eco zones; Data base for local planning; Need for decentralized planning; Sustainable rural development.	**06**

IV	Post 73rd Amendment Scenario 73rd Constitution Amendment Act, including - XI schedule, devolution of powers, functions and finance; Panchayati Raj institutions - organizational linkages; Recent changes in rural local planning; Gram Sabha - revitalized Panchayati Raj; Institutionalization; resource mapping, resource mobilization including social mobilization; Information Technology and rural planning; Need for further amendments.	**04**
V	Values and Science and Technology Material development and its values; the challenge of science and technology; Values in planning profession, research and education. Types of Values Psychological values — integrated personality; mental health; Societal values — the modern search for a good society; justice, democracy, rule of law, values in the Indian constitution; Aesthetic values — perception and enjoyment of beauty; Moral and ethical values; nature of moral judgment; Spiritual values; different concepts; secular spirituality; Relative and absolute values; Human values— humanism and human values; human rights; human values as freedom, creativity, love and wisdom.	**10**
VI	Ethics Canons of ethics; ethics of virtue; ethics of duty; ethics of responsibility; Work ethics; Professional ethics; Ethics in planning profession, research and education	**04**

Outcomes: Learner will be able to…

1. Apply knowledge for Rural Development.
2. Apply knowledge for Management Issues.
3. Apply knowledge for Initiatives and Strategies
4. Develop acumen for higher education and research.
5. Master the art of working in group of different nature.
6. Develop confidence to take up rural project activities independently

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. **Only Four questions need to be solved**

Reference

1. ITPI, Village Planning and Rural Development, ITPI, New Delhi
2. Thooyavan, K.R. Human Settlements: A 2005 MA Publication, Chennai
3. GoI, Constitution (73rd GoI, New Delhi Amendment) Act, GoI, New Delhi
4. Planning Commission, Five Year Plans, Planning Commission
5. Planning Commission, Manual of Integrated District

Planning, 2006, Planning Commission New Delhi

6. Planning Guide to Beginners
7. Weaver, R.C., The Urban Complex, Doubleday.
8. Farmer, W.P. et al, Ethics in Planning, American Planning Association, Washington.
9. How, E., Normative Ethics in Planning, Journal of Planning Literature, Vol.5, No.2, pp. 123-150.
10. Watson, V. , Conflicting Rationalities: -- Implications for Planning Theory and Ethics, Planning Theory and Practice, Vol. 4, No.4, pp.395 – 40

Semester-VII

Course Code	Course Name	Credits
CEL701	Design and Drawing of Reinforced Concrete Structures	1

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
--	--	2	--	--	1	1

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
--	--	--	--	--	25	--	25	50

Course Objective:

1. To explain the LSM design procedure of G+ 3 RCC framed Building by application of IS code clauses including loading calculation, analysis and design of individual elements with detailing of reinforcements.
2. To explain the concept in the design of water tanks.
3. To explain the concept in the design of retaining walls.
4. To introduce the basics of structural dynamics, structural behavior under the dynamic load and the effect of damping.
5. To introduce earthquake resistant design approach.
6. To develop the practice of design using charts and tables from SP:16 published by BIS.
7. To introduce concept of Pre-stressed Concrete.

Course Outcomes:

At the end of the course, learner will be able to:

1. Design G+3 RCC framed building using IS code recommendations.
2. Design different types of water tanks with detailing of reinforcement.
3. Design different types of retaining walls with detailing of reinforcement
4. Apply the basic concepts of structural dynamics
5. Explain response of structure during an earthquake and calculate design forces.
6. Explain principles of Prestressed Concrete and its losses.

List of Tutorials and Assignments		
Week (Activity)	**Detailed Content**	**Hours**
1st Week (Tutorial)	Project – I – Design of G+3 RCC Framed Building. (Drawing of structural plan on Sheet no. 1)	**02**
2nd Week (Tutorial)	Project – I – Design of G+3 RCC Framed Building. (Design of Staircase)	**02**
3rd Week (Tutorial)	Project – I – Design of G+3 RCC Framed Building. (Design of simply supported and continuous one way and two-way slabs and detailing of reinforcement for slabs including staircase on sheet no. 2)	**02**
4th Week (Tutorial)	Project – I – Design of G+3 RCC Framed Building. (Design of simply supported and continuous Beams and Detailing of reinforcement for beams on sheet no. 3)	**02**
5th Week (Tutorial)	Project – I – Design of G+3 RCC Framed Building. (Design of Columns and Detailing of reinforcement for columns on sheet no. 4)	**02**
6th Week (Tutorial)	Project – I – Design of G+3 RCC Framed Building. (Design of isolated & combined footing and Detailing of reinforcement for footing on sheet no. 5)	**02**
7th Week (Assignment)	Assignment no. 1 Introduction to Structural Dynamics (Maximum 5 Questions)	**02**
8th Week. (Assignment)	Assignment no. 2 Earthquake resistant design of structures (Maximum 5 Questions)	**02**
9th Week (Tutorial)	Project – II – Design of Counterfort retaining wall Design of the elements of counterfort retaining wall using LSM	**02**
10th Week (Tutorial)	Project – II – Design of Counterfort retaining wall (Detailing of reinforcement of counterfort retaining wall on sheet no. 6)	**02**
11th Week (Assignment)	Assignment no. 3 Design of water tanks using WSM (Maximum 5 Questions)	**02**
12th Week (Assignment)	Assignment no. 4 Introduction to prestressed concrete Maximum 5 Questions	**02**
13th Week	Viva – Voce Examination	**02**

Assessment:

- **Term Work**

The Term work shall consist of neatly written design report on Project – I & II & reinforcement detailing on A2 size sheets of paper, detailed drawings using AutoCAD and Assignments 1 to 4. A visit to be conducted at RCC or Prestressed concrete construction site and a detailed report to be submitted by the groups of students. Students may be asked to check manual calculations with available structural design software.

Distribution of marks for Term Work shall be as follows:

Tutorial Work	:	15 Marks
Assignments & Site Visit Report	:	05 Marks
Attendance	:	05 Marks

- **End Semester Oral and Sketching Examination**

  Oral examination will be based on entire syllabus and sketching examination will be conducted for 60 minutes duration before oral examination.

Recommended Books:

1. Design of Reinforced Concrete Structures*: Dayaratnam, P;* Oxford and IBH.
2. Reinforced Concrete - Limit State Design: Ashok K. Jain, Nemchand& bro.
3. Limit State Design of Reinforced Concrete: Shah and Karve, Structure Publications, Pune.
4. Design of Prestressed Concrete Structures: Lin T.Y. and Ned Burns; John Wiley.
5. Reinforced Concrete: H.J. Shah, Charotar Publishers, Anand.
6. Prestressed concrete : Krishna Raju, Tata Mc-Graw Hill Publishing House, New Delhi
7. Illustrated Reinforced Concrete Design: Dr. V. L. Shah and Dr. S. R. Karve, Structure Publications, Pune.
8. Reinforced Concrete Design: Wang, C. K., Salmon, C. G., and Pincheira, J. A, John Wiley (2007), 7th Edition.
9. Reinforced Concrete Fundamentals: Ferguson, P. M., Breen, J. E., and Jirsa, J. O., John Wiley & Sons (1988) 5th Edition.

Reference Books:

1. Design of RCC structural Elements (RCC Vol-I): Bhavikatti, S. S., New Age International Publications.
2. Reinforced Concrete: Syal and Goel; Wheeler Publishers.
3. Reinforced Concrete Design: Pillai, S.U. and Menon, Devdas, Tata Mc-Graw Hill Publishing House, New Delhi.
4. Reinforced Concrete Design by S.N. Sinha, Tata Mc-Graw Hill Publishing House, New Delhi.
5. Theory of Reinforced concrete structures by N. Subramanian, Oxford University Press.
6. Prestressed concrete : N. Rajgopalan, Narosa Publishers.
7. Earthquake resistant design of structures: Pankaj Agarwal, Manish Shrikhande, PHI, New Delhi.
8. Relevant IS Codes: BIS Publications, New Delhi.

Semester VII

Course Code	Course Name	Credits
CEL702	Quantity Survey, Estimation & Valuation	1

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
--	--	2	--	--	1	1

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
--	--	--	--	--	25	--	25	50

Course Objective:

1. To emphasize the importance of relevant IS: 1200 - 1964 codes and understand measurement systems for various items of civil engineering structures
2. To draft the specifications for various items of work & determine unit rates of items of works by preparing rate analysis
3. To study the various methods of detailed and approximate estimates.
4. To calculate the quantity of earthwork by using various methods.
5. To study the process of tendering and its various stages, various types of contracts, its suitability and validity as per the Indian Contract Act of 1872 and draft various clauses and conditions of a contract.
6. To understand the concept of valuation & to determine the present fair value of any constructed building at stated time.

Course Outcomes:

On completion of the course, the learners will be able to:

1. **Identify** current unit rates of various construction materials through market survey & also study District Schedule of Rates (DSR)
2. **Prepare** rate analysis of few important Items of work
3. **Estimate** approximate cost of the structures by using various methods & **prepare** detailed estimates of various civil engineering structures, including bar bending schedule, by referring drawings.
4. **Assess** the quantities of earthwork & **construct** mass haul diagrams.
5. **Draft** tender notice & **demonstrate** the significance of the tender as well as contract process.
6. **Evaluate** present fair value of any constructed building at stated time.

Activity Based Tutorials		
Tutorial No.	Tutorial	Tutorial Hours
1	Market Survey for rates of materials & items	02
2	Study of District Schedule of Rates & Prepare rate analysis of few important Items of work	02
3	Prepare approximate estimate of residential building	02
4	Prepare detailed estimate (Measurement sheet & Abstract Sheet) of any **two** of the following • RCC structure • Road work • Cross drainage work	02
5	Work out Steel quantity by using BBS	02
6	Work out earthwork volume in banking & cutting for a Road section	02
7	Draft Tender Notice for proposed construction Project & study tender documents & Conditions of contract	02
8	Prepare Valuation Report of any Civil Engineering Structure	02

Internal Assessment

Term work: - **25 Marks**

The term work shall consist of all tutorials enlisted in the syllabus
The use of quantity survey software and the use of worksheets/databases while solving some of the afore-mentioned tutorial is desirable.

Distribution of marks for Term Work shall be as follows:

Tutorials: 20 Marks **Attendance: 05 Marks**

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks

End Semester Oral Examination: - **25 Marks**

Oral examination will be based on Term-work & entire syllabus

Reference Books: -

1) Estimating, Costing, Specifications and Valuation: Chakraborty, M., Kolkata.
2) Estimating and costing: Datta, B. N., UBS Publications
3) Building and Engineering Contracts: Patil, B. S., University Press, Hyderabad.
4) Professional Practice: Dr. Roshan H. Namavati

<table>
<tr><th colspan="9">Semester - VII</th></tr>
<tr><th colspan="2">Course Code</th><th colspan="6">Course Name</th><th>Credits</th></tr>
<tr><td colspan="2">CEP701</td><td colspan="6">Major Project Part-I</td><td>03</td></tr>
<tr><th colspan="3">Contact Hours</th><th colspan="6">Credits Assigned</th></tr>
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<tr><th colspan="5">Theory</th><th colspan="3">Term Work/Practical/Oral</th><th rowspan="3">Total</th></tr>
<tr><th colspan="3">Internal Assessment</th><th rowspan="2">End Sem Exam</th><th rowspan="2">Duration of End Sem Exam</th><th rowspan="2">TW</th><th rowspan="2">PR</th><th rowspan="2">OR</th></tr>
<tr><th>Test–I</th><th>Test–II</th><th>Average</th></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>25</td><td>-</td><td>25</td><td>50</td></tr>
</table>

Rationale

In the field of Civil Engineering, new problems arise every now and then; but a professional Civil Engineer must know how to precisely identify & state those problems, define the scope & objectives of the probable solution(s), carry out effective review of available literature in the domain of the problem and formulate a systematic methodology to solve the problem. Modern tools and multidisciplinary knowledge are vastly used nowadays for the effective solution of Civil Engineering problem. It is also important to work effectively & ethically as a team and communicate the work done in the form of written reports. The aim of this course is to acquaint the learners with all of the above-mentioned aspects of the Civil Engineering field by inculcating the process of research.

Objectives

1. To acquaint the learners to identify problems
2. To accustom the learners to formulate the scope and objectives
3. To familiarize the learners with the process of review of literature
4. To advice the learners to formulate a methodology
5. To accustom the learners to work as a team
6. To appraise the learners on proper documentation of work

Detailed Syllabus

1. A project group should consist of minimum 3 and maximum of 4 students.
2. The problem statement of the project should preferably be (but not limited to) from the domains of civil engineering.
3. The solutions to the problem may be multidisciplinary i.e., incorporating concepts, tools, techniques etc. of disciplines apart from Civil Engineering.
4. The project work may include:
    a) Experimental Analysis
    b) Design of Structures
    C) Preparation of Working Drawing
    D) Research on Novel Materials
    E) Development of Working Models

F) Studies on Technical and Economic Feasibility

G) Application of Internet of things (IOT) and Software in field of Civil Engineering.

H) Application of any other innovative tools and techniques.

Guidelines for Project

- Students should do literature survey/visit industry/analyse current trends and identify the problem for Project and finalize in consultation with Guide/Supervisor
- Students should use multiple literatures and understand the problem.
- Students should attempt solution to the problem by experimental/simulation methods.
- The solution to be validated with proper justification and report to be compiled in standard format.

Guidelines for Assessment of Project I

Project I should be assessed based on following points

1. Quality of problem selected
2. Clarity of Problem definition and Feasibility of problem solution
3. Relevance to the specialization
4. Clarity of objective and scope
5. Breadth and depth of literature survey

Project I should be assessed through a presentation by the student project group to a panel of internal and external examiners appointed by the Head of the Department/Institute of respective Programme.

Contribution to Outcomes

On completion of this course, the students will be able to:

1. Review & comprehend literature in the selected domain
2. Articulate problem statement & identify the objectives
3. Identify existing methods or solutions to solve identified problem
4. Identify modern engineering tools & other resources to solve the problem
5. Formulate methodology to solve the identified problem
6. Effectively communicate their project work by writing reports & presentations

Semester-VIII

Semester VIII

Course Code	Course Name	Credits
CEC801	Construction Management	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	-	--	03	-	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Practical.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3	-	-	-	100

Rationale

This course is intended to teach students the management skills to be applied during all the stages of Civil Engineering Project. The professional construction engineering practice will be rendered meaningless if service is not offered with a scientific approach and managerial practices. This course deals with the techniques to be applied for planning and scheduling projects, optimizing time-cost and other resources in construction, monitoring & ensuring quality and safety aspects in projects.

Objectives

1 To understand the basic functions and construction management.

2 To apply scheduling techniques such as CPM & PERT

3 To gain knowledge of time-cost optimization & effective utilization of resources on construction sites.

4 To understand allocating the resources and project monitoring

5 To know about safety and quality aspect of construction works.

Detailed Syllabus

Module	Sub-Modules/ Contents		Hrs.
I	**Introduction to Construction Management**		03
	1.1	Concept and Principles of Management, contribution by eminent personalities like F.W.Taylor, Henry Fayol and Elton Mayo towards growth of management thoughts.	

	1.2	Significance, objectives & functions of construction management	
II	**Construction Projects:**		03
	2.1	Role and unique features of Construction industry in economic development of country	
	2.2	Construction projects- Classification, Characteristics, Project life cycle	
	2.3	Roles and responsibilities of various agencies associated with a Construction project	
III	**Construction project planning & Scheduling:**		12
	3.1	Stages of planning in the view of owner / department as well as contractor.	
	3.2	W.B.S, Bar Charts its limitations and its uses, Milestone charts	
	3.3	Network-Terminology, Network Rules, Fulkerson's rule, Precedence network.	
	3.4	C.P.M- Activity & event with their types, activity times, event times, Critical path, forward pass, backward pass, float & its types.	
	3.5	P.E.R.T- Assumption underlying PERT analysis time estimates, slack& its types, probability of completing the project.	
IV	**Resources Management & Allocation :**		08
	4.1	Material Management- Importance, objectives and functions of material management. Inventory control, A-B-C analysis and E.O.Q.	
	4.2	Human Resource Management- Importance, objectives and functions	
	4.3	Resources Allocation Methods- Resource levelling and Smoothening	
V	**Project Monitoring & Cost Control :**		08
	5.1	Network Updating- Purpose and frequency of updating.	
	5.2	Time and cost optimization in construction projects - Compression & decompression of network.	
	5.3	Common causes of time over run & cost overrun & Corrective measures.	
VI	**Construction Safety, Quality Control & Labour Acts**:		05
	6.1	Common causes of accidents on construction sites, costs of accident and precautionary measures to avoid accidents.	
	6.2	Introduction to O.S.H.A. Occupational health hazards & Health Campaign in construction industry.	
	6.3	Concept of Quality and quality control.	
	6.4	Importance of labour acts as applicable to Indian construction labour such as Payment of wages act, Minimum wages act, Workmen's compensation act.	

Contribution to Outcome

On completion of this course, the students will be able to:

1	Explain & apply the knowledge of management functions like planning, scheduling, Executing & controlling the construction projects.
2	Prepare feasible project schedule by using various scheduling techniques.
3	Gain knowledge of managing various resources & recommend best method of allocating resources to the project
4	Develop optimum relationship between time & cost for construction project
5	Implement quality & safety measures on construction sites during execution of Civil Engineering projects.
6	Describe the importance of labour acts.

Internal Assessment: 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination: 80 marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1	Question paper will comprise of total six questions, each carrying 20 marks.
2	Question 1 will be compulsory and should cover maximum contents of the curriculum.
3	Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4	Only Four questions needs to be solved.

Recommended Books:

1	Construction Engineering and Management: S. Seetharaman.
2	Construction Planning & Management – Dr. U. K. Shrivastava.
3	Construction Projects planning and Management: P. S. Gahlot and Dhir New Age International (p) Publishers
4	Construction Project Management: Chitkara K. K. Tata McGraw Hill
5	Handbook of Construction Management: P K Joy, Macmillan, India
6	Critical Path Methods in Construction Practice: Antill J M &Woodhead R W, Wiley

Reference Books:

1	Construction Hazard and Safety Handbook: King &Hudson, Butterworth
2	Professional Construction Management: Barrie D.S. & Paulson B C, McGraw Hill
3	NPTEL: Civil Engineering-NOC: Principles of construction https://nptel.ac.in/courses/105/104/105104161/

Semester VIII

Course Code	Course Name	Credits
CEDLO8011	Department Level Optional Course-5: Bridge Engineering	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3Hr	-	-	-	100

Rationale

In the age of increase in traffic load and rapid transportation, bridges are very important part of nation's transportation infrastructure associated with the economic growth. Bridges allow for roads and railways to cross over obstacles such as rivers, valleys or other roads etc. Bridges are being built mainly with reinforced concrete, pre-stressed concrete or structural steel depending on various factors such as environment, site conditions, nature of loads and spans etc. The civil engineering profession is much concerned with proper planning, design, construction, maintenance, repairs and rehabilitation of bridges which are of utmost importance.

Objectives

1. Learner will be able to take the appropriate decision in respect of selection of site, type of bridge superstructure, sub structure, bearing, foundation, launching method of girder and construction methods as per conditions.
2. Learner will be able to analyze and design reinforced concrete culverts and pre-stressed concrete bridges using relevant IRCs.
3. Learner will be able to analyze and design lattice girder steel bridge for railway loading using relevant Bridge Rules and IRS code.
4. Learner will be able inspect the bridge and understand general aspects of repairs and rehabilitation.

Detailed Syllabus

Module	Sub-Modules/ Contents		Hrs.
I	**Introduction of Bridge Engineering**		02
	1.1	Types of bridges and their classification, components of a bridge	
	1.2	Selection of suitable site (data required and investigations)	
	1.3	Economic span	
II	**IRC loads, their distribution and design of superstructure for roadway bridges using limit state method**		20
	2.1	IRC loads: IRC-Class AA and 70R tracked vehicle, Class-A and Class-B train of vehicles	
	2.2	Design of RC culvert	
	2.3	Preliminary design of balanced cantilever bridge	
	2.4	Design of PSC deck slab bridge	
	2.5	Design of PSC I- girder bridge.	
III	**IRS loads, analysis and design of steel lattice girder bridge for broad gauge railway**		8
	3.1	Various IRS loadings, analysis of steel lattice girder bridge for broad gauge loading	
	3.2	Design guidelines for main components (top chord, bottom chord, diagonal member, end post) of steel lattice girder bridge [Numerical not expected]	
IV	**Substructure**		4
	4.1	Types of foundations and their choices, well foundation, pile foundation	
	4.2	Types of piers & abutments and their shapes, wing walls	
	4.3	Need of bearing, types and suitability	
V	**Erection of girder and construction methods**		2
	5.1	Various methods of erection of bridge girders	
	5.2	Cantilever method of construction of bridge	
VI	**Inspection and repairs of bridges**		3
	6.1	Categories of bridge inspection and instruments	
	6.2	General aspects of repairs, retrofitting and rehabilitation	

Contribution to Outcome

On completion of this course, the students will be able to:

1 Choose the suitable type of bridge according to site condition.

2 Design RC Culvert and RC balanced cantilever bridge using relevant IRCs.

3 Design prestressed concrete deck slab bridge and I-girder bridge using relevant IRCs.

4	Design steel lattice girder bridge using IRS loading.
5	Choose different bearings, foundations, piers and abutments based on their suitability.
6	Choose method of erection of bridge superstructure and repair techniques of existing bridges.

Site Visit/ Field Visit:
The learner shall visit an under construction prestressed concrete bridge or steel lattice girder bridge site and prepare a detailed report on the same.

Internal Assessment Examination **20 Marks**

Consisting of two compulsory Class Tests. First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

1	Question paper will comprise of total six questions, each carrying 20 marks.
2	Question 1 will be compulsory and should cover maximum contents of the curriculum.
3	Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4	Only Four questions need to be solved.
5	IRC: 6, IRC: 112 and IS: 1343 are allowed in the examination.

Recommended Books:

1	Design of Bridges: *Raju N. K.*, Oxford and IBH
2	Bridge Engineering: *Ponnuswamy S.*, Tata Mc Graw Hill
3	Design of Bridge Superstructures: *T.R. Jagdeesh* and*M.A. Jayaram,* Prentice Hall India Private Ltd., New Delhi
4	Comprehensive Design of Steel Structures: Dr. B C Punmia, Ashok Kumar Jain and Arun Kumar Jain; Laxmi Publications (P) Limited

IRC Codes:
IRC: 5- 2015, IRC: 6- 2017, IRC: 78-2014, IRC: 83-(Part-I)-2015, IRC: 83-(Part-II)-2018, IRC: 83-(Part – III)-2018, IRC: 112-2020, IRC:123-2017, IRC SOR17-1996, IRC SOR18-1996, IRC SP13-2004, IRC SP37-2010, IRC SP40-1993, IRC SP54-2000, IRC: SP105-2015

IRS Codes:
Bridge Rules: Rules specifying the loads for design of super-structure and sub-structure of bridges and for assessment of the strength of existing bridges -2014
Indian railway standard code of practice for the design of steel or wrought iron bridges carrying rail, road or pedestrian traffic (steel bridge code) -2017

Reference Books:

1	Concrete Bridge Practice: *Raina V. K.*, Tata Mc Graw Hill
2	Essentials of Bridge Engineering: *Victor D.J*, Oxford and IBH
3	Bridge Engineering Handbook: *Chen W. F. and Duan L.*, CRC Press, 2000
4	Bridge Bearings and Expansion Joints: *David Lee*, E & FN Spon

Semester VIII

Course Code	Course Name	Credits
CEDLO8012	**Department Level Optional Course-5: Design of Hydraulic Structures**	**03**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	**--**		**03**	**--**	**--**	**03**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam (Hours)	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3	--	--	---	100

Rationale

Hydraulic structures are the structures designed to retain, convey, control, regulate, mix and dissipate the energy of water. Such structures are constructed in all domains of water engineering; primary domains being water quantity management (water supply, irrigation, hydro power, flood control, drainage, navigation, socio-economic and recreational use), water-quality management and various transportation aspects. While the course emphasizes the "WHY" aspect; e.g., design of multi-purpose reservoirs and canal works, it also examines the "HOW" aspect of hydraulic structures. It is only through this mindful approach that the engineer can determine the advantages of a proposed design for a specific application.

Objectives	
1	To understand the reservoir and planning of reservoir, different zones, capacity and sedimentation control.
2	To convey the knowledge on the various types of Dams, utility and adaptability of various dams.
3	To develop understanding of the various causes of failure, design criteria and stability analysis of Gravity & Embankment dam.
4	To understand Spillways and Energy dissipators, their applicability.
5	To impart knowledge of canal headworks, canal regulation works and cross drainage works

Detailed Syllabus

Module	Sub-Modules/ Contents	Hrs.
I	**Reservoir Planning and Management:** Purpose of reservoir, classification of Reservoir, site selection, Investigation works for reservoir, storage zones storage capacity of reservoir, Yield and capacity of reservoir, mass inflow curve and demand curve, Determination of reservoir capacity, determination of safe yield, reservoir losses, reservoir sedimentation, sediment control, Multipurpose reservoirs, Flood Routing and its methods.	5
II	**Gravity Dams:** Various forces acting on gravity dam, Load combinations for design, Stability requirements& modes of failure, principal and shear stress, Profile of dam- elementary and practical profile, low and high gravity dam, Limiting height of gravity dam, High and Low gravity dam, Design of gravity dams, Galleries, Joints, Keys, Water seals, crack control in concrete dams.	10
III	**Arch and Buttress Dams:** Types of arch dams, forces acting on arch darn, design of arch dams, types of buttress dams.	4
IV	**Earth and Rock Fill Dams:** Types of earth dams, causes of failures of earth dams, design criteria, section of earth dam, downstream drainage system, seepage analysis, phreatic line, Stability analysis, stability of d/s slope during steady seepage, stability of u/s slope during sudden drawdown, stability of u/s and d/s slopes during construction, slope protection, seepage control measures, design considerations in earthquake regions, types of rock fill dams.	9
V	**Spillways and Flood Control Works:**	6
	Introduction, Necessity of spillways, location of spillway, design consideration of main spillway, Classification of spillways, straight drop spillway, design principles of ogee spillway, Chute spillway, Side channel spillway, conduit spillway, Siphon spillway and shaft spillway, energy dissipation below spillways, location of hydraulic jump and its	

	characteristics, design of bucket type energy dissipator and stilling basin,. Crest gates, types, advantages, design of radial gate, outlet works.	
VI	**Miscellaneous Topics:**	5
	Diversion head works-Component parts, functions, weirs and barrages, Bligh's Creep theory, Lane's weighed theory, Khosla's Theory. Canal regulation works - classification, Sarda type fall, Head regulators and Cross regulators, Canal escape. Cross Drainage Works-Types, classification of aqueducts and syphon aqueducts	

Contribution to Outcome

On completion of this course, the students will be able to:

1 Explain the Reservoir planning, storage capacity, Sedimentation & Reservoir losses.

2 Carry out the stability analysis of Gravity & Earth Dam.

3 Explain the causes of failure of various dams & their design criteria.

4 Design an ogee spillway.

5 Suggest suitable energy dissipation measures.

6 Describe the various minor irrigation structures such as Weirs & barrages, Canal Regulators and Cross-drainage works.

Internal Assessment_20 Marks

Consisting Two Compulsory Class Tests - First test of 20 marks based on approximately 40% of contents and second test of 20 marks based on remaining contents (approximately 40% but excluding contents covered in Test I). Average marks scored in the above two tests will be considered for final assignment of marks which will be out of 20.

End Semester Examination_80 Marks

Weightage of each module in end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

1) Question paper will comprise of a total six questions, each carrying 20 marks.
2) Question 1 will be compulsory and should cover maximum contents of the curriculum.
3) Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4) Only Four questions need to be solved.

Recommended Books:

1. Irrigation and Water Power Engineering: B.C. Punmia, PandeB.B.Lal, A.K Jain. Laxmi Publications Pvt, Ltd. New Delhi.
2. Irrigation Engineering and Hydraulic Structures: S.K. Ukarande, Ane Books Pvt. Ltd. ISBN-9789383656899.
3. Irrigation Water Resources and Water Power Engineering: P.N. Modi, Standard Book House, Delhi, ISBN 978-81-87401-29-0.
4. Irrigation Engineering and Hydraulics Structures: S. K. Garg, Khanna Publishers. Delhi.
5. Design of Irrigation Structures: S. K. Sharma, S. Chand and Co.

Reference Books:

1. Theory and Design of Irrigation Structures: R. S. Varshney and R, C. Gupta, Nem Chand
2. Engineering for Dams, Vol. I to III: Crager, Justin and Hinds, John Wiley
3. Design of Small Dams: USBR.
4. Hydro Power Structures: R. S. Varshney, Nem Chand and Bross.
5. Concrete Dams: R. S. Varshney, Oxford and IBH Publishing Co.

Semester VIII		
Course Code	**Course Name**	**Credits**
CEDLO8013	**Department Level Optional Course-5: Construction Safety**	**3**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
3	**-**	**-**	**3**	**-**	**-**	**3**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Practical	Oral	Total
Test-I	Test-II	Average						
20	20	20	80	3 Hrs	-	-	-	100

Rationale

The primary goal of this course is to have students learn that a "culture" of safety needs to be developed within companies for a safety program to be effective. This course is more about managing the safety process than the details involved in the specific construction activities.
Students in this course will be provided an understanding of safe working practices, various training that are required to be undergone by employees to ensure safe working environment on construction sites, record keeping and maintenance of records, compliance with OSHA worker safety, codes and environmental safety laws, inspection procedures, and penalties for lack of conformance to safety laws.
Students will also learn procedures for recognizing hazards, CPR, site safety meetings and accident investigations.

Objectives

1	Plan to comply with safety documentation/procedures and legal requirements
2	Differentiate OSHA requirements for different work activities
3	Design Safety and Emergency response plans
4	Analyse the cost of Accidents
5	Design an effective company safety culture manual
6	Prepare complete corporate safety plan and site-specific safety plan containing hazard analysis of actual construction projects.

Detailed Syllabus

Module	Sub-Modules/ Contents		Hrs.
I	**Construction Safety Management:**		04
	1.1	Role of top management, Duties & responsibilities of various officers on site, Responsibilities of general employees	
	1.2	Safety committee. Role of safety officer	
	1.3	General OSHA Requirements, Safety training, Safety campaign	

II	**Safety in construction operations and emergency response**		06
	2.1	Safety on various construction sites viz. buildings, dams, Tunnels, bridges, roads	
	2.2	Safety at various stages of construction. CPR, site safety meetings	
	2.3	Prevention of accidents. Safety measures. (preferably, site visit shall be arranged to understand the actual safety measures undertaken on construction sites)	
III	**Safety in use of construction equipment**		07
	3.1	Safety while operating construction equipment. vehicles, cranes, hoists and lifts	
	3.2	Safety of scaffolding and working platforms	
	3.3	Safety while using electrical appliances and explosives used.	
IV	**Accident prevention mechanisms**		12
	4.1	Hazard Recognition, Evaluation, and Control.	
	4.2	Fall Hazards & Fall Arrest- Ladders, Stairs, & Scaffolds	
	4.3	Electrical Safety Guidelines & Lockout, Tag-out. Struck-By and Caught-in-Between Hazards	
	4.4	Personal Protective gear, first aid on construction sites	
	4.5	Job-Site Exposure Hazards, Occupational Hazards	
	4.6	Environmental Extremes - extreme hot and extreme cold weather hazards	
	4.7	Fire Hazards and Fire fighting - Use of fire extinguishers and other fire control measures. Occupational Health Hazards	
V	**Labor Laws and legal requirements**		04
	5.2	Study of various existing national and state laws for worker safety and well-being	
	5.2	Accident Analysis, computation of costs of accidents for various scenarios, Worker's compensation insurance	
VI	**Study of Safety Policies**		06
	6.1	Study of safety policies, methods, equipment and training provided on any ISO approved construction company. Safety Standards and codes	
	6.2	Safety in office, working on sites of high rise construction, prevention of workplace violence	
	6.3	Observance of safety week, zero accident period, awards to best employee (for safety adherence), reprimands to habitual defaulters, etc.	

Contribution to Outcome	
On completion of this course, the students will be able to:	
1	Apply safety mechanisms and concepts for improving overall safety of construction sites
2	Demonstrate the various safety requirements
3	Explain the various techniques to prevent accidents.
4	Examine construction safety management.
5	Implement safety policies, methods and training on construction sites.
6	Practice safety in construction operations.

Internal Assessment		**20 Marks**
Consisting 2 Compulsory Class Tests - 1st test based on approximately 40% of contents and 2nd test based on remaining contents (approximately 40% but excluding contents covered in Test I)		
End Semester Examination		**80 Marks**
Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.		
1	Question paper will comprise of total six questions, each carrying 20 marks.	
2	Question 1 will be compulsory and should cover maximum contents of the curriculum.	
3	Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).	
4	Only Four questions need to be solved.	
Recommended Books:		
1	Construction Safety and Health (2nd ed), David L. Goetsch, Publish by Pearson ISBN-13: 978-0-13-237469-9, ISBN-10: 0-13-237469-2	
2	Safety Management, Girmaldi and Simonds, AITBS Publishers, New Delhi	
3	Construction Safety, Jimmy W. Hinze , Prentice Hall Inc.,	
4	Construction Safety and Health Management, Richard J. Coble, Jimmie Hinze and Theo C. Haupt, , Prentice Hall Inc., 2001.	
5	Construction Safety, R.K. Mishra, AITBS Publishers, New Delhi	
6	Safety Management in Construction (Principles and Practice), S.K. Bhattacharjee, Khanna Publishers, New Delhi	
7	Safety, Occupational Health And Environmental Management In Construction, S. C. Sharma and Vineet Kumar,	
8	Construction Safety (English), by D.S.S.Ganguly and C.S.Changeriya, Chetan Publication; 2017th edition, ISBN-10 : 9386953293,ISBN-13 : 978-9386953292	
9	Construction Safety Handbook - Davis V.S Thomasin K, Thomas Telford, London	
Reference Books:		
1	Construction Safety Manual published by National Safety Commission of India	
2	Safety Management in Construction Industry"- A manual for project managers- NICMAR, Pune	
3	Construction Safety Handbook - Davis V.S Thomasin K, Thomas Telford, London	
4	IS standards for safety in construction - Bureau of Indian Standards	
5	OSHA Standards (CFR 1926) at www.osha.gov/readingroom.html	

Semester VIII

Course Code	Course Name	Credits
CEDLO8014	**Department Level Optional Course-5: Pavement Design**	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	-	-	-	100

Rationale

The pavements are classified according to mode of transportation (highway and airways) and structural behaviour (flexible and rigid). The design of any pavement warrants the proper analysis thereof. The course deals with the various methods of the analyses and design of pavements.

Objectives

1 To study the different types of pavements depending upon the mode of transportation, factors affecting pavement design, and methods.

2 To understand the concept of analysis of stress, strain and deflection in pavement.

3 To enable the students to understand and analyse the mechanics related to flexible pavements as applicable for highways.

4 To study the various types of structural responses (stresses and deformations) inducing the pavements due to wheel load and other climatic variations. To enable the students to understand and analyses the concrete pavements as applicable for highways.

5 To enable the students to understand and analyse the mechanics related to flexible and concrete pavements as applicable for airports.

6 Evaluation of the existing pavements using different methods and rehabilitation of the distressed pavements and introduce pavement management system

Detailed Syllabus

Module	Sub-Modules/ Contents		Hrs.
I	Introduction		04
	1.1	Classification of Pavement, Pavement structure and functional attributes, factors affecting pavement design.	
	1.2	Types of wheel loads for highways and airports, development of design method for highway and airport pavements	
II	Stresses in Pavement		06
	2.1	Stresses in flexible pavements, 1-layer, 2-layer, 3-layers theories, EWLF,ESWL	
	2.2	Stresses in Rigid pavement: load and temperature stresses, combined stresses.	
III	Flexible Pavement Design		08
	3.1	Empirical methods using no soil strength criteria, empirical method based no soil strength criteria: CBR method as specified by IRC-37 -1970, 1984, 2001, 2012, 2018.	
	3.2	Road note 29 methods, AASHTO method, Asphalt institute method. Fatigue and rutting as a failure criterion.	
	3.3	Introduction to use of software for flexible pavement design.	
IV	Rigid Pavement Design		08
	4.1	Load and temperature stresses in rigid pavements Westergaard's, Bradburry's and Picket's concepts	
	4.2	Design steps as per IRC-58-2012,2015 method	
	4.3	Design of joints in rigid pavements	
	4.4	Introduction to use of software for rigid pavement design	
V	Design of Airport Pavements		08
	5.1	Factors affecting, types of wheel loads , aircraft loading, gear configuration and tyre pressure , development of design method	
	5.2	Design Methods: Corps of Engineer's method, FAA method CDOT method, Asphalt institute method. PCA methods	
	5.3	Joints and reinforcement requirement.	
VI	Design of Overlay		05
	6.1	Design aspects of flexible and rigid overlays design of overlays (IRC-81-1997)	
	6.2	Introduction to pavement management systems: Components of pavement management systems	

Contribution to Outcome

On completion of this course, the students will be able to:

1. Explain the structural actions involved in the pavement due to different types of load acting thereon and the various methods of analysis of pavements.
2. Describe the applications of the analysis in the design of pavements using different methods of pavement design.
3. Explain of the design of flexible pavement.
4. Describe the design of Rigid pavement.
5. Explain the design of airfield pavements and apply this knowledge in the field
6. Evaluate the different types of distresses occurring in the existing pavements and carry out the structural and functional evaluation of the pavements. Understand the pavement management system.

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I) Average marks scored in the above two tests will be considered for final assignment of marks which will be out of 20.

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Recommended Books:

1. Principles and Practice of Highway Engineering: *L.R.Kadiyali*, Khanna publications.
2. Highway Engineering: *Khanna S.K. and Justo* C.E.G. Nem Chand (Revised 10th Edition, 2014)
3. Principles, Practice and Design of Highway Engineering (Including Airport Pavements): *Sharma, S.K.*, S. Chand Technical Publications (3rd Revised Edition, 2013)
4. Pavement Design: *Yoder* and*Witzech*, McGraw-Hill, 1982.

Reference Books:

1. Rajib Mallick & Tahar El-Korchi, *Pavement Engineering: Principles and Practice*, CRC Press , 2nd Edition, 2013
2. A. T. Papagiannakis, Eyad A Masad, *Pavement Design and Materials*, John Willey and Sons , 1st Edition 2008
3. Relevant Latest IRC, ASTM, AASHTO and other Codes, Manuals and Specifications
4. R Srinivasa Kumar, Pavement Design , University Press.
5. Pavement Analysis and Design: *Yang H. Huang*, Prentice Hall, New Jersey, 1993
6. The Design and Performance of Road Pavements: *Croney, David et al*, McGraw Hill.

Semester VIII

Course Code	Course Name	Credits
CEDLO8015	Department Optional Course 5: Industrial Waste Treatment	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hrs.	--	--	--	100

Rationale

Industrial wastewater is much more polluted than the domestic wastewater and hence has to be treated with the efficient choice of treatment units by preventing pollution of natural streams and rivers. Wastewater treatments may not suffice only with primary treatments until they are modified and supplemented by additional techniques because of toxic chemicals. Industries are therefore generally prevented by legal aspects, from discharging their untreated effluents. It becomes mandatory for industries to treat their wastewater in their individual treatment plant or common effluent treatment plant before discharging their waste on land, lake, river, municipal sewer, streams as the case may be.

Objectives

1. To enable the students to understand quality, characteristics, toxicity of industrial wastewater and its effects on streams.
2. To enable the students to understand the impact of industrial wastewater on natural streams.
3. To enable the students to understand waste minimization techniques for industrial wastewater.
4. To enable the students to understand the necessary knowledge and concepts of biological treatment and advanced/emerging techniques.
5. To enable the students to understand various industrial manufacturing process, effluents and treatments.
6. To enable the students to understand legislative framework for the remediation of industrial wastewater through environmental audit, environmental impact assessment and common effluent treatment plant.

Detailed Syllabus

Module	Sub-Modules/ Contents		Hrs.
I	**Introduction to industrial waste and treatments:** Sources and types of industrial waste-water, Effects of industrial waste-water on streams and waste-water treatment plants. Population equivalence, generation rates, characterization, important contaminants of concern from industries. Toxicity and Bioassay tests. Regulation for protection of streams. BOD Numericals.		06
II	**Stream Protection Measures:** Stream and effluent standards, stream sampling, stream sanitation, Procedures for improving stream water quality, zones of pollution, oxygen sag curve, Streeter Phelps Equation and numerical.		06
III	**Waste minimization:**		06
	3.1	Minimizing effects of industrial waste water: Volume reduction and Strength reduction	
	3.2	Equalization, Neutralization, Proportioning, Precipitation, Coagulation and flocculation. Flotation - Oil separation and Emulsion breaking.	
IV	**Waste-water treatments for industries**		06
	4.1	**Biological treatments:** Aerobic and Anaerobic biological treatment methods (Ponds, lagoons, UASB, RBC). Sludge dewatering techniques- Filter Press, Vacuum Filtration, Sludge thickening, Membrane filtration and Centrifuge.	
	4.2	**Advanced treatments:** Need for advance technologies, Automated Chemostat Treatment (ACT) Soil Biotechnology (SBT) Reed Bed Technology (RBT) Ozonation	
V	**Industries and waste-water management:** Raw material, Manufacturing process and flow-sheets, sources of effluents, characteristics, ETP, byproduct recovery for following industries: ● Sugar ● Distillery ● Tannery ● Dairy ● Paper and Pulp ● Metal Processing Industry (Electroplating)		10

VI	**Legal Aspects, Environment Management Tools and Common Treatment Facility for industries**		05
	6.1	Environmental Impact Assessment, Case Study.	
	6.2	Environmental Audit for industries.	
	6.3	Common Effluent Treatment Plants (CETPs): Flow chart, Location, Need, Operation & Maintenance Problems and Economical aspects. Case study.	

Contribution to Outcome

Having completed this course, the students shall acquire the knowledge of biological treatment and will be able to decide and select precise treatment for particular waste. The students shall be able to determine and design the treatment facilities and assess the guidelines for disposing of waste. They shall be able to formulate approaches to treat waste water in the most effective manner for contamination removal.

After the completion of the course the learner should be able to:

1. Explain the impact of industrial wastewater characteristics on natural streams.
2. Analyze various stream protections measures to protect the natural streams.
3. Summarize waste minimization techniques for industrial wastewater.
4. Relate biological treatment concept and summarize various treatments along with advance technologies.
5. Describe waste water generated during manufacturing process and decide the suitable treatment for effluents.
6. Evaluate legislative framework for the remediation of industrial wastewater through environmental audit, environmental impact assessment and common effluent treatment plant.

Internal Assessment: **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I) Average marks scored in the above two tests will be considered for final assignment of marks which will be out of 20.

End Semester Examination: **80 Marks**

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of a total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature

4 Only Four questions need to be solved.

Recommended Books:

1. Industrial Pollution Control by Eckenfedlar W.W, 2017
2. Wastewater Engineering Treatment, Disposal, Refuse: Metcalf and Eddy, T.M.H. Edition, New Delhi, 1995.
3. Environmental Engineering Vol II- Sewage Disposal and Air Pollution Engineering: S. K. Garg, Khanna Publishers New Delhi.
4. Water supply and sanitary Engineering: Hussain S. K., Oxford and IBH Publication, New Delhi.
5. Wastewater Treatment for Pollution Control and Reuse Hardcover – 1 July 2017, Soli. J Arceivala , Shyam. R Asolekar.
6. Environmental Engineering: B. C. Punmia, Laxmi Publications, New Delhi.
7. Water Supply and Sewerage: E.W. Steel.
8. Introduction to Environmental Engineering, Vesilind, PWS Publishing Company 2000.
9. Introduction to Environmental Engineering: P. Aarne Vesilind, Susan M. Morgan, Thompson.
10. Wastewater Treatment- Concepts and Design Approach: G. L. Karia and R. A. Christian.
11. Basic Principles of Wastewater Treatment Book ,Marcos Von Sperling
12. Industrial Waste Water Treatment Book, A. D. Patwardhan
13. Waste Water Treatment , M.N. Rao and Dutta

Reference Books:

1) Manual on Wastewater Treatment 3rd Ed. Pub: CPH and Env. Engg. Organization, Ministry of Urban Development, Govt. of India, New Delhi, 1991.
2) CPHEEO Manual on Sewage and Treatment.
3) Relevant Indian standard specifications and BIS publications.
4) Handbook of Water and Wastewater Treatment Plant Operations Book,y Frank R. Spellman

Semester VIII		
Subject Code	**Subject Name**	**Credits**
CEDLO8016	**Department Level Optional Course-5: Soil Dynamics**	**03**

Teaching Scheme						
Contact Hours			**Credits Assigned**			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorials**	**Total**
03	--	--	03	--	--	03

Evaluation Scheme								
Theory					**Term Work/ Practical/Oral**			**Total**
Internal Assessment			**End Sem Exam**	**Duration of End Sem Exam**	**TW**	**PR**	**OR**	
Test 1	**Test 2**	**Average**						
20	20	20	80	03 Hrs.	--	--	--	100

Rationale

In basic geotechnical engineering course normally various static loads are considered in the theories and analysis of soil. But practically many geotechnical applications require the knowledge of the behavior. properties and response of soil as a material which is subjected to various types of dynamic or cyclic time-dependent loadings. Some of the structures which are subjected to dynamic loadings are machine foundations, shallow and deep foundations, retaining structures, slopes, subgrade soil below railway, pavement, runway etc. This course provides the fundamental theoretical and computational aspects of dynamics for some important geotechnical problems and structures.

Objectives

1. To study fundamental concepts of vibrations, degrees of freedom and damping systems.
2. To study phenomena like liquefaction and their effects.
3. To study principals of machine foundation design and dynamic earth pressure theories on Retaining wall.
4. To learn test methods of evaluating dynamic properties of soil.
5. To know the earth pressure on retaining walls.

Detailed Syllabus		
Module	**Sub- Modules/Contents**	**Hrs**
I.	**Introduction to Soil Dynamics**	**04**
	1.1 Introduction to vibration (simple harmonic motion), Types of waves **1.2** Introduction to the concept of degree of freedom **1.3** Introduction to dynamic soil properties (IS4249) **1.4** Scope and objective, Nature and types of dynamic loading, Importance of soil dynamics.	
II.	**Dynamic approach in different components**	**05**
	2.1 Wave propagation in elastic rods, in an elastic finite medium and in semi-elastic half space **2.2** Wave generated by surface footing	
III.	**Liquefaction of Soil**	**08**
	3.1 Introduction to liquefaction of soils and its basic terminologies, criterion and factors affecting liquefaction of soil. **3.2** Liquefaction studies in triaxial shear, field studies on liquefaction **3.3** Evaluation of liquefaction potential using analytical method and SPT.	
IV.	**Machine Foundation**	**06**
	4.1 Principles of machine foundation design, criteria for satisfactory machine foundation, degree of freedom of a block foundation, analysis of vertical and sliding vibration of a machine foundation **4.2** Practical design considerations and codal provisions.	
V.	**Dynamic behavior of Machine Foundation**	**05**
	5.1 Mass of soil participating in vibration. **5.2** Vibration isolation and screening methods, improvement of distressed machine foundation.	
VI.	**Dynamic behavior of Retaining Wall**	**11**
	6.1 Field and laboratory tests for evaluation of dynamic properties of soil under vertical vibration coefficient of elastic uniform shear, spring constant damping modulus of elasticity typical values of soils. **6.2** Basics of dynamic earth pressure on retaining walls conventional gravity type, reinforced soils, distribution of pressure, and point of application of the resultant, simple examples.	
	Total teaching Hours	**39**

Course Outcome

On successful completion of the course, the students are expected to:

1. Demonstrate the knowledge of concepts, principles, and applications of soil response under dynamic loading.
2. Develop an ability to design with reference to code provisions and solve the practical soil problems subjected to vibrations.
3. Able to explain the concept of Liquefaction Potential of different types of soil
4. Provide an impetus to new developments in related dynamic topics.
5. Carryout field tests on soil to know the dynamic properties of soil.
6. Calculate the dynamic earth pressure on retaining walls.

Internal Assessment: **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents And second test based on remaining contents (approximately 40% but excluding contents covered in Test I) Average marks scored in the above two tests will be considered for final assignment of marks which will be out of 20.

Theory Examination:-

- Question paper will comprise of **six** questions: each carrying 20marks.
- The **first** question will be **compulsory** which will have the short questions covering the entire syllabus.
- The remaining five questions will be based on all the modules of Entire syllabus. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub- module and contents thereof.
- There can be an internal choice in various sub-questions / questions to accommodate the Questions on all the topics /sub-topics.
- The students will have to attempt any **three** questions out of remaining **five** Questions.
- Total **four** questions need to be attempted.

Recommended books:

1. Soil Dynamics: *Shamsher Prakash,* McGraw-Hill book company
2. Principles of Soil Dynamics: *Braja, M.Das,* PWS-Kent Publishing Company
3. Dynamics of Bases and Foundations: *Barkan, D.D.*, McGraw- Hill Book company
4. Geotechnical Earthquake Engineering", StevenL.Kramer ,PrenticeHalllnc.
5. Vibrations of Soils and Foundations", E.E.Richartetal ,PrenticeHallInc.
6. Relevant IS codes

Semester VIII

Course Code	Course Name	Credits
CEDLO8021	Department Optional Course 6: Repairs, Rehabilitation and Retrofitting of Structures	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hrs.	--	--	--	100

Rationale

Structures need strengthening and repairs due to variety of reasons. Now a days different materials, techniques and machineries are used to improve the structures and prolong their serviceable life. A structure needs regular maintenance to perform satisfactorily during its lifetime. This subject deals with damage assessment, preparing a strengthening strategy of RCC , steel structures, Seismic Retrofitting and maintenance of heritage structures.

Objectives

1. To understand the concept of Repair of repair and its need.
2. To understand various causes of deterioration of concrete structure and Distresses monitoring techniques.
3. To understand various materials of repairs and their properties.
4. To understand various methods of repairs of concrete structure.
5. To understand various methods of repairs of steel structure.
6. To understand seismic retrofitting and maintenance of heritage structures.

Detailed Syllabus

Module	Sub- Modules/Contents		Hrs
1	**Introduction**		03
	1.1	Need for repair, rehabilitation and maintenance of structure. Repair Management. Sustainable development.	
	1.2	Maintenance and it's importance, life cycle cost of structure	
	1.3	Heritage structure and need for their Rehabilitation	
2	**Damage Assessment**		08
	2.1	Causes of deterioration of concrete: Physical , Chemical and Mechanical causes.	
	2.2	Distresses monitoring, Visual inspection, Non Destructive Testing using Rebound hammer, Ultra sonic pulse velocity, Semi destructive testing, Probe test, Pull out test, Chloride penetration test, Carbonation, Carbonation depth testing, Corrosion activity measurement.	
	2.3	Types of cracks: Diagonal Cracks, Horizontal Cracks, Splitting Cracks, Corrosion Cracks, Plastic shrinkage cracks, thermal cracks	
	2.4	Crack Measurement techniques: Steel Ruler, Magnified Graticule , Plastic Tell Tale Glass Tell Tale Brass Screws and Caliper Displacement Transducer	
3	**Repair of Concrete Structures**		06
	3.1	Methods of crack repairs: Epoxy injection, Routing and Sealing of Cracks, Stitching Prestressing steel Drilling and Plugging Method Gravity Filling Method	
	3.2	Repair Materials: Essential parameters for repair materials.. Materials for repair: Materials for Surface Preparation, Chemical Rust removers for corroded reinforcement, Passivators for reinforcement protection, Bonding Agents, Structural Repair Materials, Non-structural Repair Materials, Injection grouts, Joint sealants,Surface coatings for protection of RCC. Premixed Cement concrete/mortars, Polymers/latex modified cement mortars, Epoxy resins	
	3.3	Corrosion repair methods: Cathodic Protection, Chloride Removal	
4	**Rehabilitation and Retrofitting Methods**		10
	4.1	Repair Stages: Concrete Removal and Surface Preparation, Fixing formwork, Bonding / passivating coat and repair application.	
	4.2	Repair Methods: Repairs using mortars/modified mortars, Epoxy based material repairs, Shotcrete, Ferro-cement, Plate bonding, RCC Jacketing Propping and Supporting, Fibre Wrap Technique.	

	4.3	Foundation Rehabilitation Methods: Shoring, Raking shores, Flying shores, Dead shores. Underpinning. Slab jacking.	
5	**Repair of steel structures**		**06**
	5.1	Types and causes for deterioration - Preventive measures - Repair procedure - Brittle fracture - Lamellar tearing - Defects in welded joints -	
	5.2	Design and fabrication errors - Distress during erection - Causes and remedies	
	5.3	Repair methods for structures.	
6	**Seismic Retrofitting and Maintenance of Heritage Structures**		**06**
	6.1	Earthquake damages of buildings, their retrofitting and restoration. Effects of earthquakes.	
	6.2	Methods of seismic retrofitting, restoration of buildings Special care in repair and rehabilitation of heritage structures.	
		Total	**39**

Contribution to Outcome

On completion of this course, the students will be able to:

1. Describe the concept of repair and its need.
2. Classify various causes of deterioration of concrete structure and Distresses monitoring techniques.
3. Classify various materials of repairs and their properties.
4. Explain various methods of repairs of concrete structure.
5. Describe various methods of repairs of steel structure.
6. Explain seismic retrofitting and maintenance of heritage structures.

Internal Assessment: **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I) Average marks scored in the above two tests will be considered for final assignment of marks which will be out of 20.

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

- Question paper will comprise of **six** questions: each carrying 20marks.
- The **first** question will be **compulsory** which will have the short questions covering the entire syllabus.

- The remaining five questions will be based on all the modules of Entire syllabus. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub- module and contents thereof.
- There can be an internal choice in various sub-questions / questions to accommodate the Questions on all the topics /sub-topics.
- The students will have to attempt any **three** questions out of remaining **five** Questions.
- Total **four** questions need to be attempted.

Recommended Books:

1. CPWD Handbook on Repair and Rehabilitation of RCC buildings, Govt of India Press, New Delhi
2. Santhakumar A.R., "Concrete Technology" Oxford University Press, 2007, New Delhi
3. Bhattacharjee J, Concrete Structures Repair Rehabilitation and Retrofitting- 2019 , CBS Publishers & Distributors Pvt. Ltd.

Reference Books:

1. Raikar, R.N., "Learning from failures - Deficiencies in Design, Construction and Service" R and D Centre (SDCPL), Raikar Bhavan, Bombay, 1987.
2. Maintenance, Repair & Rehabilitation and Minor Works of Buildings P.C.Varghese, PHI Publications
3. P.K.Guha , Maintenance & Repairs of Buildings, New Central Book Agency (P) Limited,
4. R.Dodge , Concrete structures Concrete Structures Protection Repair and Rehabilitation, woodson

Semester VIII

Course Code	Course Name	Credits
CEDLO8022	Department Optional Course 6: Physico - Chemical Treatment of Water and Waste Water	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hrs.	--	--	--	100

Rationale

This course introduces the principles and physico-chemical methods to control water and wastewater pollution. The aim of the course is to give a more fundamental and theoretical understanding of the specific unit processes, providing a better understanding of the principles of how they function and the degree of treatment that can be achieved. Students should be conversant with the sedimentation, coagulation, filtration, disinfection, advanced physico-chemical processes of water and wastewater. They should be conversant with de-watering and disposal of sludge.

Objectives

1. To study the impact of water and waste-water treatment on the environment.
2. To develop the rational approach towards the design of preliminary treatments.
3. To design primary treatment units.
4. To Explain and apply chemical unit techniques.
5. To impart knowledge about the advanced treatment for water and waste-water.
6. To study sludge de-watering & disposal techniques.

Detailed Syllabus

Module	Sub- Modules/Contents	Hrs.
I	**Quality, Quantity of Water and Waste-water** Characteristics of water and waste-water, conventional water and waste-water treatment, Sampling and analysis, Health and environmental concerns, Components of waste water flows, sources, strategies for reducing interior water use and waste water flow rates, waste water reclamation and reuse	6
II	**Preliminary Treatment of Water and Waste-water** Screens: significance, Classification of screens, Design for head loss, Grit chambers: Gravity settling, stoke's law, Classification and Design Skimming Tank design and flotation	6
III	**Primary Treatment of Water and Waste-water** **Sedimentation:** Significance, Types of sedimentation tanks, Zones of settling, Design parameters, Design of sedimentation tank, Tube settlers **Filtration:** Mechanisms of filtration, hydraulics of filtration, different types of filters, filter clogging, filter washing, Design criteria of Rapid sand filter	8
IV	**Chemical units-Techniques:** Role of chemical unit processes in water and waste water treatment, **Coagulation:** Fundamentals, coagulant aids, polyelectrolytes, Design of flash mixer, power requirement **Flocculation:** Types of flocculation and flocculators, Design of flocculator, power requirement	6
V	**Advanced Physico-chemical Processes:** Softening, methods of softening, Chemical precipitation, Desalination, solar distillation, Reverse osmosis, Electrolysis Disinfection, Disinfection using chlorine and UV. Estimation of Chorine doses, Use of various forms of chlorine Removal of heavy metals, neutralization, Chemical oxidation of BOD and COD, Removal of colour, Gas stripping, Adsorption and Ion Exchange, Reverse osmosis, Membrane filtration, Activated carbon treatment	08
VI	**Sludge De-watering and Disposal** Sources of sludge, Estimation of bulk density of sludge, Principles of dewatering, Methods and suitability, thickening of sludge, Chemical conditioning, Elutriation of sludge, Vacuum and pressure filtration, sludge drying beds, Design of sludge drying beds	05

Contribution to Outcome

After the completion of the course the learner should be able to:

1. Explain the quality, quantity and treatment of water and waste-water.
2. Design preliminary units for treatment of water and waste-water
3. Evaluate the removal efficiencies of physico-chemical treatment units.
4. Identify optimized dose of chemical coagulation as well as disinfecting agents.
5. Apply advanced physico-chemical processes to water and waste-water.
6. Administer sludge de-watering and disposal process

Internal Assessment: **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I) Average marks scored in the above two tests will be considered for final assignment of marks which will be out of 20.

End Semester Examination **80 Marks**

Weightage of each module in the end semester examination will be proportional to the number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of a total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature
4 Only Four questions need to be solved.

Recommended Books:

1. Wastewater Engineering Treatment, Disposal, Refuse: Metcalf and Eddy, T.M.H. Edition
2. Water Supply Engineering: S. K. Garg, Khanna Publication.
3. Environmental Engineering Vol II- Sewage Disposal and Air Pollution Engineering: S. K. Garg, Khanna Publishers.
4. Water supply and sanitary Engineering: Hussain S. K., Oxford and IBH Publication, New Delhi.
5. Industrial Pollution Control by Eckenfedlar W.W
6. Wastewater Treatment for Pollution Control and Reuse Hardcover – by Soli. J Arceivala (Author), Shyam. R Asolekar (Author)
7. Environmental Engineering: B. C. Punmia, Laxmi Publications, New Delhi.
8. Water Supply and Sewerage: E.W. Steel.
9. Introduction to Environmental Engineering, Vesilind, PWS Publishing Company 2000.
10. Wastewater Treatment- Concepts and Design Approach: G. L. Karia and R. A. Christian.
11. Basic Principles of Wastewater Treatment Book by Marcos Von Sperling
12. Industrial Waste Water Treatment Book by A. D. Patwardhan
13. Environmental Engineering: Peavy,H.S., RoweD.R.,
14. CPHEEO Manual on Water Supply and Treatment.
15. CPHEEO Manual on Sewage and Treatment

Semester VIII

Course Code	Course Name	Credits
CEDLO8023	Department Level Optional Course-6: Transportation System Engineering	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Rationale

Transportation contributes to the economical, industrial, social cultural development of any country. The adequacy of Transportation system of a country indicates its economic social development. Three basic modes of transportation include land, water and air. The land mode further includes highways and railways. This course is developed so as to impart the basic principles behind Railway Engineering, Airport Engineering, Water Transportation Engineering, Public Transportation system in respect of various types of materials used, function of component parts and planning principles.

Objectives

1. To enable the students to study the various elements of Transportation system in the country, NUTP and its Environmental consideration.
2. To study, plan and design different elements of airports and understand aircraft movement controls.
3. To explain and design various geometric elements of railways and study the elements of modern rails.
4. To Explain different components of water transport such as Ports, Harbors and Docks.
5. To study and Explain planning elements of public transport systems.
6. To Explain different components of bridges, planning of bridges and analyzing different hydrological elements of bridge.

Detailed Syllabus

Module	Sub- Modules/Contents		Hrs
I	Introduction to Transportation System		05
	1.1	Role of transportation system in development of country, Different modes of transportation; their merits and demerits, present scenario of each mode in India. Different modes of Public Transportation modes available in Mumbai and Suburban areas with advantages and disadvantages of each.	
	1.2	Urban Transport: National Urban Transport Policy, Sustainable Transportation, Transit Oriented Development.	
	1.3	Environmental Guidelines for Transportation Infrastructure Projects: Environmental Impact Assessment, Identification of Impacts, Measures for offsetting adverse impacts.	
II	Air Transportation System		10
	2.1	Introduction: Aircraft: Types and components Airport: Site selection, classification, obstruction, zones and zoning laws, Environmental impacts and guidelines for Airport projects	
	2.2	Airport components: Requirements and functions of each Terminal building: Layout and planning, gate positions and gate capacity, blast consideration Apron and holding apron Taxiway: Design Runway: Configuration, orientation, wind rose diagram, basic runway length and corrections to runway length, Aircraft parking and hangars Airport drainage: Requirements and types	
	2.3	Aircraft movement control: Lighting and marking of runway, taxiway and other areas Air traffic control aids, en-route aids and landing aids	
	2.4	Planning of Heliports: Characteristics of Helicopter, Selection of site, Size of landing area, Obstruction clearance requirements, Marking and Lighting of Heliports.	
III	Rail Transportation System		08
	3.1	Introduction: Alignment of Railway lines, Engineering Surveys for new railway lines. Introduction to Railway Track Components: Requirements and functions of each	
	3.2	Geometrics- Gradient: Types Curves: Widening on curves, cant and cant deficiency Turnout: Components and design	
	3.3	Yards: Types and functions, Signaling- classifications,	

		interlocking of signals and points	
	3.4	Modern Rails: Characteristics of MAGLEV, Metro rails and mono rails, modernization of track and railway station, high speed trains (Bullet trains) and high-speed tracks	
IV	Water Transportation System		04
	4.1	Harbour: Classification, functions and requirements Harbour Infrastructures: Types of breakwaters, jetty, dock fenders, piers, wharves, dolphin, mooring accessories	
	4.2	Docks: Repair facilities, wet docks, lift docks, dry docks, gates for graving docks, floating docks	
	4.3	Port facility: Transit shed, warehouses, cargo handling, container handling	
V	Public Transportation System		06
	5.1	Introduction: Para Transit system, Street Transit system, Rapid Transit System.	
	5.2	Route and Schedule: Properties of good route set, stopping policy and Stop location, Properties of good schedule.	
	5.3	Capacity of Transit system: Capacity of Rapid Transit system, Capacity of Street Transit system.	
VI	Bridge Engineering		06
	6.1	Introduction: History and classification of bridge, Components of bridge, Requirement of Ideal bridge, Site selection and selection of alignment of bridges, Various loads on bridges	
	6.2	Low-cost Bridges: Introduction to Causeways, Culverts, Floating bridges etc.	
	6.3	Bridge superstructure and its types, Bearings and Joints on bridges Piers, abutments, Wing walls and approaches, Types of bridge foundations	
	6.4	Bridge Hydrology: Flood Discharge, Waterway, Economic span, Scour depth, Afflux.	

Contribution to Outcome

On completion of this course, the students will be able to:

1. Compare different modes of transportation and describe National Urban Transport Policies.
2. Plan and design different elements of Airports, movements of aircrafts and helicopters.
3. Plan and design geometric elements of railway system and explain the elements of modern trains.
4. Explain different components of water transport.
5. Plan different public transport system, routing, scheduling and estimating transit capacity of the system.
6. Explain different elements of bridge and analyse various hydrological elements of bridge.

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Recommended Books:

1. Khanna S.K., Arora M.G., Jain S.S., Airport Planning & Design, Nemchand Bros., Roorkee
2. Saxena S.C., Railway Engineering, Dhanpat Rai & Sons, 1995
3. Srinivasan R., Harbours, Docks & Tunnel Engineering, Charotar Publishing House, Anand
4. Partha Chakroborty, Animesh Das, Principles of Transportation Engineering
5. Bindra S.P., Bridge Engineering, Dhanpat Rai & Sons

Reference Books:

1. Horenjeff Robert, The planning & Design of Airports, McGraw Hill Book Co.
2. Indian Railway Track: *Agarwal, M. M.,* Suchdeva Press New Delhi.
3. Planning Design of Airport: *Horonjeff Mckelrey*, Tata Mc-Graw Hill India Publishing House, New Delhi.
4. Docks & Harbour Engineering, Bindra S.P., Dhanpat Rai Publications,
5. Design and Construction of Ports and Marine Structures: Quinn, A. D., Tata Mc-Graw Hill India Publishing House
6. Transportation Engineering and Planning: C.S. Papacostas and P.D. Prevedouros; Prentice Hall India Learning Pvt. Ltd., New Delhi
7. Transportation Engineering: *Khisty, C.J. and Lall, Kent, B.;* Prentice Hall India Learning Pvt. Ltd., New Delhi

Semester - VIII

Course Code	Course Name	Credits
CEDLO8024	Department Level Optional Course-5: Smart Building Materials	03

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--	--	--	100

Rationale

A safe, comfortable, and sustainable built environment is highly desirable, as we spent most of our time in offices, factories, or homes. So smart building materials can play a vital role. Smart materials that are able to respond to an external stimulus have received great attention, especially in last two decades. These materials can change their dimensions, solubility, color, and shape, etc., upon a specific trigger. A wide range of smart materials including alloys, composites, gels, and polymers have been investigated for various applications from aerospace industry to medical technologies and now a days in the buildings and infrastructures. Smart materials can be designed with various responses and actuation mechanism based on the requirements of applications. Study of the importance and working principles of the smart materials is todays need. The concept of "smart" or "intelligent" materials, systems, and structures has been around for many years. A great deal of progress has been made recently in the development of structures that continuously and actively monitor and optimize themselves and their performance through emulating biological systems with their adaptive capabilities and integrated designs. The field of smart materials is multidisciplinary and interdisciplinary, and there are a number of enabling technologies-materials, control, information processing, sensing, actuation, and damping and system integration across a wide range of industrial applications.

Objectives

1. To study the importance of smart materials and technology
2. To Explain the types, properties of smart materials and learn to select appropriate materials.
3. To develop smart technology using smart materials
4. To Describe requirements of structural health monitoring
5. To understand the smart concrete
6. To learn applications of smart materials and technology via case studies.

Detailed Syllabus

Module	Sub- Modules/Contents	Hrs
I	**Introduction to Smart Building Materials & Technology** History, importance and need, merits and demerits of smart building materials. Smart Structure system, Components, Importance of smart structures.	**02**
II	**Fundamentals of Smart Materials** Types and characteristics of smart materials:- **Property-changing materials:** Thermo-chromics, Photochromics, Mechanochromics, Chemochromics, Electrochromics, Liquid crystals, Suspended particle, Electrorheological, Magnetorheological **Energy-exchanging materials**: Electroluminescents, Photoluminescents, Chemoluminescents, Thermoluminescents, Light-emitting diodes, Photovoltaics, **Energy-exchanging (reversible) materials:** Piezoelectric, Pyroelectric, Thermoelectric, Electrorestrictive, Magnetorestrictive. **Miscellaneous Materials:** Shape Memory alloy, optical fiber, Construction chemicals, Sealants etc. Review of material, effect, working principle, advantages and disadvantages, application in Smart Structures, Use of alternative materials for structural steels and rebars.	**09**
III	**Energy Efficient Materials, Durability and Technology** Use of solar energy, wind energy, Smart window, Smart paints, Smart Wall skin, Smart roof. Green buildings and Green Material, Intelligent buildings. FRP rebars and its properties, smart lighting. Service life, Life cycle concept for structures and selection of materials for durability and sustainability. Use of Thermal and Sound Insulation systems and materials.	**06**

IV	**Smart Structural Health Monitoring** Important structural sensing parameters, Basic sensing system, Different types of sensors for monitoring stress, strain, temperature, moisture, displacements, vibration, corrosion etc. Active and passive structural health monitoring system. Specifically for buildings and bridges.	**09**
V	**Smart Concrete:** Transparent concrete, Polymer modified concrete and mortars, self-healing concrete, self-compacting concrete, light weight concrete, pervious concrete, fiber reinforced concrete, temperature controlled concrete, coloured concrete- Constituents, Proportions, material properties, Importance and its application, Electrically conductive concrete, fire/ heat resistant concrete, acid resistant concrete, Ultra high performance concrete and its application in bridge engineering.	**08**
VI	**Applications of Smart Materials and Technology:** Structural health monitoring of buildings, bridges geotechnical and transportation structures, Different types of sensors their working and principles, Repairs and Rehabilitations, Modern Construction, Energy efficient Buildings- A case study.	**05**
		39

Contribution to Outcome

On completion of this course, the students will be able to:

1. Explain the importance of the smart materials in Civil Engineering structures.
2. Describe the working principles of the smart materials.
3. Learn to select appropriate sensors.
4. Explain the smart concrete and its use in bridges
5. Explain the use of smart materials in the structural health monitoring.
6. Describe the sensing technology and select appropriate sensors for structural health monitoring.

Recommended Books:

1. D. Michelle Addington, Daniel L. Schodek, “Smart Materials and New Technologies For the architecture and design professions”, Harvard University. ISBN0750662255.
2. Vinod K. Wadhawan, “Smart Structures: Blurring the Distinction between the Living and the Nonliving”, Oxford University place, ISBN 978–0–19–922917–8.
3. Nilesh Y. Jadhav, Green and Smart Buildings Advanced Technology Options, Springer Nature, ISBN 978-981-10-1002-6.

4. Mel Schwartz, Encyclopaedia of Smart Materials, Vol. 1 and Vol. 2, John Wiley & Sons, Inc.
5. James Sinopoli, Advanced Technology for Smart Buildings, ARTECH HOUSE, Boston, London.
6. Jacob Fraden, “Hand Book of Modern Sensors: physics, Designs and Applications”, 2015, 3rd edition, Springer, New York.
7. Jon. S. Wilson, “Sensor Technology Hand Book”, 2011, 1st edition, Elsevier, Netherland.
8. D. Patranabis – Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003.
9. Structural health monitoring of civil infrastructure Systems, Edited by Vistasp M. Karbhari and Farhad Ansari, CRC Press Boca Raton Boston New York Washington, DC, Woodhead Publishing Limited, New Delhi.
10. HuaPeng Chen and Yi-Qing Ni Structural Health Monitoring of Large Civil Engineering Structures, John Wiley & Sons Ltd, 2018.
11. SP-7 (National Building Code of India), Bureau of Indian Standards.

Semester-VIII		
Subject Code	**Subject Name**	**Credits**
CEDLO8025	**Department Level Optional Course 6: Structural Dynamics**	**3**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorials**	**Theory**	**Practical**	**TW/Tutorials**	**Total**
3	**--**	**--**	**3**	**--**	**--**	**3**

Evaluation Scheme

Theory					Termwork/Practical/ Oral/Tutorials			Total
Internal Assessments			ESE	Durationof ESE	TW/TU	PR	OR	
IA-I	IA-II	Avg.						
20	20	20	80	3 Hr	--	--	--	100

Course Objective

- To expose the students to the basic theory of structural dynamics, structural behaviour under vibratory load and the effect of damping.
- To study the difference between static load and different types of dynamic loads.
- To study the free vibration analysis of SDOF systems, concept of damping and dynamic analysis of SDOF system subjected to different dynamic loads.
- To study the dynamic degrees of freedom and calculation of the frequencies and mode shapes for lumped mass for discrete Two DOF systems,
- To study the modal analysis of Two DOF systems and analysis of systems with distributed mass for continuous system.

Detailed

Module	Sub- Modules/Contents	Hrs
I	**Introduction to structural Dynamics- Definition of Basic Problem inDynamics.** Static vs. Dynamic loads. Different types of dynamics loads	**4**
II	**Introduction to single Degree of freedom (SDOF) Systems.** Undamped vibration of SDOF system natural frequency and period of vibration. Damping in structures, viscous damping and Coulomb damping, effect of damping on frequency of vibration and amplitude of vibration, Logarithmic decrement. Forced vibration, response to periodic loading, response to pulsating forces,dynamic load factor. Response of structure subjected to General dynamic load, Duhamel's IntegralNumerical. Evaluation of Dynamics Response of SDOF system. Equivalent stiffness of spring in series and parallel.	**8**

III	**Introduction to Distributed mass system**. Distributed mass system idealized as SDOF system, use of Rayleigh's method. Response of SDOF system subjected to ground motion	**4**
IV	**Lumped mass multi-degree of freedom (Two DOF) system, coupled anduncoupled system** Direct determination of frequencies of vibration and mod shape. Orthogonality principle. Vibration of Two DOF systems with initial conditions Approximate method of determination of natural frequencies of vibration andmode shapes – Energy methods	**9**
V	**Earthquake analysis – Introduction.** Seismicity of a region, causes of earthquake Intensity of earthquake, Richter Scale, Measurement of Earthquake groundmotion, Seismogram, construction of seismograph Application of modal analysis concept to seismic disturbance, Introduction to Response spectrum method.	**8**
VI	**I.S code provisions for seismic analysis of buildings.** Approximate method of earthquake analysis– Seismic co-efficient methodand its limitation. Introduction to time history analysis.	**6**

Contributions to Outcomes

On completion of the course, the students will be able to

- Summarize the difference between static and dynamic loads and analysis.
- Evaluate the response of SDOF systems for different types of dynamic loadsincluding ground motions.
- Describe Distributed mass system idealized as SDOF system
- Evaluate the response of MDOF systems to different types of dynamic loadsincluding ground motions.
- Explain the basics of Concepts of Earthquake analysis.
- Describe the I.S code provisions for seismic analysis of buildings.

Theory Examination:

- Question paper will comprise of six questions; each carrying 20 marks.
- The first question will be compulsory which will have the short questions covering the entire syllabus.
- The remaining five questions will be based on all the modules of entire syllabus. For this,the module shall be divided proportionately further, and the weightage of the marks shallbe judiciously awarded in proportion to the importance of the sub-module and contents thereof.
- There can be an internal choice in various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
- The students will have to attempt any three questions out of remaining five questions.
- Total four questions need to be attempted.

Recommended Books:-

1. Craig R.R.: 'Structural Dynamics-An Introduction to Computer Methods', *John Wiley and Sons.*
2. Anil K. Chopra: 'Dynamics of Structures', *Prentice Hall India Pvt. Ltd.*
3. Cloguhand Penzein: 'Dynamics of Structures' *TataMc-Graw Hill Pvt. Ltd.*
4. John M. Biggs: 'Structural Dynamics', *Tata Mc-Graw Hill.*
5. Mario Paz: 'Structural Dynamics Theory and Computation', *CBS Publisher.*

Semester VIII

Course Code	Course Name	Credits
CEDLO8026	**Department Level Optional Course 6: Ground water Engineering**	03

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	-	-	03	-	-	03

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 hours	-	-	-	100

Rationale

This subject deals with the various processes involved in ground water Engineering which provides in depth understanding of the theories and concepts of hydrological parameters, well hydraulics, ground water quality etc. It also explains the concept of basin water management concept and its evaluation.

Objectives

1 To introduce the student to the principles of hydrological parameters

2 To Explain to the students the principles of Well Hydraulics.

3 To introduce the student the concept of ground water quality and conservation.

4 To introduce the student the concept of basin management

Detailed Syllabus

Module	Sub- Modules/Contents		Hrs
I	**Hydrogeological Parameters**		6
	1.1	Introduction – Water bearing Properties of Rock – Type of aquifers - Aquifer properties	
	1.2	permeability, specific yield, transmissivity and storage coefficient – Methods of Estimation	
	1.3	GEC norms - Steady state flow - Darcy's Law - Groundwater Velocity – Dupuit Forchheimer assumption	
	1.4	Steady Radial Flow into a Well	

II	**Well Hydraulics**		8
	2.1	Unsteady state flow - Theis method - Jacob method	
	2.2	Chow's method – Law of Times – Theis Recovery	
	2.3	Bailer method – Slug method - tests - Image well theory	
	2.4	Partial penetrations of wells – Well losses	
	2.5	Specific Capacity and Safe yield	
	2.6	Collector well and Infiltration gallery	
III	**Groundwater Management**		6
	3.1	Need for Management Model – Database for Groundwater Management – Groundwater	
	3.2	Balance study – Introduction to Mathematical model – Model Conceptualization	
	3.3	Initial and Boundary Condition – Calibration – Validation – Future Prediction – Sensitivity	
	3.4	Analysis – Uncertainty – Development of a model	
IV	**Groundwater Quality**		7
	4.1	Ground water chemistry - Origin, movement and quality - Water quality standards	
	4.2	Drinking water – Industrial water – Irrigation water	
	4.3	Ground water Pollution and legislation	
	4.4	Environmental Regulatory requirements	
V	**Groundwater Conservation**		5
	5.1	Artificial recharge techniques – Reclaimed wastewater recharge – Soil aquifer treatment (SAT)	
	5.2	Aquifer Storage and Recovery (ASR)Seawater Intrusion and Remediation	
	5.3	Ground water Basin management and Conjunctive use	
	5.4	Protection zone delineation, Contamination source inventory and remediation schemes Name of Module 6 Management of Groundwater	
VI	6.1	Concept of basin management	7
	6.2	Ground water basin investigations	
	6.3	Basin management and conjunctive use	
	6.4	Basin yields	

Contribution to Outcome

On completion of this course, the students will be able to:

1 Apply the principals of hydrological parameters for design of wells.

2 Calculate the specific yield and yield of well under different ground water conditions.

3 Develop a model for groundwater management.

4 Explain the concept of ground water quality models

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Recommended Books:

1. Numerical Ground Water Hydrology: A.K. Rastogi, Penram International Publishing, Mumbai,2007
2. Ground Wter Hydrology: D.K.Todd, John Wiley &Sons, New York, USA, 1980
3. Ground water Hydrology by A. K. Rastogi
4. Hydrology- Principles, Analysis, Design: H.M.Raghunath, New Age International Publishers.
5. Engineering Hydrology: C.S.P.Ojha, R.Berndtsson, &P.Bhunya:, Oxford University Press

Reference Books:

1. Fitts R Charles, "Groundwater Science". Elsevier, Academic Press, 2002.
2. Ramakrishnan, S, Ground Water, K.J. Graph arts, Chennai, 1998

Semester VIII		
Subject Code	**Subject Name**	**Credits**
ILOC8011	**Institute Level Optional Course – II : Project Management**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	**--**	**--**	**03**	**--**	**--**	**03**

Evaluation Scheme

Theory					Term work / Practical / Oral			Total Marks
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Avg						
20	**20**	**20**	**80**	**03 Hrs.**	**--**	**--**	**--**	**100**

Objectives:

- To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
- To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Module	Sub- Modules/Contents	Hrs
I	**Project Management Foundation:** Definition of a project, Project Vs Operations, Necessity of project management, Triple constraints, Project life cycles (typical & atypical) Project phases and stage gate process. Role of project manager. Negotiations and resolving conflicts. Project management in various organization structures. PM knowledge areas as per Project Management Institute (PMI).	**5**
II	**Initiating Projects:** How to get a project started, Selecting project strategically, Project selection models (Numeric /Scoring Models and Non-numeric models), Project portfolio process, Project sponsor and creating charter; Project proposal. Effective project team, Stages of team development & growth (forming, storming, norming & performing), team dynamics.	**6**
III	**Project Planning and Scheduling:** Work Breakdown structure (WBS) and linear responsibility chart, Interface Co-ordination and concurrent engineering, Project cost estimation and budgeting, Top down and bottoms up budgeting, Networking and Scheduling techniques. PERT, CPM, GANTT chart. Introduction to Project Management Information System (PMIS).	**8**
IV	**Planning Projects:** Crashing project time, Resource loading and leveling, Goldratt's critical chain, Project Stakeholders and Communication plan.	**6**

	Risk Management in projects: Risk management planning, Risk identification and risk register. Qualitative and quantitative risk assessment, Probability and impact matrix. Risk response strategies for positive and negative risks	
V	**5.1 Executing Projects:** Planning monitoring and controlling cycle. Information needs and reporting, engaging with all stakeholders of the projects. Team management, communication and project meetings. **5.2 Monitoring and Controlling Projects:** Earned Value Management techniques for measuring value of work completed; Using milestones for measurement; change requests and scope creep. Project audit. **5.3 Project Contracting** Project procurement management, contracting and outsourcing,	**8**
VI	**6.1 Project Leadership and Ethics:** Introduction to project leadership, ethics in projects. Multicultural and virtual projects. **6.2 Closing the Project:** Customer acceptance; Reasons of project termination, Various types of project terminations (Extinction, Addition, Integration, Starvation), Process of project termination, completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	**6**

Outcomes

Students will be able to :

- Apply selection criteria and select an appropriate project from different options.
- Write work break down structure for a project and develop a schedule based on it.
- Identify opportunities and threats to the project and decide an approach to deal with them strategically.
- Use Earned value technique and determine & predict status of the project.
- Capture lessons learned during project phases and document them for future reference

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six question carrying 20 marks
- Question no. 1 is compulsory. Attempt any 3 from remaining 5 questions

- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Jack Meredith & Samuel Mantel, Project Management: A managerial approach, Wiley India, 7th Ed.
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Gido Clements, Project Management, Cengage Learning.
4. Gopalan, Project Management, , Wiley India
5. Dennis Lock, Project Management, Gower Publishing England, 9 th Ed.

Semester VIII		
Course Code	**Course Name**	**Credits**
ILOC8012	**Institute Level Optional Course – II : Finance Management**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	**--**	**--**	**03**	**--**	**--**	**03**

Evaluation Scheme

Theory					Term work / Practical / Oral			Total Marks
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Avg						
20	**20**	**20**	**80**	**03 Hrs.**	**--**	**--**	**--**	**100**

Objectives:

- Overview of Indian financial system, instruments and market
- Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
- Knowledge about sources of finance, capital structure, dividend policy

Module	Sub- Modules/Contents	Hrs
I	**Overview of Indian Financial System:** Characteristics, Components and Functions of Financial System. **Financial Instruments:** Meaning, Characteristics and Classification of Basic Financial Instruments — Equity Shares, Preference Shares, Bonds-Debentures, Certificates of Deposit, and Treasury Bills. **Financial Markets:** Meaning, Characteristics and Classification of Financial Markets — Capital Market, Money Market and Foreign Currency Market **Financial Institutions:** Meaning, Characteristics and Classification of Financial Institutions — Commercial Banks, Investment-Merchant Banks and Stock Exchanges	**06**
II	**Concepts of Returns and Risks:** Measurement of Historical Returns and Expected Returns of a Single Security and a Two-security Portfolio; Measurement of Historical Risk and Expected Risk of a Single Security and a Two-security Portfolio. **Time Value of Money:** Future Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Present Value of a Lump Sum, Ordinary Annuity, and Annuity Due; Continuous Compounding and Continuous Discounting.	**06**
III	**Overview of Corporate Finance:** Objectives of Corporate Finance; Functions of Corporate Finance—Investment Decision, Financing Decision, and Dividend Decision. **Financial Ratio Analysis:** Overview of Financial Statements—Balance Sheet, Profit and Loss Account, and Cash Flow Statement; Purpose of Financial Ratio Analysis; Liquidity Ratios; Efficiency or Activity Ratios;	**09**

	Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	
IV	**Capital Budgeting:** Meaning and Importance of Capital Budgeting; Inputs for Capital Budgeting Decisions; Investment Appraisal Criterion—Accounting Rate of Return, Payback Period, Discounted Payback Period, Net Present Value(NPV), Profitability Index, Internal Rate of Return (IRR), and Modified Internal Rate of Return (MIRR) **Working Capital Management:** Concepts of Meaning Working Capital; Importance of Working Capital Management; Factors Affecting an Entity's Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	**10**
V	**Sources of Finance:** Long Term Sources—Equity, Debt, and Hybrids; Mezzanine Finance; Sources of Short Term Finance—Trade Credit, Bank Finance, Commercial Paper; Project Finance. **Capital Structure:** Factors Affecting an Entity's Capital Structure; Overview of Capital Structure Theories and Approaches— Net Income Approach, Net Operating Income Approach; Traditional Approach, and Modigliani-Miller Approach. Relation between Capital Structure and Corporate Value; Concept of Optimal Capital Structure	**05**
VI	**Dividend Policy:** Meaning and Importance of Dividend Policy; Factors Affecting an Entity's Dividend Decision; Overview of Dividend Policy Theories and Approaches—Gordon's Approach, Walter's Approach, and Modigliani-Miller Approach	03

Outcomes

Students will be able to…

- Describe Indian finance system and corporate finance
- Take investment, finance as well as dividend decisions

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six questioncarrying20 marks
- Question no. 1 is compulsory. Attempt any 3 from remaining 5 question
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Fundamentals of Financial Management, 13th Edition (2015) by Eugene F. Brigham and Joel F. Houston; Publisher: Cengage Publications, New Delhi.
2. Analysis for Financial Management, 10th Edition (2013) by Robert C. Higgins; Publishers: McGraw Hill Education, New Delhi.
3. Indian Financial System, 9th Edition (2015) by M. Y. Khan; Publisher: McGraw Hill Education, New Delhi.

Semester VIII		
Course Code	**Course Name**	**Credits**
ILOC8013	**Institute Level Optional Course – II : Entrepreneurship Development and Management**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
03	**--**	**--**	**03**	**--**	**--**	**03**

Evaluation Scheme

Theory					Term work / Practical / Oral			Total Marks
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Avg						
20	**20**	**20**	**80**	**03 Hrs.**	**--**	**--**	**--**	**100**

Objectives:

- To acquaint with entrepreneurship and management of business
- Understand Indian environment for entrepreneurship
- Idea of EDP, MSME

Module	Sub- Modules/Contents	Hrs
I	**Overview Of Entrepreneurship:** Definitions, Roles and Functions/Values of Entrepreneurship, History of Entrepreneurship Development, Role of Entrepreneurship in the National Economy, Functions of an Entrepreneur, Entrepreneurship and Forms of Business Ownership Role of Money and Capital Markets in Entrepreneurial Development: Contribution of Government Agencies in Sourcing information for Entrepreneurship	**04**
II	**Business Plans And Importance Of Capital To Entrepreneurship:** Preliminary and Marketing Plans, Management and Personnel, Start-up Costs and Financing as well as Projected Financial Statements, Legal Section, Insurance, Suppliers and Risks, Assumptions and Conclusion, Capital and its Importance to the Entrepreneur **Entrepreneurship And Business Development:** Starting a New Business, Buying an Existing Business, New Product Development, Business Growth and the Entrepreneur Law and its Relevance to Business Operations	**09**
III	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises.	**05**
IV	**Indian Environment for Entrepreneurship:** key regulations and legal aspects , MSMED Act 2006 and its implications, schemes and policies of the Ministry of MSME, role and responsibilities of various government organisations, departments, banks etc., Role of State governments in terms of infrastructure developments and support etc., Public private partnerships,	**08**

	National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	
V	**Effective Management of Business:** Issues and problems faced by micro and small enterprises and effective management of M and S enterprises (risk management, credit availability, technology innovation, supply chain management, linkage with large industries), exercises, e-Marketing	**08**
VI	**Achieving Success In The Small Business:** Stages of the small business life cycle, four types of firm-level growth strategies, Options – harvesting or closing small business Critical Success factors of small business	**05**

Outcomes:

Students will be able to…

- Explain the concept of business plan and ownerships
- Interpret key regulations and legal aspects of entrepreneurship in India
- Describe government policies for entrepreneurs

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

1. Question paper will comprise of total six questioncarrying20 marks
2. Question no. 1 is compulsory. Attempt any 3 from remaining 5 question
3. Remaining question (Q.2 to Q.6) will be selected from all the modules.
4. Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Poornima Charantimath, Entrepreneurship development- Small Business Enterprise, Pearson
2. Education Robert D Hisrich, Michael P Peters, Dean A Shapherd, Entrepreneurship, latest edition, The McGrawHill Company
3. Dr TN Chhabra, Entrepreneurship Development, Sun India Publications, New Delhi
4. Dr CN Prasad, Small and Medium Enterprises in Global Perspective, New century Publications, New Delhi
5. Vasant Desai, Entrepreneurial development and management, Himalaya Publishing House
6. MaddhurimaLall, ShikahSahai, Entrepreneurship, Excel Books
7. Rashmi Bansal, STAY hungry STAY foolish, CIIE, IIM Ahmedabad
8. Law and Practice relating to Micro, Small and Medium enterprises, Taxmann Publication Ltd.
9. Kurakto, Entrepreneurship- Principles and Practices, Thomson Publication
10. Laghu Udyog Samachar
11. www.msme.gov.in
12. www.dcmesme.gov.in
13. www.msmetraining.gov.in

Semester VIII		
Course Code	**Course Name**	**Credits**
ILOC8014	**Institute Level Optional Course – II : Human Resource Management**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- To introduce the students with basic concepts, techniques and practices of the human resource management.
- To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations.
- To familiarize the students about the latest developments, trends & different aspects of HRM.
- To acquaint the student with the importance of inter-personal & inter-group behavioral skills in an organizational setting required for future stable engineers, leaders and managers.

Module	Sub- Modules/Contents	Hrs
I	**Introduction to HR** Human Resource Management- Concept, Scope and Importance, Interdisciplinary Approach Relationship with other Sciences, Competencies of HR Manager, HRM functions. Human resource development (HRD): changing role of HRM – Human resource Planning, Technological change, Restructuring and rightsizing, Empowerment, TQM, Managing ethical issues.	5
II	**Organizational Behavior (OB)** Introduction to OB Origin, Nature and Scope of Organizational Behavior, Relevance to Organizational Effectiveness and Contemporary issues Personality: Meaning and Determinants of Personality, Personality development, Personality Types, Assessment of Personality Traits for Increasing Self Awareness Perception: Attitude and Value, Effect of perception on Individual Decision-making, Attitude and Behavior. Motivation: Theories of Motivation and their Applications for Behavioral Change (Maslow, Herzberg, McGregor); Group Behavior and Group Dynamics: Work groups formal and informal groups and stages of group development. Team Effectiveness: High performing teams, Team Roles, cross functional and self-directed team. Case study	7
III	**Organizational Structure &Design** Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress.	6

	Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership. Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	
IV	**Human resource Planning** Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale. Performance Appraisal Systems: Traditional & modern methods, Performance Counseling, Career Planning. Training & Development: Identification of Training Needs, Training Methods	5
V	**Emerging Trends in HR** Organizational development; Business Process Re-engineering (BPR), BPR as a tool for organizational development , managing processes & transformation in HR. Organizational Change, Culture, Environment Cross Cultural Leadership and Decision Making**:** Cross Cultural Communication and diversity at work**,** Causes of diversity, managing diversity with special reference to handicapped, women and ageing people, intra company cultural difference in employee motivation.	6
VI	**HR & MIS** Need, purpose, objective and role of information system in HR, Applications in HRD in various industries (e.g. manufacturing R&D, Public Transport, Hospitals, Hotels and service industries **Strategic HRM** Role of Strategic HRM in the modern business world, Concept of Strategy, Strategic Management Process, Approaches to Strategic Decision Making; Strategic Intent – Corporate Mission, Vision, Objectives and Goals **Labour Laws & Industrial Relations** Evolution of IR, IR issues in organizations, Overview of Labor Laws in India; Industrial Disputes Act, Trade Unions Act, Shops and Establishments Act	10

Contribution to Outcomes:

Students will be able to:

- Explain the concepts, aspects, techniques and practices of the human resource management.
- Describe the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective.
- Gain knowledge about the latest developments and trends in HRM.
- Apply the knowledge of behavioral skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers.

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

1. Question paper will comprise of total six questioncarrying20 marks

2. Question no. 1 is compulsory. Attempt any 3 from remaining 5 question
3. Remaining question (Q.2 to Q.6) will be selected from all the modules.
4. Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Stephen Robbins, Organizational Behavior, 16th Ed, 2013
2. V S P Rao, Human Resource Management, 3rd Ed, 2010, Excel publishing
3. Aswathapa, Human resource management: Text & cases, 6th edition, 2011
4. C. B. Mamoria and S V Gankar, Dynamics of Industrial Relations in India, 15th Ed, 2015, Himalaya Publishing, 15thedition, 2015
5. P. Subba Rao, Essentials of Human Resource management and Industrial relations, 5th Ed, 2013, Himalaya Publishing
6. Laurie Mullins, Management & Organizational Behavior, Latest Ed, 2016, Pearson Publications

Semester VIII		
Course Code	**Course Name**	**Credits**
ILOC8015	**Institute Level Optional Course – II : Professional Ethics and CSR**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- To understand professional ethics in business
- To recognized corporate social responsibility

Module	Sub- Modules/Contents	Hrs
I	**Professional Ethics and Business:** The Nature of Business Ethics; Ethical Issues in Business; Moral Responsibility and Blame; Utilitarianism: Weighing Social Costs and Benefits; Rights and Duties of Business	04
II	**Professional Ethics in the Marketplace:** Perfect Competition; Monopoly Competition; Oligopolistic Competition; Oligopolies and Public Policy **Professional Ethics and the Environment:** Dimensions of Pollution and Resource Depletion; Ethics of Pollution Control; Ethics of Conserving Depletable Resources	08
III	**Professional Ethics of Consumer Protection:** Markets and Consumer Protection; Contract View of Business Firm's Duties to Consumers; Due Care Theory; Advertising Ethics; Consumer Privacy **Professional Ethics of Job Discrimination:** Nature of Job Discrimination; Extent of Discrimination; Reservation of Jobs.	06
IV	**Introduction to Corporate Social Responsibility:** Potential Business Benefits—Triple bottom line, Human resources, Risk management, Supplier relations; Criticisms and concerns—Nature of business; Motives; Misdirection. Trajectory of Corporate Social Responsibility in India	05
V	**Corporate Social Responsibility:** Articulation of Gandhian Trusteeship Corporate Social Responsibility and Small and Medium Enterprises (SMEs) in India, Corporate Social Responsibility and Public-Private Partnership (PPP)	08
VI	**Corporate Social Responsibility in Globalizing India:** Corporate Social Responsibility Voluntary Guidelines, 2009 issued by the Ministry of Corporate Affairs, Government of India, Legal Aspects of Corporate Social Responsibility—Companies Act, 2013.	08

Contribution to outcomes

Students will be able to…

- Summarize rights and duties of business
- Distinguish different aspects of corporate social responsibility
- Demonstrate professional ethics
- Explain legal aspects of corporate social responsibility

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six questioncarrying20 marks
- Question no. 1 is compulsory
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Business Ethics: Texts and Cases from the Indian Perspective (2013) by Ananda Das Gupta; Publisher: Springer.
2. Corporate Social Responsibility: Readings and Cases in a Global Context (2007) by Andrew Crane, Dirk Matten, Laura Spence; Publisher: Routledge.
3. Business Ethics: Concepts and Cases, 7th Edition (2011) by Manuel G. Velasquez; Publisher: Pearson, New Delhi.
4. **Corporate Social Responsibility in India (2015) by BidyutChakrabarty, Routledge, New Delhi.**

Semester VIII		
Course Code	**Course Name**	**Credits**
ILOC8016	**Institute Level Optional Course – II : Research Methodology**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Average						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- To understand Research and Research Process
- To acquaint students with identifying problems for research and develop research strategies
- To familiarize students with the techniques of data collection, analysis of data and interpretation

Module	Sub- Modules/Contents	Hrs
I	**Introduction and Basic Research Concepts** **1.1** Research – Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Research methods vs Methodology **1.2** Need of Research in Business and Social Sciences **1.3** Objectives of Research **1.4 Issues** and Problems in Research **1.5** Characteristics of Research: Systematic, Valid, Verifiable, Empirical and Critical	**09**
II	**Types of Research** **2.1**. Basic Research **2.2**. Applied Research **2.3.** Descriptive Research **2.4.** Analytical Research **2.5**. Empirical Research **2.6** Qualitative and Quantitative Approaches	**07**
III	**Research Design and Sample Design** **3.1** Research Design – Meaning, Types and Significance **3.2** Sample Design – Meaning and Significance Essentials of a good sampling Stages in Sample Design Sampling methods/techniques Sampling Errors	**07**
IV	**Research Methodology** **4.1** Meaning of Research Methodology **4.2**. Stages in Scientific Research Process: **a.** Identification and Selection of Research Problem **b.** Formulation of Research Problem	**08**

	c. Review of Literature **d.** Formulation of Hypothesis **e.** Formulation of research Design **f**. Sample Design **g.** Data Collection **h.** Data Analysis **i.** Hypothesis testing and Interpretation of Data **j.** Preparation of Research Report	
V	**Formulating Research Problem** **5.1** Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	**04**
VI	**Outcome of Research** **6.1** Preparation of the report on conclusion reached **6.2** Validity Testing & Ethical Issues **6.3** Suggestions and Recommendation	**04**

Course Outcomes

Students will be able to:

- Prepare a preliminary research design for projects in their subject matter areas
- Accurately collect, analyze and report data
- Present complex data or situations clearly
- Review and analyze research findings

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six questioncarrying20 marks
- Question no. 1 is compulsory. Attempt any 3 from remaining 5 question
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2^{nd}ed), Singapore, Pearson Education

Semester VIII		
Course Code	**Course Name**	**Credits**
ILOC8017	**Institute Level Optional Course – II : IPR & Patenting**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Avg						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- To understand intellectual property rights protection system
- To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures
- To get acquaintance with Patent search and patent filing procedure and applications

Module	Sub- Modules/Contents	Hrs
I	**Introduction to Intellectual Property Rights (IPR)**: Meaning of IPR, Different category of IPR instruments - Patents, Trademarks, Copyrights, Industrial Designs, Plant variety protection, Geographical indications, Transfer of technology etc. **Importance of IPR in Modern Global Economic Environment:** Theories of IPR, Philosophical aspects of IPR laws, Need for IPR, IPR as an instrument of development	05
II	**Enforcement of Intellectual Property Rights:** Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) activein IPR enforcement **Indian Scenario of IPR:** Introduction, History of IPR in India, Overview of IP laws in India, Indian IPR, Administrative Machinery, Major international treaties signed by India, Procedure for submitting patent and Enforcement of IPR at national level etc.	07
III	**Emerging Issues in IPR:** Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	05
IV	**Basics of Patents:** Definition of Patents, Conditions of patentability, Patentable and non-patentable inventions, Types of patent applications (e.g. Patent of addition etc), Process Patent and Product Patent, Precautions while patenting, Patent specification Patent claims, Disclosures and non-disclosures, Patent rights and infringement, Method of getting a patent	07

V	**Patent Rules:** Indian patent act, European scenario, US scenario, Australia scenario, Japan scenario, Chinese scenario, Multilateral treaties where India is a member (TRIPS agreement, Paris convention etc.)	08
VI	**Procedure for Filing a Patent (National and International):** Legislation and Salient Features, Patent Search, Drafting and Filing Patent Applications, Processing of patent, Patent Litigation, Patent Publication etc, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases:** Important websites, Searching international databases	07

Outcomes:

Students will be able to…

- Explain Intellectual Property assets
- assist individuals and organizations in capacity building
- work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six questioncarrying20 marks
- Question no. 1 is compulsory. Attempt any 3 from remaining 5 question
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

Reference Books:

1. Rajkumar S. Adukia, 2007, A Handbook on Laws Relating to Intellectual Property Rights in India, The Institute of Chartered Accountants of India
2. Keayla B K, Patent system and related issues at a glance, Published by National Working Group on Patent Laws
3. T Sengupta, 2011, Intellectual Property Law in India, Kluwer Law International
4. Tzen Wong and Graham Dutfield, 2010, Intellectual Property and Human Development: Current Trends and Future Scenario, Cambridge University Press
5. Cornish, William Rodolph & Llewelyn, David. 2010, Intellectual Property: Patents, Copyrights, Trade Marks and Allied Right, 7th Edition, Sweet & Maxwell
6. LousHarns, 2012, The enforcement of Intellactual Property Rights: A Case Book, 3rd Edition, WIPO
7. Prabhuddha Ganguli, 2012, Intellectual Property Rights, 1st Edition, TMH
8. R Radha Krishnan & S Balasubramanian,2012,Intellectual Property Rights, 1st Edition,Excel Books
9. M Ashok Kumar and mohd Iqbal Ali, 2-11, Intellectual Property Rights, 2nd Edition, Serial

Publications
10. Kompal Bansal and Praishit Bansal, 2012, Fundamentals of IPR for Engineers, 1st Edition, BS Publications
11. Entrepreneurship Development and IPR Unit, BITS Pilani, 2007, A Manual on Intellectual Property Rights,
12. Mathew Y Maa, 2009, Fundamentals of Patenting and Licensing for Scientists and Engineers, World Scientific Publishing Company
13. N S Rathore, S M Mathur, Priti Mathur, Anshul Rathi**,** IPR: Drafting,Interpretation of Patent Specifications and Claims**,** New India Publishing Agency
14. Vivien Irish, 2005, Intellectual Property Rights for Engineers,IET
15. Howard B Rockman, 2004, Intellectual Property Law for Engineers and scientists, Wiley-IEEE Press

Semester VIII		
Course Code	**Course Name**	**Credits**
ILOC8018	**Institute Level Optional Course – II : Digital Business Management**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			Total Marks
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Avg						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- To familiarize with digital business concept
- To acquaint with E-commerce
- To give insights into E-business and its strategies

Module	Sub- Modules/Contents	Hrs
I	**Introduction to Digital Business-** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts fference between physical economy and digital economy, **Drivers of digital business**- Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things(digitally intelligent machines/services) Opportunities and Challenges in Digital Business,	09
II	**Overview of E-Commerce** **E-Commerce-** Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals Other E-C models and applications, innovative EC System-From E-government and learning to C2C, mobile commerce and pervasive computing EC Strategy and Implementation-EC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC	06
III	**Digital Business Support services**: ERP as e –business backbone, knowledge Tope Apps, Information and referral system **Application Development:** Building Digital business Applications and Infrastructure	06
IV	**Managing E-Business**-Managing Knowledge, Management skills for e-business, Managing Risks in e –business Security Threats to e-business -Security Overview, Electronic Commerce	06

	Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications	
V	**E-Business Strategy**-E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition (Process of Digital Transformation)	04
VI	**Caterializing e-business: From Idea to Realization**-Business plan preparation **Case Studies and presentations**	08

Outcomes:

Students will be able to:

- Identify drivers of digital business
- Illustrate various approaches and techniques for E-business and management
- Prepare E-business plan

Assessment:

Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:

In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six question carrying 20 marks
- Question no. 1 is compulsory
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. A textbook on E-commerce**,** Er. Arunrajan Mishra, Dr W K Sarwade, Neha Publishers & Distributors, 2011
2. E-commerce from vision to fulfilment, Elias M. Awad, PHI-Restricted, 2002
3. Digital Business and E-Commerce Management, 6th Ed, Dave Chaffey, Pearson, August 2014
4. Introduction to E-business-Management and Strategy, Colin Combe, ELSVIER, 2006
5. Digital Business Concepts and Strategy, Eloise Coupey, 2nd Edition, Pearson
6. Trend and Challenges in Digital Business Innovation, Vinocenzo Morabito, Springer
7. Digital Business Discourse Erika Darics, April 2015, Palgrave Macmillan
8. E-Governance-Challenges and Opportunities in : Proceedings in 2nd International Conference theory and practice of Electronic Governance
9. Perspectives the Digital Enterprise –A framework for Transformation, TCS consulting journal Vol.5
10. Measuring Digital Economy-A new perspective -DOI:10.1787/9789264221796-enOECD Publishing

Semester VIII		
Course Code	**Course Name**	**Credits**
ILOC8019	**Institute Level Optional Course – II: Environmental Management**	**03**

Teaching Scheme

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
03	--	--	03	--	--	03

Evaluation Scheme

Theory					Term work / Practical / Oral			**Total Marks**
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test 1	Test 2	Avg						
20	20	20	80	03 Hrs.	--	--	--	100

Objectives:

- Understand and identify environmental issues relevant to India and global concerns
- Learn concepts of ecology
- Familiarise environment related legislations

Module	Sub- Modules/Contents	Hrs
I	Introduction and Definition of Environment: Significance of Environment Management for contemporary managers, Career opportunities. Environmental issues relevant to India, Sustainable Development, The Energy scenario.	10
II	Global Environmental concerns : Global Warming, Acid Rain, Ozone Depletion, Hazardous Wastes, Endangered life-species, Loss of Biodiversity, Industrial/Man-made disasters, Atomic/Biomedical hazards, etc.	06
III	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
IV	Scope of Environment Management, Role & functions of Government as a planning and regulating agency. Environment Quality Management and Corporate Environmental Responsibility	10
V	Total Quality Environmental Management, ISO-14000, EMS certification.	05
VI	General overview of major legislations like Environment Protection Act, Air (P & CP) Act, Water (P & CP) Act, Wildlife Protection Act, Forest Act, Factories Act, etc.	03

Contribution to Outcomes

Students will be able to…

- Describe the concept of environmental management
- Evaluate ecosystem and interdependence, food chain etc.
- Compare and interpret environment related legislations

Assessment:
Internal:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approximately 40% syllabus is completed and second class test when additional 40% syllabus is completed. The average marks of both the test will be considered for final Internal Assessment. Duration of each test shall be of one hour.

End Semester Theory Examination:
In question paper, weightage of each module will be approximately proportional to number of respective lecture hours as mentioned in the syllabus.

- Question paper will comprise of total six questioncarrying20 marks
- Question no. 1 is compulsory. Attempt any 3 from remaining 5 question
- Remaining question (Q.2 to Q.6) will be selected from all the modules.
- Questions may be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) may be from any module other than module 3)

References:

1. Environmental Management: Principles and Practice, C J Barrow, Routledge Publishers London, 1999
2. A Handbook of Environmental Management Edited by Jon C. Lovett and David G. Ockwell, Edward Elgar Publishing
3. Environmental Management,T V Ramachandra and Vijay Kulkarni, TERI Press
4. Indian Standard Environmental Management Systems — Requirements With Guidance For Use, Bureau Of Indian Standards, February 2005
5. Environmental Management: An Indian Perspective, S N Chary and Vinod Vyasulu, Maclillan India, 2000
6. Introduction to Environmental Management, Mary K Theodore and Louise Theodore, CRC Press
7. Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

Semester-VIII

Course Code	Course Name	Credits
CEL801	Construction Management	01

Contact Hours			Credits Assigned			
Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
-	-	02	-		01	01

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	25	--	25	50

Course Objective:

1 To understand the basic functions and construction management.

2 To apply scheduling techniques such as CPM & PERT

3 To gain knowledge of time-cost optimization & effective utilization of resources on construction sites.

4 To gain knowledge of time-cost optimization & effective utilization of resources on construction sites.

5 To know about safety and quality aspect of construction works.

Course Outcomes:

At the end of the course, learner will be able to:

1 Summarize & apply the knowledge of management functions like planning, scheduling, Executing & controlling the construction projects.

2 Prepare feasible project schedule by using various scheduling techniques.

3 Gain knowledge of managing various resources & recommend best method of allocating resources to the project.

4 Develop optimum relationship between time & cost for construction project.

5 Implement quality & safety measures on construction sites during execution of Civil Engineering projects.

6 Explain the importance of labour acts.

List of Assignments		
Module No.	Assignment	Tutorial Hr.
1	**Assignment No. 1:** Principles, Functions, and contribution eminent personalities towards Management	02
2	**Assignment No.2**: Project classifications, Unique features of construction, Various agencies involved in construction industry	02
3	**Assignment No.3**: Bar Charts its limitations and its uses Numerical on development of networks and calculation of floats using CPM technique.	02
4	**Assignment No.4:** Assumption underlying PERT analysis time estimates, slack& its types, probability of completing the project.	02
5	**Assignment No.5**: Numerical on Resources Allocation Methods- Resource levelling and Smoothening	02
6	**Assignment No.6**: Procedure and Numerical on Time and cost optimization in construction projects - Compression & decompression of network.	02
7	**Assignment No.7**: Network Updating- Purpose and frequency of updating. Numerical on Project Updating	02
8	**Assignment No.8**: Construction Safety, Quality Control & Labour Acts	02

Term Work

Comprises of Assignments, which has to be submitted by each student individually.

Distribution of marks for Term Work shall be as follows:

Assignments: 20 Marks

Attendance : 05 Marks

Further, while giving **weightage of marks on the attendance, following guidelines shall be resorted to.**

Attendance	Marks awarded
75%- 80%	03 Marks
81%- 90%	04 Marks
91% onwards	05 Marks

End Semester Oral Examination: The oral examination shall be based on the entire syllabus & the Term-work prepared by the students including assignments.

Reference Books:

1 Construction Engineering and Management: S. Seetharaman.

2 Construction Planning & Management – Dr. U. K. Shrivastava.

3 Construction Project Management: Chitkara K. K. Tata McGraw Hill.

4 Construction Projects planning and Management: P. S. Gahlot and Dhir New Age International (p) Publishers

5 Critical Path Methods in Construction Practice: Antill J M &Woodhead R W, Wiley

6 Construction Hazard and Safety Handbook: King &Hudson, Butterworth

<table>
<tr><th colspan="10">Semester - VIII</th></tr>
<tr><th colspan="2">Course Code</th><th colspan="6">Course Name</th><th>Credits</th></tr>
<tr><td colspan="2">CEP801</td><td colspan="6">Major Project- Part II</td><td>06</td></tr>
<tr><th colspan="3">Contact Hours</th><th colspan="7">Credits Assigned</th></tr>
<tr><th>Theory</th><th>Practical</th><th>Tutorial</th><th colspan="3">Theory</th><th>Practical</th><th colspan="2">Tutorial</th><th>Total</th></tr>
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<tr><th colspan="6">Theory</th><th colspan="3">Term Work/Practical/Oral</th><th rowspan="3">Total</th></tr>
<tr><th colspan="3">Internal Assessment</th><th rowspan="2">End Sem Exam</th><th rowspan="2">Duration of End Sem Exam</th><th rowspan="2">TW</th><th rowspan="2">PR</th><th rowspan="2">OR</th></tr>
<tr><th>Test–I</th><th>Test–II</th><th>Average</th></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>50</td><td>-</td><td>100</td><td>150</td></tr>
</table>

Rationale

In the field of Civil Engineering, new problems arise every now and then; but a professional civil engineer must know how to precisely identify & state those problems, define the scope & objectives of the probable solution(s), carry out effective review of available literature in the domain of the problem and formulate a systematic methodology to solve the problem. Modern tools and multidisciplinary knowledge are vastly used nowadays for the effective solution of civil engineering problem. It is also important to work effectively & ethically as a team and communicate the work done in the form of written reports. The aim of this course is to acquaint the learners with all of the above-mentioned aspects of the civil engineering field by inculcating the process of research

Objectives

1. To acquaint the learners to analyse the problem.
2. To accustom the learners to apply various techniques and methods.
3. To familiarize the learners about interpreting the results and discuss the issues.
4. To advice the learners to write and infer conclusions of the project.
5. To accustom the learners to work as a team.
6. To apprize the learners on proper documentation of work.

Detailed Syllabus

After completion of the work at the end of Semester VIII, the student shall compile the report in a standard format and written in the systematic manner and chapter wise.

The student shall adhere to the following scheme of chapterization while compiling the final report in general. The Guide/ Supervisor shall ensure the student has written the Dissertation Report in appropriate language (grammatically correct).

Contribution to Outcomes

On completion of this course, the students will be able to:

1: Perform on analytical, experimental or numerical method to solve identified problem
2: Produce alternative design solution to meet the functional requirements of the defined problem.
3: Represent the data in Tabular or graphical forms so as to facilitate, analysis & explain of the data.
4: Express Engineering principles & manage the finance required for the execution of the Project.
5: Infer at results, conclusion with its validation, also propose the future scope of work on the identified problem.
6: Communicate effectively their project work by writing reports and publishing technical papers based on entire project work.

Guidelines for Assessment of Project II
Project II should be assessed based on following points
1. Quality of problem selected
2. Clarity of Problem definition and Feasibility of problem solution
3. Relevance to the specialization / Industrial trends
4. Clarity of objective and scope
5. Quality of work attempted
6. Validation of results
7. Quality of Written and Oral Presentation

Project Report has to be prepared strictly as per University of Mumbai report writing guidelines.
Project II should be assessed through a presentation by the student project group to a panel of Internal and External Examiner approved by the University of Mumbai

Students should be motivated to publish a paper in Conferences/students competitions based on the work

UNIVERSITY OF MUMBAI

Honours/Minor Degree Programs Booklet

Part 2- Detailed Syllabus

(with effect from 2022-2023)

UNIVERSITY OF MUMBAI
Honours/Minor Degree Programs
(with effect from 2022-2023)

Note: Course code format used in the document

1. Course Code: HXXC-Z01: (example- HEVC-501)
   H stands for Honours/ Minor course
   XX : Abbrevation of Program code: eg. For Electric Vehcile- it is 'EV'
   C- Theory Course
   Z for semester. For sem 5 -> 501

2. Skill Based Lab Code: HXXSBL-Z01: (example- HEVSBL-701)
   H stands for Honours/ Minor course
   XX : Abbrevation of Program code: eg. For Electric Vehcile- it is 'EV'
   SBL- Theory Course
   Z for semester. For sem 7 -> 701

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

in

Infrastructure Engineering

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Infrastructure Engineering (With effect from 2022-23)										
Year &Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HIEC501: Transportation Infrastructure**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HIEC601: Energy and IT Infrastructure**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HIEC701: Geographic Information System**	04	--	--	20	80	--	--	100	04
	HXXSBL701: Lab-1 GIS	--	--	04	--	--	--	50	50	02
	Total	**04**	**-**	**04**	**100**		**--**	**50**	**150**	**06**
									Total Credits =	**06**
BE Sem. VIII	**HIEC801: Infrastructural Planning and Management**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Infrastructure Engineering: Semester-V		
Subject Code	**Subject Name**	**Credits**
HIEC501	**Transport Infrastructure**	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**3 hrs.**	**-**	**-**	**-**	**100**

Rationale

Urban sprawl worldwide is causing tremendous pressure on transport infrastructure. Transportation infrastructure is one of the most important factors for a country's progress. The complex network of connections between coastal ports, inland ports, rails and air routes is the 'lifeline' of a nation and it forms a foundation of economic development. Transportation is an important sector of the economy in its own right and that has been proven by so many instances how transport infrastructure has added speed and efficiency to a country's progress. India has a large and diverse transport sector with its own share of challenges and students will be conversant with transport infrastructure, diverse Transportation needs and equipments after completion of this course.

Objectives

1. To understand the fundamentals of infrastructure and different modes of transportation globally and current state of affairs in India
2. To illustrate the types of modern highways, bridges and tunnels required for the transport infrastructure.
3. To identify the Mass Transit systems, for end to end transport and the structural systems required for the same.
4. To design airport infrastructure mechanism
5. To classify water way infrastructure
6. To study all the important tools and equipments required for the efficient functioning of Transportation infrastructure.

Module	Contents	Hours
1	**Introduction to Infrastructure:** Definition of infrastructure, Need of infrastructure, different forms of infrastructure, physical and social infrastructure, role of infrastructure in the development of a nation, Transportation scenario globally and in India; Overview of various transport systems in India-rail, road, air, waterways. Major organizations and players in the field of transport infrastructure	07
2	**Modern Highways**: Roads, Planning concepts, Uninterrupted traffic systems, Signal free intersections, Freeway, Expressway, Service roads, bye pass, Turnpike.	10

	Bridges and Tunnels: Classification based on Structural Materials like Steel, RCC, Pre-stressed concrete or Composite. Bridge types based on structural behaviour such as Beam bridge, Truss Bridge, Arch Bridge, Suspension& Cable stayed cantilever and special purpose bridges. Tunneling Methods: Types and purpose of tunnels; factors affecting choice of excavation technique; Methods – soft ground tunneling, hard rock tunneling, shallow tunneling, deep tunneling; Supports in Tunnels: Different types of supports in tunneling and their applicability.	
3	**Mass Transit system**: trains, ferries, buses, trams, Rapid mass transit systems such as subways and surface light rail systems, Cable cars, Various types of guided transport, tube, U-Bahn, metropolitan or underground, Metro rails, Structural components and their selection criteria.	07
4	**Airport Planning**: Airport Master Plan, Airport Site Feature, Economic and Financial feasibility, Zoning around airports, design considerations for Apron, Runway, Taxiway, Hangar. **Air traffic control**: radar, satellite navigation, One way, Two-way radio communication. ATC assistance during Departure, En-Route, Descent, Approach and Landing.	08
5	**Waterways transportation**: History of water transportation, policies related to water transportation in India. Status of river, canals and ocean transportation in India. Modes of water transport - pontoons, amphibians, hovercrafts, boats, ships, water taxi. Advantages and disadvantages of water transportation. **Ports harbours and docks**: Historical development of Port, Docks and Harbour. Port building facilities, Classification of harbours, Requirement of Harbour, Jetty, Harbour components, characteristics of good harbour and principles of harbour planning	09
6	**Modern surveying tools** - Drones, satellite survey, GIS software, GPS system, Total station, Electronic Distance Measurement (EDM) Instruments **Modern Equipment**- Dumper trucks, dozers, vibratory rollers, graders, tunneling equipments, lifting equipments (Cranes), sand washing equipments, earth movers, different excavators, wheel tractor scraper, trenchers, loaders, pile boring and pile driving machine, concrete mixers. concrete batching/mixing plant, concrete pumps, slip forms, concrete vibrator, hot mix plant	11

Contribution to Outcomes

After completion of the course work, students will be able to,

1. Understand the fundamentals of infrastructure and different modes of transportation
2. Illustrate the types of modern highways, bridges and tunnels along with tunnelling methods required for the transport infrastructure.
3. Identify the mass transit system in transport infrastructure
4. Design different components of airport infrastructure along with it's economical and financial feasibility
5. Classify different modes of water transportation and evaluate the principles of harbour planning
6. Study different modern surveying tools and modern equipment required for transport infrastructure

Theory Examination:-

1. The question paper will comprise **six** questions; each carrying 20 marks.
2. The **first** question will be **compulsory** that will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The remaining **five** questions will be based on all the modules. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. There can be an **internal** choice in various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
5. The students will have to attempt any **three** questions out of remaining five questions.
6. A total of **four** questions need to be attempted.

Text Books:-

1. A Sustainable Vision for Urban India, Jain A K, Publisher: Kalpaz Publications
2. Highway Engineering, C. E. G. Justo and S. K. Khanna, Nem Chand & Bros; 10th Edition 2015 (1 January 2001)
3. Railway Engineering, M. M. Agarwal and Satish Chandra, Oxford University Press.
4. Design of Bridges, N. Krishna raju, Oxford and IBH Publishing
5. Airport Engineering: Planning And Design by Saxena S C , CBS Publication
6. Airport planning and design, S.K. Khanna, S. S Jain, M.G Arora , Nem Chand Brothers; 6th edition (January 1, 1999)
7. Inland Water Transport in India by R.P. Misra published by Prasaranga, University of Mysore in 1972.
8. Docks and Harbour Engineering: Dr. S.P Bindra, Dhanpatrai Publications, India
9. Harbour, Dock and Tunnel Engineering: R. Srinivasan, Charotar Publication, India
10. Remote sensing and Geographical Information System, By A. M. Chandra and S. K. Ghosh, Narosa Publishing House.
11. Advanced Surveying -Total Station, GIS and Remote Sensing by Satheesh Gopi, R. Sathikumar and N. Madhu, Pearson publication
12. Surveying Vol. 2 by S. K. Duggal, McGraw Hill Publication

Recommended Books:-

1. Introduction to Infrastructure: An Introduction to Civil and Environmental Engineering, Michael R Penn
2. Remote Sensing & GIS,2/E—Bhatta– Oxford University Press
3. Modern Construction Equipment and Methods by Frank Harris
4. Construction Planning, Equipment, and Methods (McGraw-Hill Series In Civil Engineering) by Robert L Peurifoy), Clifford J. Schexnayder, AviadShapira
5. Driving Horizontal Workings and Tunnel, by Pokorovski, Mir Publishers, 1980.
6. Harbour, Dock and Tunneling Engineering by R. Srinivasan Published by Charotar Publication

Infrastructure Engineering: Semester-VI		
Subject Code	**Subject Name**	**Credits**
HIEC601	**Energy and IT Infrastructure**	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**3 hrs.**	**-**	**-**	**-**	**100**

Rationale

The power infrastructure consists of generation, transmission, and distribution systems that are essential to all other infrastructures and every aspect of the economy. In India, various sources of energy are used to generate power. These include coal, natural gas, hydro, nuclear, and renewable (includes solar, wind, small hydro and biomass). Telecommunications infrastructure is a physical medium through which all Internet traffic flows. This includes telephone wires, cables and mobile technology such as fifth-generation (5G) mobile networks. The IT infrastructure consists of all elements that support the management and usability of data and information. These include the physical hardware and facilities (including data centers), data storage and retrieval, network systems, legacy interfaces, and software to support the business goals of an enterprise.

Objectives

1. Evaluate energy infrastructure and hydroelectric power plant.
2. Classify the tidal, wind and solar energy and its operation
3. Explain nuclear energy infrastructure, policies and regulations for establishing nuclear power plant and issues related to radioactive waste
4. Design criterions for telecommunication tower
5. Describe the fundamental elements of IT infrastructure
6. Design criterions for development of smart grid networks

Module	Contents	Hours
1	**Introduction to energy infrastructure**: Types of electrical generation; generation system architecture; power plant planning and design. **Hydroelectric infrastructure**: Site selection; classification; hydrographs; storage and pondage; essential elements; selection of turbines, environmental impact assessment.	04
2	**Tidal energy infrastructure**: Fundamentals of tide; wave theory, loading and energy; operating principle - oscillating device; turbine characteristics; devices; moorings and anchors; foundations. **Wind energy infrastructure**: Offshore and onshore wind; properties of wind; wind resource assessment; wind turbine blades; wind turbines in grid; wind projects.	06

	Solar energy infrastructure: Basics of solar PV, fundamentals of the design of solar energy fields; concentrated solar power plant; solar water heating systems	
3	**Nuclear energy infrastructure**: Policy and regulations; economics and financing of nuclear power plants; nuclear technology selection and project implementation; fuel supply, radioactive waste and management; issues; environmental impact	10
4	**Telecommunication** – Definition, use, functions, and components, site surveys- raw land tower site survey and boundary survey, classification of telecommunication towers, Telecommunication signals, Design of towers – configuration, tower erection, transmission lines construction, operation and maintenance of distribution systems.	13
5	**IT infrastructure** – components of IT infrastructure, Internet and world wide web, design, planning, and implementation of networks and servers, storage management , Backup / Restore Methodology, Remote Access, Control, Administration.	12
6	**Smart grid, transmission and distribution**: Grid resilience; environmental performance; operational efficiencies; network architecture; transmission systems; wide area monitoring, protection and control, transmission and distribution architecture; micro grids; vulnerability; peak load shifting and grid storage.	07

Contribution to Outcomes

After completion of the course work, students will have ability to

1. Explain generation of hydroelectric power and its impact on environment
2. Classify and design infrastructure for non conventional energy sources
3. Describe the policies and regulations for nuclear power plant, infrastructural requirement and its environmental impact assessment
4. Evaluate the components and functions of telecommunication
5. Summarize the fundamental elements of IT infrastructure such as networks and servers, storage and remote access
6. Design and develop smart grid networks for transmission and distribution of the energy

Theory Examination:-

1. The question paper will comprise **six** questions; each carrying 20 marks.
2. The **first** question will be **compulsory** that will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The remaining **five** questions will be based on all the modules. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. There can be an **internal** choice in various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
5. The students will have to attempt any **three** questions out of remaining five questions.
6. A total of **four** questions need to be attempted.

Text Books:-

1. Textbook of Renewable Energy (Wood head Publishing India in Energy) ,by S.C. Bhatia , R.K. Gupta
2. P. Jain, Wind Energy Engineering, McGraw-Hill.
3. Nuclear Power in India by N. Sharma, B. Banerjee, Rupa Publication 2008
4. Environmental Issues for 21st Century by S. P. Dasgupta, Mittal Publication.
5. Steve Morris, Up the Tower: The complete Guide to Tower Construction, Champion Radio Products Brian W. Smith, Communication Structures, Thomas Telford publications
6. ICT in Urban services, Compendium of global good practices, National Institute of Urban affairs, http://pearl.niua.org/sites/default/files/books/GPGL1_ICT.pdf
7. Fundamentals of telecommunication- https://www.net.t-labs.tuberlin.de/teaching/computer_networking/documents/telecomm_fundamentals.pdf

Recommended Books:-

1. Hydroelectric Energy, Renewable Energy and the Environment By Bikash Pandey, Ajoy Karki, ISBN 9781439811672 CRC Press
2. Tidal Energy Systems, 1st Edition, Design, Optimization and Control, Vikas Khare Cheshta Khare Savita Nema Prashant Bareda, Elsevier
3. E book on Energy Law in India by Mohammad Naseem, Saman Naseem, 2017, publisher Wolters Kluwer
4. Graham, S. and Marvin, S. Planning Cybercities Integrating Telecommunications into Urban Planning, The town planning review, 70(1), Liverpool University Press
5. S. Borlase (2013) Smart Grid Infrastructure, Technology, and Solutions, CRC Press. ISBN 9781439829103.
6. L.F. Drbal, P.G. Boston, K.L. Westra, R.B. Erickson (1996) Power Plant Engineering, Kluwer Academic Publishers. ISBN 9781461380474.
7. D. Greaves, G. Iglesias (2018) Wave and Tidal Energy, John Wiley & Sons Ltd. ISBN 9781119014454.
8. S. A. Kalogirou (2009) Solar Energy Engineering Processes and Systems, Elsevier. ISBN 9780123745019.
9. Basic Infrastructure for a Nuclear Power Project (2006) Technical Report, CI#128 IAEA. ISBN 9201085060.
10. Kiessling,F., Nefzger,P., Nolasco,J.F., Kaintzyk,U., (2003), Overhead Power Lines Planning Design Construction, 4th Edition, Springer
11. Ganguli,S.K., Kohli,V., (2016), Power Cable Technology, CRC Press

Infrastructure Engineering: Semester-VII		
Subject Code	**Subject Name**	**Credits**
HIEC701	**Geographical Information Systems**	**4**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
20	20	20	80	3 hrs.	-	-	-	100

Rationale

Geographic information system (**GIS**) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships. IS technology is a crucial part of spatial data infra-structure. Many different types of information can be compared and contrasted using GIS. The system can include data about people, such as population, income, or education level. It can include information about the landscape, such as the location of streams, different kinds of vegetation, and different kinds of soil. It can include information about the sites of factories, farms, and schools, or storm drains, roads, and electric power lines. Use of Geographic's Information system in all infrastructures will enhance the social, economic, development of India in all aspects.

Objectives

1. To understand the fundamentals of GIS, basics tools, and its applications in all branches of Civil and infrastructure Engineering.
2. To Illustrate the variousComponent of GIS, co-ordinate systems for creations of vector data and raster dataset by using various GIS tools.
3. To understand Basic geodata base system for Creation of various types of maps.
4. To create various thematic maps by using the vector Data set as well as raster data set.
5. To analyze spatial Data for solving real word problems.
6. To apply GIS output data for solving real life problems.

Module	Contents	Hours
1	**Introduction to Geographic Information System** GIS: History, Development of GIS, Objective of GIS, Advantages of GIS.	03
2	**Introduction to Maps:** Definition, Scale, Types of Maps, elements of Map, Projection Coordinate Systems: Geographic, rectangular and Polar – Transformation, types and application. **GIS:** What is GIS, components of GIS, its applications, open source softwares.	09

3	**DBMS: -**Database Management system – function – types – advantages, Introduction to Toposheet. Various open data sources. **GIS Data Model**: Spatial Data Types- , Vector data, Raster data, TIN (Triangulated reregulated network) data model, comparison of Vector &raster data, Non spatial data (attributes) & its types. Preprocessing of spatial data set.	10
4	**GIS input data:** **Vector Data: -**Sources for GIS Data Shape files, Vector Data Input – Georeferencing, Map digitization and editing, and Topology – Topological Relationship. **Raster Data Input** – Digital Elevation Mode (DEM)- Introduction to DEM, types of Dem, Uses of Dem & different types of resolution, Introduction to satellite images, image classification, Quality assessment of freely available Digital Elevation Model, Raster File Formats, Vector File Formats – Raster to Vector and Vector to Raster Conversion.	12
5	**GIS Data Analysis**: Introduction to GIS data Analysis – Data selection, reclassification, overlaying analysis, Buffer Analysis, Spatial Analysis (Dem Analysis,) Surface Analysis, Network Analysis , proximity Analysis, Vector & Raster Analysis Methods. Error in GIS and key elements of maps.	12
6	**GIS Output Design and Presentation** Introduction - Spatial and non-spatial data presentation - Map layout – Charts, graphs and multimedia output, elements of spatial data quality, Meta data and introduction to web GIS.	06

Contribution to Outcomes

After completion of the course work, students will be able to,

1. Explain GIS applications in various fields
2. Illustrate the types of maps, their characteristics and different co-ordinate system, Components of GIS& Familiar with new GIS software.
3. Compare the basics of Data Base Management system for GIS - vector data set, raster data set & Produce an error free GIS database for civil engineering applications.
4. Create & design basic database like creation of shape files, vector data set, raster data set & Produce an error free GIS database for civil engineering applications
5. Analyze GIS Data which includes creating buffers, Clipping Features, raster data analysis, vector Data Analysis and Dissolve Features.
6. Application of spatial data output along with quality assessment for applications in Civil & Infrastructure Engg.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests** - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weight age of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1) Question paper will comprise of total **six questions**, **each carrying 20 marks.**

2) **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum.**

3) **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3) .

4) The students will have to attempt any **three** questions out of remaining five questions

5) Total Four questions need to be attempted.

Text Books:-

1. Remote Sensing and Geographic Information System, By A.M. Chandra and S.K. Ghosh, Narosa Publication House.
2. Remote Sensing: Principles and Applications by B C Panda.
3. Geographic Information System by Jatin Pandey .
4. Remote Sensing and GIs by Basudeb Bhatta, Oxford University.

Recommended Books:-

1. Jonathan Campbell and Michael Shin, Essentials of Geographic Information Systems, 2011, Saylor Foundation, ISBN: 9781453321966.
2. Michael N. DeMeres, Fundamentals of Geographic Information Systems, 4th Edition, 2009, Wiley, ISBN: 9780470129067
3. NPTEL GIS web course.

Infrastructure Engineering: Semester-VII		
Subject Code	**Subject Name**	**Credits**
HIESBL701	**Geographic Information System – Lab**	**2**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**4**	**-**	**-**	**2**	**-**	**2**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
					50	**-**	**50**	**100**

Objectives

1. To acquire basic knowledge of Geographic Information System Lab practices and applying it for solving real life problem in Civil & Infrastructure Engineering.
2. To illustrate basic GIS-terms which are connected to data processing by means of exercises
3. To prepare basic geo data for Spatial and non spatial Analysis.
4. To apply Google earth in Geographic information system for preparation of various shapes files, preparation of vector data set.
5. To analyze basic geodata base by using various tools.
6. To convert GIS output into various thematic maps for solving various real life problems in Civil – infrastructure Engineering.

List of Experiments

Module	Contents	Hours
1	Getting started with GIS software (QGIS, ArcGIS) & data collection from various free available sources.	**4**
2	Georeferenceing and projection of toposheet, Digitization of map/ Toposheet.	**4**
3	Creation of thematic maps, Base Map preparation, Data Conversion – Vector to Raster, Raster to Vector.	**4**
4	Google earth integrations in GIS.	**4**
5	Vector analysis and Raster analysis, adding attribute data – quarries on attribute data, Map composition.	**4**
6	Developing Digital Elevation Model, its application & analysis.	**4**
7	A case study of GIS applications.	**4**

Contribution to Outcomes

Learner will be able to…

1. Apply the installation of GIS software's and various tools.
2. Explain various Database structure like vector data, raster data set.
3. Prepare and convert vector data set into raster data set.

4. Interpret Google earth with GIS.
5. Perform various types of Analysis on raster data, vector data.
6. Transform GIS output by preparation of various thematic maps.

GIS Software's: Arc GIS 10.3, QGis.

Assessment

Term Work Including

Laboratory work : 25 Marks

Case Study/Report/Tutorial: 20 Marks

Attendance: 05 Marks

End Semester Oral Examination

Oral examination will be based on the entire syllabus.

Text Books:-

1. Remote Sensing and Geographic Information System, By A.M. Chandra and S.K. Ghosh, Narosa Publication House.
2. Remote Sensing: Principles and Applications by B C Panda.
3. Geographic Information System,by JatinPandey .
4. Remote Sensing and GIs by Basudeb Bhatta, Oxford University.

Recommended Books:-

1. Jonathan Campbell and Michael Shin, Essentials of Geographic Information Systems, 2011, Saylor Foundation, ISBN: 9781453321966.
2. Michael N. DeMeres, Fundamentals of Geographic Information Systems, 4th Edition, 2009, Wiley, ISBN: 9780470129067
3. NPTEL GIS web course.

Infrastructure Engineering: Semester-VIII		
Subject Code	**Subject Name**	**Credits**
HIEC801	**Infrastructural planning and management**	**4**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
20	20	20	80	3 hrs.	-	-	-	100

Rationale

Infrastructure is the resources required for a society and its economy to function. Infrastructure Planning primarily relates to new infrastructure creation but also phasing out of deficient and outdated infrastructure when it is cost-effective.

Economic infrastructure is an internal facility of a country that make business activity possible, Such as communication, transportation and distribution networks, financial institutions and markets, and energy supply systems. Economic infrastructure definitely ensures the mobility of labour and capital within/from the economy. It results in the overall growth of towns and cities. Infrastructures provide for a lot of employment generation and employment opportunities. They also play a crucial role in national defense activities.

Objectives

1. To understand the infrastructural scenario in India and opportunities and challenges to be faced in road development.
2. To understand the Infrastructure economics, finance and social environmental risk in infrastructure
3. To Realizing the real-world risks and challenges in managing infrastructure.
4. To identify the needs in urban infrastructure development and recycling technologies
5. To Understand the impact of infrastructural projects on environment
6. To analyse success and failure of measure infrastructural projects in India

Module	Contents	Hours
1	**Introduction-** Infrastructure scenario in India, transportation, power and telecom sectors, urban and rural infrastructure in India, road infrastructure development in India, rural roads development in India-opportunities and challenges	06
2	Infrastructure economics and finance, project structuring and risk allocation in project finance, Public-Private Partnership (PPP) for infrastructure- case studies, risk management in infrastructure projects, term sheet development economic and social e4nvironmental risk in infrastructure,	08
3	Project Governance, public sector governance, strategies for governing against infr6astructure project turbulence, the governance model, data–base management,	10

	actor mapping and social network analysis, fair process and negotiations, design thinking, life cycle and benefit cost analysis	
4	Innovative infrastructure financing, urban infrastructure needs in India and funding options, new and innovative materials for long lasting road infrastructure, green highways –recycling technology, durable road infrastructure –options and recent developments, polycentric governance and incomplete design, successful project delivery strategies.	10
5	Environmental impact assessment: Tools, impact on air ,water, soil & Noise, Role of Biodiversity impact Assessment, Identification ,Prediction &Evaluation of Impacts on Biodiversity, Techniques of Biodiversity impact assessment, E I A Report Preparation	10
6	Case Studies: Case studies for 1)BOT 2)Dams 3)Mass Transit System 4)Government Funded Projects	08

Contribution to Outcomes

Students will have the ability to

1. Explain Indian Infrastructural framework and future challenges.
2. Analyze the infrastructure projects based on various risks.
3. Develop critical thinking on a variety of novel solutions or fixes which aids in execution infrastructure projects better.
4. Design innovative methods for long lasting infrastructure and understand the successful project delivery strategies.
5. Analyze the effect of infrastructural projects on environment.
6. Apply the design methodologies to the real world case studies

Theory Examination:-

1. The question paper will comprise **six** questions; each carrying 20 marks.
2. The **first** question will be **compulsory** that will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The remaining **five** questions will be based on all the modules. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. There can be an **internal** choice in various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
5. The students will have to attempt any **three** questions out of remaining five questions.
6. A total of **four** questions need to be attempted.

Text Books:-

1. Infrastructure Planning and Management (2018) by Prof. Ashwin Mahalingam NPTEL. https://nptel.ac.in/courses/105/106/105106188/
2. Projects planning, Analysis Selection, Implementation and Review, Prasanna Chandra Tata McGraw Hill, New Delhi, 2005
3. Vasant Desai, “Project Management”, Himalaya Publishing, 1st Edition, 2010
4. Arbitration”, Jubilee Publications, 2nd Edition., 1996 Engineering Contracts and B. J. Vasavada, “

5. Construction Management & PWD Accounts --- D Lal, S. K. Kataria & Sons, 2012
6. Fundamentals of Engineering Economics—Pravin Kumar, Wiley, India

Recommended Books:-

1. Goodman AS, Hastak M (2006). Infrastructure planning handbook: planning, engineering, and economics. New York: ASCE Press.
2. Miller R, Lessard DR (2001). The strategic management of large engineering projects: Shaping institutions, risks, and governance. MIT press.
3. J. Parkin and D. Sharma, Infrastructure planning, Thomas Telford, London, 1999.
4. Construction project scheduling and control ----Mubarak, Wiley India
5. Construction Management: Planning and finance-- Cormican D. Construction press, London, Feb 2002.

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

in

Smart Cities

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Smart Cities (With effect from 2022-23)										
Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/ Tutorial	Pract	Internal Assess-ment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HSCC501: Smart City Planning and Development**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
TE Sem VI	**HSCC601: Smart City-Project Management**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
BE Sem VII	**HSCC701: Smart Urban Infrastructures**	04	--	--	20	80	--	--	100	04
	HSCSBL701: Lab-1: Smart City-Project Management	--	--	02	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
										Total Credits = 06
BE Sem VIII	**HSCC801: Smart Management of Smart Urban Infrastructures**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Smart Cities: Semester V		
Course Code	**Course Name**	**Credits**
HSCC501	**Smart City Planning and Development**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs.	-	-	-	100

Rationale

Today, more than 54% of the world's total population lives in urban areas. It is projected that urbanization will continue in the coming years, raising the urban population to 6.0 billion people by 2045. The significant increase in urban population will put awesome load on urban infrastructure which results in increasing the demand for energy, mobility, water, and other urban services in cities. So, cities have to become smarter in provision of urban services. Also due to the global awareness about negative environmental impacts of pollution, cities are feeling more pressure to improve their environmental performance, while improving their level of services. Increasing demand for sustainable, inclusive, reliable and efficient urban service puts our urban infrastructures under a huge pressure. But digitalization provides a powerful tool to address these issues and create a paradigm shift in our concept of cities. Due to this novel nature of smart cities, it is important that policymakers, urban managers and other relevant actors be prepared to understand and address the challenges that the transition will bring about. This course will provide the basic principles that to consider for a successful transition into a smart city.

Objectives

1. Enable students in understanding the concepts, discourses and practices of "Smart Cities" across the Globe.
2. To develop competence in planning projects at the city level to ensure sustainability of environment and human beings.
3. Apply smart technologies across the spectrum of infrastructure and governance.
4. Develop overall city strategy to become contemporary and competitive.
5. Enable students to understand city centric capital formation and finance, risk and feasibility to ensure the economic health of the city.
6. Develop overall smart cities and villages.

Detailed Syllabus		
Module	**Course Module / Contents**	**Hours**
1	**Introduction to Smart Cities-**	09

	1.1	Definition and concept of smart city, Introduction to City planning, Introduction to Development Control Rules, Building Bye Laws	
	1.2	Conventional Vs. Smart city, Understanding Smart City	
	1.3	Various approaches to smart city, Pan city concept	
	1.4	Challenges of Urbanization, Smart City Characteristics	
2	**Smart City Standards-**		09
	2.1	Smart City Planning and Development, Dimensions of Smart Cities	
	2.2	Government of India initiatives "100 Smart Cities" Policy and Mission	
	2.3	Global experience of smart cities	
	2.4	Smart cities –Global standards	
	2.5	Smart cities-Performance benchmarks	
	2.6	Smart cities-Practice codes	
3	**Important sectors of smart city**		09
	3.1	Various sectors in smart city, Smart building and home device	
	3.2	Smart water, Smart Transportation, Smart Health, Smart Energy, smart public service	
	3.3	Cyber security, Safety and privacy, Concept of smart community	
	3.4	Concept of Digitalization, brief information about the various tools used for digitalization such as- ICT, IoT, Sensors, Artificial Intelligence	
4	**Governance of Smart Cities-E-Governance**		09
	4.1	Introduction to smart E-Governance, Smart E-Governance for Citizen services	
	4.2	Smart E-Governance for Industries and Commerce	
	4.3	Smart E-Governance within Government	
	4.4	Envisaging Future Smart E-Governance	
	4.5	Models for smart Governance	
	4.6	Regulatory Guidelines and Standards for E-Governance	
5	**Smart Citizen Services**		08
	5.1	Smart leadership and strategy; Stakeholder's engagement	
	5.2	Smart healthcare	
	5.3	Smart education, skill development centers, incubation/ Trade facilitation centers	
	5.4	Safety and security of citizens particularly women, children and the elderly people	
6	**Green Building in Smart Cities and Smart Villages-**		08
	6.1	Sustainability, smart housing, Green buildings, Rating system of Green Building	
	6.2	Energy efficient buildings, Energy Saving System in buildings	
	6.3	Introduction to Rural Planning and Development, Understanding Concept of Smart Village, Issues of Smart Village	
	6.4	Smart Village Performance Benchmark, Smart Village Policy and Mission, Planning and Management of Smart Village, Financing Smart Village	

Contribution to Outcome

On completion of this course, the students will be able to:

1. Conceptualize cities as socio-technical systems
2. Evaluate the main impacts of information and communication technologies on urban infrastructures and services.
3. Describe the main steps and considerations of the smart city transition.
4. Compare the main managerial and governance challenges of developing and managing a smart city.
5. Apply such concepts and tools in the case of smart water and smart housing systems.

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Reference Books:

1. “Smart Cities Unbundled” by, Sameer Sharma, Bloomsbury Publishing India Pvt. Ltd.
2. **“**Introduction to Smart Cities” by P.P. Anil Kumar, Pearson Publications
3. “Smart Cities & Urban Development in India “by N. Mani, New Century Publications
4. “Smart City” by Arun Firodia, Vishwakarma Publications.
5. “The Smart City Transformations: The Revolution of the 21st Century” by Amitabh Satyam & Igor Calzada, Bloomsbury Publishing India Pvt. Ltd.
6. “Financing Cities in India: Municipal Reforms, Fiscal Accountability and Urban Infrastructure” by, Prasanna K. Mohanty, SAGE publications India pvt. Ltd.
7. “Transforming Our Cities: Facing Up To India's Growing Challenge: Postcards of Change”, by Isher Judge Ahluwalia,Harper Collins publications
8. "Urban Systems Design Creating Sustainable Smart Cities in the Internet of Things Era”, by Yoshiki Yamagata, Perry P. J. Yang, Elsevier publications
9. “Internet of Things in Smart Technologies for Sustainable Urban Development” by G. R. Kanaga chidambaresan, R. Maheswar V. Manikandan, K. Ramakrishnan by Springer Publications
10. “Smart Cities: Introducing Digital Innovation to Cities” by Oliver Gassmann, Jonas Böhm, Maximilian Palmié, Emerald Publications.

Honours in Smart Cities: Semester VI		
Course Code	**Course Name**	**Credits**
HSCC601	**Smart City-Project Management**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs.**	**-**	**-**	**-**	**100**

Rationale

Smart City projects involve great technical complexity, and require a wide diversity of skills to control and monitor them. Project Management would be an integral part for smart infrastructure and cities. Like other complex infrastructure projects; smart city projects are subjected to risk and uncertainties leading to huge time and cost overrun. Managers are faced with the problem of putting together and directing large temporary organizations subjected to constrained resources, limited time, and environmental uncertainty. Project management plays an important role in developing the Smart Cities. It has grown in response to the need for a managerial approach that deals with the problems and opportunities of modern society. It provides the technical and managerial competency, communication and decision making necessary to meet the challenges of complex activities. Application of modern project management tools would ensure more collaboration, communication flow and much flawless implementation of Smart City projects. Modern project management concepts of application of Integrated Project Delivery (IPD) and Building Information Modeling (BIM) would reduce the co-ordination problems and ensure much higher probability of successful completion of the projects within stipulated time and cost frame

Objectives

1. This course is designed to give exposure to project management tools and techniques applicable for planning, controlling and monitoring of Smart Infrastructure and Cities.
2. This course would also enable to develop insight for managing project risks, uncertainties and complexities of smart city projects.
3. To provide overview on sound disaster risk management practices for preparing towards “Safe Cities”. To educate and sensitize students, government officers, planners, policy makers, academician, researchers and others on process of disaster management in smart cities.
4. To educate participants on various tools and methods that can be adopted for hazard identification, vulnerability analysis and disaster risk reduction measures.
5. To stimulate thought process to address hazard risks and vulnerabilities of distinct groups within the city to make more resilient communities.
6. To stimulate process of critically analyzing risks to various urban sectors like Health, Transport, Communication, Housing, Services, Infrastructure etc to come up with strategy to reduce risks Researchers and Academicians.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	Name of Module 1: **Philosophy and Concepts of Project Management in smart cities-**		08
	1.1	Philosophy and Concepts of Project Management-Phases	
	1.2	Philosophy and Concepts of Project Management- Stages of Project-	
	1.3	Philosophy and Concepts of Project Management-Approval Status	
	1.4	Philosophy and Concepts of Project Management-Work Break down Structure	
2	Name of Module 2: **Project Organization Structure-**		08
	2.1	Project Organization Structure- Planning	
	2.2	Project Organization Structure- Scheduling	
	2.3	Project Organization Structure-Controlling	
	2.4	Project Organization Structure-CPM	
	2.5	Project Organization Structure-The PERT Model	
	2.6	Project Management using BIM	
3	Name of Module 3: **Project Cost Analysis**		09
	3.1	Project Cost Analysis	
	3.2	Updating a Project	
	3.3	Resource Allocation and Leveling	
	3.4	Line of Balance Technique	
4	Name of Module 4: **Smart City Project Management with Case Studies -**		09
	4.1	Smart Project Planning	
	4.2	Smart Project Scheduling	
	4.3	Smart Project Monitoring	
	4.4	Smart Project Controlling	
	4.5	Project Risk Management	
	4.6	Case Studies on Smart Cities	
5	Name of Module 5: **Safety, Security and Disaster Management for Smart Citizen-**		09
	5.1	Safety, Security and Disaster Management for Smart Citizen	
	5.2	Disaster Risk Reduction (DRR) Overview	
	5.3	Smart Cities and Disaster Management	
	5.4	DRR Framework for Smart Cities	
6	Name of Module 6: **Thematic Analysis and Resilience Strategy for Smart Cities-**		09
	6.1	Thematic Analysis, Infrastructure Data/Digital Services	

	6.2	Data Management and Analytics	
	6.3	Resilience Strategy for Smart Cities	
	6.4	Stakeholder Capacity Building, Self-Assessment at project and city level	

On completion of this course, the students will be able to:

1. Explain role of project management in developing the Smart Cities.
2. Evaluate the risk and uncertainties throughout all the phases of Smart City projects.
3. Compare application of modern project management tools for flawless implementation of smart city projects.
4. Evaluate the managerial approach that deals with the problems and opportunities challenges of modern society of developing and managing a smart city.
5. Apply such concepts and tools for smart infrastructure and cities.

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only four questions need to be solved.

Reference Books:

1. Principles of Sustainable Project Management" by Mohamed Salama, Goodfellow Publishers
2. "Smart Cities Unbundled" by Sameer Sharma , Bloomsbury Publishing India Pvt. Ltd.
3. "Introduction to Smart Cities" by P.P. Anilkumar, Pearson Publications
4. "Smart Cities & Urban Development in India" by N. Mani, New Century Publications
5. "Smart City" by Arun Firodia,Vishwakarma Publications
6. "The Smart City Transformations: The Revolution of the 21st Century" by Amitabh Satyam & Igor Calzada, Bloomsbury Publishing India Pvt. Ltd.
7. "Financing Cities in India: Municipal Reforms, Fiscal Accountability and Urban Infrastructure" by, Prasanna K. Mohanty, SAGE publications India pvt. Ltd.
8. "Transforming Our Cities: Facing Up To India's Growing Challenge: Postcards of Change", by Isher Judge Ahluwalia, Harper Collins publications
9. Smart City Tech Planning Handbook by Wade Sarver
10. https://www.projectsmart.co.uk/project-management-ebooks.php

Smart Cities: Semester VII		
Course Code	**Course Name**	**Credits**
HSCC701	**Smart Urban Infrastructures**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4		**-**	**4**		**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs.**		**-**		**100**

Rationale

The smart city infrastructure is the introductory step for establishing the overall smart city framework and architecture. The scope of these cities is mainly limited to construct a technology park converting the industrial real estate to state-of-the-art information technology using the evolution in the telecom and IP networks including insignificant asset management automation system. Urbanization is not only associated with economic development but over the time it started aspiring people to better quality of life. Cities are seen as solutions for boosting economy, generating employment, creating skills, providing better health services and many more things. However, the state of urban service delivery in India's cities and towns is far poorer than is desirable for India's current income levels. Considering that the Indian economy has been one of the fastest growing economies in the world for some time, and aspirations and standards are raising, the current state of service delivery is simply unacceptable. Moreover, a successful city cannot operate efficiently in isolation from its environment. It must balance social, economic and environmental needs. Smart Cities focus on their most pressing needs and on the greatest opportunities to improve lives. They tap a range of approaches – digital and information technologies, urban planning best practices, public private partnerships, and policy change to make a difference.

Objectives

1. To study application of Solar Energy for Smart Cities-Conventional vs. Smart City
2. To prepare the qualified resource persons for the upcoming specialization in solid waste management practices after the mission period of SBM i.e., after 2020.
3. To learn from the challenges and limitations faced in e-governance projects in Citizen Services delivery, industries and commerce and intra-government systems for efficiency and transparency.
4. To develop ability to conceptualize, design, implement and manage the new era smart e-governance projects.
5. An understanding of the urban water supply and sanitation systems and linkages with urban forms.
6. Understanding the fundamentals of large project financing-Financial markets for smart city project finance such as syndicated bank loans, capital markets, private equity fund, multilateral institutions, joint ventures, public-private-partnership (PPP)
7. Understanding the projects and their business risks.
8. Understanding the documentation used to structure individual large project financings.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Conceptualization of Smart Energy System for Smart city:**		08
	1.1	Application of Solar Energy for Smart Cities, Conventional vs. Smart City, Green approach to meet Energy demand, Energy scenarios of conventional cities, Energy Efficient Building	
	1.2	Meeting energy demand through direct and indirect solar resources, Efficiency of indirect solar resources and its utility, Structure of Smart Grid, Indian Perspective, Advantage and limitation	
	1.3	Renewable in Smart grid Structural concept, Specific applications, Perspective in Smart Cities	
	1.4	Application of Solar in mobility, Matching demand and supply of energy in typical Smart city through Green mobility	
2	**Smart Water Management in Smart Cities-**		10
	2.1	Introduction to water Bye-Laws	
	2.2	Details of Water Supply system, various stages in implementing the system	
	2.3	Planning Stage: Conversion of existing maps to GIS	
	2.4	Assessing earlier population forecast, Demand estimation	
	2.5	Validation of ground elevations	
	2.6	Design Stage: Hydraulic model of distribution system	
3	**Solid Waste Management in Smart Cities**		09
	3.1	Introduction to an effective urban Solid Waste Management (SWM) with 5Rs, MSW Characteristics and Quantities, MSW Rules 2016, Swachh Bharat Mission and Smart Cities Program	
	3.2	Disposal of Municipal Solid Waste: Landfill, Biochemical Processes and Composting, Energy Recovery from Municipal Solid Waste, case study of any Smart Cities in the Country	
	3.3	Construction and Demolition (C&D) Waste Management - Overview, Regulation, Beneficial Reuse of C&D Waste Materials, E-Waste Management Issues & Challenges and Status in India, E-Waste Management Rules 2016 and Management	
	3.4	Critical examinations of SBM endeavor with special emphasis on clean city rankings along with case study on solid waste management	
4	**Smart Transportation in Smart Cities-**		08
	4.1	Introduction of “Smart Transport”	
	4.2	Application of traffic engineering to smart cities: Level of service, Traffic system management, reduction of conflicts, signal design	
	4.3	Smart pavement materials: plastic pavement, porous pavement, electric generating roads (Piezo electric roads) etc.	
	4.4	Introduction to Urban Transportation system planning: Trip Generation, distribution	
	4.5	Modal split and traffic assignment	

	4.6	Highway economics	
5	**Smart sanitation and storm water drainage system for Smart city-**		09
	5.1	Crisis of Sanitation- India, Key Sanitation policy issues and goals, Benchmarks for Smart Sewerage and Sanitation, steps required to achieve these benchmarks	
	5.2	Need of sewer model, Assessment of sewerage system at Planning and Design stage for transforming into smart sanitation	
	5.3	Sludge Management, Wastewater Reuse and Recycling. Need of Storm water drainage system, Storm water Planning, Challenges in Sustainable Storm water Planning	
	5.4	Trends and issues in storm water system Storm water management to for sustainable water management in Indian smart cities	
6	**Smart Funding for Smart Cities-**		08
	6.1	Financing Smart Cities Development-Types of sources for sustainable smart city funding: GOI seed capital grant of Rs 500 crore to each smart city, Leveraging this grant for funding from open sources, Business Risk Assessment, Public Private Partnership PPP concept and Modes of Smart City funding-BOOT, BOT, BOO, DBFOT etc.	
	6.2	PPP Request for Qualification (RFQ) and Criteria as per Planning Commission guidelines (Case Study), PPP request for Proposal (RFP) along with Concession agreement terms and conditions as per Planning Commission Guidelines	
	6.3	Debt funding, Consortium of financiers, Guarantees and mortgage, Joint venture, Municipal Bonds, Documentation of debt funding, Equity Funding through Initial Public Offer	
	6.4	Private equity funding and risk factors in IPO, Procedure of IPO funding, Other funding sources like Viability gap funding, Special subsidy for the project, Merger and Acquisition, Long term Lease, Financing etc.	

Contribution to Outcome

Conceptualize on completion of this course, the students will be able to:

1. Smart Energy System required for Smart city.
2. Explain the effective urban Solid Waste Management practices, MSW rules.
3. Evaluate the importance of best sanitation practices, storm water management and its linkage for the smart city transition.
4. Describe the evolution of e-governance and smart public services to be provided for developing and managing a smart city.
5. Evaluate application of traffic engineering to smart cities

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Assessment:

- Term Work

Including Laboratory Work and neatly written project report of the work done.

- Laboratory Work : 50 Marks
- End Semester Oral Examination : 50 Marks

Recommended Books:

1. "Water, Wastewater, and Stormwater Infrastructure Management", by Neil S. Grigg, CRC Press Taylor and Francis Group
2. "Smart Cities Unbundled" by Sameer Sharma, Bloomsbury Publishing India Pvt. Ltd.
3. "Introduction to Smart Cities" by P.P. Anilkumar, Pearson Publications
4. "Smart Cities & Urban Development in India" by N. Mani, New Century Publications
5. "Smart City" by Arun Firodia, Vishwakarma Publications
6. "Municipal Stormwater Management" by Debo, Thomas, Reese, Andrew, Lewis Publishers
7. "State of the Capital: Creating a Truly Smart City", by K.S.Mehra,Rupa Publications India
8. Security in Smart Cities: Models, Applications, and Challenges", by Aboul Ella Hassanien Mohamed Elhoseny , Syed Hassan Ahmed, Amit Kumar Singh Published by Springer
9. "Transportation and Power Grid in Smart Cities: Communication Networks and Services" by Melike Erol-Kantarci , Hussein T. Mouftah, Mubashir Husain Rehmani , Wiley Publications
10. Cities and Mobility & Transportation: Towards the next generation of Urban Mobility by Pascual Berrone, Joan EnricRicart Costa , Ana Duch T-Figueras, IESE CITIES IN MOTION: International.

Smart Cities: Semester VII							
Course Code	**Course Name**					**Credits**	
Lab 1: HSCSBL701	**Smart City-Project Management**					**02**	
Contact Hours			**Credits Assigned**				
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**	
-	**04**	**-**	**-**	**02**		**02**	

Theory					**Term Work/Practical/Oral**			**Total**
Internal Assessment			**End Sem Exam**	**Duration of End Sem Exam**	**Term Work**	**Pract.**	**Oral**	
Test-I	**Test-II**	**Average**						
-	-	-	-	-	**50**	**-**	**50**	**100**

Rationale

Smart City projects involve great technical complexity. It requires a widespread diversity of skills to control and monitor them. For any smart infrastructure project management would be an integral part. Like other complex infrastructure projects; smart city projects are subjected to risk and uncertainties leading to huge time and cost overrun. Project managers are faced with many problems that are putting together subjected to constrained resources, finance, time, and environmental uncertainty. Therefore, project management plays an important role in the development of the Smart Cities. It provides the technical and managerial competency, communication and decision making necessary to meet the challenges of complex activities. It has grown in response to the need for a managerial approach that deals with the problems and opportunities of modern society. A successful city operates efficiently only when it balances social, economic and environmental needs. Smart Cities focus on their most demanding needs to improve lives. They tap various approaches like digital and information technologies, urban planning best practices, public private partnerships, capacity building, policy change to achieve the success.

Course Objective:

1. To acquire knowledge on various components of Smart Cities.
2. To study ongoing projects and their business risks
3. To understand documentation, financings, capacity building used to structure individual large project
4. To study urban water supply, sanitation, solid waste management, transportation & application of Solar Energy for Smart Cities

List of Experiments (Conduct three practical out of six practical's mentioned below)		
Module	**Detailed Content**	**Lab Session / Hours.**

1	Preparing a report on Project Management-**Phases-Stages of project -Work Break down Structure of Smart city in India** (Ongoing Smart City Project-Case study).	08
2	Preparing a report of **Project Cost Analysis-Resource Allocation and Leveling, Line of Balance Technique** (Ongoing Smart City Case Study).	08
3	Preparing a report on **Smart Energy System for Smart city** (Ongoing Smart City-Case Study).	08
4	Preparing a report on **Smart Water Management in Smart Cities** (Ongoing Smart City-Case Study).	08
5	Preparing a report on **Solid Waste Management in Smart Cities** (Ongoing Smart City-Case Study).	08
6	Preparing a report on **Smart Transportation in Smart Cities** (Ongoing Smart City-Case Study).	08

Course Outcomes:

At the end of the course, learner will be able to:

1. Compare various stages of project of smart city.
2. Evaluate the effective urban Solid Waste Management practices, MSW rules.
3. Compare the importance smart water management, best sanitation practices, storm water management and its linkage for the smart city transition.
4. Prepare application of traffic engineering to smart cities

Assessment:

- End Semester Oral Examination

Oral exam will be based on experiments performed, site visit and theory syllabus.

Recommended Books:

1. Manual on Water Supply and Treatment, (latest Ed.): Ministry of Urban Development, New Delhi
2. Manual on Wastewater Treatment 3rd Ed. Pub: CPHEEO, Ministry of Urban Development, Govt. of India, New Delhi,
3. Municipal Solid Waste Management Manual, (Part1,2,3) Ministry of Urban Development, CPHEEO, 2016
4. Refer various websites of municipal corporations of the cities selected under the smart city mission to study success story,
5. Refer following official government websites
    - http://cpheeo.gov.in
    - https://moef.gov.in/en/

Smart Cities: Semester VIII		
Course Code	**Course Name**	**Credits**
HSCC801	**Smart Management of Smart Urban Infrastructures**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hours**	**-**	**-**	**-**	**100**

Rationale

The introduction of Smart urban technologies into legacy infrastructures has resulted in numerous challenges and opportunities for contemporary cities and will continue to do so. Over the past few years, advances in the Information and Communication Technologies (ICTs) have significantly challenged the traditionally stable landscape of urban infrastructure service provision. This has resulted in increasing interest from both technology vendors and public authorities in the transition of cities towards so-called “Smart Cities”. Although such “Smart technologies” can provide immense opportunities for citizens and service providers alike, the ICTs often act as disruptive innovators of urban infrastructure service provision.

Objectives

1. Enable students to develop competence in planning of projects at the city level to ensure sustainability of environment and humans
2. Enable students to apply smart technologies across the spectrum of infrastructure and governance
3. Enable students to develop overall city strategy to become contemporary and competitive
4. Enable students to understand city centric capital formation and finance, risk and feasibility to ensure the economic health of the city

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Management of Smart Urban Infrastructures**		08
	1.1	Issues and Challenges in Construction and Maintenance of Infrastructure, Information Technology and Systems for Successful Infrastructure Management	

	1.2	Innovative Design and Maintenance of Infrastructure Facilities, Infrastructure Modeling and Life Cycle Analysis Techniques	
	1.3	Capacity Building and Improving the Governments Role in Infrastructure Implementation	
	1.4	An Integrated Framework for Successful Infrastructure Planning and Management, Infrastructure Management Systems and Future Directions	
2	**Management of Smart water, Wastewater System-**		10
	2.1	Overview of Urban Water Supply, Rainwater Harvesting, Dual water supply system, water recycling	
	2.2	Building blocks of 24x7 water supply system,	
	2.3	Performance indicator and Benchmark for water supply services	
	2.4	Smart metering, Leakage management & NRW reduction for achieving 24x7 water supply	
	2.5	Smart monitoring through SCADA system for various components of water and sewerage system	
	2.6	Redressal of complaints on real time basis, Current Practices in Wastewater Recycling	
3	**Management of Smart Urban Energy Systems**		08
	3.1	Meaning of 'Smart Energy Management	
	3.2	Smart Energy Management – Water, Transport	
	3.3	Smart Energy Management-Waste Management and Public Services etc	
	3.4	Challenges and Implementation Barriers for Smart Energy Management, Way forward for achieving integrated Smart Energy Management	
4	**Management of Smart Solid Waste System-**		10
	4.1	The environmental impact of waste management and its relationship on the sustainable development and smart city development	
	4.2	Management of Solid Waste using IoT	
	4.3	management issues in source reduction, recycling, material recovery and transformation of waste through composting	
	4.4	Implementation of solid waste management options -collection system, energy recovery and landfill disposal.	
	4.5	Biomedical waste management, Economy and financial aspects of solid waste management.	
	4.6	Case Studies of Smart cities having successful solid waste Management program	
5	Name of Module 5: **Management of Smart Urban Transportation Systems**		08
	5.1	Introduction of "Smart Transport", Smart Automobile and Sustainable fuels	
	5.2	Smart infrastructure-Intelligent Transport systems (ITS), GIS, RS, GPS, Navigation and Identification Systems	
	5.3	Electronic fee payment technology (E-ticketing), Traffic Safety Management	

	5.4	Human and Environmental Impacts, Safety and Sustainability, Case Study: BRTS or Smart Parking with economics and costing, Mobility Services, Smart Mobility	
6	**Case Study Towards Smart Cities: Part I & II**		08
	6.1	**Towards Smart Cities: Part I: (0 4 hours)** The transition of legacy cities to Smart Cities is not a spontaneous process. To get the transition process right, and to the benefit of citizens, cities have to adopt effective management and governance approaches to successfully deal with numerous complexities of this process. This Module will help to understand the most important factors in the transition phase of legacy cities to smart cities and their managerial implications	
	6.2	**Towards Smart Cities: Part II: (04 hours)** Management of Smart Cities calls for different approaches from conventional urban management approaches, Role of city government in the network of actors who play an important role in management of clean, safe, healthy living conditions. Modern, efficient infrastructure that enables and promotes high-quality work opportunities and high-quality living, Efficient and sustainable use of resources, The city challenges such as city master plans, long term urban plans, city mobility plans, city strategic plans for renewable energy, water sources, waste management, pricing on water, power, tax assessment and frequent revisions, appropriation of resources, water harvesting and recycling, public participatory approach, citizen participation, citizen audit, capacity building in key disciplines, effective urban governance, adoption of ICT facilities, in due respect to local and regional culture, social aspects, safety and security based on economical vibrancy-Smart Cities-Internet of Things (IoT) and Artificial Intelligence (AI).	

Contribution to Outcome

On completion of this course, the students will be able to:

1. Explain how to make the best of these smart technologies in your cities' legacy infrastructures.
2. Learn about state-of-the-art strategies for effectively managing the transition from legacy infrastructures to smart urban systems.
3. Evaluate Life Cycle Analysis Techniques and sustainable development of Infrastructure.
4. Describe principles for the management of Smart urban infrastructures as well as the applications of these principles in the various sectors.

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Recommended Books:

1. Integrated Solid Waste management, George Tchobanoglous, Hilary Theisen and Samuel A Vigil Tata McGraw Hill
2. “Smart Cities Unbundled” by Sameer Sharma, Bloomsbury Publishing India Pvt. Ltd.
3. “Introduction to Smart Cities” by P.P. Anilkumar, Pearson Publications
4. “Smart Cities & Urban Development in India”by N. Mani, New Century Publications
5. “Smart City” by Arun Firodia, Vishwakarma Publications
6. “The Smart City Transformations: The Revolution of the 21st Century” by Amitabh Satyam & Igor Calzada, Bloomsbury Publishing India Pvt. Ltd.
7. “Financing Cities in India: Municipal Reforms, Fiscal Accountability and Urban Infrastructure” by, Prasanna K. Mohanty, SAGE publications India pvt. Ltd.
8. “Transforming Our Cities: Facing Up To India's Growing Challenge: Postcards of Change”, by Isher Judge Ahluwalia, Harper Collins publications
9. “Urban Systems Design Creating Sustainable Smart Cities in the Internet of Things Era”, by Yoshiki Yamagata, Perry P. J. Yang, Elsevier publications
10. “Internet of Things in Smart Technologies for Sustainable Urban Development” by G. R. Kanaga chidambaresan, R. Maheswar V. Manikandan, K. Ramakrishnan by Springer Publications
11. “Smart Cities: Introducing Digital Innovation to Cities” by Oliver Gassmann, Jonas Bohm, Maximilian Palmie, emerald Publications

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Waterways Transportation Engineering

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Waterways Transportation Engineering (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HWTC501: Waterways and Ports**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HWTC601: Design of Ports and Harbour structures**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HWTC701: Port and Harbour Operations and Services**	04	--	--	20	80	--	--	100	04
	HWTSBL701: Lab-1	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits =	**06**
BE Sem. VIII	**HWTC801: Construction and Management of Port and Harbour**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**

Waterways Transportation Engineering : Semester V		
Course Code	**Course Name**	**Credits**
HWTC501	**Waterways and Ports**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs.**	**-**	**-**	**-**	**100**

Rationale

Waterways are critically important to the transportation of people and goods throughout the world. The complex network of connections between coastal ports, inland ports, rail, air, and truck routes forms a foundation of material economic wealth worldwide. This subject introduces the basic elements related to waterway engineering.

Objectives

- To understand the historical development of waterways at a national and global level and also the significance of ports and harbours as a mode of transport.
- To understand the present status and different surveys required for the planning of Ports and Harbours.
- To understand the policies related to water transportation in India.
- To understand the natural phenomenon affecting waterways and its elements.
- To understand the coastal protection works and coastal Regulations to be adopted
- To study and understand all the important facilities required at the port for the efficient planning of port.

Detailed Syllabus		
Module	**Contents**	**Hours**
1	**General:** Comparison of different modes of transportation. Types, Characteristics, advantages and disadvantages of water transportation. History of water transportation at world level and at national level. Case studies of countries with excellent water transportation facilities.	04
2	**Historical development and Harbour planning:** Development and policies related to water transportation in India. Status of river, canal and ocean transportation in India. Classification of harbours, Requirement of Harbour. Harbour components, ship characteristics,	12

	characteristics of good harbour and principles of harbour planning, size of harbour, site selection criteria and layout of harbours. Surveys to be carried out for harbour planning Marine surveys, Topographic survey of marine area. Hydro graphic surveys, Tide Surveys.	
3	**Port development and planning**: Port building facilities. Differences between Port, Docks and Harbour. Requirement of a good port, Port development in India, Major ports in India. Maritime policies, Port authorities, bodies and associations. Port modernization and new port development (Sagarmala project). Connectivity enhancement Port-linked industrialization and Coastal community development and development of river information services. Environment Impact Statement (EIS). Approvals and mitigation .Case studies of various available Ports in India and abroad.	10
4	**Natural Phenomena:** Wind, waves, tide formation and currents phenomena, their generation characteristics and effects on marine structures. Wind strength, water waves, origin of water waves, effect of wind duration, and bottom friction and water depth on water waves. Wave form and generation. Velocity, height and length of waves. Diffraction, breaking and reflection of waves, wave action on vertical walls, piles. Beach protection, literal drift, silting, erosion and littoral drift.	12
5	**Coastal Structures**: Piers, Break waters, Wharves, Jetties, Quays, Spring Fenders, Dolphins and Floating Landing Stage Types, Objective, principal function and suitability.	06
6	**Harbour Terminal facilities and Navigational Aids:** Port building facilities, Transit sheds, Warehouses, Cargo handling facility, Services for shipping terminals, Inland port facilities planning, purpose and general description. Necessity of navigation aids and their types, Requirement of signals, Fixed and floating navigation aid.	08

Contribution to Outcomes

After completion of the course work, the students are expected to

1. Develop a strong fundamentals related to waterways transportation Engineering.
2. Understand the present status and different surveys required for the planning of Ports and Harbours.
3. The students shall be in a commanding position to plan and execute hydrographic surveys required at various stages of planning, construction and execution of Port and harbours. Also understand the policies related to water transportation in India.
4. The student will also be able to understand the role and effect of natural phenomenon such as wind and waves on the waterways.
5. Understand the coastal protection works and coastal Regulations to be adopted.
6. The student is expected to get full knowledge related to all the modern techniques and various important methods for effective management of port facilities.

Internal Assessment (20 Marks)

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks)

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of **total six questions, each carrying 20 marks.**
2. Question 1 will be compulsory and should cover **maximum contents of the curriculum.**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. **Only Four questions need to be solved.**

Recommended Books:-

1. Docks and Harbour Engineering: *Dr. S.P Bindra*, Dhanpatrai Publications, India
2. Docks and Harbour Engineering: *Hasmukh P. Oza, Gautam H. Oza,* Charotar Publication, India
3. Harbour, Dock and Tunnel Engineering: *R. Srinivasan*, Charotar Publication, India
4. Alonzo Def. Quinn, Design and Construction of Ports and Marine Structure, McGraw – Hill Book Company, New York.
5. PeraBrunn, "Port Engineering", 1 st Edition, Gulf Publishing Company, 2000.
6. Leslie A.Bryan, "Principles of Water Transportation", University of Chicago Press

Waterways Transportation Engineering : Semester VI		
Course Code	**Course Name**	**Credits**
HWTC601	**Design of Ports and Harbour structures**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs.**	**-**	**-**	**-**	**100**

Rationale

In the subject of Transportation Engineering, study of Harbour, Dock and Port Engineering is essential. This course is designed to give the basic understanding of ports and harbour structures. The course will also cover wide areas such as vessel types, types of harbours, design of entrance channel, turning circle, breakwaters, berthing structures etc. A key feature of this course is to introduce the international practice and technologies in fields of coastal, ports and harbour including the codal requirements for designing the various components of port and harbour structures.

Objectives

1. To make the students understand the basic principles of design of port and harbour structures.
2. To cover the design aspects of areas such as vessel types, types of harbours, design of entrance channel, turning circle, breakwaters, berthing structures etc.
3. To understand the importance of load consideration and will enable the students to calculate the different loads in designing the various components.
4. To introduce the international practices and construction technologies in order to design the foundation and fenders of ports and harbour.
5. To appreciate the design principles and codal requirements for designing a breakwater with the help of model studies.
6. To enable the students in understanding the concept, types and differences of docks and locks in order to navigate safely.

Detailed Syllabus		
Module	**Content**	**Hours**
1	**Introduction:** Ports and harbours – an infrastructure layer between two transport media. Introduction to navigation channel, entrance channel and turning circle.	08

	Design issues: Sea port layout with regards to - wave action- siltation - navigability, berthing facilities.-Vessel type and size	
2	**Wind rose and wave rose** as per IS 4651, Operational and design wave as per return period, seismic, sidescan and bathymetry charts	08
3	**Load consideration and calculations:** Environmental Loads: Wind, Currents, Waves. Mooring Loads: Mooring Lines Arrangement, Mooring Line Materials, Mooring Forces. Loads From Cargo Handling and Hauling Equipment and Uniform Distributed Loads. Design Load Assumptions, Uniform Distributed Cargo Loads and Miscellaneous Live Loads, Rubber Tire and Crawler Track Mounted Equipment, Rail-Mounted Cargo, Fixed-Base Equipment, Ship Impact.	12
4	**Foundation Design:** Vertical Loads on Piles or Piers Due to Changes in Water Level Ice Load of Thermal Origin, Other Ice-Induced Loads design methodology for pier , girder, slab, foundations and fenders - codes and standards	10
5	**Design of breakwater** and physical model studies on stability. Introduction to effect of breakwater on shoreline, dredging and disposal	06
6	**Docks and Locks:** Tidal basin, wet docks-purpose, design consideration, operation of lock gates and passage, repair docks - graving docks, floating docks	08
	Total	**52**

Contribution to Outcomes

After successful completion of the course the students shall be able to

1. Understand the different terminologies and components of port and harbour and will enable the students to understand the design issues.
2. Embrace the concept and principle behind load consideration and will eable the students to determine the different loads as well.
3. Design the foundation of different structures of ports and harbour and explore the codal requirements while designing.
4. Understand the concept of breakwater and will enable the students to design a breakwater.
5. Discuss the various international practices and modern construction technologies introduced in ports and harbour in order to design the foundation and fenders.
6. Understand the purpose of docks and locks with the major differences between them.

Internal Assessment (20 Marks)

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks)

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of **total six questions, each carrying 20 marks.**

2	Question 1 will be compulsory and should cover **maximum contents of the curriculum.**
3	**Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4	**Only Four questions need to be solved.**

References:

1. Port Design - Guidelines and recommendations by C. A. Thoresen, Tapir Publications.
2. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by J. W. Gaythwaite, Van Nostrand.
3. Handbook of Offshore Engineering by S.K. Chakrabarti, Elseviers, 2005.
4. Agerschou, H., Lundgren, H., Sorensen, T., Ernst, T., Korsgaard, J., Schmidt, L.R. and Chi, W.K., (1983). "Planning and Design of Ports and Marine Terminals", A Wiley-Interscience Publication.
5. Per brun (1983). "Port Engineering" Gulf Publishing Co.
6. Docks and Harbour Engineering: Bindra, S. P.; Dhanpat Rai and Sons, New Delhi.
7. Harbour, Dock and Tunnel Engineering: Shrinivas, R.; Charotar Publishing House, Anand
8. Design and Construction of Ports and Marine Structures: Quinn, A. D., Tata Mc-Graw Hill India Publishing House

Additional Reading

IS-4651 Indian standard Code of practice for planning and design of ports and harbour, Bureau of Indian Standards, New Delhi.

Waterways Transportation Engineering : Semester VII		
Course Code	**Course Name**	**Credits**
HWTC701	**Port and Harbour Operations and Services**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs.**	**-**	**-**	**-**	**100**

Rationale

Today 80% of the world's cargo is being transported by waterways. The boom in e-commerce has led to the thinning of borders between countries and goods being exchanged seamlessly. Thus, ports have become the bedrock of todays' global economy and India is no exception. Thus it's imperative for students to understand how seaport operates and apply the best practices along with the latest industrial developments. This course is designed in line with the contemporary developments. The syllabus covers global port management practices at the regulatory, commercial, technological, operational and financial levels. The shipping industry has myriad complexities and the syllabus provides students wide-ranging and up-to-date understanding required to thrive in today's highly competitive and evolving environment.

Objectives

1. To study History of Ports, its evolution, Governance and Ownership structure.
2. To Understand different types of logistic integration, Port operations and services.
3. To study planning of vessel movements and improvement of Port capacity.
4. To study the different types of International agreements which are the tools for growth in Indian ports.
5. To study and analyze traffic forecasting in order to plan the port operations effectively.
6. To study port authorities and regulatory framework

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Introduction**		08
	1.1	The History of Ports: Ports history, Planning, and Development.	
	1.2	Port Ownership, Structure, and Organization. Port Governance and Structural Type.	
	1.3	Port Workforce: Productivity, Growth, and Empowerment Strategies. Measuring Productivity, Throughput, and Growth.	
	Connecting Hub port Gateways to the Inland Infrastructure		

2	2.1	Logistics Integration of Port Activities: The Five Stages of Integration for the Maritime Industry.	08
	2.2	Strategic Location and Market Accessibility for Existing and Emerging Seaports.	
	2.3	Ports' Success Factors. Supply Chain Opportunities, Competition, and Conflict Prevention	
3	Port Operations		14
	3.1	Terminal Operators; Property Leasing Opportunities. Port Management Services and Operations. The Harbourmaster's Department and Functions, Terminal Manager, Vessels' Planning.	
	3.2	The Four Stages of Port Management and Operations: Leasing Opportunities, Marine Terminal Operator (MTO) Agreements and Leasing Opportunities and MTO case studies	
	3.3	Charter Party Types, Charter Party Clauses and Areas of Dispute, The Port and Charter Party Terms	
	3.4	The Components of Shipbuilding, Intellectual Property Rights, The History of Shipbuilding , Reasons for Shipyards Losing Market Share, Contemporary Shipbuilding Trends, Shipbuilding and Oil Market Analysis, Global Market Analysis.	
	3.5	Liner Services, Tramp Trade, and Offshore Support Agents. Agency Selection and Practices, Port Agency Responsibilities. General Agency Duties, for Tramp, Liner, and Logistics Services.	
4	International Trade and Port capacity		06
	4.1	The General Agreement on Tariffs and Trade. The World Trade Organization. Ports' Growth and the Global Trade Agreements Matrix.	
	4.2	Traffic Forecasting, Ports and the Principles of Derived Demand, Shipping, Ports, and the Ripple Effect. Optimum Size and Economies of Scale	
	4.3	Port Capacity Utilization, Capacity Management, Capacity Planning and Ports' Technology and Innovation.	
5	Strategic Planning		08
	5.1	Strategic Planning, Development, and Management: Corporate Objectives and factors considered in planning, developing and management	
	5.2	Port Pricing Strategies: Tariff Changing and Competitiveness. Port Pricing. Pricing Systems and Price-Setting Considerations.	
	5.3	KPIs: Measuring Financial and Operational Performance.	
	5.4	Port Equipment and Berth Facilities: Operations and Maintenance, Port Cargo Handling Equipment (CHE). Performance Management and the Human Factor	
6	Port Regulations and Future of Ports		08
	6.1	ISM: International Safety Management ISPS: International Ship and Port Facility Security Code OHSAS and OSHA: Occupational Safety and Health Administration VGP: Vessel General Permit by the US Environmental Protection Agency	
	6.2	ISO 14001: Environmental Management System HAZMAT: Hazardous Materials; HAZWOPER: Hazardous Waste Operations and Emergency Response BWM: Ballast Water Management	
	6.3	Incident Investigation and Root Cause Analysis; Inspections, Surveys, and Audits; Global and National Regulatory Compliance for Ships	

	6.4	Port Development Strategy: Elements of Long-Term Strategic Planning, Strategic Port Planning and Tactical Port Planning, Port Planning and the Factors of Production	
	6.5	Forecasting the Market: Port Management and Forecasting Areas. The Risk Element in Forecasting, Forecasting Methods and Tools	

Contribution to Outcome

On completion of this course, the students will be able to:

1. Port operations and planning
2. Port capacity Planning and Forecasting
3. Understand the Key Performance Indicators (KPIs) for strategic planning and management in port operations
4. Understand the different types of International agreements which are the tools for growth in Indian ports
5. Understand the regulatory framework involved in running a port.
6. Understand the traffic forecasting in order to plan the port operations effectively

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Maria G. Burns , “Port Management and Operations ”1st Edition,2015

2 Muir Wood, A.M., and Fleming. C.A., “Coastal Hydraulics Sea and Inland Port Structures”, 1st Edition, Hallstead Press, 2002.

3 Ozha&Ozha, “Dock and Harbour Engineering”, 1 st Edition, Charotar Books, Anand., 1990

Reference Books:

1 S. Seetharaman, “Construction Engineering and Management”, 4 thEdition ,Umesh publications, New Delhi, 1999.

2 Richand L. Silister, “Coastal Engineering Volume I & II, Elsevier Publishers, 2000.

3 PeraBrunn, “Port Engineering”, 1 st Edition, Gulf Publishing Company

Waterways Transportation Engineering : Semester VII		
Course Code	**Course Name**	**Credits**
Lab 1: HWTSBL701	**Port and Harbour Operations and Services**	**02**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**04 Per Week**	**-**	**-**	**02**		**02**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	50	-	50	100

Rationale

This subject is designed to give the basic understanding of ports and harbour structures. The course will also cover wide areas such as design of entrance channel, turning circle, breakwaters, berthing structures etc. Thus it's imperative for students to understand how seaport planned, designed, operates and apply the best practices along with the latest industrial developments. The course equips students with necessary field exposure and makes them aware of complex administration and structural reforms and acquaints them with necessary precautions and precision of this profession.

Course Objectives

- To study and understand all the important facilities required at the port for the efficient planning.
- To make the students to understand design and analysis of port and harbour structures using conventional approach as well as software.
- To understand the importance of load consideration and will enable the students to calculate the different loads in designing the various components.
- To study and analyse traffic forecasting in order to plan the port operations effectively
- To understand organizational behavior and management techniques for management of port.
- To study human resource management skills required at port.

List of Experiments(Any Six)		
Exp.No.	**Detailed Content**	**Lab Session / Hr.**
1	The visit of any harbour and port to understand the various structures, its construction and operations-Report	02
2	Effect of earth quake and Tsunami on port structures - Case studies	02
3	IT System and Port Planning	02

4	Design of Jetties using STAAD Pro and Midas	02
5	Design of Jetties using Sacs	02
6	Design of breakwater using STAAD Pro and Midas	02
7	Design of breakwater using Sacs	02
8	Planning and Designing of Storage, warehouse using STAAD Pro or any other designing software's.	02
9	Planning of placing the components of Port and estimating its capacity.	02
10	Current Issues in Port Management: Report on Case Study	02
11	Marine Structure, Navigation Aids	02
12	Docks and Repair Facilities, Port Facilities	02
13	Dredging, Coastal Protection	02

Contribution to Outcomes

- Develop a strong fundamental related to waterways transportation Engineering. Understand the different terminologies and components of port and harbour and will enable the students to understand the design issues.
- Understand the concept and principle behind load consideration and will enable the students to determine the different loads as well.
- Understand the concept of design the foundation and breakwater of different structures of ports and harbour and explore the codal and software requirements while designing.
- Understand the Port operations, planning and process of Dredging
- Understand skill required for effective organizational behavior, project management and port management skills.

Term work

Shall consist of Assignment, design report, case study and Site visit report related to this course. Distribution of marks for Term Work shall be as follows:
Assignment : 15 marks
Case study and design report: 15 marks
Site visit : 15 marks
Attendance: 05 Marks
Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%-80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

End Semester Oral Examination

The oral examination shall be based upon the entire theory and laboratory syllabus.

Reference Books:

1. Docks and Harbour Engineering: Dr. S.P Bindra, Dhanpatrai Publications, India
2. Docks and Harbour Engineering: Hasmukh P. Oza, Gautam H. Oza, Charotar Publication, India.

3. Port Design - Guidelines and recommendations by C. A. Thoresen, Tapir Publications.
4. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by J. W. Gaythwaite, Van Nostrand.
5. Handbook of Offshore Engineering by S.K. Chakrabarti, Elseviers, 2005.
6. Maria G. Burns, “Port Management and Operations ”1st Edition,2015
7. Detnorskeveritas, Rules for the Design, Construction and Inspection of Fixed Offshore Structures
8. R. Srinivasan and S. C. Rangwala, Harbour, Dock and Tunnel Engineering, 1995, Charotar Pub.House, Anand
9. SCI/SCOPUS Indexed Refereed International Journals (For Case Studies) 2 Relevant Indian Standard Specifications Codes, BIS Publications, New Delhi. 3 Departmental Laboratory Manual
10. Standard Geotechnical Engineering Handbook
11. NPTEL Video lectures on Practical.

Waterways Transportation Engineering : Semester VIII		
Course Code	**Course Name**	**Credits**
HWTC801	**Construction and Management of Port and Harbour**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
04	**--**	**--**	**04**	**--**	**--**	**04**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**3 Hrs.**	**--**	**--**	**--**	**100**

Rationale

This is a course which deals with various construction equipment and processes of various structures involved in the port and shipping business as well as teaching capable administration strategies for the same. The course equips students with necessary field exposure and makes them aware of complex administration and structural reforms and acquaints them with necessary precautions and precision of this profession.

Objectives

1. To study the various construction equipment and process of Port and harbor structures.
2. To study the construction and maintenances of Fishing Harbor.
3. To understand the process of Dredging
4. To understand organizational behavior and management techniques for management of port.
5. To study human resource management skills required at port.
6. To understand health, safety, security and environment concerns related to port activities.

Detailed Syllabus		
Module	**Course Module / Contents**	**Hours**
1	Marine and offshore construction equipment: Basic motions of Barges, crane barges, Offshore derrick barges, semisubmersible barges, Jack-up construction barges, launch barges, pipe laying barges, floating concrete plant. Pile driving equipment.	10
2.	**Fishing Harbour Construction**	12

	Fishing Harbour and Fish landing centres – Types, Various components of fishing Harbour and landing centre. Land side and water side facilities and structures of fishing Harbour. Small and medium fishing Harbour, Deep sea fishing Harbour, Environmental auditing for fishing Harbour. Dredging and breakwater construction. Layout and construction of Jetties, quays and slipways. Use of different construction materials for shore based and seaside structures. Fishing Harbour maintenance and waste disposal, Water treatment plant in fishing Harbour. Status of fishing Harbours in India.	
3	**Dredging** General ,Classification of dredging works, Types of dredgers, Uses of dredged material ,Execution of dredging work	06
4	**Introduction to Port management:** Organizational behavior: Definition, diversity in workplace, Ethics and ethical behavior in organizations. Project Management: Principles of management, Project definition, Project manager skills, Stages of project, Scheduling, Contract Strategy, selection and appointment of contractors, project implementation and execution, closure of project. Port and terminal operations, types of ports and terminals, terminal ownership, port and cargo movements, competition and other challenges facing the industry	08
5	**Port Labour, People Management and Port master planning:** Historic and current port labour environment, effective management of staff on ports, Labour reforms and social issues, employment framework and employee relations. Introduction to post master planning, land parcelisation, development phasing strategy, developing 30 year masterplan. Terminal Ownership: Impact of port ownership, Privatization benefits and concerns, BOT, BOOT and BOO, Concession agreement, Tariff setting, role of port regulators.	08
6	**Health, Safety, Security and the Environment (HSSE) in Ports:** Importance of HSSE culture, HSSE concepts, HSS on Ports, safety and security indicators, regulations related to HSSE. Risk awareness and risk management, system approach to port safety and security. Environment management: Introduction, Environment impact, Environment regulations and governance.	08

Contribution to Outcome

On completion of this course, the students will be able to:

1 Understand the various methods and equipment for the construction of Port and harbor structures

2 Understand the construction and maintenances of Fishing Harbor.

3 Understand the process of Dredging.

4 Understand skill required for effective organizational behavior, project management and port management skills.
5 Carry out human resource management in accordance to labour laws and to develop master plan for port.
6 Understand the importance of health, safety, security and environment concerns at port and to suggest measure.

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.
2 Question 1 will be compulsory and should cover maximum contents of the curriculum.
3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4 Only Four questions need to be solved.

Recommended Books:

1 S. Seetharaman, "Construction Engineering and Management", 4th Edition , Umesh publications, New Delhi, 1999.
2 Detnorskeveritas, Rules for the Design, Construction and Inspection of Fixed Offshore Structures.
3 R. Srinivasan and S. C. Rangwala, Harbour, Dock and Tunnel Engineering, 1995, Charotar Pub.House, Anand
4 Alonzo Def. Quinn, Design and Construction of Ports and Marine Structure, McGraw – Hill **Book Company, New York**
5 Construction project management by KK Chitkara, Tata McGraw Hill (2010)

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Professional Practices in Structural Engineering

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Professional Practices in Structural Engineering (With effect from 2022-23)										
Year &Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	HPSC501: Concrete Consultant Practices	04	--	--	20	80	--	--	100	04
	Total	04	-	--	100		-	-	100	04
									Total Credits = 04	
TE Sem VI	HPSC601: Formwork Design Practices	04	--	--	20	80	--	--	100	04
	Total	04	-	-	100		-	-	100	04
									Total Credits = 04	
BE Sem VII	HPSC701: Structural Consultant practices – I	04	--	--	20	80	--	--	100	04
	HPSSBL701: Structural Consultant Practices (SBL)			04	--		50	50	100	02
	Total	04		04	100		50	50	200	06
									Total Credits = 04+02=06	
BE Sem VIII	HPSC801: Structural Consultant practices – II	04	-	--	20	80	--	--	100	04
		04	--		100		--	--	100	04
									Total Credits = 04	
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Professional Practices in Structural Engineering: Semester V		
Course Code	**Course Name**	**Credits**
HPSC501	**Concrete Consultant Practices**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
04	**--**	**--**	**04**	**--**	**--**	**04**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**3 Hrs.**	**--**	**--**	**--**	**100**

Rationale

Basic concept of concrete technology is essential for civil engineering students to execute the civil engineering projects as per the standard laid down time to time. The concrete technology is the backbone of infrastructure of civil engineering field. The students must know various concreting operations and testing operations during and after construction. It is expected to know the properties of materials, especially concrete and to maintain quality in construction projects. The civil engineering students ought to know the selection of materials, its mix proportioning, mixing, placing, compacting, curing and finishing.

Objectives

1 To study the properties of fresh and hardened concrete.

2 To study the properties such as workability and durability.

3 To acquaint the practical knowledge by experimental processes of various materials required for concrete.

4 To understand the Mix design by different methods.

5 To understand ordering and handling of RMC.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Introduction to concrete making materials**		09
	1.1	**Cement** Physical properties of cement as per IS Codes, types of cements and their uses.	
	1.2	**Aggregates** Properties of coarse and fine aggregates and their influence on properties of concrete, properties of crushed aggregates.	
2	**Special cementitious materials**		07

	2.1	GGBS: properties, advantages and disadvantages, uses	
	2.2	Silica fume: properties, advantages and disadvantages, uses	
	2.3	**Admixture** Plasticizers, Super-plasticizers, Retarders, Accelerators, Mineral admixtures and other admixtures, test on admixtures, chemistry and compatibility with concrete.	
3	**Concrete and its properties**		13
	3.1	Grades of concrete, Manufacturing of concrete, importance of w/c ratio.	
	3.2	**Properties of fresh concrete-** workability and factors affecting it, consistency, cohesiveness, bleeding, segregation.	
	3.3	**Properties of hardened concrete-** Compressive, Tensile and Flexural strength, Modulus of Elasticity, Shrinkage and Creep.	
	3.4	**Durability-** Factors affecting durability, Relation between durability and permeability	
4	**Concrete Mix Design**		10
	4.1	Design of concrete mixes by IS code method	
	4.2	Design of concrete mixes by ACI method	
	4.3	Design of concrete mixes by Road Note 4 method	
	4.4	Design of high strength concrete mixes, design of light weight aggregate concrete mixes, design of fly-ash cement concrete mixes, design of high-density concrete mixes.	
5	**Testing of Concrete**		07
	5.1	**Non-Destructive testing of concrete** Rebound Hammer test, ultrasonic pulse velocity test, load test, carbonation test, 1⁄2 cell potentiometer test, core test and relevant provisions of I.S. codes.	
	5.2	**Durability** Permeability test, Rapid chloride penetration test.	
6	**Ready mix concrete**		06
	6.1	Advantages of RMC, components of RMC plant, distribution and transport, handling and placing, mix design of RMC.	
	6.2	Distribution and transport, handling and placing, mix design of RMC.	
	6.3	Handling Quality Complaints	

Contribution to Outcome

On completion of this course, the students will be able to:

1 Identify the properties of ingredients of concrete.

2 Know the properties of wet concrete, hardened concrete.

3 Understand the Mix design by different methods for different grades of concrete.

4 Perform various test on concrete.

5 Understand the concept of durability and cracking in concrete.

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Concrete Technology: A. R. Shanthakumar, Oxford University Press.

2 Concrete mix proportioning-guidelines (IS 10262:2009).

3 Method making, curing and determining compressive strength of accelerated-cured concrete test specimens as per IS: 9013-2004.

4 Tentative Guidelines for cement concrete mix design for pavements (IRC: 44-1976): Indian Road Congress, New Delhi.

5 Properties of concrete: Neville, Isaac Pitman, London.

Reference Books:

1 Concrete Technology Theory and Practice: Shetty M.S., S. Chand.

2 Relevant I.S. codes: Bureau of Indian standard.

3 Concrete Technology: D.F. Orchardi, Wiley, 1962.

4 Chemistry of Cement and Concrete: F.M. Lue, Edward Arnold, 3rd Edition, 1970.

5 Concrete Technology: Neville A.M. & Brooks. J. J., ELBS-Longman.

6 Concrete Technology: Gambhir M.L., Tata McGraw Hill, New Delhi.

Professional Practices in Structural Engineering: Semester VI		
Course Code	**Course Name**	**Credits**
HPSC601	**Formwork Design Practices**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
04	**--**	**--**	**04**	**--**	**--**	**04**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Practi.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**3 Hrs.**	**--**	**--**	**--**	**100**

Rationale

Course focuses on importance of Formwork design in RCC construction apart from concreting and bar bending work. It deals with the changing scenario towards formwork designing as a career option in Construction Industry. The course helps the students to know the market outlook as well as the requirements of formwork design by knowing all the technical as well as field considerations while designing formwork for various components of building. It gives the exposer to students regarding cost benefits and time saving along with advanced technologies and new formwork material in construction industry.

Objectives

1 To know the different types of formwork and importance of formwork in RCC Construction

2 To study the market outlook and requirements of system formwork in construction industry.

3 To design a formwork for walls, columns, beams and slabs considering all the live loads, concrete pressures, wind loads, concreting methods and do the necessary checks.

4 To understand the formwork selection criteria for various tunnel construction methods, bridge construction methods and high-rise construction.

5 To plan and estimate the material and man power required for Formwork.

6 To know the various advancements in formwork design in construction market.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Introduction to Formwork**		08
	1.1	Various Activities and Equipment involved in concrete construction- Concrete, Reinforcement, Batching Plant, Boom Placer, Concrete Pumps, Buckets, Crane, Formwork (Shuttering/Centering), Scaffolding, etc.	

	1.2	Introduction of Formwork, Types of Formwork, Importance of Formwork in RCC Structure	
	1.3	Conventional Formwork and Scaffolding- Advantages and Disadvantages in view of ongoing approach and site requirements	
	1.4	System Formwork and Scaffolding, Time-Cost Distribution in RCC Construction with respect to Formwork, Reinforcement and Concreting.	
2	**System Formwork**		09
	2.1	Importance of System Formwork- Construction Market Outlook, Market Growth Drivers (Increasing Urbanization, Housing Shortage, Economic Development),	
	2.2	Factors driving demand for System Formwork and Scaffolding, Key Challenges at construction sites, Requirements and Solutions against Challenges- Design and Planning, Equipment usage time, etc.	
	2.3	Design and Planning- Project Planning Sequence- Current and Correct Practice, Any TWO Case Studies.	
	2.4	Equipment usage time- Crane Availability, Boom Placer, labour, etc.	
	2.5	Parameters considered in High Rise Buildings- Comparison between System Formwork and Conventional Formwork	
3	**Formwork Design- Walls, Columns & Slabs**		14
	3.1	Introduction to Formwork Design- Factors related to Concreting, Concrete Placing method influence pressure of Concrete - Crane Bucket Concreting, Boom Placer Concreting	
	3.2	Loads on formwork and lateral pressure of concrete, Calculation of design pressure based on type of concrete, method of concreting, grade of concrete, type of structure and rate of concreting	
	3.3	Concrete Pressure Calculation- Column and Wall Formwork	
	3.4	Design of formwork for slab (less than 4 m height)- Design Loads for slabs and beams formwork	
	3.5	Design of formwork Material for walls & Columns (Vertical application) - Sheathing Member (Plywood), Secondary Member, Primary Member, Tie System; Check against various forces and bending.	
	3.6	Design of Slab Formwork Material- Primary, Secondary and Prop Members; Checks against failures.	
	3.7	Planning & Estimation of Formwork for Residential & Commercial Buildings, Column Formwork Sets, Cycle time- Slabs and Beams	
4	**Formwork for High Rise Constructions, Tunnels and Bridges**		12
	4.1	Design Concept for Climbing system- Define, Types, CB 240 and SCS 250 system, Anchoring System	
	4.2	Study of IS: 875(Part3): Wind Loads on Buildings and Structures, Wind Force for Formwork design- High Rise Construction and Slab height more than 4 m	
	4.3	Design of Formwork system for any typical floor plan with self-climbing system for walls, columns, beams and slabs	
	4.4	Overview of Tunnel Construction Methods & Formwork selection	
	4.5	Overview Bridge Construction Methods & Formwork Selection	
	4.6	Overview of High-Rise Construction & Formwork Selection	

5	**Economics and Maintenance of Formwork**		05
	5.1	Factors affecting supply and demand of Formwork	
	5.2	Manpower Management required for formwork	
	5.3	Maintenance of Formwork & its Stacking.	
6	**Advancement & Scope of Formwork Design**		04
	6.1	Advance formwork technology Available in the market	
	6.2	Advanced Material used as a Formwork	
	6.3	Formwork field as career option	

Contribution to Outcome

On completion of this course, the students will be able to:

1 Understand the different types of formwork and its importance in various RCC construction activities.

2 Understand various aspects of system formwork over conventional formwork. Also, understand the market outlook and various parameters need to be considered in design of formwork

3 Design a formwork for walls, columns, beams and slabs considering all the live loads, concrete pressures, wind loads in a view of different concreting methods and do the necessary checks

4 Understand the formwork selection criteria for various tunnel construction methods, bridge construction methods and high-rise construction.

5 Plan and estimate the material and man power required for Formwork.

6 Know the advance formwork technologies and advanced material available in the market.

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1 Formwork for concrete structures: Robert L. Peurifoy and Garold D. Oberlender, The McGraw hill publishing company.

2 Concrete Formwork Systems: Awad S. Hanna, Marcel Dekker.

3 Design and Construction of Formwork for Concrete Structures: Albert Edward Wynn, Cement and Concrete Assn.

4 Concrete Formwork: Leonard Koel, Amer Technical Pub.

Reference Books:

1 IS: 875(Part3): Wind Loads on Buildings and Structures

2 Formwork for concrete structures: Dr. Kumar Neeraj Jha, The McGraw Hill Education India

3 Modern Practices in Formwork for Civil Engineering Construction Work: Dr. Janardan Jha, Prof. S. K. Sinha.

Professional Practices in Structural Engineering: Semester VII		
Course Code	**Course Name**	**Credits**
HPSC701	**Structural Consultant Practice-1**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
04	**--**	**--**	**04**	**--**	**--**	**04**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	3 Hrs.	--	--	--	100

Rationale

Course is equipped with the basic knowledge about structural designs and various other consultants and venders related with the structural consultant which combines together to carry out the design of any structural project. This will make students to understand the hierarchy of the work which has to carry out the structural consultant and structural engineer with other agencies and consultants and also it will highlight the brief information regarding structural quantity estimation and tenders.

Objectives

1 To understand types of various structures, importance of structural consultant and role of structural engineer

2 To understand the scope, responsivities and activities of structural engineer

3 To study the schematic designs, documentation and certification in structural design.

4 To understand the roles of client, architect, another consultant with structural consultant.

5 To understand relation of structural consultant with different agencies and vendors.

6 To study structural quantity estimation and tender preparation and also documentation.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	Introduction		09
	1.1	Types of Structures, functionality, various forms of structures, usage driven requirements, notable structures in the world, country, state, city.	
	1.2	Information on team of consultants required for the comprehensive design of structures. Responsibilities of various consultants' team members – legal, professional, ethical and moral	

	1.3	Place of a structural engineer in the matrix of the overall project, Set up of a structural designer's office, Various personnel working in a structural designer's office	
2	Role of Structural Consultant		07
	2.1	Scope of a structural consultant, Tasks and deliverables for a structural consultant	
	2.2	Activities that a structural engineer has to carry out	
	2.3	Legal responsibilities of a structural engineer	
3			09
	3.1	Introduction to: Concept, Schematic, Tender, Design Development, Detail Design of various structural designs	
	3.2	Construction Stage Documentation, Construction Administration, Completion Stage Documentation, Certification	
	3.3	Bye laws pertaining to structural engineers in MCGM rule book, HRC, liaison, NBC, DCR etc.	
	3.4	Licensing requirements for a structural engineer	
4	Teaming up with other consultants, contractors and vendors – Nature of communication transactions – Part 1		11
	4.1	Client – Brief and scope defined by Client's representative Architects – Design and Liaison, Surveyor, Geotechnical Engineer, Wind Engineer	
	4.2	Façade Engineer, Interior Architect, Landscape architect, Steel Fabrication contractor's detailers	
	4.3	Water proofing Consultant/vendor, Fire proofing Consultant/Vendor, Concrete technologists, concrete manufacturers	
5	Teaming up with other consultants, contractors and vendors – Nature of communication transactions – Part 2		08
	5.1	Agencies: Material Testing Agency, Rebaring Agency, Anchoring Agency, Post Tensioning Agency, Ground Anchoring Agency, Piling Agency.	
	5.2	Vendors: Steel suppliers/manufacturers, Alternate material suppliers/ manufacturers/ vendors, Bearings/isolators suppliers/manufacturers / vendors, Electrical Engineers, Mechanical Engineers	
	5.3	Other vendor and agencies: Plumbing/Drainage Engineers, Traffic Consultants / Parking system vendor / parking requirements, Vertical Transportation Consultants, Pre-Engineered Building Agencies Contractors in general	
6	Structural Quantity Estimation and Tender		08
	6.1	Structural Quantity Estimation: Structural Specifications, Structural Bill of Quantities, General material consumption ratios, Actual sample workout problem.	
	6.2	Tender Stage: Preparation of Tender Drawings, Bill of Quantities, Specifications, Special Notes, Consultant's estimate, Disclaimers	
	6.3	Construction Documentation and Construction Administration Delivery of drawings and other documents to site for execution.	
Contribution to Outcome			

On completion of this course, the students will be able to:

1 Understand types of various structures, importance of structural consultant and role of structural engineer.

2 Understand the various scope, responsivities and activities of structural engineer has in structural consultant.

3 Study and understand the schematic designs, documentation and certification in structural design

4 Understand the roles and nature of client, architect, other consultant with structural consultant and also safety measures at site.

5 Understand the nature of communication transactions of structural consultant with different agencies and vendors.

6 Study the structural quantity estimation and tender preparation and also documentation works required to the structural consultant.

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1. Fundamentals of Reinforced Concrete: Sinha& Roy, S. Chand and Co. Ltd.
2. Estimating, Costing, Specifications and Valuation: Chakraborty, M., Kolkata.
3. Relevant Indian Standard Specifications, BIS Publications
4. Professional Construction Management: Barrie D.S. & Paulson B C, McGraw Hill
5. The cost management toolbox; A Managers guide to controlling costs and boosting profits- Oliver, Lianabel (Tata McGraw Hill).

Professional Practices in Structural Engineering: Semester VII		
Course Code	**Course Name**	**Credits**
HPSSBL701	**Structural Consultant Practice-Lab**	**02**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
--	--	**04**	--	--	**02**	**02**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
--	--	--	--	--	**50**	--	**50**	**100**

Course Objectives	
1	To understand types of various structures, importance of structural consultant and role of structural engineer
2	To understand the scope, responsibilities and activities of structural engineer
3	To study the schematic designs, documentation and certification in structural design.
4	To understand the roles of client, architect, another consultant with structural consultant.
5	To understand relation of structural consultant with different agencies and vendors.
6	To study structural quantity estimation and tender preparation and also documentation.

Contribution to Outcome

On completion of this course, the students will be able to:

1. Understand types of various structures, importance of structural consultant and role of structural engineer.
2. Understand the various scope, responsibilities and activities of structural engineer has in structural consultant.
3. Study and understand the schematic designs, documentation and certification in structural design
4. Understand the roles and nature of client, architect, and other consultant with structural consultant and also safety measures at site.
5. Understand the nature of communication transactions of structural consultant with different agencies and vendors.
6. Study the structural quantity estimation and tender preparation and also documentation works required to the structural consultant.

List of Tutorials and Assignments		
Week (Activity)	**Detailed Content**	**Lab Session / Hr.**
1	Study of different types of structures based on its utility, roles and responsibilities of various consultants.	02/04
2	Study of Legal responsibilities, scope and activities for structural consultant	02/04
3	Preparation of tender, documentations and detailed design of various structural components of any one structure	02/04
4	Design of single bay double storey building structure using softwares like ETAB/STAAD and SAFE	03/06
5	Application of different IS codes for the selection of parameters (like loading, design, materials, etc) for different types of structural systems	02/04
6	Structural quantity estimation which includes bill of quantities, general material consumption ratios, consultant's estimate	02/04

Assessment:

- **End Semester Oral Examination**
  Oral examination will be based on entire syllabus

Reference Books:

1. Design of Reinforced Concrete Structures: Dayaratnam, P; Oxford and IBH.
2. Illustrated Reinforced Concrete Design: Dr. V. L. Shah and Dr. S. R. Karve, Structure Publications, Pune
3. Relevant IS codes, BIS Publication, New Delhi
4. Project Preparation, Appraisal, Budgeting, and Implementation: Prasanna Chandra (Tata McGraw Hill).
5. Construction Engineering and Management: S. Seetharaman, Umesh Publications, Delhi.

Professional Practices in Structural Engineering: Semester VIII		
Course Code	**Course Name**	**Credits**
HPSC801	**Structural Consultant Practice-II**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
04	**--**	**--**	**04**	**--**	**--**	**04**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**3 Hrs.**	**--**	**--**	**--**	**100**

Rationale

This course is capable of different parameters with the designs and drawing of various structures and the roles of different structural consultant. The course will give ideas regarding the software applications in the structural engineering works which ease the design and drawing stage difficulties. It also provides students the brief knowledge about different tests required from various agencies, consultants and venders.

Objectives

1 To understand different structures, material required for construction and various interpretations

2 To study the various IS codes, loadings and framing structure systems.

3 To understand and prepare the cost comparison report and hand calculation techniques.

4 To study and run different software used in structural consultant.

5 To understand reinforcement details, drawings and various design audit

6 To conduct different tests and to form stagewise and final certifications for the designs.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	Introduction		09
	1.1	Concept and Schematic Stages Definition of a given structure – identifying the structural system	
	1.2	Material of construction – Appropriate selection based on functional requirement, space constraints, aesthetics, special demands from client/architect/function	
	1.3	Data and drawing reading and its interpretation as received from all collaborating agencies	
2	Introduction to IS codes		07

	2.1	Introduction to IS 456, IS 800, IS 1786, Loading parameters – as per architectural drawings and usage requirements	
	2.2	Introduction to IS 875, IS 875-Part 3, IS 1893	
	2.3	Various types of framing, structural systems – gravity and lateral, codal interpretations, parameter selection – comparative studies	
3	Cost Comparison and Report		12
	3.1	Comparative costing of components: Flooring, Column grids, Types of columns, Lateral Systems, Foundation systems and Soil retention structures – retaining walls, shoring systems etc	
	3.2	Formation of Design Basis Report, Preliminary Analysis Tools – Introduction	
	3.3	Preparation of Concept and Schematic Drawings. Contents of these drawings.	
	3.4	Hand Calculation techniques, Sofwares available, tips for usage of software Introduction to Etabs/ Staad	
4	Softwares to carry out structural designs		10
	4.1	Hands on ETABS / STAAD / SAFE modelling for sample simple structures for understanding of the working of the software only, its various facilities, capacity and limitations. Meaning of various parameter definitions	
	4.2	Design Development / Working Stage, Incorporation of other consultants' requirements, Preparation of DD stage drawings	
	4.3	Running final ETABS model, Running final SAFE mode	
5	Reinforcement details		06
	5.1	Reinforcement calculations, Feeding data to structural draughtsman Preparation of GFC / working reinforcement drawings – contents	
	5.2	Notes on reinforcement drawings, Typical details, Standard formats of reinforcement drawings	
	5.3	Special requirements of detailing – Introduction to SP34 and IS 13920 Drawing and design audit	
6	Tests and Certifications		08
	6.1	List of submittals expected from contractors/vendors/agencies for structural engineer's approval	
	6.2	Site visit records / reports / approvals / comments / suggestions, Changes in design / drawings / details as per site situations, Monitoring safety / stability on the site during construction, Retrofitting / repairs / modifications etc. if necessary	
	6.3	Stage wise Certification, Monitoring quantities as construction progresses as in built drawings, Final certification	

Contribution to Outcome

On completion of this course, the students will be able to:

1 Explain different concepts and schematic stages of structures, material required for construction and various interpretations.

2 Demonstrate use of the various IS codes, loadings parameters and different framing structure systems.

3	Prepare the cost comparison report and hand calculation techniques.
4	Prepare and run sample models in different software such as ETABS, STAAD, SAFE used in structural consultant.
5	Explain reinforcement details from samples, preparation of drawings and various design audit.
6	Conduct different tests according to list wise submittals and to form stage wise and final certifications for the designs.

Internal Assessment 20 Marks

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination 80 Marks

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1	Question paper will comprise of total six questions, each carrying 20 marks.
2	Question 1 will be compulsory and should cover maximum contents of the curriculum.
3	Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4	Only Four questions need to be solved.

Recommended Books:

1. Design of Reinforced Concrete Structures*: Dayaratnam, P;* Oxford and IBH.
2. Illustrated Reinforced Concrete Design: *Dr. V. L. Shah and Dr. S. R. Karve*, Structure Publications, Pune
3. Relevant IS codes, BIS Publication, New Delhi
4. Project Preparation, Appraisal, Budgeting, and Implementation: Prasanna Chandra (Tata McGraw Hill).
5. Construction Engineering and Management: S. Seetharaman, Umesh Publications, Delhi.

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Green Technology and Sustainable Engineering

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Green Technology and Sustainable Engineering (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HGSC501: Green Technologies and Practices**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HGSC601: Green Building and Infrastructure Engineering**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HGSC701: Fundamentals of Sustainable Engineering**	04	--	--	20	80	--	--	100	04
	HGSSBL601: Lab-1 Green Building and Infrastructure Engineering	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HGSC801: Sustainable Built Environment Engineering**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Green Technology and Sustainable Engineering: Semester V		
Course Code	**Course Name**	**Credits**
HGSC501	**Green Technologies and Practices**	04

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	-	-	4	-	-	4

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	-	-	-	100

Rationale

Technology is application of knowledge to practical requirements. Green technologies encompass various aspects of technology which help us reduce the human impact on the environment and create ways of sustainable development. Social equitability, economic feasibility and sustainability are the key parameters for green technology. Today, the environment is racing towards the tipping point at which we would have done permanent irreversible damages to the planet earth. Our current actions are pulling the world towards an ecological landslide which if happens would make destruction simply inevitable. Green technologies are an approach towards savings earth and are necessary. Green technologies are our way out of destruction.

Objectives

1. To acquire knowledge on the concept of green technologies
2. To understand the principles of Green Chemistry in the Energy efficient technologies.
3. To analyze the methods of reducing CO2 levels in atmosphere for Cleaner Production Project Development and Implementation
4. To evaluate the methods of Pollution Prevention and Cleaner Production Awareness Plan.
5. To analyze the application of Energy Efficacy.
6. To apply the knowledge of Green Fuels during implementation.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Introduction to Green Technology**		07
	1.1	Definition- Importance – Historical evolution – advantages and disadvantages of green technologies.	
	1.2	Factors affecting green technologies.	
	1.3	Role of Industry, Government and Institutions-Industrial Ecology.	
	1.4	Role of industrial ecology in green technology.	
2	**Green Chemistry**		08

	2.1	Principles of Green Chemistry, Green chemistry metrics-atom economy.	
	2.2	E factor, reaction mass efficiency.	
	2.3	Waste: Sources of waste, different types of waste.	
	2.4	Chemical, physical and biochemical methods of waste minimization.	
	2.5	Clean development mechanism: reuse, recovery & recycle.	
	2.6	Raw material substitution: Wealth from waste, case studies.	
3	**Cleaner Production Project Development and Implementation**		09
	3.1	Overview of CP Assessment Steps and Skills, Process Flow Diagram.	
	3.2	Material Balance, CP Option Generation: Technical and Environmental Feasibility analysis.	
	3.3	Economic valuation of alternatives: Total Cost Analysis – CP Financing.	
	3.4	Preparing a Program Plan: Measuring Progress-ISO 14000.	
4	**Pollution Prevention and Cleaner Production Awareness Plan**		10
	4.1	Waste audit: Environmental Statement.	
	4.2	Carbon credit, Carbon trading, Carbon footprint.	
	4.3	Carbon sequestration.	
	4.4	Life Cycle Assessment- Elements of LCA.	
	4.5	Life Cycle Costing.	
	4.6	Eco Labeling.	
5	**Energy Efficacy**		08
	5.1	Availability and need of conventional energy resources: major environmental problems related to the conventional energy resources.	
	5.2	Future possibilities of energy need and availability.	
	5.3	Non-conventional energy sources: Solar Energy-solar energy conversion technologies and devices.	
	5.4	Solar Energy: principles, working and application.	
6	**Green Fuels**		10
	6.1	Definition-benefits and challenges: comparison of green fuels with conventional fossil fuels with reference to environmental, economical and social impacts- public policies and market driven initiatives.	
	6.2	Biomass energy: Concept of biomass energy utilization, types of biomass energy, conversion processes.	
	6.3	Wind Energy, energy conversion technologies, their principles, equipment and suitability in Indian context.	
	6.4	Tidal and geothermal energy.	

Contribution to Outcome

On completion of this course, the students will be able to:

1. Enlist different concepts of green technologies in a project.
2. Describe the principles of Green Chemistry in the Energy efficient technologies.
3. Select the best method for the carbon credits of various activities for Cleaner Production Project Development and Implementation.
4. Evaluate the importance of life cycle assessment for Pollution Prevention and Cleaner Production Awareness Plan.
5. To apply the problems related to Pollution Prevention and Cleaner Production Awareness Plan.
6. To choose the green fuels based on their benefits for sustainable development.

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks.
2. Question 1 will be compulsory and should cover maximum contents of the curriculum.
3. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
4. Only Four questions need to be solved.

Recommended Books:

1. Pollution Prevention: Fundamentals and Practice' by Paul L Bishop (2000), McGraw Hill International.
2. 'Pollution Prevention and Abatement Handbook –Towards Cleaner Production' by World Bank Group (1998), World Bank and UNEP, Washington D.C.
3. 'Cleaner Production Audit' by Prasad Modak, C.Visvanathan and Mandar Parasnis (1995), Environmental System Reviews, No.38, Asian Institute of Technology, Bangkok
4. 'Handbook of Organic Waste Conversion' by Bewik M.W.M.
5. 'Solar Energy' by Sukhatme S.P.

Reference Books:

1. 'Energy, The Solar Hydrogen Alternative' by Bokris J.O.
2. 'Non-conventional Energy Sources' by Rai G.D.
3. 'Waste Energy Utilization Technology' by Kiang Y. H.
4. Wind, Tidal, Geothermal, Biomass and Non–conventional energy Green fuel by G.D.Rai.

Green Technology and Sustainable Engineering : Semester VI		
Course Code	**Course Name**	**Credits**
HGSC601	**Green Building and Infrastructure Engineering**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hours**	**-**	**-**	**-**	**100**

Rationale

This course incorporating sustainable design/thinking as a new civil engineering course and experiences from the pilot offering. Important areas are outlined to aid all engineers in understanding sustainability in context with traditional engineering principles. Green-building rating systems are used to introduce the concepts of sustainability in buildings and infrastructure, highlighted by presentations from green-building professionals. By providing a better understanding of sustainability through education, civil engineers can provide proactive solutions to a growing global infrastructure.

Objectives

1. To acquire knowledge on various aspects of green building concepts.
2. To acquire knowledge on Indian Green Building Council.
3. To understand to green building design.
4. To apply knowledge on material conservation handling of non-process waste.
5. To analyze green building assessment systems national as well international.
6. To evaluate various terminologies Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Green Building Concepts**		07
	1.1	What is Green Building, Why to go for Green Building, Benefits of Green Buildings-	
	1.2	Green Building Materials and Equipment in India, What are key Requisites for Constructing a Green Building?	

	1.3	Principles of green building – Selection of site and Orientation of the building – usage of low energy materials – effective cooling and heating systems-	
	1.4	Effective electrical systems – effective water conservation systems-	
2	**Green Building Practices in India**		09
	2.1	Practices Indian Green Building Council, Green Building Moment in India, Benefits Experienced in Green Buildings-	
	2.2	Launch of Green Building Rating Systems, Residential Sector, Market Transformation-	
	2.3	Green Building Opportunities And Benefits: Opportunities of Green Building-	
	2.4	Green Building Features, Material and Resources, Water Efficiency	
	2.5	Optimum Energy Efficiency-	
	2.6	Typical Energy Saving Approach in Buildings-	
3	**Introduction to Green Building Design**		09
	3.1	Green Building Design Introduction, Reduction in Energy Demand-	
	3.2	Onsite Sources and Sinks, Maximize System Efficiency-	
	3.3	Steps to Reduce Energy Demand and Use Onsite Sources and Sinks, Use of Renewable Energy Sources.	
	3.4	Eco-friendly captive power generation for factory, Building requirement-	
4	**Material Conservation and Occupational Health**		09
	4.1	Material Conservation Handling of non -process waste, waste reduction during construction-	
	4.2	Materials with recycled content, local materials, material reuse, certified wood, Rapidly renewable building materials and furniture-	
	4.3	Indoor Environment Quality And Occupational Health: Air conditioning, Indoor air quality, Sick building syndrome, Tobacco smoke control-	
	4.4	Minimum fresh air requirements avoid use of asbestos in the building-	
	4.5	Improved fresh air ventilation, Measure of IAQ-	
	4.6	Reasons for poor IAQ, Measures to achieve Acceptable IAQ levels-	
5	**Green building Rating Systems**		09
	5.1	Green building assessments system studying e.g. LEED US (Leadership in Energy and Environmental Design)-	
	5.2	Living Building Challenge, Green Globes (Green Building Initiative) (US), Green Globes (ECD-Canada; LEED-Canada, Built Green CANADA	
	5.3	BREEAM (Building Research Establishment Environmental Assessment Method) (UK)-	
	5.4	LEED India (Indian GBC); IGBC Green modules; TERI-GRIHA (Green Rating for Integrated Habitat Assessment) (India) Rating modules-	
6	**Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management**		09
	6.1	Introduction to the Concept: “Life Cycle assessment of materials”-	

	6.2	EIA: Introduction to EIA. Process of EIA and its application through a case study, EIA as a strategic tool for sustainable development-Social Impact Assessment of Infrastructure projects-	
	6.3	Embodied energy of various construction materials-Energy Management with respect to buildings-	
	6.4	Clean Development Mechanism, Kyoto Protocol, Energy Conservation Building Code-	

Contribution to Outcome

On completion of this course, the students will be able to:

1. Explain the concepts of green building.
2. Learn practices Indian Green Building Council and GRIHA.
3. Use the green building design in the projects.
4. Learn material conservation handling of non -process waste.
5. Learn green building assessment systems national as well international.
6. Study various terminologies Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management.

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1. Manual of Tropical housing and climate by Koenisberger
2. Climate responsive architecture by Arvind Krishnan
3. Manual of solar passive architecture - by Nayak J.K. R. Hazra J. Prajapati.
4. Energy Efficient Buildings in India by Milli Mujumdar
5. Solar Energy in Architecture and Urban Planning by Herzog Thomas
6. Sustainable Building Design Manual-Volume I and II –TERI Publication
7. Green building codes and standards
8. International Green Construction Code
9. Complete Guide to Green Buildings by Trish riley
10. Standard for the design for High Performance Green Buildings by Kent Peterson, 2009

Reference Books:

1. Green Building Hand Book by Tom woolley and Sam kimings, 2009.
2. Green Building Materials by Ross Spiegel and Dru Meadows
3. Publications from - CBRI, SERC, BMTPC
4. Shahane, V. S, “Planning and Designing Building”, Poona, Allies Book Stall, 2004.
5. Michael Bauer, Peter Mösle and Michael Schwarz “Green Building – Guidebook for Sustainable Architecture” Springer, 2010.
6. Tom Woolley, Sam Kimmins, Paul Harrison and Rob Harrison “Green Building Handbook” Volume I, Spon Press, 2001.

Green Technology and Sustainable Engineering : Semester VII		
Course Code	**Course Name**	**Credits**
HGSC701	**Fundamentals of Sustainable Engineering**	04

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	-	-	4	-	-	4

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	20	20	80	03 Hours	-	-	-	100

Rationale

This course contains content that address sustainability issues and innovations of relevance to the discipline area. Sustainability content (principles and theory) is well integrated into the course. The course outline specifically addresses the sustainability content.

Objectives

1. To acquire knowledge and awareness among students on issues in areas of sustainability.
2. To understand the role of engineering Environmental Pollution and Environmental legislations in India.
3. To understand the International Environmental Management Standards.
4. To apply a clear understanding of the role and impact of various aspects of engineering and engineering decisions on environmental, societal, and economic problems.
5. To analyze the Sustainable Engineering.
6. To evaluate the Sustainable Assessment Systems.

Detailed Syllabus

Module	Course Module / Contents		Hours
1	**Introduction to Sustainability**		08
	1.1	Sustainability-Introduction, Historical Evolution-Goals of Sustainable Development-Principles of Sustainability-Sustainability-need and concept, challenges.	
	1.2	Social, Environmental and Economic sustainability concepts	
	1.3	Sustainable development, Nexus between Technology and Sustainable development, Challenges for Sustainable Development.	
	1.4	Multilateral environmental agreements and Protocols-Clean Development Mechanism (CDM)	
2	**Environmental Pollution and Environmental legislations in India**		09

	2.1	Regional and Local Environmental Issues-Air Pollution, Sources- Effects-Preventative Measures of Air Pollution; Water pollution- Land Pollution	
	2.2	Sustainable wastewater treatment, Solid waste - sources, impacts of solid waste, Zero waste concepts, 3 R concept-	
	2.3	Environmental legislations in India-Water Act, Air (Pollution & Prevention) Act	
	2.4	Environmental Protection Act and Climate Change Act	
	2.5	Forest Act, Animal Protection Act, Factory Act, Labour Act	
	2.6	SEZ Notifications, CRZ Notifications etc	
3	**International Environmental Management Standards**		09
	3.1	International Environment Acts and Protocols, Global, Regional and Local environmental issues, Natural resources and their pollution, Carbon credits, Carbon Trading, Carbon Foot Print	
	3.2	ISO 14000, ISO 14001, Life Cycle Analysis, Environmental Impact Assessment studies, Sustainable habitat	
	3.3	Global environmental issues-Resource degradation, Climate change, Global warming, Ozone layer depletion	
	3.4	Sustainable materials-Conventional and renewable material sources, sustainable development, Sustainable urbanization, Industrial Ecology	
4	**Basic concepts of sustainable habitat and Energy sources**		09
	4.1	Basic concepts of sustainable habitat, Sustainable materials for building construction	
	4.2	Material selection for sustainable design	
	4.3	Conventional and non-conventional energy sources-Solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans, Geothermal energy-Methods for increasing energy efficiency of buildings	
	4.4	Embodied energy of various construction materials-Energy Management with respect to buildings	
	4.5	Clean Development Mechanism	
	4.6	Kyoto Protocol, and Energy Conservation Building Code	
5	**Sustainable Engineering**-		08
	5.1	Sustainable Urbanization- Sustainable cities-	
	5.2	Sustainable transport-Industrialization and poverty reduction-Social and technological change-	
	5.3	Industrial Processes: Material selection, Pollution Prevention, Industrial Ecology, Industrial symbiosis	
	5.4	Bio-mimicking	
6	**Sustainable Assessment Systems**		09
	6.1	Studying few Green/Sustainable building assessments systems e.g. Living Building Challenge, Green Globes (Green Building Initiative) (US)	
	6.2	LEED India and GRIHA Sustainability Assessment Techniques-	
	6.3	Green Globes (ECD–Canada, International Initiative for a Sustainable Built Environment: iiSBTool	

	6.4	SBModel 15	
Contribution to Outcome			

On completion of this course, the students will be able to:

1. To explain issues in areas of sustainability.
2. To summarize the role of engineering Environmental Pollution and Environmental legislations in India.
3. To interpret the International Environmental Management Standards.
4. To relate a clear understanding of the role and impact of various aspects of engineering and engineering decisions on environmental, societal, and economic problems.-
5. To connect the Sustainable Engineering
6. To develop the Sustainable Assessment Systems.

Internal Assessment **20 Mark**s

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
2. Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
3. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
4. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Lang.
5. Prohit, S. S., Green Technology - An approach for sustainable environment, Agrobios publication uage Book Society (ELBS).

Reference Books:

1. Environment Impact Assessment Guidelines, Notification of Government of India, 2006
2. ECBC Code 2016, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System
3. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.

Green Technology and Sustainable Engineering : Semester-VII		
Course Code	**Course Name**	**Credits**
Lab 1: HGSSBL601	**Green Building and Infrastructure Engineering**	**02**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**04 Per Week**	-	-	**02**		**02**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	50	-	50	100

Course Objective:

1. To acquire knowledge on various aspects of green building concepts.
2. To acquire knowledge on Indian Green Building Council.
3. To understand green building design.
4. To analyze green building assessment systems national as well international.
5. To apply knowledge on material conservation handling of non-process waste.
6. To evaluate various terminologies of Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management

List of Experiments (Conduct six practicals out of nine mentioned below)		
Module	**Detailed Content**	**Lab Session / Hr.**
1	To study sustainable planning aspects for urban housing (Literature based).	04
2	To study the benefits given by Municipal Corporations to Green Buildings (Literature based).	04
3	To prepare detailed plan for a hypothetical site indicating utility of solar path, wind direction, rainfall intensity etc., to make it sustainable (Literature based)	04
4	To prepare a report on energy efficient buildings in India (Case Study based).	04
5	To compare the benefits under different green building rating systems (Literature based)	04
6	To study: Innovative Materials Developed by CBRI, SERC (Literature based).	04
7	To study, analyze present scenario of organic waste collection and management of any of the premise; preferably hotels (Case Study based)	04
8	To prepare a report on carbon credit, carbon Trading and Carbon footprint (Literature based).	04

9	To study: Environmental Audit of any existing building and prepare a report (Case Study based).	04

Course Outcomes

At the end of the course, learner will be able to:

1. Understand the concepts of green building.
2. Learn practices of Indian Green Building Council and GRIHA
3. Design a sustainable green building
4. Assessed green building systems nationally as well internationally.
5. Learn material conservation handling of non-process waste.
6. Study various terminologies of Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management.

Assessment:

Term work:

Shall consist of Assignment, design report, case study and Site visit report related to this course. Distribution of marks for Term Work shall be as follows:
Assignment: 15 marks
Case study/Literature report: 15 marks
Site visit: 15 marks
Attendance: 05 marks
Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%- 80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

End Semester Oral Examination:

Oral examination shall be based upon the entire theory, site visit and laboratory syllabus.

Recommended Books:

1. 'Handbook of Organic Waste Conversion' by Bewik M.W.M.
2. Green Building Hand Book by Tom woolley and Sam kimings, 2009.
3. Energy Efficient Buildings in India by Milli Mujumdar
4. Allen, D. T. and Shonnard, D. R., 'Sustainability Engineering: Concepts, Design and Case Studies', Prentice Hall.
5. 'Solar Energy' by Sukhatme S.P.
6. 'Waste Energy Utilization Technology' by Kiang Y. H.

Reference Books:

1. Handbook on Green Practices published by Indian Society of Heating Refrigerating and Air-conditioning Engineers, 2009.
2. Manual of Tropical housing and climate by Koenisberger
3. Climate responsive architecture by Arvind Krishnan
4. Manual of solar passive architecture - by Nayak J.K. R. Hazra J. Prajapati.
5. Green Building Materials by Ross Spiegel and Dru Meadows Publications from - CBRI, SERC, BMTPC
6. Solar Energy in Architecture and Urban Planning by Herzog Thomas
7. Sustainable Building Design Manual-Volume I and II –TERI Publication
8. Green building codes and standards
9. International Green Construction Code
10. Complete Guide to Green Buildings by Trish riley
11. Standard for the design for High Performance Green Buildings by Kent Peterson, 2009

12. Shahane, V. S, “Planning and Designing Building”, Poona, Allies Book Stall, 2004.
13. Michael Bauer, Peter Mösle and Michael Schwarz “Green Building – Guidebook for Sustainable Architecture” Springer, 2010.
14. Tom Woolley, Sam Kimmins, P. Harrison and R. Harrison “Green Building Handbook” Volume-I, Spon Press, 2001.

Green Technology and Sustainable Engineering : Semester VIII		
Course Code	**Course Name**	**Credits**
HGSC801	**Sustainable Built Environment Engineering**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hours**	**-**	**-**	**-**	**100**

Rationale

Education for sustainability is an important part of the journey to live and work in a sustainable manner. Curricula changes to incorporate sustainability education in the built environment disciplines is not a new phenomenon. Often, curricula changes are made from the perspective of the discipline and the individual learning the course.

Objectives

1. To Understand Sustainable Development
2. To apply knowledge for Understanding Ecosystems
3. To evaluate Environmental Sustainability.
4. To create Socio-economic Sustainability.
5. To create Urban Planning and Environment.
6. To analyze the Built in Environment.

Detailed Syllabus

Module	Course Module / Contents		Hours
1	**Sustainable Development**		08
	1.1	Definitions and principles of Sustainable Development - History and emergence of the concept of Sustainable Development.	
	1.2	Environment and Development linkages- Globalization and environment.	
	1.3	Millennium Development Goals- Status (global and Indian)-	
	1.4	Impacts on approach to development policy and practice in India, future directions.	
2	**Understanding Ecosystems**		09
	2.1	Understanding Ecosystems-biodiversity hotspots, Understanding Critical Perspectives on Environment and Development-Environmental Policy and Law, Landscape Ecology and human development.	
	2.2	Introduction to Policy, Institutions and Governance-Urbanization-Conservation of natural resources and livelihood security.	

	2.3	Environment- Evaluation and Impact Assessment Frameworks-Knowledge of ecosystem dynamics, ecosystem-livelihood linkages, Environmental vulnerabilities and adaptations.	
	2.4	Resilience towards climate change and disasters-Environment-development-poverty linkages, issues of access and justice.	
	2.5	Understanding of field techniques and skills to assess ecological processes-Skills to engage with local communities, undertake impact assessments.	
	2.6	Experiential learning of conservation and development issues.	
3	**Environmental Sustainability**		09
	3.1	Land, Water and Food production	
	3.2	Moving towards sustainability: Energy powering	
	3.3	Sustainable Development - Financing the environment	
	3.4	Sustainable Development- Development of Environmental Protection Mechanism	
4	**Socio-economic Sustainability**		09
	4.1	Empowerment of Women, Children, Youth, Indigenous People	
	4.2	Non-Governmental Organizations, Local Authorities, Business and Industry	
	4.3	Sustainability Performance indicators and Assessment mechanism	
	4.4	Hurdles to sustainability- Constraints and barriers for sustainable development	
	4.5	Operational guidelines-Interconnected prerequisites for sustainable development	
	4.6	Science and Technology for sustainable development	
5	**Urban Planning and Environment**		08
	5.1	Environment and Resources	
	5.2	Sustainability Assessment- Future Scenarios	
	5.3	Form of Urban Region- Managing the change	
	5.4	Integrated Planning-Sustainable Development	
6	**The Built in Environment**		09
	6.1	Urban Form	
	6.2	Land Use-Compact Development	
	6.3	Principles of street design-complete streets	
	6.4	Transport Integrated Urban land use Planning- Guidelines for Environmentally sound Transportation	

Contribution to Outcome

On completion of this course, the students will be able to:

1. Describe the concept and socio-economic policies of Sustainable Development.
2. Identify the strategies for implementing eco development programs.
3. Identify different approaches for resource conservation and management.

4. Suggest action plans for implementation of sustainable development.
5. Explain Urban Planning and Environment.
6. Explain the built in environment.

Internal Assessment **20 Marks**

Consisting Two Compulsory Class Tests - First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination **80 Marks**

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1 Question paper will comprise of total six questions, each carrying 20 marks.

2 Question 1 will be compulsory and should cover maximum contents of the curriculum.

3 Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

4 Only Four questions need to be solved.

Recommended Books:

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
2. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
3. ECBC Code 2016, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System
4. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.
5. Prohit, S. S., Green Technology - An approach for sustainable environment, Agrobios publication uage Book Society (ELBS).
6. Ganesha Somayaji and Sakarama Somayaji, "Environmental Concerns and Sustainable development: Some perspectives from India", Editors:, publisher TERI Press, ISBN 8179932249.
7. Kirkby. J, O'Keefe P. and Timberlake, "Sustainable development" Earth Scan Publication, London, 1996.

Reference Books:

1. Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
2. Environment Impact Assessment Guidelines, Notification of Government of India, 2006
3. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Lang
4. Gilg A W and Yarwood R, "Rural Change and Sustainability - Agriculture, the Environment and Communities", CABI Edited by S J Essex, September2005.
5. James H. Weaver, Michael T. Rock, Kenneth Kustere, "Achieving Broad-Based Sustainable Development: Governance, Environment, and Growth with Equity", Kumarian Press, West Hartford, CT. Publication Year, 1997.
6. Kerry Turner. R, "Sustainable Environmental Management", Principles and Practice Publisher: Belhaven Press, ISBN: 1852930039.
7. Munier N, "Introduction to Sustainability", Springer2005.

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Infrastructure Policies & Regulations

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Honours in Infrastructure Policies & Regulations (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract.	Internal Assess-ment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HIPC 501: Environmental Policies & Regulations**	04	--	--	20	80	-	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
TE Sem. VI	**HIPC 601: Land Policies & Regulations**	04	--	--	20	80	-	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
BE Sem. VII	**HIPC 701: Infrastructure Finance & Business Policies**	04	--	--	20	80	--	--	100	04
	HIPSBL 701: Lab-1 Infrastructure Finance & Business Policies	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
Total Credits = 06										
BE Sem. VIII	**HIPC 801: Arbitration & Conciliation**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
Total Credits for Semesters V, VI, VII & VIII = 04+04+06+04 = 18										

Infrastructure Policies & Regulations : Semester-V		
Course Code	**Course Name**	**Credits**
HIPC 501	**Environmental Policies & Regulations**	04

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	**Test-II**	**Average**						
20	**20**	**20**	**80**	**3 hrs.**	**-**	**-**	**-**	**100**

Rationale

Environmental law describes a network of regulations and customary laws that address the effects of human activity on the natural environment. These laws are also referred to as environmental and natural resource laws and centre on the idea of environmental pollution. Environmental law is necessary to combat issues related to the environment and conservation of natural resources. Environmental law addresses a wide variety of different areas like reducing air pollution and maintaining air quality, Water Quality, Waste management, Sustainability of resources. This course covers the laws related to sustainable development and protections of environment under general laws. It also emphasizes the laws regarding hazardous and solid waste management, water, air and noise pollution and its prevention. It explores the compliance and enforcement of international environmental law.

Objectives

1. To understand and explain the significance of sustainable development and laws regarding protection of environment.
2. To study the laws related to environment (protection) act, 1986.
3. To emphasize the salient features of water act and describe the laws related to water pollution.
4. To study the salient features of air pollution act and understand the laws related to air and noise pollution.
5. To study the laws regarding hazardous and solid waste management.
6. To understand the International Environment Laws and policies.

Detailed Syllabus

Module	Course Modules / Contents	Hours
1	**Sustainable Development and Protection of environment under General Laws**	**10**
	Introduction, Sustainable development, Precautionary principle, the polluter pays principle, the public trust doctrine, eco-development, sustainable development and the Indian judiciary, Environment protection under the law of Torts, Environment protection under the Indian Penal Code:1860, Environment protection under the criminal procedure code:1973, Constitutional provisions and environment protection in India.	
2	**The Environment (Protection) Act, 1986**	**8**

	Introduction, Aims and objectives, Scope and commencement of the act, Salient features of the act, definitions, general powers of the central government, prevention, control and abatement of environmental pollution, offences and penalties, miscellaneous provisions.	
3	**Water Pollution**	**9**
	Introduction, aims and objectives, Salient features of the water pollution act, constitution of central and state boards and their powers and functions, appeals and revisions, offences and penalties, prevention and control of water pollution, miscellaneous provisions.	
4	**Air pollution and Noise Pollution**	**10**
	Introduction, Aims and objectives, Salient features of the air pollution act, constitution of central and state boards and their powers and functions, appeals and revisions, offences and penalties, miscellaneous provisions, Noise Pollution regulation and control rule 2000, legislative and non-legislative measures, control of noise pollution.	
5	**Hazardous and Solid Waste Management**	**8**
	Introduction, ozone depleting substances (Regulation and control rule 2000), Hazardous and other waste (Management and transboundary movement) Rules 2016, Construction and demolition waste management Rule 2016, Solid waste management Rule 2016, Wetland (Conservation and management) Rule 2017.	
6	**International Environment Law**	**7**
	An introduction to international law, Sources and basic principles of international law, development of international laws, nature and scope, establishment of environment institutions like UNEP, World charter for nature 1982, Relationship between international laws and domestic laws: Compliance and enforcement.	
	Total	**52**

Contribution to Outcome

On completion of this course, the students will be able to:

1. Illustrate the significance of sustainable development and protection of environment under general laws.
2. Explain and implement the laws related to environment (protection) act, 1986.
3. Summarize the salient features of water act and identify the laws related to water pollution.
4. Understand the salient features of air pollution act and classify the laws related to air and noise pollution.
5. Analyze and appraise the laws regarding hazardous and solid waste management.
6. Explore and justify the importance of International Environment Laws and policies.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lectures hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks.**

2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

Term Work:

The term work shall comprise the neatly written assignments. The assignments shall be given covering the entire syllabus in such a way that the students would attempt at least four questions on each sub-modules and contents thereof further. Apart from this, the students shall conduct at least one case study and shall prepare a detailed report on case study mentioned. This report shall also form a part of the term work.

Distribution of the Term Work Marks:

The marks of term work shall be judiciously awarded for various components depending upon its quality. The final certification and acceptance of the term-work warrants the satisfactory and the appropriate completion of the assignments; and the minimum passing marks to be obtained by the students. The following weightage of marks shall be given for different components of the term work:

- Assignments : 10 Marks
- Case studies : 10 Marks
- Attendance : 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to. 75%- 80%; 03 Marks; 81%- 90%: 04 Marks 91% onwards: 05 Marks

Recommended Books:

1. Divan S. and Rosencranz A. (2005) Environmental Law and Policy, 2nd ed., New Delhi.
2. Leelakrishnan P. (2008) Environmental Law in India, 3rd ed., Lexis Nexis, India.
3. Shastri S. C. (2012) Environmental Law, Eastern Book Company, 4th ed., Lucknow.
4. Gurdip Singh (2016)Environmental Law in India, 2nd ed.
5. Dr. Paramjit Jaswal, Dr. Nishtha Jaswal and Vibhuti Jaswal (2021) Environmental Law, Allahabad Law Agency, 5th ed., Allahabad.

Reference Books:

1. Alaxander kiss and Diana Shelton (2007) Guide to International Environmental Laws, Martinus Nijhoff Publisher, USA.
2. Philippe Sands and Jacqueline Peel, Principles of International EnvironmentalLaw (4th ed., 2018).
3. Shibani Ghosh ed., Indian Environmental Law: Key Concepts and Principles(2019).
4. Geetanjoy Sahu, Environmental Jurisprudence and the Supreme Court:Litigation, Interpretation, Implementation (2014).
5. Stuart Bell & Donald Mc Gillivray, Environmental Law (7th ed., 2008).

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Infrastructure Policies & Regulations : Semester-VI		
Course Code	**Course Name**	**Credits**
HIPC 601	**Land Policies & Regulations**	04

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
04	-	-	04	-	-	04

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**3 hrs.**	**--**	**-**	**-**	**100**

Rationale

Land law is important in relation with the Infrastructure Engineering students. This will familiarize the students with the acts and codes that are applicable as per actual conditions in the field. The course deals with the overall knowledge of the central and state acts and rules. Land law is the form of law that deals with the rights to use, alienate, or exclude others from land. In many jurisdictions, these kinds of property are referred to as real estate or real property, as distinct from personal property. Land use agreements, including renting, are an important intersection of property and contract law. Civil and Infrastructural Engineers need to have a working knowledge of the land laws that affect their work and that will enable them to comply with local, state & national regulations; understand the boundaries of their personal and professional liability; negotiate contracts; protect their intellectual property; develop a relationship with a law firm that understands the engineering business.

Objectives

1. To understand and explain the registration act and coastal regulations zones.
2. To provide knowledge of the urban land act & the land acquisition act.
3. To understand Maharashtra stamp act & the development control regulations.
4. To understand the MHADA and MahaRERA act.
5. To study Maharashtra Regional Town Planning Act.
6. To study the Maharashtra Land Revenue Code.

Detailed Syllabus

Module		Course Module / Contents	Periods
A		**CENTRAL LEGISLATION**	
1		**The Registration Act, 1908 & The Environment (Protection) Act, 1986 – Coastal Regulation Zones (CRZ)**	**08**
	1.1	The Registration Act, 1908: Introduction, definitions, documents, time limit for registration and effects of non-registrations of documents.	
	1.2	The Environment (Protection) Act, 1986 – Coastal Regulation Zones (CRZ): Areas covered, prohibited and regulated activities and classification of CRZ.	
2		**The Urban Land (Celling and Regulation) Act, 1976 & The Land Acquisition Act, 1894**	**09**
	2.1	The Urban Land (Celling and Regulation) Act, 1976: Introduction and repeal, definitions, celling limits on vacant lands and power to exempt and retention of excess vacant land	

	2.2	The Land Acquisition Act, 1894: General, introduction and definitions, acquisition of land, reference to the court, miscellaneous provisions and case law. Land Records documents i.e. 7x12 abstract, 8A, Ferfar, property card, Gut book. CTS Plan	
B	**STATE LEGISLATION**		
3	**Maharashtra Stamp Act, 1958 & The Development Control Regulations (DCR), 1991**		**07**
	3.1	Maharashtra Stamp Act, 1958: Constitutional provisions, objects & summary of the act, payment of stamp duty, adjudication of stamp duty, impounding of instruments, admissibility of instrument and prosecution for stamp law offences.	
	3.2	The Development Control Regulations (DCR), 1991: Floor Space Index (FSI), transfer of development rights (TDR), heritage buildings and precincts.	
4	**The Maharashtra Housing & Area Development Act (MHADA), 1976 & Maharashtra's Real Estate (Regulation and Development) Act, 2016 (MahaRERA)**		**14**
	4.1	The Maharashtra Housing & Area Development Act (MHADA), 1976: Definitions, powers & duties of the Mumbai repairs and reconstruction board, levy and collection of cess, structural repairs, acquisition of cessed properties for cooperative societies.	
	4.2	Maharashtra's Real Estate (Regulation and Development) Act, 2016 (MahaRERA): Introduction, regulatory framework, registration of real estate project and registration of real estate agents, functions and duties of promoter, rights and duties of allottees, the real estate regulatory authority, central advisory council, offences, penalties and adjudication, FAQ's.	
5	**Maharashtra Regional Town Planning (MRTP) Act, 1966**		
	5.1	Introductory & definitions, control of development, unauthorized development and acquisition of land.	**04**
6	**Maharashtra Land Revenue Code, 1966**		
	6.1	Introduction, use of land, removal & regularisation of encroachments, grant of sanad, record of rights, rights in unoccupied land, appeals, revision and review	**10**
	6.2	Special provisions for land revenue in Bombay city: general, assessment and collection of land revenue, Bombay city survey & boundary marks, government lands and foreshore, transfer of lands.	
		Total	**52**

Contribution to Outcome

After the completion of the course the student should be able to:

1. Understand the functionality of the registration act and coastal regulations zones as per central regulations of India.
2. Analyse and integrate functionality of the urban land act & the land acquisition act in India.
3. Explain Maharashtra Stamp Act & the development control regulations.
4. Understand the MHADA and MahaRERA act.
5. Understand Maharashtra Regional Town Planning Act.
6. Familiarise with the Maharashtra Land Revenue Code.

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks.**
   2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
   3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
   4. Only **Four questions need to be solved**.

Term Work:

The term work shall comprise the neatly written assignments. The assignments shall be given covering the entire syllabus in such a way that the students would attempt at least four questions on each sub-modules and contents thereof further. Apart from this, the students shall conduct at least one case study and shall prepare a detailed report on case study mentioned. This report shall also form a part of the term work.

Distribution of the Term Work Marks:

The marks of term work shall be judiciously awarded for various components depending upon its quality. The final certification and acceptance of the term-work warrants the satisfactory and the appropriate completion of the assignments; and the minimum passing marks to be obtained by the students. The following weightage of marks shall be given for different components of the term work.

- Assignments : 10 Marks
- Case study : 10 Marks
- Attendance : 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to. 75%- 80%; 03 Marks; 81%- 90%: 04 Marks 91% onwards: 05 Marks

Recommended & Reference Books:

1. MahaRERA Act, The Real Estate (Regulation and Development) Act, 2016 and Rule 2017 - Y. M. Agarwala, Adv. A. B. Shah; Aarti & Company's Publications
2. Land Law – Prof. H.D. Pithawalla; C. Jamndas & Co.
3. Maharashtra Land Laws by D N Mathur, Central Law Publications
4. Land Laws in Maharashtra by Sunil Dighe, Snow White Pub. P Ltd
5. Land Laws by Abhay Shah; Aarti & Company's Publications
6. Land Law (Law and Real Estate Laws) by Krishan Keshav; Singhal's Publications
7. Land Laws (Including Land Acquisition and Rent Laws) by Kanwal D.P. Singh; Satyam Law International

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Infrastructure Policies & Regulations : Semester-VII		
Course Code	**Course Name**	**Credits**
HIPC 701	**Infrastructure Finance & Business Policies**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**3 hrs.**	**--**	**-**	**-**	**100**

Rationale

Looking at India's exponential growth with the infrastructure space teeming with activity and the government as well as the private sector heavily investing in the creation of better infrastructure both in terms of its business and with an eye on its longevity, this course will prove to be a holy grail for students considering the aspects of business law. The course will provide an overview of the underlying legal framework for doing business in India including Constitutional Acts, Companies Act and other relevant statutes. The course will familiarize students with the sector specific legislation, the constitutional, general legal context, regulatory law, where it exists. The course intends to enable each student to have knowledge of fundamental tools of legal research and application of the same in development of the infrastructure sector.

Objectives

1. To highlight the business environment, forms of business, scale of business and emerging trends in business.
2. To describe about the general legal environment and framework in India.
3. To provide an overview of Indian Constitutional Acts, Companies Act and other relevant statutes.
4. To define & interpret the financing of infrastructure and growth of PPP (Public Private Partnership) in various sectors of Infrastructural development.
5. To understand preconstruction and post construction processes involved in infrastructural projects/contracts.
6. To examine the details of Project Financing in Infrastructure Contracts.

Detailed Syllabus

Module	Course Modules / Contents	Hours
1	**Business Environment**	**8**
	Types of Business Environment, Forms of Business Organization, Concept and Features in relation to following business models- Sole Proprietorship; Partnership, Company; Statutory Bodies and Corporations; HUF and Family Business. Scales of Business, Micro, Small and Medium Enterprises; Large Scale Enterprises and Public Enterprises; MNC's Emerging Trends in Business, Concepts, Advantages and Limitations-Franchising, Aggregators, Business Process Outsourcing (BPO)& Knowledge Process Outsourcing (KPO); E-Commerce, Digital Economy.	
2	**Legal Environment of Business in India**	**10**
	Introduction to Bills, Laws/Acts, Rules, Regulations, and associated legal reasoning and procedures, Introduction to Constitution and Constitutional Law. Stakeholders including legal	

	system covering judicial, quasi-judicial authorities & Constitutional Authorities etc. and other Advisory Boards/entities. Outline the intent of Business Allocation of Rules of Government (e.g. Departments in States and Ministries at the Centre)	
3	**Acts, Statutes and Regulation**	**10**
	Introduction to various Acts and their key provisions, such as Indian Companies Act- 2013, Negotiable Instruments Act, Industrial Dispute Act, Minimum Wages Act, Special Relief Act, Transfer of property act, Right to fair compensation & transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013, Income Tax Act.	
4	**Infrastructure Contracts**	**8**
	Introduction and Features of Infrastructure contracts, Introduction to PPP in India, PPP Models in India, Contracts in PPP model Principles of contract-essential conditions, Void & voidable contract, capacity & consideration, types & terms of contracts (in accordance with Indian Contract Act 1872); Performance and discharge of contract; breaches of contracts and remedies; introduction to special contracts such as contract of indemnity, guarantee, leasing agreement.	
5	**Infrastructure Project Contracts**	**8**
	Parties in Infrastructure Contracts, Bidding Process, Negotiation of Infrastructure Project Management Contracts, Allotment of Contracts, Drafting EPC & Concession Agreements, Project Appraisal, Compliances and Due Diligence.	
6	**Project Financing in Infrastructure Contracts**	**8**
	Introduction to project financing, Equity and corporate debt financing, Stages in Project Financing, Regulatory Framework and Authorities, Borrowing from International financial institutions, FDI in Infrastructure developments, Documentation in Project Financing, Restructuring in project finance transactions, Case Studies on Infrastructure Project Management	
	Total	**52**
Contribution to Outcome		

On completion of this course, the students will be able to:

1. Explain the concepts related to Business environment
2. Elaborate the general legal environment and framework in India
3. Understand the acts, statutes and their regulation involved in infrastructure projects
4. Apply models of infrastructure development on respective projects in PPP
5. Understand preconstruction and post construction processes involved in infrastructural projects/contracts.
6. Define and interpret the financing of Infrastructure Contracts.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lectures hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks.**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

Term Work:

The term work shall comprise the neatly written assignments. The assignments shall be given covering the entire syllabus in such a way that the students would attempt at least four questions on each sub-modules and contents thereof further. Apart from this, the students shall conduct at least one case study and shall prepare a detailed report on case study mentioned. This report shall also form a part of the term work.

Distribution of the Term Work Marks:

The marks of term work shall be judiciously awarded for various components depending upon its quality. The final certification and acceptance of the term-work warrants the satisfactory and the appropriate completion of the assignments and presentations; and the minimum passing marks to be obtained by the students. The following weightage of marks shall be given for different components of the term work.

- Assignments : 10 Marks
- Presentations : 10 Marks
- Attendance : 05 Marks

Recommended Books:

1. Satyanarayana, G. (2017). Infrastructure Development & the Role of Public-PrivatePartnership. 1st ed. New Delhi, India: New Century Publications.
2. Piyush Joshi(2003), Law Relating to Infrastructure Projects, New Delhi: Butterworths.
3. N.D. Kapoor &DinkarPagare Business Laws and Management; Sultan Chand & Sons.
4. P. P. S. Gogna A Textbook of Business Law; Sultan Chand & Company, New Delhi.
5. Poonam Gandhi Business Studies; Dhanpat Rai & Company Private Limited, Delhi.
6. Willie Tan, (2007). Principles of Project and Infrastructure Finance, 1 edition. Routledge;
7. Hoffman, Scott L., (2007). The Law and Business of International Project Finance, 3rd Edition,London: Cambridge University Press.
8. Vinter, Graham (2013) Project Finance, 4th Edition, London: Sweet and Maxwell.
9. Gajendra Haldea, (2011). Infrastructure at Crossroads: The Challenges of Governance, Oxford University Press; 1st ed edition
10. Dewar, John (2015) International Project Finance: Law and Practice, 2nd Edition, Oxford University Press
11. Mulla, D.F., The Indian Contract Act, 13th Ed., LexisNexis/Butterworths
12. Tripathi, S.C., Modern Company Law, 5th Ed., Central Law Publications

13. I.P Massey (2008), Administrative Law, Lucknow: Eastern Book Company.

14. D D Basu (2009), The Constitutional Law of India, New Delhi: Lexis Nexis Butterworths.

Reference Books:

1. Sen & Mitra Commercial Law; The World Press Pvt. Ltd., Calcutta.

2. Ian Wirthington & Chris Britton The Business Environment; Pearson Education Ltd., England.

3. Raymond W.Y. Kao Entrepreneurship and Enterprises Development

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Infrastructure Policies & Regulations : Semester-VII		
Course Code	**Course Name**	**Credits**
HIPSBL 701	**Infrastructure Finance & Business Policies (Lab)**	**02**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**04**	-	-	**02**	-	**02**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
-	-	-	-	-	**50**	-	**50**	**100**

Objectives

1. To study the business environment and emerging trends in business.
2. To learn the general legal environment followed for infrastructure projects in India.
3. To provide detail overview of land acquisition, rehabilitation and redevelopment of infrastructure.
4. To explain emerging sectoral growth of PPP (Public Private Partnership) in various sectors of infrastructural development.
5. To develop contracts and agreements with various stakeholders related to infrastructure projects.
6. Examine the intricacies of Project Financing in Infrastructure Contracts.

Module	Detailed Contents (Any Six)	Lab Sessions/Hr
1	To prepare a case study report of Knowledge Process Outsourcing (KPO) related to infrastructure-based company.	4
2	To prepare a case study report of Business Process Outsourcing (BPO) related to infrastructure-based company.	4
3	To prepare a case study report based on legal environment of business in India.	4
4	To prepare a case study report based on land acquisition and rehabilitation (eg. Sardar Sarovar).	4
5	To prepare a case study report of PPP in one of the sectors of Infrastructural development.	4
6	Prepare a sample draft of EPC contracts enlisting all the necessary elements for infrastructure project.	4
7	To prepare a case study report of business model applying key parameters in project financing.	4
8	To prepare a case study report highlighting the important features of slum rehabilitation (eg. SRA project).	4
9	To prepare a case study report based on mega redevelopment projects in India (eg. BDD chawl).	4

Lab Outcomes

Learner will be able to…

1. Explain the business environment and emerging trends in business.
2. Elaborate the general legal environment followed for infrastructure projects in India.
3. Apply intricacies of land acquisition, rehabilitation and redevelopment of infrastructure.
4. Apply emerging techniques related to PPP (Public Private Partnership) in various sectors of infrastructural development.
5. Build contracts and agreements with various stakeholders related to Infrastructure projects.
6. Define the intricacies of project financing in infrastructure contracts.

End Semester Oral Examinations:

Oral exam will be based on laboratory work performed (case study report).

Recommended Books:

1. Satyanarayana, G. (2017). Infrastructure Development & the Role of Public-Private Partnership. 1st ed. New Delhi, India: New Century Publications.
2. Piyush Joshi(2003), Law Relating to Infrastructure Projects, New Delhi: Butterworths.
3. N. D. Kapoor & Dinkar Pagare Business Laws and Management; Sultan Chand & Sons.
4. P. P. S. Gogna A Textbook of Business Law; Sultan Chand & Company, New Delhi.
5. Poonam Gandhi Business Studies; Dhanpat Rai & Company Private Limited, Delhi.
6. Willie Tan, (2007). Principles of Project and Infrastructure Finance, 1 edition. Routledge;
7. Hoffman, Scott L., (2007). The Law and Business of International Project Finance, 3rd Edition, London: Cambridge University Press.
8. Vinter, Graham (2013) Project Finance, 4th Edition, London: Sweet and Maxwell.
9. Gajendra Haldea, (2011). Infrastructure at Crossroads: The Challenges of Governance, Oxford University Press; 1st ed edition
10. Dewar, John (2015) International Project Finance: Law and Practice, 2nd Edition, Oxford University Press
11. Mulla, D. F., The Indian Contract Act, 13th Ed., LexisNexis/Butterworths
12. Tripathi, S.C., Modern Company Law, 5th Ed., Central Law Publications
13. I. P. Massey (2008), Administrative Law, Lucknow: Eastern Book Company.
14. D. D. Basu (2009), The Constitutional Law of India, New Delhi: Lexis Nexis Butterworths

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Infrastructure Policies & Regulations : Semester-VIII		
Course Code	**Course Name**	**Credits**
HIPC801	**Arbitration & Conciliation**	

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03**	**--**	**-**	**-**	**100**

Rationale

The Arbitration and Conciliation concept has been modelled on lines of the UNCITRAL (United Nations Commission on International Trade Law) framework of laws with the idea to modernize Indian arbitration law and bring it in line with the best global practices and also make India a global hub for arbitration. Arbitration and conciliation play significant role in construction industry due to disputes arising on large scale construction projects. Alternative Dispute Resolution (ADR) mechanism provides scientifically developed techniques to Indian judiciary. ADR provides various modes of settlement including arbitration, conciliation, mediation, negotiation, etc. This course deals with introduction to arbitration and conciliation, there requisites, rules, proceedings, roles of individuals, etc.

Objectives

1. To understand the importance of arbitration in resolving disputes in construction infrastructure industry.
2. To study the constitution of arbitral tribunal in the process of arbitration.
3. To study the procedures and conduct of arbitral proceedings.
4. To understand the making of arbitral award & termination of proceedings.
5. To study the significance and concepts of conciliation.
6. To study of the alternative means of settlement of disputes with negotiations.

Detailed Syllabus

Module	Course Modules / Contents	Hours
1	**Arbitration** Arbitration and its significance in construction industry, Role of arbitrator, The Construction Industry Arbitration Commission (CIAC), Arbitration agreement- Form, constitution, Guarantor to agreement, Interim measures by court, Arbitral award, Arbitral tribunal, International commercial arbitration, legal representative, Scope of arbitration, Arbitral disputes, the arbitration & conciliation act 1996- Consolidating & amendment act, provisions, preamble & its purpose.	**09**
2	**Composition of Arbitral Tribunal**	**09**

	Arbitrator, No. of arbitrator, Agreement providing two arbitrators, Appointment of arbitrator, Appointment of international commercial arbitrator, appointment of sole arbitrator, objection to nationality of arbitrator, Selection of arbitrator, appointment of arbitrator by court, Removal of arbitrator, Grounds for challenge, challenge procedure, Termination and substitution of mandate of arbitrator, insolvency notice.	
3	**Conduct of Arbitral Proceedings**	**06**
	Equal treatment of parties, Determination of rules of procedure- English law, Indian law, Place of arbitration, Commencement of arbitral proceedings, Statement of claim and defense, Expert appointment by arbitral tribunal,	
4	**Making of Arbitral Award & Termination of Proceedings**	**06**
	Rules applicable to substance of disputes, decision making by panel of arbitrators, Settlement, Form and contents of arbitral award, Termination of proceedings, Correction and interpretation of award, Additional award	
5	**Conciliation**	
	Application and scope, commencement of proceedings, Appointment of conciliation, Role of conciliator, sole conciliator, Communication between conciliator and parties, Settlement agreement- Concept, status and effect, Confidentiality, Termination of proceedings, costs, Deposits, Role of conciliator in other proceedings, Difference between conciliation and mediation. ICC Rules of Conciliation and arbitration, Rules of arbitration of the Indian council of arbitration.	**13**
6	**Alternative Means of Settlement of Disputes (ADR)**	
	Introduction, Methods, merits, demerits, Indian statutes, Difference between mediation and arbitration, Mediator and its necessity, Rules and Limitation of mediation, mediator's settlement. Negotiation- Necessity, state of negotiation, power sources, , styles, kinds of approaches, qualities of negotiation power, Obstructions to negotiation, Trade unions and negotiation.	**09**
	Total	**52**

Contribution to Outcome

On completion of this course, the students will be able to:

1. Appraise the significance and concepts of arbitration in resolving disputes in construction infrastructure industry.
2. Explain the intricacies of constitution of arbitral tribunal in the process of arbitration.
3. Value the importance of the procedures and conduct of arbitral proceedings.
4. Comply the making of arbitral award & termination of proceedings.
5. Compare and study the significance and concepts of conciliation and mediation.
6. Apply the process of alternative means of settlement of disputes with negotiations.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination (80 Marks):

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions**, **each carrying 20 marks.**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**.

Term Work:

The term work shall comprise the neatly written assignments. The assignments shall be given covering the entire syllabus in such a way that the students would attempt at least four questions on each sub-modules and contents thereof further. Apart from this, the students shall conduct at least one case study and shall prepare a detailed report on case study mentioned. This report shall also form a part of the term work.

Distribution of the Term Work Marks:

The marks of term work shall be judiciously awarded for various components depending upon its quality. The final certification and acceptance of the term-work warrants the satisfactory and the appropriate completion of the assignments; and the minimum passing marks to be obtained by the students. The following weightage of marks shall be given for different components of the term work.

- Assignments : 10 Marks
- Case studies : 10 Marks
- Attendance : 05 Marks

Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to. 75%- 80%; 03 Marks; 81%- 90%: 04 Marks 91% onwards: 05 Marks

Recommended Books:

1. Dr. S C Tripathi (2012), The Arbitration and Conciliation Act, 1996, 6th Edn. Central Law Publication.
2. Dr. Rega Surya Rao. (2021), Lextures on Arbitration, Conciliation and ADR Systems, Andhra Law House.
3. Dr. Harman Shergil Sullar (2021), Alternative Dispute Resolution - Including Arbitration Conciliation Act, 1996 Amended Amendment Act, 4th Edn., Shreeram Law House Publication.
4. H C Johari Edition, A Guide to Arbitration and Conciliation Act, 1996 (2022), Kamal Law House.
5. Rahul Ranjan (2020), Alternative Dispute Resolution Arbitration, Conciliation, Negotiation and Mediation, 2022 Edn., Proflic Publication.
6. Madhusudan Saharay, Textbook on Arbitration & Conciliation with Alternative Dispute Resolution, 4th Edn., Universal Law Publishing.
7. Dr. Anupam Kurlwal (2017), An Introduction to Alternative Dispute Resolution, 3rd Edn., Central Law Publications.

Reference Books:

1. P. C. Markanda, Naresh Markanda & Rajesh Markanda (2020), Law Relating to Arbitration and Conciliation, 10th Edn., LexisNexis.
2. Abraham P. Ordover & Andrea Doneff (2002), Alternatives to Litigation: Mediation, Arbitration, and the Art of Dispute Resolution, 2nd Edn., LexisNexis / National Institute for Trial Advocacy Publication.
3. Elkouri & Elkouri (2003), How Arbitration Works, Bna Books Publications, Edison, New Jersey, USA.

UNIVERSITY OF MUMBAI

Syllabus for

Honours/Minor Degree Program

In

Blockchain

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai
Blockchain
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HBCC501: Bit coin and Crypto currency**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HBCC601: Blockchain Platform**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HBCC701: Block chain Development**	04	--	--	20	80	--	--	100	04
	HBCSBL601: Private Blockchain Setup Lab(SBL)	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HBCC801: DeFi (Decentralized Finance)**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
									Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18	

Blockchain: Sem V								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HBCC501	**Bit coin and Crypto currency**	04	--	--	04	--	--	04

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HBCC501	**Bit coin and Crypto currency**	20	20	20	80	--	--	--	100

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To get acquainted with the concept of Block and Blockchain.
2	To learn the concepts of consensus and mining in Blockchain.
3	To get familiar with the bitcoin currency and its history.
4	To understand and apply the concepts of keys, wallets and transactions in the Bitcoin Network.
5	To acquire the knowledge of Bitcoin network, nodes and their roles.
6	To analyze the applications& case studies of Blockchain.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Describe the basic concept of Block chain.	L1,L2
2	Associate knowledge of consensus and mining in Block chain.	L1,L2
3	Summarize the bit coin crypto currency at an abstract level.	L1,L2
4	Apply the concepts of keys, wallets and transactions in the Bit coin network.	L3
5	Interpret the knowledge of Bit coin network, nodes and their roles.	L1,L2
6	Illustrate the applications of Block chain and analyze case studies.	L3

Detailed Syllabus:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	**Introduction to Cryptography:** Hash functions, Public key cryptography, Digital Signature (ECDSA).	**2**	--
I	**Introduction to Block chain**	Structure of a Block, Block Header, Block Identifiers: Block Header Hash and Block Height, The Genesis Block, Linking Blocks in the Block chain, Merkle Trees and Simplified Payment Verification (SPV). **Self-learning Topics:** Block chain Demo.	**6**	CO1

II	**Consensus and Mining**	Decentralized Consensus, Byzantine General's Problem, Independent Verification of Transactions, Mining Nodes, Aggregating Transactions into Blocks, Constructing the Block header, Mining the Block, Successfully Mining the Block, Validating a New Block, Assembling and Selecting Chains of Blocks, Block chain Forks **Self-learning Topics:** Study different consensus algorithms	**12**	CO2
III	**Introduction to Bit coin**	What is Bit coin and the history of Bit coin, Getting the first bit coin, finding the current price of bit coin and sending and receiving bit coin, Bit coin Transactions. **Self-learning Topics:** Study the website coinmarketcap.com/	**4**	CO3
IV	**Concepts of Bit coin**	**Keys and addresses, Wallets and Transactions:** Public Key Cryptography and Crypto currency, Private and Public Keys, Bit coin Addresses, Base58 and Base58Check Encoding, Nondeterministic (Random) Wallets, Deterministic (Seeded) Wallets, HD Wallets (BIP-32/BIP-44), Wallet Best Practices, Using a Bit coin Wallets, Transaction Outputs and Inputs, Transaction Fees, Transaction Scripts and Script Language, Turing Incompleteness, Stateless Verification, Script Construction (Lock + Unlock), Pay-to-Public-Key-Hash (P2PKH), Bitcoin Addresses, Balances, and Other Abstractions **Self-learning Topics:** Visit and use https://bitcoin.org/en/	**13**	CO4
V	**Bit coin Networks**	Peer-to-Peer Network Architecture, Node Types and Roles, Incentive based Engineering The Extended Bitcoin Network, Bitcoin Relay Networks, Network Discovery, Full Nodes, Exchanging "Inventory", Simplified Payment Verification (SPV) Nodes, Bloom Filters, SPV Nodes and Privacy, Encrypted and Authenticated Connections, Transaction Pools **Self-learning Topics:** Study technical papers based on bitcoin security	**7**	CO5
VI	**Blockchain Applications & case studies**	Domain-Specific Applications: FinTech, Internet of Things, Industrial and Manufacturing, Energy, Supply chain & Logistics, Records & Identities, Healthcare Case studies related to cryptocurrencies Concept of Altcoin **Self-learning Topics:** Read Technical papers on blockchain applications	**8**	CO6

Text Books:

1. "Mastering Bitcoin, PROGRAMMING THE OPEN BLOCKCHAIN" , 2nd Edition by Andreas M. Antonopoulos, June 2017, O'Reilly Media, Inc. ISBN: 9781491954386.
2. "Blockchain Applications: A Hands-On Approach", by ArshdeepBahga, Vijay Madisetti, Paperback – 31 January 2017.
3. "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction", July 19, 2016, by Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, Steven Goldfeder, Princeton University Press.

Reference Books:

1. **"**Mastering Blockchain", by Imran Bashir, Third Edition,Packt Publishing

2. **"**Mastering Ethereum: Building Smart Contracts and Dapps Paperback" byAndreas Antonopoulos, Gavin Wood, Publisher(s): O'Reilly Media
3. "Blockchain revolution: how the technology behind bitcoin is changing money, business and the world $ don tapscott and alex tapscot, portfolio penguin, 856157449

Online References:

Sr. No.	Website Name
1	https://andersbrownworth.com/blockchain/
2	https://andersbrownworth.com/blockchain/public-private-keys/
3	https://www.coursera.org/learn/cryptocurrency
4	https://coinmarketcap.com/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Blockchain: Sem VI								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HBCC601	**Block chain Platform**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg**					
HBCC601	**Block chain Platform**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	Understand the blockchain platform and its terminologies.
2	Understand smart contracts, wallets, and consensus protocols.
3	Design and develop decentralized applications using Ethereum, and Hyperledger.
4	Creating blockchain networks using Hyperledger Fabric deployment.
5	Understand the considerations for creating blockchain applications.
6	Analyze various Blockchain Platforms.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Explain the Blockchain platform and its types.	L1,L2
2	Create Public Blockchain using Ethereum.	L3,L4,L5, L6
3	Develop Smart Contracts using REMIX IDE.	L3,L4,L5
4	Apply the concept of private blockchain using Hyperledger.	L3
5	Analyze different types of blockchain platforms.	L3,L4
6	Deploy Enterprise Applications on Blockchain.	L3,L4,L5

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Introduction to Block chain and Bit coin,	**2**	--
I	**Introduction to Block chain Platforms**	Why Blockchain Platform: Platform types, Public, Private, technology requirements for implementation. Introduction to Ethereum, Hyperledger and Smart Contracts. Case study of blockchain Application. **Self-learning Topics:** Study different applications of block chain.	**6**	CO1

II	**Public Block chain**	Introduction, Characteristics of Public Blockchain, Advantages. Examples of Public Blockchain-Bitcoin: Terminologies and Transaction, Ethereum: Smart contract, Comparison of Bitcoin and Ethereum, Other public Blockchain platforms. **Self-learning Topics:** Study any one case study on public block chain.	**8**	CO2, CO3
III	**Ethereum Blockchain**	Introduction, Ethereum and Its Components: Mining, Gas, Ethereum, Ether, Ethereum Virtual Machine, Transaction, Accounts. Architecture of ethereum, Smart Contract: Remix IDE, Developing smart contract for ethereum blockchain, e-voting applications using smart contract, Dapp Architecture. Types of test-networks used in ethereum, Transferring Ethers Using MetaMask, Mist Wallet, Ethereum Frameworks, Case study of Ganache for ethereum blockchain. Deploying e-voting applications on Ganache framework. Ethereum 2., Concept of Beacon chain, POS (Proof of Stake), Shading of Chain. **Self-learning Topics:** Study case study on any ethereum blockchain.	**12**	CO2, CO3, CO6
IV	**Private Blockchain**	Introduction, Key Characteristics, Need of Private Blockchain. Consensus Algorithm for private Blockchain (Ex. RAFT and PAXOS), Smart Contract in Private Blockchain, Case Study of E-commerce Website, Design Limitations. **Self-learning Topics:** Case study on private block chain.	**8**	CO4
V	**Hyperledger Blockchain**	Introduction to Hyperledger, tools and frameworks, Hyperledger Fabric, Comparison between Hyperledger Fabric & Other Technologies, Distributed Ledgers. Hyperledger Fabric Architecture, Components of Hyperledger Fabric: MSP, Chain Codes etc., Transaction Flow, Advantages of Hyperledger Fabric Blockchain, working of Hyperledger Fabric, Creating Hyperlegder network, Case Study of Supply chain management using Hyperledger **Self-learning Topics:** Case study on Hyperledger blockchain.	**12**	CO5, CO6
VI	**Other Blockchain platforms**	Corda, Ripple, Quorum and other emerging blockchain platforms, Case Study on any of the blockchain platforms. Developing Blockchain application on Cloud(AWS/Azure) **Self-learning Topics:** Compare different blockchain platforms.	**4**	CO5

Text Book:

1) Blockchain Technology, Chandramouli Subramanian, Asha A George, Abhillash K. A and MeenaKarthikeyen, Universities press.
2) Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.

Reference Books:

1) Blockchain for Beginners, Yathish R and Tejaswini N, SPD
2) Blockchain Basics, A non Technical Introduction in 25 Steps, Daniel Drescher, Apress.

3) Blockchain with Hyperledger Fabric, LucDesrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing

E Books:

1) Blockchain By Example, BellajBadr, Richard Horrocks, Xun (Brian) Wu, November 2018, Implement decentralized blockchain applications to build scalable Dapps.
2) Blockchain for Business, https://www.ibm.com/downloads/cas/3EGWKGX7.

Online References:

Sr. No.	Website Name
1.	https://www.hyperledger.org/use/fabric

Assessment:
Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Blockchain: Sem VII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HBCC701	**Blockchain Development**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg**					
HBCC701	**Block chain Development**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To understand Ethereum Ecosystem.
2	To understand aspects of different programming languages.
3	To explain how to use the solidity programming language to develop a smart contract for blockchain.
4	To demonstrate deployment of smart contracts using frameworks.
5	To understand principles of Hyperledger fabric.
6	To understand challenges to apply blockchain in emerging areas.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	To use Ethereum Components.	L1,L2
2	To analyse different blockchain programming languages.	L3
3	To implement smart contract in Ethereum using solidity.	L4,L5
4	To analyse different development frameworks.	L4
5	To implement private blockchain network with Hyperledger fabric.	L4,L5
6	To illustrate blockchain integration with emerging technologies and security issues.	L1,L2

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Blockchain cryptocurrency, Blockchain platform	**2**	--
I	**Ethereum Ecosystem**	Ethereum components: miner and mining node, Ethereum virtual machine, Ether, Gas, Transactions, accounts, swarm and whisper, Ethash, end to end transaction in Ethereum, architecture of Ethereum **Self-learning Topics**: Emerging blockchain platforms	**4**	CO1
II	**Blockchain Programming**	Types of Blockchain Programming, Solidity, GoLang, Vyper, Java, Simplicity, Rholang, Game Theory and Cryptonomics,	**8**	CO2

		Comparative study of different blockchain programming languages Decentralized file system-IPFS. **Self-learning Topics:** Emerging blockchain programming languages		
III	**Smart Contract**	Solidity programming, Smart Contract programming using solidity, mapper function, ERC20 and ERC721 Tokens, comparison between ERC20 & ERC721, ICO, STOMetamask (Ethereum Wallet), setting up development environment, use cases of smart contract, smart Contracts: Opportunities, Risks **Self-learning Topics:** Cryptocurrencies and their security issues, Consensus mechanisms, Digital Signatures	**10**	CO3
IV	**Blockchain Deployment**	Ethereum client, Ethereum Network, Introduction to Go Ethereum (Geth), Geth Installation and Geth CLI, Setting up a Private Ethereum Blockchain. Introduction to Truffle, Smart Contract deployment on a Private Blockchain. Introduction to Ganache Introduction to Dapp,Dapp architecture, Daaps Scalability,testing Connecting to the Blockchain and Smart Contract, Web3js, Deployment **Self-learning Topics:** Smart Contract deployment using Ganache.	**10**	CO4
V	**Hyperledger Application Development**	Installing Hyperledger Fabric, Hyperledger Fabric Network , Building Your First Network, Hyperledger Fabric Demo, Hyperledger Fabric Network Configuration, Certificate Authorities, Chaincode Development and Invocation, Deployment and testing of chaincode on development network, Hyperledger Fabric Transactions **Self-learning Topics:** Hyperledger sawtooth,Hyperledger caliper	**12**	CO5
VI	**Blockchain integration and Research challenges**	Integrating Blockchain with cloud, IoT, AI, ERP, End to end blockchain integration, Risks and Limitations of Blockchain: Privacy & Security. Criminal Use of Payment Blockchains, The "Dark" Side of Blockchain Research challenges in blockchain, **Self-learning Topics**: Use Cases: Blockchain for Health Insurance, Blockchain in Supply chain management, Blockchain & PropTech, Blockchain in Banking	**6**	CO6

Text Books:

1. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
2. Blockchain Technology, Chandramouli Subramanian, Asha A George, Abhillash K. A and Meena Karthikeyen, Universities press

References:

1. Blockchin enabled Applications,Vikram Dhillon,,DevidMetcalf,Max Hooper,Apress
2. Building Blockchain Projects,NarayanPrusty,Packt

Online References:

Sr. No.	Website Name
1.	https://ethereum.org/en/
2.	
3.	https://hyperledger-fabric.readthedocs.io/en/release-2.2/whatis.html
4.	https://www.blockchain.com/
5.	https://docs.soliditylang.org/en/v0.7.4/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Blockchain: Sem VII								
		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical & Oral	Tutorial	Total
HBCSBL601	Private Blockchain Setup Lab(SBL)	--	4	--	--	2	--	02

Course Code	Course Title	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg.				
HBCSBL601	Private Blockchain Setup Lab(SBL)	--	--	--	--	50	50	100

Lab Objectives:

Sr. No.	Lab Objectives
The Lab aims:	
1	To build and test Private Ethereum Blockchain.
2	To learn the concept of the genesis block and Account in the Blockchain.
3	To get familiar with the mining blocks to create a ether.
4	To understand and apply the concepts of keys, wallets.
5	To acquire the knowledge of gateway and desktop application.
6	To analyze the applications & case studies of Blockchain.

Lab Outcomes:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of lab, learner/student will be able to:		
1	To understand how blockchain systems (mainly Etherum) work .	L1,L2
2	To create the genesis block using Puppeth, a CLI tool and account using Smart Contract.	L6
3	To create mining blocks, check the account and PoW.	L6
4	To use cryptocurrency exchanges and wallets safely.	L1,L2,L3
5	To create Gateway to Blockchain Apps.	L6
6	To use Blockchain on Mobile App and on Cloud.	L1,L2,L3

Prerequisite: Expertise in Programming, Basic knowledge of Computer Security, Networking.

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. PC i3/i5/i7 Processor or above. 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card	1. NodeJs 2. Ethereum 3. Geth 4. Solidity	1. Internet Connection.

DETAILED SYLLABUS:

Note: All practical are to be conducted on Linux platform its Compulsory for this entire practical

Sr. No	Module .	Description	Hours	LO Mapping
1	**Build and Test**	**Install Ethereum network to create a private Ethereum Blockchain** **Self- learning topic : Hyperledger**	**4**	LO1
2	**Build and Test**	**Installation of geth**	**5**	LO1
3	**Create the Genesis block**	**Create the genesis block using Puppeth, a CLI tool**	**5**	LO2
4	**Create Account in the blockchain**	**Smart contract**	**6**	LO2
5	**Mining Blocks to create Ether**	**Mine blocks, check account balance, PoWvsPoA**	**6**	LO3
6	**Gateway to Blockchain Apps**	**Metamask**	**5**	LO4
7	**Web and Desktop Application**	**Solidity programming on remix**	**6**	LO4
8	**Application Development**	Crypto Exchange and Wallet	**4**	LO5
9	**Application Development**	Blockchain Mobile App or Web Application using Dapp	**6**	LO6
10	**Application Development**	Hosting of a private blockchain on cloud(AWS/Azure)	**5**	LO6

Text Books:

1. Mastering Ethereum: Building Smart Contracts and Dapps, Andreas Antonopoulos, Gavin Wood, O'Reilly Publication
2. Mastering Blockchain, Second Edition: Distributed ledger technology, decentralization, and smart contracts explained, 2nd Edition, Imran Bashir
3. Solidity Programming Essentials: A beginner's Guide to Build Smart Contracts for Ethereum and Blockchain, RiteshModi, Packt publication
4. Mastering Blockchain, Imran Bashir, Second Edition, Packt Publication.

References Books:

1. Mastering Bitcoin, PROGRAMMING THE OPEN BLOCKCHAIN, 2nd Edition by Andreas M. Antonopoulos, June 2017, Publisher(s): O'Reilly Media, Inc. ISBN: 9781491954386.
2. Blockchain Applications: A Hands-On Approach, by ArshdeepBahga, Vijay Madisetti, Paperback – 31 January 2017.
3. Mastering Blockchain, Imran Bashir, Packt Publication.

Online References:

Sr. No.	Website Name
1.	https://geth.ethereum.org/downloads/

2.	https://medium.com/@agrawalmanas09/how-to-setup-private-ethereum-blockchain-on-windows-10-machine-ab497e03d6b8
3.	https://geth.ethereum.org/docs/dapp/
4.	https://www.edureka.co/blog/ethereum-private-network-tutorial
5.	https://docs.soliditylang.org/en/develop/index.html
6.	https://metamask.io
7.	https://medium.com/publicaio/a-complete-guide-to-using-metamask-updated-version-cd0d6f8c338f
8.	https://docs.aws.amazon.com/blockchain-templates/latest/developerguide/blockchain-templates-create-stack.html

Term Work:
The Term work shall consist of at least 10 to 12 practical based on the above syllabus. The term work Journal must include at least 2 assignments. The assignments should be based on real world applications which cover concepts from all above syllabus**.**

Term Work Marks: 50 Marks (Total marks) = 40 Marks (Experiment) + 5 Marks (Assignments/tutorial/write up) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above syllabus.

Blockchain: Sem VIII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HBCC801	**DeFi (Decentralized Finance)**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg**					
HBCC801	**DeFi (Decentralized Finance)**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	The basic concepts of Centralized and Decentralized Finance and compare them.
2	The DeFi System and its key categories.
3	The DeFi components, primitives,incentives,metrics and major business models where they are used.
4	The DeFi Architecture and EcoSystem.
5	The DeFi protocols.
6	The real time use cases of DeFi.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Explain the basic concepts of Centralized and Decentralized Finance and compare them.	L1, L2
2	Describe the the DeFi System and its key categories.	L1
3	Discuss the DeFi components, primitives, incentives, metrics and major business models where they are used.	L1, L2
4	Explain the DeFi Architecture and EcoSystem.	L1, L2
5	Illustrate the DeFi protocols.	L1
6	Discuss the real time use cases of DeFi.	L1,L2

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Blockchain & Cryptocurrency, Blockchain Platform, Blockchain Development	**02**	-
I	**Introduction:**	Difference between Centralized and Decentralized Finance, Traditional Financial Institution- Banks: 1. Payment and	**06**	CO1

	Centralized and decentralized finance	Clearance systems, 2. Accessibility, 3. Centralization and Transparency, Decentralized Finance Vs Traditional Finance **Self-learning Topics:** The Potential Impact of Decentralized Finance		
II	**What is decentralized finance (defi)?**	The DeFi Ecosystem, Problems that DeFi Solves How Decentralized is DeFi? Defi key Categories:-Stablecoins, Stable coin and pegging, Lending and Borrowing, Exchanges, Derivations, Fund Management, Lottery, Payments, Insurance **Self-learning Topics:** How Decentralized Finance Could Make Investing More Accessible.	**06**	CO2
III	**DeFi Primitives and Business Models**	3.1 DeFi Components: Blockchain Cryptocurrency The Smart Contract Platform Oracles Stablecoins Decentralized Applications 3.2 DeFi Primitives: Transactions Fungible Token: Equity Tokens, Utility Tokens and Governance TokensNFT: NFT Standard, Multi-token standard Custody Supply Adjustment: Burn-Reduce Supply, Mint-Increase Supply, Bonding Curve-Pricing Supply Incentives: Staking Rewards, Slashing, Direct Rewards and Keepers, Fees Swap: Order Book Matching, Automated Market Makers Collaterlized Loans Flash Loans (Uncollaterlized Loans) 3.3 DeFi Key Metrics: Total Value Locked,Daily Active Users,Market Cap 3.4 DeFi Major Business Models: Decentralized Currencies, Decentralized Payment Services, Decentralized fundraising, Decentralized Contracting **Self-learning Topics:** Study any real time Business model.	**10**	CO3
IV	**DeFi Architecture and EcoSystem**	4.1DeFi Architecture:Consumer Layer: Blockchains, Cross-Blockchain networks, Oracles, Digital Asset Layer: Cryptocurrencies, Infrastructure Layer: Wallets and Asset Management, DEXes and Liquidity, Lending and Borrowing, Prediction Markets, Synthetic Assets, Insurance 4.2 DeFi EcoSystem and Protocols: On-chain Asset Exchange, Loanable Fund Markets on-chain assets, Stablecoins, Portfolio Management, Derivatives, Privacy-preserving mixers 4.3 DeFi Risk and Challenges: Technical Risks, Usability Risks, Centralization Risks, Liquidity Risks, Regulation Risk	**10**	CO4

		Self-learning Topics: Study of the Problems which are holding DeFi adoption back		
V	**DeFi Deep Dive**	5.1.Maker DAO:Maker Protocol: Dai Stablecoins, Maker Vaults, Maker Protocol Auctions Maker Actors: Keepers, Price Oracles, Emergency Oracles, DAO Teams, Dai Savings Rate Dai Use case Benefits and Examples 5.2.UniSwap:UniSwap Protocol Overview: How UniSwap Works, EcoSystem Participants, Smart Contracts UniSwap Core Concepts: Swaps, Pools, Flash Swaps, Oracles 5.3. Compound: Compound Protocol: Supplying Assets, Borrowing Assets, Interest Rate Model Compound Implementation and Architecture: cToken Contracts, Interest Rate Mechanics, Borrowing, Liquidation, Price Feeds, Comptroller, Governance 5.4. wBTC:Need for wBTC: Tokenization and common Issues wBTC Implementation and Technology: Users, Custodian Wallet Setup, Minting, Burning wBTC Governance, wBTC vs Atomic Swaps, Fees, Legal Binding, Trust Model and Transparency **Self-learning Topics:** MakerDAO Governance, UniSwap Governance Protocol Math, Compound Protocol Math	**10**	CO5
VI	**Use Cases**	6.1Decentralized Exchanges 6.2Decentralized Stablecoins 6.3Decentralized Money Markets 6.4Decentralized Synthetix 6.5Decentralized Insurance 6.6Decentralized Autonomous Organization (DAO), **Self-learning Topics:** Stock Exchange Operations, Derivatives, Tether, Ampleforth, How to get stablecoins, Synthetix Network, Token, The Ongoing Impact of The DAO's Rise and Fall, DAO Projects	**08**	CO6

Text Books:

1. How to DeFi,Darren Lau, Daryl Lau, Teh Sze Jin,Kristian Kho, Erina Azmi, TM Lee,Bobby Ong-1st Edition, March 2020
2. DeFi and the Future of Finance-Campbell R. Harvey
3. DeFi Adoption 2020 A Definitive Guide to Entering the Industry

Reference Books/White Papers:

1. Blockchain disruption and decentralized finance: The rise of decentralized business models-Yan Chen, Cristiano Bellavitis
2. SoK: Decentralized Finance (DeFi)-Sam M. Werner, Daniel Perez, Lewis Gudgeon,Ariah Klages-Mundt,Dominik Harz∗‡, William J. Knottenbelt,Imperial College London, † Cornell University, Interlay
4. Decentralized Finance (DeFi) –A new Fintech Revolution?
5. https://makerdao.com/da/whitepaper/
6. https://uniswap.org/
7. https://compound.finance/documents/Compound.Whitepaper.pdf
8. https://wbtc.network/assets/wrapped-tokens-whitepaper.pdf

9. https://defiprime.com/exchanges
10. https://defirate.com/stablecoins/
11. https://academy.ivanontech.com/blog/decentralized-money-markets-and-makerdao
12. https://www.gemini.com/cryptopedia/nexus-mutual-blockchain-insurance-nxm-crypto
13. https://consensys.net/blockchain-use-cases/decentralized-finance/
14. https://tokenlon.zendesk.com/hc/en-us/articles/360041114431-DeFi-Explained-Synthetic-Assets, https://www.blockchain-council.org/synthetix/synthetix-snx-the-biggest-ecosystem-in-decentralized-finance/

Online References:

Sr. No.	Website Name
1.	https://www.udemy.com/
2.	https://www.coursera.org/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

UNIVERSITY OF MUMBAI

Syllabus

Honours/ Minor Degree Program

in

Cyber Security

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Cyber Security (With effect from 2022-23)										
Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HCSC501: Ethical Hacking**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
TE Sem. VI	**HCSC601: Digital Forensic**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
BE Sem. VII	**HCSC701: Security Information Management**	04	--	--	20	80	--	--	100	04
	HCSSBL601: Vulnerability Assessment Penetration Testing (VAPT) Lab (SBL)	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
										Total Credits = 06
BE Sem. VIII	**HCSC801: Application Security**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Cyber Security: Sem V								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HCSC501	**Ethical Hacking**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HCSC501	**Ethical Hacking**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To describe Ethical hacking and fundamentals of computer Network.
2	To understand about Network security threats, vulnerabilities assessment and social engineering.
3	To discuss cryptography and its applications.
4	To implement the methodologies and techniques of Sniffing techniques, tools, and ethical issues.
5	To implement the methodologies and techniques of hardware security.
6	To demonstrate systems using various case studies.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Articulate the fundamentals of Computer Networks, IP Routing and core concepts of ethical hacking in real world scenarios.	L1,L2
2	Apply the knowledge of information gathering to perform penetration testing and social engineering attacks.	L3
3	Demonstrate the core concepts of Cryptography, Cryptographic checksums and evaluate the various biometric authentication mechanisms.	L1,L2
4	Apply the knowledge of network reconnaissance to perform Network and web application-based attacks.	L3
5	Apply the concepts of hardware elements and endpoint security to provide security to physical devices.	L3
6	Simulate various attack scenarios and evaluate the results.	L4,L5

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Computer Networks, Databases, system security	**2**	-

I	**Introduction to Ethical Hacking**	Fundamentals of Computer Networks/IP protocol stack, IP addressing and routing, Routing protocol, Protocol vulnerabilities, Steps of ethical hacking, Demonstration of Routing Protocols using Cisco Packet Tracer **Self-learning Topics**:TCP/IP model, OSI model	**10**	CO1
II	**Introduction to Cryptography**	Private-key encryption, public key-encryption, key Exchange Protocols, Cryptographic Hash Functions & applications, steganography, biometric authentication, lightweight cryptographic algorithms.Demonstration of various cryptographic tools and hashing algorithms **Self-learning Topics**: Quantum cryptography, Elliptic curve cryptography	**08**	CO3
III	**Introduction to network security**	Information gathering, reconnaissance, scanning, vulnerability assessment, Open VAS, Nessus, System hacking: Password cracking, penetration testing, Social engineering attacks, Malware threats, hacking wireless networks (WEP, WPA, WPA-2), Proxy network, VPN security, Study of various tools for Network Security such as Wireshark, John the Ripper, Metasploit, etc. **Self-learning Topics**: Ransomware(Wannacry), Botnets, Rootkits, Mobile device security	**12**	CO2
IV	**Introduction to web security and Attacks**	OWASP, Web Security Considerations, User Authentication, Cookies, SSL, HTTPS, Privacy on Web, Account Harvesting, Web Bugs, Sniffing, ARP poisoning, Denial of service attacks, Hacking Web Applications, Clickjacking, Cross-Site scripting and Request Forgery, Session Hijacking and Management, Phishing and Pharming Techniques, SSO, Vulnerability assessments, SQL injection, Web Service Security, OAuth 2.0, Demonstration of hacking tools on Kali Linux such as SQLMap, HTTrack, hping, burp suite,Wireshark etc. **Self-learning Topics**: Format string attacks	**10**	CO4
V	**Elements of Hardware Security**	Side channel attacks, physical unclonable functions, Firewalls,Backdoors and trapdoors, Demonstration of Side Channel Attacks on RSA, IDS and Honeypots. **Self-learning Topics**: IoT security	**6**	CO5
VI	**Case Studies**	Various attacks scenarios and their remedies. Demonstration of attacks using DVWA. **Self-learning Topics**: Session hijacking and man-in-middle attacks	**4**	CO6

Text Books:

1. Computer Security Principles and Practice --William Stallings, Seventh Edition, Pearson Education, 2017

2. Security in Computing -- Charles P. Pfleeger, Fifth Edition, Pearson Education, 2015
3. Network Security and Cryptography -- Bernard Menezes, Cengage Learning, 2014
4. Network Security Bible -- Eric Cole, Second Edition, Wiley, 2011
5. Mark Stamp's Information Security: Principles and Practice --Deven Shah, Wiley, 2009

References:

1.UNIX Network Programming –Richard Steven,Addison Wesley, 2003
2. Cryptography and Network Security -- Atul Kahate, 3rd edition, Tata Mc Graw Hill, 2013
3.TCP/IP Protocol Suite -- B. A. Forouzan, 4th Edition, Tata Mc Graw Hill, 2017
4. Applied Cryptography, Protocols Algorithms and Source Code in C -- Bruce Schneier, 2nd Edition / 20th Anniversary Edition, Wiley, 2015

Online Resources:

Sr. No.	Website Name
1.	https://www.owasp.org/index.php/Category:OWASP_Top_Ten_Project
2.	https://dvwa.co.uk/
3.	http://testphp.vulnweb.com/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

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- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Cyber Security: Sem VI								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HCSC601	**Digital Forensic**	**04**	--	--	**04**	--	--	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HCSC601	**Digital Forensic**	**20**	**20**	**20**	**80**	--	--	--	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To understand the various computer and cyber-crimes in the digital world.
2	To understand a significance of digital forensics life cycle, underlying forensics principles and investigation process.
3	To understand the importance of File system management with respect to computer forensics.
4	To be able to identify the live data in case of any incident handling and application of appropriate tools and practices for the same.
5	To Develop the skills in application of various tools and investigation report writing with suitable evidences.
6	To be able to identify the network and mobile related threats and recommendation of suitable forensics procedures for the same.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Identify and define the class for various computer and cyber-crimes in the digital world.	L1,L2
2	Understand the need of digital forensic and the role of digital evidence.	L1,L2
3	Understand and analyze the role of File systems in computer forensics.	L1,L2,L3
4	Demonstrate the incident response methodology with the best practices for incidence response with the application of forensics tools.	L3
5	Generate/Write the report on application of appropriate computer forensic tools for investigation of any computer security incident .	L5
6	Identify and investigate threats in network and mobile.	L4

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**

0	**Prerequisite**	**Computer Hardware**: Motherboard, CPU, Memory: RAM, Hard Disk Drive (HDD), Solid State Drive (SSD), Optical drive **Computer Networks:** Introduction CN Terminology: Router, Gateway, OSI and TCP/IP Layers **Operating Systems:** Role of OS in file management, Memory management utilities, Fundamentals of file systems used in Windows and Linux.	**2**	--
I	**Introduction to Cybercrime and Computer-crime**	**1.1 Definition and classification of cybercrimes:** Definition, Hacking, DoS Attacks, Trojan Attacks, Credit Card Frauds, Cyber Terrorism, Cyber Stalking. **1.2 Definition and classification of computer crimes:** Computer Viruses, Computer Worms. **1.3 Prevention of Cybercrime**: Steps that can be followed to prevent cybercrime, Hackers, Crackers, Phreakers. **Self-learning Topics:** Steps performed by Hacker	**4**	CO1
II	**Introduction to Digital Forensics and Digital Evidences**	**2.1 Introduction to Digital Forensics:** Introduction to Digital Forensics and lifecycle, Principles of Digital Forensic. **2.2 Introduction to Digital Evidences:** Challenging Aspects of Digital Evidence, Scientific Evidence, Presenting Digital Evidence. **2.3 Digital Investigation Process Models:** Physical Model, Staircase Model, Evidence Flow Model. **Self-learning Topics:** Digital Investigation Process Models comparison and its application, Rules of Digital Evidence.	**5**	CO2
III	**Computer Forensics**	**3.1 OS File Systems Review:** Windows Systems- FAT32 and NTFS, UNIX File Systems, MAC File Systems **3.2 Windows OS Artifacts:** Registry, Event Logs **3.3 Memory Forensics :** RAM Forensic Analysis, Creating a RAM Memory Image, Volatility framework, Extracting Information **3.4 Computer Forensic Tools:** Need of Computer Forensic Tools, Types of Computer Forensic Tools, Tasks performed by Computer Forensic Tools **Self-learning Topics:** Study of 'The Sleuth Kit' Autopsy tool for Digital Forensics	**7**	CO3
IV	**Incident Response Management, Live Data Collection and Forensic Duplication**	**4.1 Incidence Response Methodology:** Goals of Incident Response, Finding and Hiring IR Talent **4.2 IR Process:** Initial Response, Investigation, Remediation, Tracking of Significant Investigative Information. **4.3 Live Data Collection:** Live Data Collection on Microsoft Windows,	**10**	CO4

		4.4 Forensic Duplication: Forensic Duplicates as Admissible Evidence, Forensic Duplication Tools: Creating a Forensic evidence, Duplicate/Qualified Forensic Duplicate of a Hard Drive. **Self-learning Topics:** Live Data Collection on Unix-Based Systems		
V	**Forensic Tools and Report Writing**	**5.1 Forensic Image Acquisition in Linux :** Acquire an Image with dd Tools, Acquire an Image with Forensic Formats, Preserve Digital Evidence with Cryptography, Image Acquisition over a Network, Acquire Removable Media **5.2 Forensic Investigation Report Writing:** Reporting Standards, Report Style and Formatting, Report Content and Organization. **Self-learning Topics:** Case study on Report Writing	**10**	CO5
VI	**Network Forensics and Mobile Forensics**	**6.1 Network Forensics:** Sources of Network-Based Evidence, Principles of Internetworking, Internet Protocol Suite, Evidence Acquisition, Analyzing Network Traffic: Packet Flow and Statistical Flow, Network Intrusion Detection and Analysis, Investigation of Routers, Investigation of Firewalls **6.2 Mobile Forensics:** Mobile Phone Challenges, Mobile phone evidence extraction process, Android OS Architecture, Android File Systems basics, Types of Investigation, Procedure for Handling an Android Device, Imaging Android USB Mass Storage Devices. **Self-learning Topic:** Elcomsoft iOS Forensic Toolkit, Remo Recover tool for Android Data recovery	**14**	CO6

Text Books:

1. Digital Forensics by Dr. Dhananjay R. Kalbande Dr. Nilakshi Jain, Wiley Publications, First Edition, 2019.
2. Digital Evidence and Computer Crime by Eoghan Casey, Elsevier Academic Press, Third Edition, 2011.
3. Incident Response & Computer Forensics by Jason T. Luttgens, Matthew Pepe and Kevin Mandia, McGraw-Hill Education, Third Edition (2014).
4. Network Forensics : Tracking Hackers through Cyberspace by Sherri Davidoff and Jonathan Ham, Pearson Edu,2012
5. Practical Mobile Forensic by Satish Bommisetty, Rohit Tamma, Heather Mahalik, PACKT publication, Open source publication, 2014 ISBN 978-1-78328-831-1
6. The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory by Michael Hale Ligh (Author), Andrew Case (Author), Jamie Levy (Author), AAron Walters (Author), Publisher : Wiley; 1st edition (3 October 2014),

References:

1. Scene of the Cybercrime: Computer Forensics by Debra Littlejohn Shinder, Syngress Publication, First Edition, 2002.
2. Digital Forensics with Open Source Tools by Cory Altheide and Harlan Carvey, Syngress Publication, First Edition, 2011.
3. Practical Forensic Imaging Securing Digital Evidence with Linux Tools by Bruce Nikkel,NoStarch Press, San Francisco,(2016)
4. Android Forensics : Investigation, Analysis, and Mobile Security for Google Android by Andrew Hogg, Elsevier Publication,2011

Online References:

Sr. No.	Website Name
1.	https://www.pearsonitcertification.com/articles/article.aspx?p=462199&seqNum=2
2.	https://flylib.com/books/en/3.394.1.51/1/
3.	https://www.sleuthkit.org/autopsy/
4.	http://md5deep.sourceforge.net/md5deep.html
5.	https://tools.kali.org/
6.	https://kalilinuxtutorials.com/
7.	https://accessdata.com/product-download/ftk-imager-version-4-3-0
8.	https://www.amazon.in/Art-Memory-Forensics-Detecting-Malware/dp/1118825098

Research Papers: Mobile Forensics/Guidelines on Cell Phone Forensics

1. Computer Forensics Resource Center: NIST Draft Special Publication 800-101 : https://csrc.nist.gov/publications/detail/sp/800-101/rev-1/final
2. https://cyberforensicator.com/category/white-papers
3. https://www.magnetforensics.com/resources/ios-11-parsing-whitepaper/
4. Samarjeet Yadav , Satya Prakash , Neelam Dayal and Vrijendra Singh, "Forensics Analysis WhatsApp in Android Mobile Phone", Electronic copy available at: https://ssrn.com/abstract=3576379

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Cyber Security: Sem VII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HCSC701	**Security Information Management**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test 1	**Test 2**	**Avg.**					
HCSC701	**Security Information Management**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	The course is aimed to focus on cybercrime and need to protect information.
2	Understand the types of attacks and how to tackle the amount of risk involved.
3	Discuss the role of industry standards and legal requirements with respect to compliance.
4	Distinguish between different types of access control models, techniques and policy.
5	Awareness about Business Continuity and Disaster Recovery.
6	Awareness about Incident Management and its life cycle.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Understand the scope of policies and measures of information security to people.	L1,L2
2	Interpret various standards available for Information security.	L1,L2
3	Apply risk assessment methodology.	L3
4	Apply the role of access control to Identity management.	L3
5	Understand the concept of incident management**,** disaster recovery and business continuity.	L1,L2
6	Identify common issues in web application and server security.	L3

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Vulnerability Assessment for Operating Systems, Network (Wired and Wireless). Tools for conducting Reconnaissance.	**2**	--

I	**Basics of Information Security**	**1.1** What is Information Security & Why do you need it? – **1.2** Basics Principles of Confidentiality, Integrity **1.3** Availability Concepts, Policies, procedures, Guidelines, Standards **1.4** Administrative Measures and Technical Measures, People, Process, Technology, IT ACT 2000, IT ACT 2008 **Self-learning Topics:** Impact of IT on organizations, Importance of IS to Society	**6**	CO1, CO2
II	**Current Trends in Information Security**	**2.1** Cloud Computing: benefits and Issues related to information Security. **2.2** Standards available for InfoSec: Cobit, Cadbury, ISO 27001, OWASP, OSSTMM. **2.3** An Overview, Certifiable Standards: How, What, When, Who. **Self-learning Topics:** Cloud Threats, Impact of cloud computing on users, examples of cloud service providers: Amazon, Google, Microsoft, Salesforce etc.	**8**	CO2
III	**Threat & Risk Management**	**3.1** Threat Modelling**:** Threat, Threat-Source, Vulnerability, Attacks. **3.2** Risk Assessment Frameworks**:** ISO 31010, NIST-SP-800-30, OCTAVE **3.3** Risk Assessment and Analysis: Risk Team Formation, Information and Asset Value, Identifying Threat and Vulnerability, Risk Assessment Methodologies **3.4** Quantification of Risk, Identification of Monitoring mechanism, Calculating Total Risk and Residual Risk. **Self-learning Topics:** Risk management trends today and tomorrow.	**8**	CO3
IV	**Identity and Access Management**	**4.1** Concepts of Identification, Authentication, Authorization and Accountability. **4.2** Access Control Models: Discretionary, Mandatory, Role based and Rule-based. **4.3** Access Control Techniques: Constrained User, Access control Matrix, Content-dependent, Context – dependent **4.4** Access Control Methods: Administrative, Physical, Technical, Layering of Access control **4.5** Access Control Monitoring: IDS and IPS and anomaly detection. **4.6** Accountability: Event-Monitoring and log reviews. Log Protection **4.7** Threats to Access Control: Various Attacks on the Authentication systems. **Self-learning Topics:** challenges and solutions in identity and access management	**10**	CO4
V	**Operational Security**	**5.1** Concept of Availability, High Availability, Redundancy and Backup. **5.2** Calculating Availability, Mean Time Between Failure (MTBF), Mean Time to Repair (MTTR)	**10**	CO5

		5.3 Incident Management**:** Detection, Response, Mitigation, Reporting, Recovery and Remediation **5.4** Disaster Recovery: Metric for Disaster Recovery, Recovery Time Objective (RTO), Recovery Point Objective (RPO), Work Recovery Time (WRT), Maximum Tolerable Downtime (MTD), Business Process Recovery, Facility Recovery (Hot site, Warm site, Cold site, Redundant site), Backup & Restoration **Self-learning Topics:** Challenges and Opportunities of Having an IT Disaster Recovery Plan		
VI	**Web Application, Windows, and Linux security**	**6.1** Types of Audits in Windows Environment **6.2** Server Security, Active Directory (Group Policy), Anti-Virus, Mails, Malware **6.3** Endpoint protection, Shadow Passwords, SUDO users, etc. **6.4** Web Application Security: OWASP, Common Issues in Web Apps, what is XSS, SQL injection, CSRF, Password Vulnerabilities, SSL, CAPTCHA, Session Hijacking, Local and Remote File Inclusion, Audit Trails, Web Server Issues, etc. **Self-learning Topics:**, Network firewall protection,Choosing the Right Web Vulnerability Scanner	**8**	CO6

Textbooks:

1. Shon Harris, Fernando Maymi, CISSP All-in-One Exam Guide, McGraw Hill Education, 7th Edition, 2016.
2. Andrei Miroshnikov, Introduction to Information Security - I, Wiley, 2018
3. Ron Lepofsky, The Manager's Guide to Web Application Security, Apress; 1st ed. edition, 2014

References:

1. Rich-Schiesser, IT Systems Management: Designing, Implementing and Managing World - Class Infrastructures, Prentice Hall; 2 edition, January 2010.
2. NPTEL Course: - Introduction to Information Security – I (URL: https://nptel.ac.in/noc/courses/noc15/SEM1/noc15-cs03/)
3. Dr. David Lanter – ISACA COBIT – 2019 Framework - Introduction and Methodology
4. Pete Herzog, OSSTMM 3, ISECOM
5. NIST Special Publication 800-30, Guide for Conducting Risk Assessments, September 2012

Online References:

Sr. No.	Website Name
1.	https://www.ultimatewindowssecurity.com/securitylog/book/Default.aspx
2.	http://www.ala.org/acrl/resources/policies/chapter14
3.	https://advisera.com/27001academy/what-is-iso-27001/

4.	https://nvlpubs.nist.gov/nistpubs/legacy/sp/nistspecialpublication800-30r1.pdf
5.	http://www.diva-portal.org/smash/get/diva2:1117263/FULLTEXT01.pdf

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Cyber Security: Sem VII								
		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical & Oral	Tutorial	Total
HCSSBL701	Vulnerability Assessment Penetration Testing (VAPT) Lab (SBL)	--	4	--	--	2	--	2

Course Code	Course Title	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg.				
HCSSBL701	Vulnerability Assessment Penetration Testing (VAPT) Lab (SBL)	--	--	--	--	50	50	100

Lab Objectives:

Sr. No.	Lab Objectives
The Lab aims:	
1	To identify security vulnerabilities and weaknesses in the target applications.
2	To discover potential vulnerabilities which are present in the system in network using vulnerability assessment tools.
3	To identify threats by exploiting them using penetration test attempt by utilizing the vulnerabilities in a system
4	To recognize how security controls can be improved to prevent hackers gaining access controls to database.
5	To test and exploit systems using various tools and understands the impact in system logs.
6	To write a report with a full understanding of current security posture and what work is necessary to both fix the potential threat and to mitigate the same source of vulnerabilities in the future

Lab Outcomes:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of lab, learner/student will be able to:		
1	Understand the structure where vulnerability assessment is to be performed.	L1,L2
2	Apply assessment tools to identify vulnerabilities present in the system in network.	L3
3	Evaluate attacks by executing penetration tests on the system or network.	L4
4	Analyse a secure environment by improving security controls and applying prevention mechanisms for unauthorised access to database.	L5
5	Create security by testing and exploit systems using various tools and remove the impact of hacking in system.	L6

6	Formation of documents as per applying the steps of vulnerabilities of assessment and penetration testing.	L3, L4, L5

Prerequisite: Computer Networks, Basic of Network Security.

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. Intel PIV Processor 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card	1. Windows or Linux Desktop OS 2. Security Software and tools	1. Internet Connection.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Computer Network, Basics of Network Security, Ethical Hacking, Digital Forensics	**2**	
I	**Human Security (Social Engineering) Assessment**	**Visibility Audit: C**ollecting information through social media and internet. Collecting contact details (like phone number, email ID, What's App ID, etc) **Active Detection Verification:** Test if the phone number, email id etc are real by test message. Test whether the information is filtered at point of reception. Test if operator / another person assistance can be obtained. **Device Information:** IP Address, Port details, Accessibility, Permissions, Role in business **Trust Verification:** Test whether the information can be planted in form of note / email / Message (Phishing) **Test Subjects:** College Staff, Reception, PA to Director / Principal. To conduct information gathering to conduct social engineering audit on various sections in your college. **Self-Learning Topics:** Networking Commands	**8**	LO1
II	**Network & Wireless Security Assessment**	**Network Discovery:** Using various tools to discover the various connected devices, to get device name, IP Address, relation of the device in network, Detection of Active port, OS Fingerprinting, Network port and active service discovery **Tools:** IP Scanner, Nmap etc **Network Packet Sniffing:** Packet Sniffing to detect the traffic pattern, Packet capturing to detect protocol specific traffic pattern, Packet capturing to reassemble packet to reveal unencrypted password **Tools:** Wireshark **Self-Learning Topics:** Learning the CVE database for vulnerabilities detected.	**8**	LO2
III	**Setting up Pentester lab**	Including an attacker machine preferably Kali and in the same subnet victim machines either DVWA/ SEEDlabs/ multiple	**9**	LO3

		VULNHUB machines as and when required. Understanding Categories of pentest and legalities/ ethics. Installed Kali machine on VM environment with some VULNHUB machines and we can find out vulnerability of Level 1-VULNHUB machine like deleted system files, permissions of files. **Self learning Topics:** Vulnerability exploitation for acquire root access of the Kioptrx machine		
IV	**Database and Access Control Security Assessment**	**Database Password Audit:** Tool based audit has to be performed for strength of password and hashes. **Tools:** DBPw Audit **Blind SQL Injection:** Test the security of the Database for SQL Injection **Tools:** BSQL Hacker **Password Audit:** Perform the password audit on the Linux / Windows based system **Tools:** Cain & Able, John the ripper, LCP Password Auditing tools for Windows. **Active Directory and Privileges Audit:** Conduct a review of the Active Directory and the Group Policy to assess the level of access privileges allocated. **Tools:** SolarWinds **Self-Learning Topics:** Federated Database security challenges and solutions.	**9**	LO4
V	**Log Analysis**	Conduct a log analysis on Server Event Log / Firewall Logs / Server Security Log to review and obtain insights Tools: graylog, Open Audit Module. **Self-Learning Topics:** Python and R-Programming scripts	**6**	LO5
VI	**Compliance and Observation Reporting**	**License Inventory Compliance:** Identify the number of licenses and its deployment in your organization. Tools: Belarc Advisor, Open Audit Report Writing: NESSUS tool Report should contain: a. Vulnerability discovered b. The date of discovery c. Common Vulnerabilities and Exposure (CVE) database reference and score; those vulnerabilities found with a medium or high CVE score should be addressed immediately d. A list of systems and devices found vulnerable e. Detailed steps to correct the vulnerability, which can include patching and/or reconfiguration of operating systems or applications f. Mitigation steps (like putting automatic OS updates in place) to keep the same type of issue from happening again **Purpose of Reporting:** Reporting provides an organization with a full understanding of their current security posture and what work is necessary to both fix the potential threat and to mitigate the same source of vulnerabilities in the future. **Self-Learning Topics:** Study of OpenVAS, Nikto, etc.	**10**	LO6

Text & Reference Books and Links:

1. The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws Paperback – Illustrated, 7 October 2011 by Dafydd Stuttard
2. Hacking: The Art of Exploitation, 2nd Edition 2nd Edition by Jon Erickson
3. Important links of Vulnhub: Vulnhub Kioptrix
   Download Link: https://www.vulnhub.com/entry/basic-pentesting-1,216/
   https://www.vulnhub.com/entry/kioptrix-level-1-1,22/
   Installation Video: https://youtu.be/JupQRHtfZmw
   Walkthrough/solutions Video: https://youtu.be/Qn2cKYZ6kBI
4. OWASP Broken Web Application Projects
   https://sourceforge.net/projects/owaspbwa/
5. Mastering Modern Web Penetration Testing By Prakhar Prasad, October 2016, Packt Publishing.
6. Kali Linux Revealed: Mastering the Penetration Testing Distribution – June 5, 2017 by Raphael Hertzog (Author), Jim O'Gorman (Author), Offsec Press Publisher

Term Work:

The Term work shall consist of at least 10 to 12 practical based on the above syllabus. The term work Journal must include at least 2 assignments. The assignments should be based on real world applications which cover concepts from all above syllabus**.**

Term Work Marks: 50 Marks (Total marks) = 40 Marks (Experiment) + 5 Marks (Assignments/tutorial/write up) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Cyber Security: Sem VIII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HCSC801	**Application Security**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HCSC801	**Application Security**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	The terms and concepts of application Security, Threats, and Attacks
2	The countermeasures for the threats wrt Application security.
3	The Secure Coding Practices
4	The Secure Application Design and Architecture
5	The different Security Scanning and testing techniques
6	The threat modeling approaches

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Enumerate the terms of application Security, Threats, and Attacks	L1
2	Describe the countermeasures for the threats with respect to Application security.	L1
3	Discuss the Secure Coding Practices.	L2
4	Explain the Secure Application Design and Architecture.	L2
5	Review the different Security Scanning and testing techniques.	L2
6	Discuss the threat modeling approaches.	L2

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Operating System, DBMS, Computer Network, Web Programming, OOP	**02**	-

I	**Introduction to Application Security, Threats, and Attacks**	Introduction to Web Application Reconnaissance, Finding Subdomains, API Analysis, Identifying Weak Points in Application Architecture **Offense:** Cross-Site Scripting (XSS), Cross-Site Request Forgery (CSRF), XML External Entity (XXE) Injection, Injection Attacks, Denial of Service (DoS), Cross-Origin Resource Sharing Vulnerabilities **Self-learning Topics: Simulate the attacks using open-source tools in virtual environment**	**05**	CO1
II	**Defence and tools**	Securing Modern Web Applications, Secure Application Architecture, Reviewing Code for Security, Vulnerability Discovery, Defending Against XSS Attacks, Defending Against CSRF Attacks, Defending Against XXE, Defending Against Injection attacks, Defending Against DoS, Defending against CORS based attacks **Self-learning Topics: Implement the countermeasures to the attacks using open-source tools**	**09**	CO2
III	**Secure Coding Practices**	Security Requirements, Encryption, Never Trust System Input, Encoding and Escaping, Third-Party Components, Security Headers: Seatbelts for Web Apps, Securing Your Cookies, Passwords, Storage, and Other Important Decisions, HTTPS Everywhere, Framework Security Features, File Uploads, Errors and Logging, Input Validation and Sanitization, Authorization and Authentication, Parameterized Queries, Least Privilege, Requirements Checklist **Self-learning Topics: OWASP Secure Coding Practices**	**09**	CO3
IV	**Secure Application Design and Architecture**	**Secure Software Development Lifecycle** Averting Disaster Before It Starts, Team Roles for Security, Security in the Software Development Lifecycle, **Design Flaw vs. Security Bug,** **Secure Design Concepts,** **Segregation of Production Data,** **Application Security Activities** **Self-learning Topics: Secure Hardware architecture**	**09**	CO4
V	**Security Scanning and testing**	Testing Your Code, Testing Your Application, Testing Your Infrastructure, Testing Your Database, Testing Your APIs and Web Services, Testing Your Integrations, Testing Your Network, Dynamic Web Application Profiling **Self-learning Topics: Open-source Application Security Tools, IAST, RASP and WAF, Selenium**	**09**	CO5
VI	**Threat Modeling**	**Objectives and Benefits of Threat Modeling**, Defining a Risk Mitigation Strategy, Improving Application Security, Building Security in the Software Development Life Cycle	**09**	CO6

		Existing Threat Modeling Approaches Security, Software, Risk-Based Variants **Threat Modeling Within the SDLC** Building Security in SDLC with Threat Modeling, Integrating Threat Modeling Within the Different Types of SDLCs, **Self-learning Topics: The Common Vulnerability Scoring System (CVSS)**		

Text Books:

1. Alice and Bob Learn Application Security, by Tanya Janca Wiley; 1st edition (4 December 2020)
2. Web Application Security, A Beginner's Guide by Bryan Sullivan McGraw-Hill Education; 1st edition (16 January 2012)
3. Web Application Security: Exploitation and Countermeasures for Modern Web Applications by Andrew Hoffman Shroff/O'Reilly; First edition (11 March 2020)
4. The Security Development Lifecycle by Michael Howard Microsoft Press US; 1st edition (31 May 2006)
5. Risk Centric Threat Modeling Process for Attack Simulation And Threat Analysis, Tony Ucedavélez and Marco m. Morana, Wiley
6. Iron-Clad Java: Building Secure Web Applications (Oracle Press) 1st Edition by Jim Manico

References:

1. Software Security: Building Security In by Gary McGraw Addison-Wesley Professional; 1st edition (January 23, 2006)
2. A Guide to Securing Modern Web Applications by Michal Zalewski
3. Threat Modeling: A Practical Guide for Development Teams by Izar Tarandach and Matthew J. Coles Dec 8, 2020

Online References:

Sr. No.	Website Name
1.	https://owasp.org/www-project-top-ten/
2.	https://owasp.org/www-pdf-archive/OWASP_SCP_Quick_Reference_Guide_v2.pdf
3.	https://pentesterlab.com/
4.	https://app.cybrary.it/browse/course/advanced-penetration-testing
5.	https://www.udemy.com/
6.	https://www.coursera.org/

Assessment:

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- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Augmented Reality and Virtual Reality

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Augmented Reality and Virtual Reality (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HVARC501: Virtual Reality**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HVARC601: AR and Mix Reality**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HVARC701: ARVR Application-I**	04	--	--	20	80	--	--	100	04
	HVARSBL701: ARVR Lab (SBL)	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HVARC801: Game Development with VR**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Augmented Reality and Virtual Reality: Sem V								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HVARC501	**Virtual Reality**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HVARC501	**Virtual Reality**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To understand primitives of computer graphics fundamental.
2	To analyze various Hardware devices suitable for VR.
3	To analyze visual physiology and issues related to it.
4	To apply the knowledge of Visual rendering.
5	To evaluate problems faced due to audio scattering in VR.
6	To create different interface in VR environment.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Solve Computer Graphics Problems.	L1
2	Analyze application of VR hardware and software components.	L1, L2, L3
3	Identify issues related to visual physiology.	L1, L2
4	Integrate various shading and rendering techniques.	L6
5	Solve problems due to Audio distortions.	L5
6	Create User Interface for VR.	L6

Prerequisite: Basic C programming

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**

0	**Prerequisite**	Functioning of human sensory organs – EYE, Ear, Touch etc. Light and Lenses Basic functioning of camera Matrix multiplication	**02**	--
I	**Geometry of Virtual World**	Geometric Modeling, 2D transformations, Homogenous coordinate system, 3D rotation and 6 degree of freedom, Viewport Transformation **Self:** Eye Transformation, demo of 2D transformation	**10**	**CO1**
II	**Introduction to VR**	Introduction to VR and definitions and its components., Hardware components: Display devices: LCD, OLED Audio: Speakers, Earphones, Bone conduction Touch: Haptic Device GPU and CPU, Input devices like game controller, data glows, Joysticks Tracking Hardware: Industrial measurement Unit-IMU, Gyroscope, accelerometer Software component: Java3D, VRML **Self:** Feedback mechanisms in VR environment	**07**	**CO2**
III	**Visual Physiology, perception and tracking**	Functioning of Eye with photoreceptors, Resolution for VR, Eye movements and issues with it in VR, Neuroscience of vision, Depth and motion perception, Frame rates and display, Orientation tracking, tilt and yaw drift correction, Tracking with camera **Self:** Light House approach	**08**	**CO3**
IV	**Visual Rendering**	Overview, shading models, rendering pipelines, rasterization, pixel shading, Distortion shading, post rendering image wrap **Self:** Rendering for VR application	**09**	**CO4**
V	**Audio**	Physics of Audio, Auditory Perception, localization, rendering, Problems due to scattering of audio **Self:** Study reaction of audio and other senses for VR environment	**10**	**CO5**
VI	**Interfaces**	Locomotion, Manipulation, system control, social interaction using open-source tool like Gopro VR etc. **Self:** Explore tools for UI in VR	**06**	**CO6**

Text Books:

1. Hearn and Baker, "Computer Graphics- C version", 2nd edition, Pearson, 2002.

2. R. K Maurya, "Computer Graphics with Virtual Reality", 3rd Edition, Wiley India, 2018.
3. Steven M. LaVelle," Virtual Reality", Cambridge University press, 2019
4. Grigore Burdea, Philippe Coiffet, "Virtual Reality Technology", 2nd Edition, Wiley India, 2003
5. Vince, "Virtual Reality Systems", 1st Edition, Pearson Education, 2002

References:

1. George Mather, "Foundations of Sensation and Perception", Psychology Press book; 3rd Edition, 2016
2. Tony Parisi, " Learning Virtual Reality", 1st edition, O'Reilly, 2015
3. Alan Craig and William Sherman," Understanding virtual reality: Interface, application and design", 2nd Edition, Morgan Kaufmann Publisher, 2019
4. Peter Shirley, Michael Ashikhmin, and Steve Marschner, "Fundamentals of Computer Graphics" ,A K Peters/CRC Press; 4th Edition, 2016.

Online Resources:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/121/106/121106013/#
2.	http://msl.cs.uiuc.edu/vr/
3.	http://lavalle.pl/vr/

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- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Augmented Reality and Virtual Reality: Sem VI								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HVARC601	**AR and Mix Reality**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HVARC601	**AR and Mix Reality**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To understand the concepts of Augmented Reality and related technologies.
2	To understand the AR tracking system and use of computer vision in AR/MR.
3	To describe the technology for multimodal user interaction and authoring in AR.
4	To use different AR toolkits and apply them to develop AR applications.
5	To demonstrate AR Applications using Mobile AR Toolkits and SDKs.
6	To understand the use of AR/MR in interdisciplinary immersive applications.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Identify and compare different Augmented Reality and Mixed Reality Technologies.	L1, L2
2	Apply concepts of Computer Vision for tracking in AR and MR Systems.	L3
3	Model different interfaces and authoring in AR/MR.	L3
4	Design AR/MR applications using open source platforms and toolkits.	L6
5	Design Mobile based AR Applications.	L6
6	Apply insights of AR/MR in different applications.	L3

Prerequisite: Programming Language, Computer Graphics, Virtual Reality

DETAILED SYLLABUS:

Module	**Title**	**Description**	**Hours**	**CO**
0	**Pre-requisite**	Basics of Computer Graphics, Coordinate Systems, VR Introduction, Tracking in VR	**02**	--

I	**Introduction to Augmented Reality and Mixed Reality**	Definition and Scope, A Brief History of Augmented Reality, AR Architecture, Related Fields of AR (like Mixed Reality, Virtual Reality, Immersive Reality, Extended Reality) and Their comparison, General Architecture of Mixed Reality System, Algorithm Steps in Mixed Reality **Self-Learning Topics**: How AR/MR are related to Ubiquitous Computing, Multidimensional Systems.	**06**	CO1
II	**Tracking and Computer Vision for AR and MR**	Multimodal Displays; Visual Perception; Spatial Display Model; Visual Displays; Tracking, Calibration and Registration; Coordinate Systems; Characteristics of Tracking Technology; Stationary Tracking Systems; Mobile Sensors; Optical Tracking; Sensor Fusion; Marker Tracking; Multiple Camera Infrared Tracking; Natural Feature Tracking by Detection; Incremental Tracking; Simultaneous Localization and Tracking; Outdoor Tracking **Self-Learning Topics**: Indoor Tracking, Full Body Tracking	**07**	CO2
III	**Interaction, Modeling and Annotation and Authoring**	Output Modalities, Input Modalities, Tangible Interfaces, Virtual User Interfaces on Real Surfaces, Multi-view Interfaces, Haptic Interaction, Multimodal Interaction, Specifying Geometry, Specifying Appearance, Semi-automatic Reconstruction, Free-form Modeling, Annotation, Requirement of AR Authoring, Elements of Authoring, Stand-alone Authoring Solutions, Plug-in Approaches, Web Technology **Self-Learning Topics**: Case Study on Object Annotation in Real Time, Avatar Modeling.	**08**	CO3
IV	**Software Architecture in AR and AR Development Toolkits**	AR Application Requirements, Software Engineering Requirements, Distributed Object Systems, Data Flow, Scene Graphs; Developer Support: Parameter Configuration, Declarative Scripting, Procedural Scripting, Mixed Language Programming, Runtime Reconfiguration, Choosing an AR Platforms and Toolkits; AR Non-programming Frameworks, AR Programming Frameworks, Programming AR using ARToolkit. **Self-Learning Topics**: Commercial AR Frameworks, AR Related Markup Languages	**10**	CO4
V	**Mobile AR**	Types of Mobile Apps, AR Browsers for Smartphones, Point of Interests (POI) in Mobile AR, POI Authoring and Publishing Tools, AR Applications for Android, AR Games for Android, Mobile AR Toolkits and SDKs, Developing Mobile AR Applications, AR Application Development for Android Smartphone **Self-Learning Topics**: AR Applications for iOS, AR Games for iOS, AR Application Development for iOS Smartphone	**10**	CO5
VI	**Applications of AR/MR and Human**	Applications of AR/MR in: Edutainment, Medical, Military, Production and Manufacturing, Navigation, Astronomical Observation, E-commerce; What are Human Factors, Physical	**07**	CO6

	Factors, Legal and Social Considerations	Side Effects, Visual Side Effects, Legal Considerations, Moral and Ethical Considerations. **Self-Learning Topics**: Applications of AR/MR in Civil Construction and Architecture, Collaboration, Information Control and Big Data Visualization		

Textbooks:

1. Dieter Schmalsteig and Tobias Hollerer, "Augmented Reality- Principles and Practice", Pearson Education, Inc. 2016 Edition.
2. Chetankumar G Shetty, "Augmented Reality- Theory, Design and Development", Mc Graw Hill, 2020 Edition.
3. Alan B. Craig, "Understanding Augmented Reality – Concepts and Applications", Morgan Kaufmann, Elsevier, 2013 Edition.

References:

1. Borko Furht, "Handbook of Augmented Reality", Springer, 2011 Edition.
2. Erin Pangilinan, Steve Lukas, and Vasanth Mohan, "Creating Augmented and Virtual Realities- Theory and Practice for Next-Generation Spatial Computing", O'Reilly Media, Inc., 2019 Edition.
3. Jens Grubert, Dr. Raphael Grasset, "Augmented Reality for Android Application Development", PACKT Publishing, 2013 Edition.

Online Resources:

Sr. No.	Website Name
1.	www.nptel.ac.in
2.	www.coursera.org

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Augmented Reality and Virtual Reality: Sem VII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HVARC701	**ARVR Application-I**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HVARC701	**ARVR Application-I**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To learn the underlying concepts of Virtual Reality, Augmented Reality and related technologies.
2	To analyse the principles of VR design, prototype.
3	To analyse the principles of AR design, prototype.
4	To design Graphical User interface using VR
5	To identify trends in XR, key issues in XR and XR Tools.
6	To analyse privacy, ethical, social concern on AR/VR problem.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Apply modelling techniques on Augmented Reality applications..	L1, L2, L3
2	Gets an overview of guidelines, methods, tools and pick design problems in Virtual Reality.	L1, L2
3	Gets an overview of guidelines, methods, tools and pick design problems in Augmented Reality.	L1, L2
4	Evaluate designs based on theoretical frameworks and build Graphical User interface using VR, Tools	L3, L4
5	Apply the appropriate XR development Approach on problem	L3
6	Analyse main concerns with respect to designed solutions and discuss the privacy, ethical, social concerns.	L3, L4

Prerequisite: Programming Language, Computer Graphics, Virtual Reality

DETAILED SYLLABUS:

Module	**Title**	**Description**	**Hours**	**CO**

0	**Prerequisite**	Fundamental Concept and Components of Virtual Reality, Augmented Reality and Mixed Reality Technologies, Authoring in AR	**02**	--
I	**AR/VR Concepts and Technologies**	Difference between AR and VR , Rendering for VR/AR, Challenges with AR,AR systems and functionality **Augmented Reality Application Development**: Types of Augmented Reality Application (Location Based AR Apps Marker-Based AR Applications), three-dimensional modeling and computer vision ,displays & tracking technologies **Self-learning Topic:** Case study on Retail shopping using AR	**08**	CO1
II	**VR Design Overview**	Principles of VR design, Overview of guidelines, methods, tools & design problem, Physical Prototyping for VR- Physical prototype of potential solution, Digital Prototyping for VR- tool choices, digital prototype of (key aspects of) solution **Self-learning Topic:** Study of 3D navigation , layout and contents	**09**	CO2
III	**AR Design Overview**	Principles of AR design, Overview of guidelines, methods, tools & design problem, Physical Prototyping for AR - Physical prototype of potential solution, Digital Prototyping for AR- tool choices, digital prototype of (key aspects of) solution. **Self-learning Topic:** Use of Anchors in AR	**09**	CO3
IV	**3 D interaction with VR**	3 D interaction Overview and types, Navigation in VR, Object interaction, Graphical User interface using VR, Challenges in VR interaction, Tools **Self-learning Topic:** Case study of Mobile applications using 3D interface	**10**	CO4
V	**XR Application Development**	XR overview, XR development Approach, XR design process, Trends in XR, key issues in XR, Tools **Self-learning Topic:** Difference between, AR, VR, MR and XR	**10**	CO5
VI	**Privacy and security**	Privacy, Ethical, and Social Implications, and the Future of AR/VR **Self-learning Topic:** Case study on Privacy and security issues using AR and VR	**04**	CO6

Textbooks:

1. John Vince, " Virtual Reality Systems", Pearson publication
2. Tony Parisi, " Learning Virtual Reality", O'REILLY'
3. Dieter Schmalsteig and Tobias Hollerer, "Augmented Reality- Principles and Practice", Pearson Education, Inc. 2016 Edition.
4. Chetankumar G Shetty, "Augmented Reality- Theory, Design and Development", Mc Graw Hill, 2020 Edition.
5. Alan B. Craig, "Understanding Augmented Reality – Concepts and Applications", Morgan Kaufmann, Elsevier, 2013 Edition.

References:

1. Borko Furht, “Handbook of Augmented Reality”, Springer.
2. Erin Pangilinan, Steve Lukas, and Vasanth Mohan, “Creating Augmented and Virtual Realities- Theory and Practice for Next-Generation Spatial Computing”, O’Reilly Media, Inc., 2019 Edition.
3. Jens Grubert, Dr. Raphael Grasset, “Augmented Reality for Android Application Development”, PACKT Publishing.

Online Resources:

Sr. No.	Website Name
3.	www.nptel.ac.in
4.	www.coursera.org

Assessment:

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➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Augmented Reality and Virtual Reality: Sem VII								
		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
HVARSBL701	ARVR Lab (SBL)	--	2	--	--	1	--	01

Course Code	Course Title	Examination Scheme						
		Theory Marks				Term Work	Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test2	Avg.				
HVARSBL601	ARVR Lab (SBL)	--	--	--	--	50	50	50

Lab Objectives:

Sr. No.	Lab Objectives
The lab course aims:	
1	To Understand the definition and significance of the VR,AR and MR.
2	To Design various applications in VR .
3	To Examine various audio tools for audio embedded in scene
4	To Explore AR and MR applications in real world
5	To develop interface for VR and AR applications
6	To Explore the interconnection and integration of the physical world and able to design & develop Mobile applications.

Lab Outcomes

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Adapt different tools to implement VR,AR and MR.	L1,L2
2	Demonstrate the working of VR background design.	L1,L2
3	Apply audio tools and developed real world application.	L1,L2,L3
4	Adapt different techniques for Integrating AR and MR concepts in applications.	L5
5	Create interface for selected application	L6
6	Create application and interface for mobile application /desktop version	L6

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. PC i3/i5/i7 Processor or above. 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card	1. Unity 2. Python 3.OpenCV 4. Solidity	1. Internet Connection.

Prerequisite: VR, AR and MR concepts

Suggested List of Experiments

ARVR lab will describe the Designing of VR and AR applications using different Tools. It starts with installation of software and then learner learn how to design background of various application. Now a day's audio implementation in VR scenes is also getting lots of attention so this aspect is also covered in the lab experiments. AR and MR are important concepts where learner design the applications for desktop as well as mobile environment.

Sr. No.	Detailed Content	LO Mapping
1	To install Open source software /Unity with its functionality	**LO1**
2	Select real world application and design background for the same	**LO2**
3	To add sound in the selected application using Open source software /Unity software	**LO3**
4	To study interface requirements and apply for the selected application	**LO3**
5	Creating Your Digital Prototype of your objects/environment – (WebVR/ Sketchup / Blender/Unity/Keynote/Figma)	**LO6**
6	To implement a depth map with Python and OpenCV and using Unity	**LO5**
7	Identify multiple surfaces and move objects between them using ARCore	**LO3**
8	To study Interact with AR objects and detect collisions.	**LO2**
9	Marker less Object Placement - WebAR	**LO4**
10	In a group of three to five students develop one real world application in VR/ AR or MR with object details and sound with good user interface	**LO6**

Text Books/ References:

1. Hearn and Baker, "Computer Graphics- C version", 2nd edition, Pearson, 2002.
2. R. K Maurya, "Computer Graphics with Virtual Reality", 3rd Edition, Wiley India, 2018.
3. Dieter Schmalsteig and Tobias Hollerer, "Augmented Reality- Principles and Practice", Pearson Education, Inc. 2016 Edition.
4. Chetankumar G Shetty, "Augmented Reality- Theory, Design and Development", Mc Graw Hill, 2020 Edition.
5. Alan B. Craig, "Understanding Augmented Reality – Concepts and Applications", Morgan Kaufmann, Elsevier, 2013 Edition.

Online Resources:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/121/106/121106013/#
2.	http://msl.cs.uiuc.edu/vr/
3.	http://lavalle.pl/vr
4.	http://nptel.ac.in
5.	www.coursera.org

Term Work:

The Term work shall consist of at least 10 to 12 practical based on the above syllabus. The term work Journal must include at least 2 assignments. The assignments should be based on real world applications which cover concepts from all above syllabus**.**

Term Work Marks: 50 Marks (Total marks) = 40 Marks (Experiment) + 5 Marks (Assignments/tutorial/write up) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above syllabus.

Augmented Reality and Virtual Reality: Sem VIII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HVARC801	**Game Development with VR**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HVARC801	**Game Development with VR**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives

Sr. No.	**Course Objectives**
The course aims:	
1	The different genres of game and explain the Unity UI Basics.
2	The use of navigation and cursor control to create a game environment.
3	How to import assets, interact with them using action objects and manage object states.
4	To build transitions by scripting events ,using physics, particle systems, and other Unity functionality action sequences with UnityGUI design.
5	To build the game project together by handling mecanim ,using dialogue trees, creating and setting up the game environment and menus for the game.
6	The VR development in Unity.

Course Outcomes

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Identify the different genres of game and explain the Unity UI Basics	L1,L2
2	Make use of navigation and cursor control to create a game environment	L3
3	Apply how to import assets ,interact with them using action objects and manage object states	L3
4	Build transitions by scripting events ,using physics, particle systems, and other Unity functionality action sequences with UnityGUI design	L3
5	Build the game project together by handling mecanim ,using dialogue trees,creating and setting up the game environment and menus for the game	L3
6	Explain VR development in Unity	L2

Prerequisite: Basics of VR

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	VR Basic concepts	**02**	-
I	**Game Development and Unity UI Basics**	The Adventure Genre, Fast Forward to Real-Time, What Draws People to This Genre? Designing Your Game: Defining a Style, Compartmentalizing Environments, First-Person or Third? Animation, Basic Human Characteristics Make for Fun? Managing Your Project, Tips for Completing the Game, Real Time vs. Pre-render.AI in Gaming-AI Guidelines, a simple workflow. Unity UI: The Layout, Toolbar, Menus, Creating Simple Objects, Selecting and Focusing, Transforming Objects In 3D, Snaps, Scene Gizmo.Lights,3D Objects, Materials Scripting: What is a script? Components of a Script, Picking an Object in the Game, Conditionals and State, Order of Evaluation **Self-learning Topics:** Understanding the role of AI in gaming	**08**	CO1
II	**Navigation and Cursor Control**	Creating Environments, Navigation-Arrow Navigation and Input, Fun with Platforms, Collision Walls, Cursor visibility, Custom cursors, GUI Texture Cursor, Hardware Cursor, UnityGUI Cursor, Object-to-Object Communication, Mouseover Cursor Changes, Object Reaction to Mouseover **Self-learning Topics:** Multimodal Gaming for Navigation Skills in Players Who Are Blind	**06**	CO2
III	**Imported Assets, Objects & Managing states**	Imported Assets:3D Art Assets, Setting Up Materials, Shadows. Action Objects: Colliders, Triggering Animation, Adding Sound F/X, Managing States: Identifying the Action Objects, Developing a State Machine, Lookup Table, Scripting in Unity, Picking a script Editor, Fundamentals of scripting in Unity. The Object Lookup Script, Action-Related Messages **Self-learning Topics:** Study the new Asset Import Pipeline: Solid foundation for speeding up asset imports, Effects of scripting on dialogues.	**09**	CO3
IV	**Transitions, Text Management**	Processing the Auxiliary Objects, Handling Object Visibility, Ensuring Player Focus, Adding New Assets, Physics, Combining Physics and Keyframe Animation, Particle systems, GUI Skin, Text Visibility, Using Layers, Creating the Inventory Screen, Adding Inventory Icons, Managing the inventory. **Self-learning Topics:** Importance of effective Text management in Gaming	**09**	CO4

V	**Game Deployment**	Dialogue Trees, The Scenario, Starting a Conversation, Mecanim and Characters, Game Environment, Setting up the game, Menus and levels **Self-learning Topics:** Branching dialogue trees and its effect in Gaming. Study of different UI designs for Menus in Games.	**09**	CO5
VI	**XR development in Unity**	Unity platform and services, XR Getting started with AR development in Unity, Getting started with VR development in Unity, XR Plug-in Framework, Configuring your Unity Project for XR, Universal Render Pipeline compatibility in XR, XR API reference, Single Pass Stereo rendering (Double-Wide rendering), VR Audio Spatializers, VR frame timing ,Unity XR SDK, Open-source repositories using Bitbucket, Asset Store Publishing, use of unity as library in other application. **Self-learning Topics:** Study any open source tool for VR Development	**09**	CO6

Text Books:

1. Beginning 3D Game Development with Unity 4 All-in-one Multi-platform Game development, 2nd Edition, Apress, Sue Backman
2. Game Development with Unity 2nd Edition, Michelle Menard and Bryan Wagstaff
3. Unity Game development Essentials, Will Goldstone, PACKT Publishing
4. Unity Game Development Cookbook-Essentials for every Game, O'reilly ,Paris Buttfield-Addison, Jon Manning-Tim Nugent.

Reference Books:

1. Introduction to Gam Development, Second Edition, Steve Rabin, CENGAGE Learning
2. Sams Teach Yourself Unity Game Development in 24 Hours-Mike Geig

Online References:

Sr. No.	Website Name
1.	https://docs.unity3d.com/Manual/VROverview.html
2.	https://www.coursera.org/
3.	https://www.udemy.com/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

UNIVERSITY OF MUMBAI

Syllabus for

Honours/Minor Degree Program

In

Artificial Intelligence and Machine Learning

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Artificial Intelligence and Machine Learning (AI&ML) (With effect from 2022-23)										
Year & Sem	Course Code & Course Title	Teaching Scheme Hrs / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar / Tutorial	Practical	Internal Assessment	End Sem Exam	Term Work	Oral / Practical	Total	Credits
TE Sem V	HAIMLC501: Mathematics for AI & ML	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**	**-**	**-**	**100**	**04**	
Total Credits = 04										
TE Sem VI	HAIMLC601: Game Theory using AI & ML	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**	**-**	**-**	**100**	**04**	
Total Credits = 04										
BE Sem VII	HAIMLC701: AI&ML in Healthcare	04	--	--	20	80	--	--	100	04
	HAIMLSBL701: AI&ML in Healthcare: Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
Total Credits = 06										
BE Sem VIII	HAIMLC801: Text, Web and Social Media Analytics	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Artificial Intelligence and Machine Learning: Sem V								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HAIMLC501	Mathematics for AI&ML	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme							
		Theory Marks				Exam Duration	Term Work	Practical and Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test1	Test2	Avg.					
HAIMLC501	Mathematics for AI&ML	20	20	20	80	03	--	--	100

Course Prerequisites:	
Applied Mathematics, Discrete mathematics	
Course Objectives:	
1	To build an intuitive understanding of Mathematics and relating it to Artificial Intelligence, Machine Learning and Data Science.
2	To provide a strong foundation for probabilistic and statistical analysis mostly used in varied applications in Engineering.
3	To focus on exploring the data with the help of graphical representation and drawing conclusions.
4	To explore optimization and dimensionality reduction techniques.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Use linear algebra concepts to model, solve, and analyze real-world problems.
2	Apply probability distributions and sampling distributions to various business problems.
3	Select an appropriate graph representation for the given data.
4	Apply exploratory data analysis to some real data sets and provide interpretations via relevant visualization
5	Analyze various optimization techniques.
6	Describe Dimension Reduction Algorithms

Module No.		Topics	Hrs.
1.0		**Linear Algebra**	**05**
	1.1	Vectors and Matrices, Solving Linear equations, The four Fundamental Subspaces, Eigenvalues and Eigen Vectors, The Singular Value Decomposition (SVD).	
2.0		**Probability and Statistics**	**09**
	2.1	Introduction, Random Variables and their probability Distribution, Random Sampling, Sample Characteristics and their Distributions, Chi-Square, t-, and F-Distributions: Exact Sampling Distributions, Sampling from a Bivariate Normal Distribution, The Central Limit Theorem.	
3.0		**Introduction to Graphs**	**10**

	3.1	Quantitative vs. Qualitative data, Types of Quantitative data: Continuous data, Discrete data, Types of Qualitative data: Categorical data, Binary data, Ordinary data, Plotting data using Bar graph, Pie chart, Histogram, Stem and Leaf plot, Dot plot, Scatter plot, Time-series graph, Exponential graph, Logarithmic graph, Trigonometric graph, Frequency distribution graph.	
4.0		**Exploratory Data Analysis**	**09**
	4.1	Need of exploratory data analysis, cleaning and preparing data, Feature engineering, Missing values, understand dataset through various plots and graphs, draw conclusions, deciding appropriate machine learning models.	
5.0		**Optimization Techniques**	**10**
	5.1	Types of optimization-Constrained and Unconstrained optimization, Methods of Optimization-Numerical Optimization, Bracketing Methods-Bisection Method, False Position Method, Newton's Method, Steepest Descent Method, Penalty Function Method.	
6.0		**Dimension Reduction Algorithms**	**05**
	6.1	Introduction to Dimension Reduction Algorithms, Linear Dimensionality Reduction: Principal component analysis, Factor Analysis, Linear discriminant analysis.	
	6.2	Non-Linear Dimensionality Reduction: Multidimensional Scaling, Isometric Feature Mapping. Minimal polynomial	
		Total	**48**

Text Books:

1 Linear Algebra for Everyone,
2 Gilbert Strang, Wellesley Cambridge Press.
3 An Introduction to Probability and Statistics, Vijay Rohatgi, Wiley Publication
4 An introduction to Optimization, Second Edition, Wiley-Edwin Chong, Stainslaw Zak.
5 Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Cambridge University Press.
6 Exploratory Data Analysis, John Tukey, Princeton University and Bell Laboratories.

References:

1 Introduction to Linear Algebra, Gilbert Strang.
2 Advanced Engineering Mathematics, Erwin Kreyszig
3 Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. Foundations of Machine Learning. MIT Press, 2018.
4 Shai Shalev-Shwartz and Shai Ben-David. Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press, 2014
5 Last updated on Sep 9, 2018.
6 Mathematics and Programming for Machine Learning with R, William B. Claster, CRC Press,2020

Useful Links:

1 https://math.mit.edu/~gs/linearalgebra/
2 https://www.coursera.org/learn/probability-theory-statistics
3 https://nptel.ac.in/courses/111/105/111105090/
4 https://onlinecourses.nptel.ac.in/noc21_ma01/preview
5 https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/video-lectures/

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.

2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning: Sem VI								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC601	**Game Theory using AI & ML**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC601	**Game Theory using AI & ML**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Knowledge of probability theory, discrete mathematics, and algorithm design is required.	
Course Objectives:	
1	To acquire the knowledge of game theory.
2	To understand the basic concept of AI, strength and weakness of problem solving and search
3	To study about various heuristic and game search algorithms
4	To optimize the different linear methods of regression and classification
5	To interpret the different supervised classification methods of support vector machine.
6	To acquire the knowledge of different generative models through unsupervised learning
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Understand basic concept of game theory.
2	Evaluate Artificial Intelligence (AI) methods and describe their foundations
3	Analyze and illustrate how search algorithms play vital role in problem solving, inference, perception, knowledge representation and learning
4	Demonstrate knowledge of reasoning and knowledge representation for solving real world problems
5	Recognize the characteristics of machine learning that makes it useful to realworld problems and apply different dimensionality reduction techniques
6	Apply the different supervised learning methods of support vector machine and tree based models

Module No.		**Topics**	**Hours.**
1.0		**Introduction to Game Theory**	**05**
	1.1	Introduction, The theory of rational choice, Games with Perfect Information, Nash Equilibrium: Theory, Prisoner's Dilemma, Stag Hunt, Matching pennies, BOS, Multi NE, Cooperative and Competitive Games, Strict and Non Strict NE, Best response functions for NE.	
	1.2	Nash Equilibrium: Illustrations, Cournot's model of oligopoly, Bertrand's model of oligopoly, Electoral competition, The War of Attrition, Auctions, Mixed Strategy Equilibrium, Strategic games in which players may randomize, Dominated actions, Extensive Games with Perfect Information	

2.0		**Games with Imperfect Information**	**09**
	2.1	Bayesian Games, Introduction, Motivational examples, General definitions, two examples concerning information, Strictly Competitive Games and Maxminimization, Rationalizability	
	2.2	Evolutionary Equilibrium, Monomorphic pure strategy equilibrium, Mixed strategies and polymorphic equilibrium, Repeated games: The Prisoner's Dilemma, Infinitely repeated games, Strategies, General Results,	
3.0		**Introduction to AI & Problem Solving**	**10**
	3.1	**Definitions** – Foundation and History of AI, Evolution of AI - Applications of AI, Classification of AI systems with respect to environment. Artificial Intelligence vs Machine learning,	
	3.2	**Heuristic Search Techniques:** Generate-and-Test; Hill Climbing; Properties of A* algorithm, Best first Search; Problem Reduction.	
	3.3	**Beyond Classical Search:** Local search algorithms and optimization problem, local search in continuous spaces, searching with nondeterministic action and partial observation, online search agent and unknown environments	
4.0		**Knowledge and Reasoning**	**09**
	4.1	**Knowledge and Reasoning:** Building a Knowledge Base: Propositional logic, first order Logic, situation calculus. Theorem Proving in First Order Logic, Planning, partial order planning. Uncertain Knowledge and Reasoning, Probabilities,	
	4.2	Bayesian Networks. Probabilistic reasoning over time: time and uncertainty, hidden Markova models, Kalman filter, dynamic bayesian network, keeping track of many objects	
5.0		**Introduction to ML**	**10**
	5.1	Introduction to Machine Learning, Examples of Machine Learning Applications, Learning Types, **Supervised Learning** -Learning a Class from Examples, Vapnik- Chervonenkis (VC) Dimension, Probably Approximately Correct (PAC) Learning, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization, Dimensions of a Supervised Machine Learning Algorithm	
	5.2	Introduction, Linear Regression Models and Least Squares, Subset Selection, Shrinkage Methods, **Logistic Regression-** Fitting Logistic Regression Models, Quadratic Approximations and Inference, L1 Regularized Logistic Regression, **SVM**-Introduction to SVM, The Support Vector Classifier, Support Vector Machines and Kernels- Computing the SVM for Classification	
6.0		**Unsupervised Learning**	**05**
	6.1	Introduction, Association Rules-Market Basket Analysis, The Apriori Algorithm, Unsupervised as Supervised Learning, Generalized Association Rules, Cluster Analysis Proximity Matrices, **Clustering Algorithms**-K-mean, Gaussian Mixtures as Soft K-means Clustering, Example: Human Tumor Microarray Data, Vector Quantization, K-medoids, Hierarchical Clustering, Self-Organizing Maps, PCA-Spectral Clustering	
	6.2	**Hidden Markov Models**-Introduction, Discrete Markov Processes, Hidden Markov Models, Three Basic Problems of HMMs, Evaluation Problem, Finding the State Sequence, Learning Model Parameters, Continuous Observations, The HMM with Input, Model Selection in HMM	
		Total	**48**

Text Books:

1 Martin Osborne, An Introduction to Game Theory, Oxford University Press.
2 Russell, S. and Norvig, P. 2015. Artificial Intelligence - A Modern Approach, 3rd edition,Prentice Hall
3 Introduction to Machine Learning Edition 2, by Ethem Alpaydin

References:

1 Thomas Ferguson, Game Theory, World Scientific, 2018.
2 Stef Tijs. Introduction to Game Theory, Hindustan Book Agency
3 J. Gabriel, Artificial Intelligence: Artificial Intelligence for Humans (Artificial Intelligence, Machine Learning), Create Space Independent Publishing Platform, First edition , 2016
4 Introduction to Artificial Intelligence & Expert Systems, Dan W Patterson, PHI.,2010 2. S Kaushik, Artificial Intelligence, Cengage Learning, 1st ed.2011
5 Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.
2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning: Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC701	**AI&ML in Healthcare**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC701	**AI&ML in Healthcare**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Artificial Intelligence, Machine Learning	
Course Objectives: The course aims	
1	To understand the need and significance of AI and ML for Healthcare.
2	To study advanced AI algorithms for Healthcare.
3	To learn Computational Intelligence techniques .
4	To understand evaluation metrics and ethics in intelligence for Healthcare systems,
5	To learn various NLP algorithms and their application in Healthcare,
6	To investigate the current scope, implications of AI and ML for developing futuristic Healthcare Applications.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Understand the role of AI and ML for handling Healthcare data.
2	Apply Advanced AI algorithms for Healthcare Problems.
3	Learn and Apply various Computational Intelligence techniques for Healthcare Application.
4	Use evaluation metrics for evaluating healthcare systems.
5	Develop NLP applications for healthcare using various NLP Techniques..
6	Apply AI and ML algorithms for building Healthcare Applications

Module		**Topics**	**Hours.**
1.0		**Introduction**	**04**
	1.1	Overview of AI and ML,A Multifaceted Discipline, Applications of AI in Healthcare - Prediction, Diagnosis, personalized treatment and behavior modification, drug discovery, followup care etc,	
	1.2	Realizing potential of AI and ML in healthcare, Healthcare Data - Use Cases.	
2.0		**AI, ML, Deep Learning and Data Mining Methods for Healthcare**	10
	2.1	Knowledge discovery and Data Mining, ML, Multi classifier Decision Fusion, Ensemble Learning, Meta-Learning and other Abstract Methods.	
	2.2	Evolutionary Algorithms, Illustrative Medical Application-Multiagent Infectious Disease Propagation and Outbreak Prediction, Automated Amblyopia Screening System etc.	
	2.3	Computational Intelligence Techniques, Deep Learning, Unsupervised learning, dimensionality reduction algorithms.	

3.0		**Evaluating learning for Intelligence**	06
	3.1	Model development and workflow, evaluation metrics, Parameters and Hyperparameters, Hyperparameter tuning algorithms, multivariate testing, Ethics of Intelligence.	
4.0		**Natural Language Processing in Healthcare**	**08**
	4.1	NLP tasks in Medicine, Low-level NLP components, High level NLP components, NLP Methods.	
	4.2	Clinical NLP resources and Tools, NLP Applications in Healthcare. Model Interpretability using Explainable AI for NLP applications.	
5.0		**Intelligent personal Health Record**	**04**
	5.1	Introduction, Guided Search for Disease Information, Recommending SCA's. Recommending HHP's , Continuous User Monitoring.	
6.0		**Future of Healthcare using AI and ML**	**07**
	6.1	Evidence based medicine, Personalized Medicine, Connected Medicine, Digital Health and Therapeutics, Conversational AI, Virtual and Augmented Reality, Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	
	6.2	Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	
		Total	**48**

Textbooks:

1 Arjun Panesar, "Machine Learning and AI for Healthcare", A Press.

2 Arvin Agah, "Medical applications of Artificial Systems ", CRC Press

References:

1 Erik R. Ranschaert Sergey Morozov Paul R. Algra, "Artificial Intelligence in medical Imaging-Opportunities, Applications and Risks", Springer

2 Sergio Consoli Diego Reforgiato Recupero Milan Petković,"Data Science for Healthcare-Methodologies and Applications", Springer

3 Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, "Emerging technologies for health and medicine", Wiley.

4 Ton J. Cleophas • Aeilko H. Zwinderman, "Machine Learning in Medicine- Complete Overview", Springer

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.

2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.

3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.

2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.

3 Remaining questions will be mixed in nature and randomly selected from all the modules.

4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning: Sem VIII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC801	**Text, Web and Social Media Analytics**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC801	**Text, Web and Social Media Analytics**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Python, Data Mining	
Course Objectives: The course aims	
1	To have a strong foundation on text, web and social media analytics.
2	To understand the complexities of extracting the text from different data sources and analysing it.
3	To enable students to solve complex real-world problems using sentiment analysis and Recommendation systems.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Extract Information from the text and perform data pre-processing
2	Apply clustering and classification algorithms on textual data and perform prediction.
3	Apply various web mining techniques to perform mining, searching and spamming of web data.
4	Provide solutions to the emerging problems with social media using behaviour analytics and Recommendation systems.
5	Apply machine learning techniques to perform Sentiment Analysis on data from social media.

Module		**Topics**	**Hours.**
1.0		**Introduction**	**06**
	1.1	**Introduction to Text Mining:** Introduction, Algorithms for Text Mining, Future Directions	
	1.2	**Information Extraction from Text**: Named Entity Recognition, Relation Extraction, Unsupervised Information Extraction	
	1.3	**Text Representation:** tokenization, stemming, stop words, NER, N-gram modelling	
2.0		Clustering and Classification	10

	2.1	**Text Clustering**: Feature Selection and Transformation Methods, distance based Clustering Algorithms, Word and Phrase based Clustering, Probabilistic document Clustering	
	2.2	**Text Classification**: Feature Selection, Decision tree Classifiers, Rule-based Classifiers, Probabilistic based Classifiers, Proximity based Classifiers.	
	2.3	**Text Modelling:** Bayesian Networks, Hidden Markovian Models, Markov random Fields, Conditional Random Fields	
3.0		**Web-Mining:**	05
	3.1	**Introduction to Web-Mining:** Inverted indices and Compression, Latent Semantic Indexing, Web Search,	
	3.2	**Meta Search:** Using Similarity Scores, Rank Positons	
	3.3	**Web Spamming**: Content Spamming, Link Spamming, hiding Techniques, and Combating Spam	
4.0		**Web Usage Mining:**	**05**
	4.1	Data Collection and Pre-processing, Sources and types of Data, Data Modelling, Session and Visitor Analysis, Cluster Analysis and Visitor segmentation, Association and Correlation Analysis, Analysis of Sequential and Navigational Patterns, Classification and Prediction based on Web User Transactions.	
5.0		**Social Media Mining**:	**05**
	5.1	Introduction, Challenges, Types of social Network Graphs	
	5.2	Mining Social Media: Influence and Homophily, Behaviour Analytics, Recommendation in Social Media: Challenges, Classical recommendation Algorithms, Recommendation using Social Context, Evaluating recommendations.	
6.0		**Opinion Mining and Sentiment Analysis**:	**08**
	6.1	The problem of opinion mining,	
	6.2	**Document Sentiment Classification**: Supervised, Unsupervised	
	6.3	**Opinion Lexicon Expansion:** Dictionary based, Corpus based	
	6.4	**Opinion Spam Detection**: Supervised Learning, Abnormal Behaviours, Group Spam Detection.	
		Total	**48**

Textbooks:

1 Daniel Jurafsky and James H. Martin, “Speech and Language Processing,” 3rd edition, 2020
2 Charu. C. Aggarwal, Cheng Xiang Zhai, Mining Text Data, Springer Science and Business Media, 2012.
3 BingLiu, “Web Data Mining-Exploring Hyperlinks, Contents, and Usage Data”, Springer, Second Edition, 2011.

4 Reza Zafarani, Mohammad Ali Abbasiand Huan Liu, “Social Media Mining- An Introduction”, Cambridge University Press, 2014

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.
2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning:Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLSBL701	**AI&ML in Healthcare: Lab**	**--**	**04**	**--**	**--**	**02**	**--**	**02**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLSBL701	**AI&ML in Healthcare: Lab**						**50**	**50**	**100**

Course Prerequisites:	
Python	
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Students will be able to understand computational models of AI and ML.
2	Students will be able to develop healthcare applications using appropriate computational tools.
3	Students will be able to apply appropriate models to solve specific healthcare problems.
4	Students will be able to analyze and justify the performance of specific models as applied to healthcare problems.
5	Students will be able to design and implement AI and ML-based healthcare applications.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Collect, Clean, Integrate and Transform Healthcare Data based on specific disease.
2	Perform Exploratory data analysis of Healthcare Data.
3	AI for medical diagnosis based on MRI/X-ray data.
4	AI for medical prognosis .
5	Natural language Entity Extraction from medical reports.
6	Predict disease risk from Patient data.
7	Medical Reviews Analysis from social media data.
8	Explainable AI in healthcare for model interpretation.
9	Mini Project-Design and implement innovative web/mobile based AI application using Healthcare Data.

10	Documentation and Presentation of Mini Project.

Useful Links:

1. https://www.coursera.org/learn/introduction-tensorflow?specialization=tensorflow-in-practice
2. https://www.coursera.org/learn/convolutional-neural-networks-tensorflow?specialization=tensorflow-in-practice
3. https://datarade.ai/data-categories/electronic-health-record-ehr-data
4. https://www.cms.gov/Medicare/E-Health/EHealthRecords
5. https://www.coursera.org/learn/tensorflow-sequences-time-series-and-prediction?specialization=tensorflow-in-practice

Term Work:

1. Term work should consist of 8 experiments and a Mini Project.
2. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3. Total 25 Marks (Experiments: 10-Marks, Mini Project-10 Marks, Attendance Theory & Practical: 05-marks)

Oral & Practical exam

1. Based on the entire syllabus of **AI ML for Healthcare**

UNIVERSITY OF MUMBAI

Syllabus for

Honours/Minor Degree Program

In

Data Science

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Data Science (With effect from 2022-23)										
Year & Sem	Course Code & Course Title	Teaching Scheme Hrs / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar / Tutorial	Practical	Internal Assessment	End Sem Exam	Term Work	Oral / Practical	Total	Credits
TE Sem V	HDSC501: Mathematics for Data Science	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**	**-**	**-**	**100**	**04**	
Total Credits = 04										
TE Sem VI	HDSC601: Statistical Learning for Data Science	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**	**-**	**-**	**100**	**04**	
Total Credits = 04										
BE Sem VII	HDSC701: Data Science for Health and Social Care	04	--	--	20	80	--	--	100	04
	HDSSBL701: Data Science for Health and Social Care: Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
Total Credits = 06										
BE Sem VIII	HDSC801: Text, Web and Social Media Analytics	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Data Science: Sem V								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSC501	**Mathematics for Data Science**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSC501	**Mathematics for Data Science**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
1	Applied Mathematics, Discrete Mathematics
Course Objectives:	
1	To build an intuitive understanding of Mathematics and relating it to Data Analytics.
2	To provide a strong foundation for probabilistic and statistical analysis mostly used in varied applications in Engineering.
3	To focus on exploring the data with the help of graphical representation and drawing conclusions.
4	To explore optimization and dimensionality reduction techniques.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Use linear algebra concepts to model, solve, and analyze real-world problems.
2	Apply probability distributions and sampling distributions to various business problems.
3	Select an appropriate graph representation for the given data analysis.
4	Apply exploratory data analysis to some real data sets and provide interpretations via relevant visualization
5	Analyze various optimization techniques for data analysis.
6	Describe Dimension Reduction Algorithms in analytics

Module		**Topics**	**Hours.**
1.0		**Linear Algebra**	**05**
	1.1	Vectors and Matrices, Solving Linear equations, The four Fundamental Subspaces, Eigenvalues and Eigen Vectors, The Singular Value Decomposition (SVD).	
2.0		**Probability and Statistics**	**09**
	2.1	Introduction, Random Variables and their probability Distribution, Random Sampling, Sample Characteristics and their Distributions, Chi-Square, t-, and F-Distributions: Exact Sampling Distributions, Sampling from a Bivariate Normal Distribution, The Central Limit Theorem.	
3.0		**Introduction to Graphs**	**10**

	3.1	Quantitative vs. Qualitative data, Types of Quantitative data: Continuous data, Discrete data, Types of Qualitative data: Categorical data, Binary data, Ordinary data, Plotting data using Bar graph, Pie chart, Histogram, Stem and Leaf plot, Dot plot, Scatter plot, Time-series graph, Exponential graph, Logarithmic graph, Trigonometric graph, Frequency distribution graph.	
4.0		**Exploratory Data Analysis**	**09**
	4.1	Need of exploratory data analysis, cleaning and preparing data, Feature engineering, Missing values, understand dataset through various plots and graphs, draw conclusions, deciding appropriate machine learning models.	
5.0		**Optimization Techniques**	**10**
	5.1	Types of optimization-Constrained and Unconstrained optimization, Methods of Optimization-Numerical Optimization, Bracketing Methods-Bisection Method, False Position Method, Newton's Method, Steepest Descent Method, Penalty Function Method.	
6.0		**Dimension Reduction Algorithms**	**05**
	6.1	Introduction to Dimension Reduction Algorithms, Linear Dimensionality Reduction: Principal component analysis, Factor Analysis, Linear discriminant analysis.	
	6.2	Non-Linear Dimensionality Reduction: Multidimensional Scaling, Isometric Feature Mapping. Minimal polynomial	
		Total	**48**

Text Books:

1 Linear Algebra for Everyone,
2 Gilbert Strang, Wellesley Cambridge Press.
3 An Introduction to Probability and Statistics, Vijay Rohatgi, Wiley Publication
4 An introduction to Optimization, Second Edition, Wiley-Edwin Chong, Stainslaw Zak.
5 Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Cambridge University Press.
6 Exploratory Data Analysis, John Tukey, Princeton University and Bell Laboratories.

References:

1 Introduction to Linear Algebra, Gilbert Strang.
2 Advanced Engineering Mathematics, Erwin Kreyszig
3 Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. Foundations of Machine Learning. MIT Press, 2018.
4 Shai Shalev-Shwartz and Shai Ben-David. Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press, 2014
5 Last updated on Sep 9, 2018.
6 Mathematics and Programming for Machine Learning with R, William B. Claster, CRC Press,2020

Useful Links:

1 https://math.mit.edu/~gs/linearalgebra/
2 https://www.coursera.org/learn/probability-theory-statistics
3 https://nptel.ac.in/courses/111/105/111105090/
4 https://onlinecourses.nptel.ac.in/noc21_ma01/preview
5 https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/video-lectures/

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.

2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Data Science: Sem VI								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HDSC601	Statistical Learning for Data Science	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme							
		Theory Marks				Exam Duration	Term Work	Practical and Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test1	Test2	Avg.					
HDSC601	Statistical Learning for Data Science	20	20	20	80	03	--	--	100

Course Prerequisites:	
1	Engineering Mathematics, Probability and Statistics
Course Objectives:	
1	To understand basic statistical foundations for roles of Data Scientist.
2	To develop problem-solving skills.
3	To infer about the population parameters using sample data and perform hypothesis testing.
4	To understand importance and techniques of predicting a relationship between data and determine the goodness of model fit.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Develop various visualizations of the data in hand.
2	Analyze a real-world problem and solve it with the knowledge gained from sampling and probability distributions.
3	Analyze large data sets and perform data analysis to extract meaningful insights.
4	Develop and test a hypothesis about the population parameters to draw meaningful conclusions.
5	Fit a regression model to data and use it for prediction.

Module No.		Topics	Hours.
1.0		**Introduction**	08
	1.1	**Data and Statistics**: Elements, Variables, and Observations, Scales of Measurement, Categorical and Quantitative Data, Cross-Sectional and Time Series Data, Descriptive Statistics, Statistical Inference, Descriptive Statistics: Tabular and Graphical Summarizing Categorical Data, Summarizing Quantitative Data, Cross Tabulations and Scatter Diagram.	
	1.2	**Descriptive Statistics: Numerical Measures**: Measures of Location, Measures of Variability, Measures of Distribution Shape, Relative Location, and Detecting Outliers, Box Plot, Measures of Association Between Two Variables	

2.0		**Probability**	**08**
	2.1	**Probability :** Experiments, Counting Rules, and Assigning Probabilities, Events and Their Probabilities, Complement of an Event, Addition Law Independent Events, Multiplication Law, Baye's theorem	
	2.2	**Discrete Probability Distributions** Random Variables, Discrete Probability Distributions, Expected Value and Variance, Binomial Probability Distribution, Poisson Probability Distribution	
	2.3	**Continuous Probability Distributions:** Uniform Probability Distribution, Normal Curve, Standard Normal Probability Distribution, Computing Probabilities for Any Normal Probability Distribution	
3.0		**Sampling and Sampling Distributions**	05
	3.1	Sampling from a Finite Population, Sampling from an Infinite Population, Other Sampling Methods, Stratified Random Sampling, Cluster Sampling, Systematic Sampling, Convenience Sampling, Judgment Sampling	
	3.2	Interval Estimation: Population Mean: Known, Population Mean: Unknown, Determining the Sample Size, Population Proportion	
4.0		**Hypothesis Tests**	**05**
	4.1	Developing Null and Alternative Hypotheses, Type I and Type II Errors, Population Mean: Known Population Mean: Unknown Inference About Means and Proportions with Two Populations-Inferences About Population Variances, Inferences About a Population Variance, Inferences About Two Population Variances	
	4.2	Tests of Goodness of Fit and Independence, Goodness of Fit Test: A Multinomial Population, Test of Independence	
5.0		**Regression**	**08**
	5.1	**Simple Linear Regression:** Simple Linear Regression Model, Regression Model and Regression Equation, Estimated Regression Equation, Least Squares Method, Coefficient of Determination, Correlation Coefficient, Model Assumptions, testing for Significance, Using the Estimated Regression Equation for Estimation and Prediction Residual Analysis: Validating Model Assumptions, Residual Analysis: Outliers and Influential Observations	
	5.2	**Multiple Regression:** Multiple Regression Model, Least Squares Method, Multiple Coefficient of Determination, Model Assumptions, Testing for Significance, Categorical Independent Variables, Residual Analysis	
6.0		**Time Series Analysis and Forecasting**	**05**
	6.1	Time Series Patterns, Forecast Accuracy, Moving Averages and Exponential Smoothing, Trend Projection, Seasonality and Trend and Time Series Decomposition	
	6.2	**Nonparametric Methods** Sign Test, Wilcoxon Signed-Rank Test, Mann-Whitney-Wilcoxon Test, Kruskal-Wallis Test, Rank Correlation	
		Total	**48**

Text Books:

1. https://static1.squarespace.com/static/5ff2adbe3fe4fe33db902812/t/6009dd9fa7bc363aa822d2c7/1611259312432/ISLR+Seventh+Printing.pdf
2. Data Science from Scratch, FIRST PRINCIPLES WITH PYTHON, O'Reilly, Joel Grus,
3. Data Science from Scratch (oreillystatic.com)
4. Practical Time Series Analysis, Prediction with statistics and Machine Learning, O'Reilly, Aileen Nielsen [DOWNLOAD] O'Reilly Practical Time Series Analysis PDF (lunaticai.com)
5. R for data science: Import, Tidy, Transform, Visualize, And Model Data, O'Reilly , Garrett Grolemund, Hadley Wickham
6. Python for Data Analysis, 2nd Edition, O'Reilly Media, Wes McKinney.
7. https://static1.squarespace.com/static/5ff2adbe3fe4fe33db902812/t/6009dd9fa7bc363aa822d2c7/1611259312432/ISLR+Seventh+Printing.pdf

References:

1. Data Science for Dummies Paperback, Wiley Publications, Lillian Pierson
2. Storytelling with Data: A Data Visualization, Guide for Business Professionals, Wiley Publications, Cole Nussbaumer Knaflic
3. Probability and Statistics for Engineering and the Sciences, Cengage Publications Jay L. Devore.

Assessment:

Internal Assessment: (20)

1. Assessment consists of two class tests of 20 marks each.
2. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3. Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1. Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2. **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3. Remaining questions will be mixed in nature and randomly selected from all the modules.
4. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5. **Total 04 questions** need to be solved.

Data Science: Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSC701	**Data Science for Health and Social Care**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSC701	**Data Science for Health and Social Care**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Artificial Intelligence, Machine Learning	
Course Objectives: The course aims	
1	To gain perspective of Data Science for Health and Social Care.
2	To understand different techniques of Biomedical Image Analysis.
3	To learn NLP techniques for processing Clinical text.
4	To understand the role of social media analytics for Healthcare data .
5	To learn advanced analytics techniques for Healthcare Data.
6	To investigate the current scope, potential, limitations, and implications of data science and its applications for healthcare.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Identify sources and structure of healthcare data.
2	Apply structured lifecycle approach for handling Healthcare data science projects.
3	Analyze the data, create models, and identify insights from Healthcare data.
4	Apply various data analysis and visualization techniques for Healthcare and social media data.
5	Apply various algorithms and develop models for Healthcare data science projects.
6	To Provide data science solutions for solving problems of Health and Social Care.

Module		**Topics**	**Hours.**
1.0		**Data Science for Healthcare**	**05**
	1.1	Introduction, Healthcare Data Sources and Data Analytics for Healthcare, Applications and Practical Systems for Healthcare.	
	1.2	Electronic Health Records(EHR), Components of EHR, Benefits of EHR, Barriers to Adopting EHR, Challenges of using EHR data, Phenotyping Algorithms	
2.0		**Biomedical Image Analysis**	06
	2.1	Biomedical Imaging Modalities, Object detection ,Image segmentation, Image Registration, Feature Extraction	
	2.2	Mining of Sensor data in Healthcare, Challenges in Healthcare Data Analysis	
	2.3	Biomedical Signal Analysis, Genomic Data Analysis for Personalized Medicine.	

3.0		**Data Science and Natural Language Processing for Clinical Text**	06
	3.1	NLP, Mining information from Clinical Text, Information Extraction, Rule Based Approaches, Pattern based algorithms, Machine Learning Algorithms.	
	3.2	Clinical Text Corpora and evaluation metrics, challenges in processing clinical reports, Clinical Applications.	
4.0		**Social Media Analytics for Healthcare**	**06**
	4.1	Social Media analysis for detection and tracking of Infectious Disease outbreaks.	
	4.2	Outbreak detection, Social Media Analysis for Public Health Research, Analysis of Social Media Use in Healthcare.	
5.0		**Advanced Data Analytics for Healthcare**	**08**
	5.1	Review of Clinical Prediction Models, Temporal Data Mining for Healthcare Data	
	5.2	Visual Analytics for Healthcare Data, Information Retrieval for Healthcare- Data Publishing Methods in Healthcare.	
6.0		**Data Science Practical Systems for Healthcare**	**08**
	6.1	Data Analytics for Pervasive Health, Fraud Detection in Healthcare	
	6.2	Data Analytics for Pharmaceutical discoveries, Clinical Decision Support Systems	
	6.3	Computer-Assisted Medical Image Analysis Systems- Mobile Imaging and Analytics for Biomedical Data.	
		Total	**48**

Textbooks:

1 Chandan K. Reddy and Charu C Aggarwal, “Healthcare data analytics”, Taylor & Francis, 2015.
2 Hui Yang and Eva K. Lee, “Healthcare Analytics: From Data to Knowledge to Healthcare Improvement, Wiley, 2016.

References:

1 Madsen, L. B. (2015). Data-driven healthcare: how analytics and BI are transforming the industry. Wiley India Private Limited
2 Strome, T. L., & Liefer, A. (2013). Healthcare analytics for quality and performance improvement. Hoboken, NJ, USA: Wiley
3 McNeill, D., & Davenport, T. H. (2013). Analytics in Healthcare and the Life Sciences: Strategies, Implementation Methods, and Best Practices. Pearson Education.
4 Rachel Schutt and Cathy O’Neil, “Doing Data Science”, O’Reilly Media
5 Joel Grus, Data Science from Scratch: First Principles with Python, O'Reilly Media
6 EMC Education Services,”Data Science and Big Data Analytics”,Wiley

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.
2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.

4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

5 **Total 04 questions** need to be solved.

Data Science: Sem VIII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSC801	**Text, Web and Social Media Analytics**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSC801	**Text, Web and Social Media Analytics**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Python, Data Mining	
Course Objectives: The course aims	
1	To have a strong foundation on text, web and social media analytics.
2	To understand the complexities of extracting the text from different data sources and analysing it.
3	To enable students to solve complex real-world problems using sentiment analysis and Recommendation systems.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Extract Information from the text and perform data pre-processing
2	Apply clustering and classification algorithms on textual data and perform prediction.
3	Apply various web mining techniques to perform mining, searching and spamming of web data.
4	Provide solutions to the emerging problems with social media using behaviour analytics and Recommendation systems.
5	Apply machine learning techniques to perform Sentiment Analysis on data from social media.

Module No.		**Topics**	**Hours.**
1.0		**Introduction**	**06**
	1.1	**Introduction to Text Mining:** Introduction, Algorithms for Text Mining, Future Directions	
	1.2	**Information Extraction from Text**: Named Entity Recognition, Relation Extraction, Unsupervised Information Extraction	
	1.3	**Text Representation:** tokenization, stemming, stop words, NER, N-gram modelling	
2.0		Clustering and Classification	10

	2.1	**Text Clustering**: Feature Selection and Transformation Methods, distance based Clustering Algorithms, Word and Phrase based Clustering, Probabilistic document Clustering	
	2.2	**Text Classification**: Feature Selection, Decision tree Classifiers, Rule-based Classifiers, Probabilistic based Classifiers, Proximity based Classifiers.	
	2.3	**Text Modelling:** Bayesian Networks, Hidden Markovian Models, Markov random Fields, Conditional Random Fields	
3.0		**Web-Mining:**	05
	3.1	**Introduction to Web-Mining:** Inverted indices and Compression, Latent Semantic Indexing, Web Search,	
	3.2	**Meta Search:** Using Similarity Scores, Rank Positons	
	3.3	**Web Spamming**: Content Spamming, Link Spamming, hiding Techniques, and Combating Spam	
4.0		**Web Usage Mining:**	**05**
	4.1	Data Collection and Pre-processing, Sources and types of Data, Data Modelling, Session and Visitor Analysis, Cluster Analysis and Visitor segmentation, Association and Correlation Analysis, Analysis of Sequential and Navigational Patterns, Classification and Prediction based on Web User Transactions.	
5.0		**Social Media Mining**:	**05**
	5.1	Introduction, Challenges, Types of social Network Graphs	
	5.2	Mining Social Media: Influence and Homophily, Behaviour Analytics, Recommendation in Social Media: Challenges, Classical recommendation Algorithms, Recommendation using Social Context, Evaluating recommendations.	
6.0		**Opinion Mining and Sentiment Analysis**:	**08**
	6.1	The problem of opinion mining,	
	6.2	**Document Sentiment Classification**: Supervised, Unsupervised	
	6.3	**Opinion Lexicon Expansion:** Dictionary based, Corpus based	
	6.4	**Opinion Spam Detection**: Supervised Learning, Abnormal Behaviours, Group Spam Detection.	
		Total	**48**

Textbooks:

1 Daniel Jurafsky and James H. Martin, “Speech and Language Processing,” 3rd edition, 2020
2 Charu. C. Aggarwal, Cheng Xiang Zhai, Mining Text Data, Springer Science and Business Media, 2012.
3 BingLiu, “Web Data Mining-Exploring Hyperlinks, Contents, and Usage Data”, Springer, Second Edition, 2011.

4 Reza Zafarani, Mohammad Ali Abbasiand Huan Liu, “Social Media Mining- An Introduction”, Cambridge University Press, 2014

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.
2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Data Science: Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSSBL701	**Data Science for Health and Social Care: Lab**	**--**	**04**	**--**	**--**	**02**	**--**	**02**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSSBL701	**Data Science for Health and Social Care: Lab**						**50**	**50**	**100**

Course Prerequisites:	
Python	
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Students will be able to, Identify sources of data, suggest methods for collecting, sharing and analyzing Healthcare data.
2	Students will be able to Clean, integrate and transform healthcare data.
3	Students will be able to apply various data analysis and visualization techniques on healthcare data.
4	Students will be able to apply various algorithms and develop models for healthcare data Analytics .
5	Students will be able to implement data science solutions for solving healthcare problems.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
	Introduction
1	Clean, Integrate and Transform Electronic Healthcare Records.
2	Apply various data analysis and visualization techniques on EHR.
3	Bio Medical Image Preprocessing, Segmentation.
4	Bio Medical Image Analytics.
5	Text Analytics for Clinical Text Data.
6	Diagnose disease risk from Patient data.
7	Social Media Analytics for outbreak prediction/ Drug review analytics.
8	Visual Analytics for Healthcare Data.

9	Implement an innovative Data Science application based on Healthcare Data.
10	Documentation and Presentation of Mini Project.

Useful Links:

1 http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=MachineLearning
2 http://www.cse.wustl.edu/~kilian/cse517a2010/
3 https://datarade.ai/data-categories/electronic-health-record-ehr-data
4 https://www.cms.gov/Medicare/E-Health/EHealthRecords
5 https://onlinecourses.nptel.ac.in/noc20_ee40

Term Work:

1 Term work should consist of 8 experiments and a Mini Project.
2 The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3 Total 25 Marks (Experiments: 10-Marks, Mini Project-10 Marks, Attendance Theory & Practical: 05-marks)

Oral & Practical exam

1 Based on the entire syllabus of **AI ML for Healthcare**

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Internet of Things

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023

University of Mumbai
Internet of Things
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HIoTC501: IoT Sensor Technologies**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HIoTC601: IoT System Design**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HIoTC701: Dynamic Paradigm in IoT**	04	--	--	20	80	--	--	100	04
	HIoTSBL601: Interfacing & Programming with IoTLab (SBL)	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HIoTC801: Industrial IoT**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Internet of Things: Sem V								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HIoTC501	**IoT Sensor Technologies**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg**					
HIoTC501	**IoT Sensor Technologies**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To provide in depth knowledge about the sensing mechanism.
2	To make students understand about the use of sensors in design of IoT based systems.
3	To familiarize students various types of sensors used to measure the physical quantities.
4	To develop reasonable level of competence in the design, construction and development of sensor suitable to the system requirements.
5	To Introduce students the current state of the art in sensor technology.
6	To familiarize students with electronics used to interface with sensors.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Understand the sensing mechanism and structural details of sensors.	L1, L2
2	Explain principles and working of the sensors.	L1,L2
3	Evaluate the performance of various types of sensors.	L5
4	Select the sensor suitable to system requirements.	L5
5	Interface the sensors with microcontrollers and Arduino	L6
6	Understand the current state of the art in sensor technology.	L2

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**

0	**Prerequisite**	1. Basics of Electrical and Electronics Engineering 2. Applied Mechanics 3. Applied Physics, Applied Chemistry	2	CO 1, CO2, CO3, CO4, CO5
I	**Sensor Fundamentals and Properties**	**Sensor Fundamentals and Properties:** Introduction to IoT, Need for sensors in IoT, Data Acquisition – sensor characteristics – electric charges, fields, potentials – capacitance – magnetism – inductance – resistance – piezoelectric – pyroelectric – Hall effect thermoelectric effects – sound waves – heat transfer – light – dynamic models of sensors. Need of actuators, all types of actuators and their working. Identification of sensor and actuator for real-time application **Self-learning Topics: IoT Systems, Transfer function and modelling of sensors**	**8**	CO1, CO2
II	**Optical, radiation and Displacement sensors**	**Optical, radiation and Displacement sensors** Photosensors: Photodiode, phototransistor and photo resistor, imaging sensors, UV detectors, Basic Characteristics of radiation sensors, Thermal infrared sensors, X-ray and Nuclear Radiation Sensors, Fibre Optic Sensors, Capacitive and Inductive Displacement Sensor, Electromagnetism and Inductance, Magnetic Field Sensors **Self-learning Topics: Optical sources and detectors, Sensors based on polymer optical fibers, Micro-structured and solid fibers**	**8**	CO1, CO2, CO3, CO4
III	**Presence, force, Pressure, Flow Sensors**	**Presence, force, Pressure, Flow Sensors** Potentiometric Sensors, Piezoresistive Sensors, Capacitive Sensors for presence, Inductive and Magnetic Sensors, Strain gages, Pressure sensitive films, piezoelectric force sensor, Piezoelectric Cables, Concept of Pressure, Mercury Pressure Sensor, Bellows, Membranes, and Thin Plates, Piezo resistive Sensors, Capacitive Sensors, VRP Sensors, Optoelectronic Pressure Sensors, Indirect Pressure Sensor, Vacuum Sensors, Basics of Flow Dynamics, Pressure Gradient Technique, Thermal Transport Sensors, Ultrasonic Sensors, Level Sensors **Self-learning Topics: Vibration energy harvesting with Piezoelectric, MEMS systems. Develop a sensor system for force measurement using piezoelectric transducer. Develop** Resistance Temperature Detector	**9**	CO1, CO2, CO3, CO4
IV	**Humidity, Moisture Chemical and Biological Sensors**	**Humidity, Moisture Chemical and Biological Sensors** Microphones: Characteristics, Resistive, condenser, Electret, Optical, Pizoelectric, Dynamic, Concept of humidity, Capacitive Humidity Sensors, Resistive Humidity Sensors, Thermal Conductivity Sensors, Optical Hygrometers, Oscillating Hygrometer, Soil Moisture	**8**	CO1, CO2, CO3, CO4, CO5

		Chemical Sensor Characteristics, Electrical and Electrochemical Sensors, Photoionization Detectors, Physical Transducers, Spectrometers, Thermal Sensors, Optical Transducers, Multi-sensor Arrays Artificial Microsystems for Sensing Airflow, Temperature, and Humidity by Combining MEMS and CMOS Technologies **Self-learning Topics: Biosensors for biomedical applications**		
V	**Interface Electronic Circuits**	**Interface Electronic Circuits** Introduction, Signal Conditioners, Sensor Connections, Excitation Circuits, Analog to Digital Converters, Integrated Interfaces, Data Transmission, Noise in Sensors and Circuits, Batteries for Low-Power Sensors, Types of Single board computers, various sensor interfacing with Arduino, Embedded C Programming. data communication protocol interfacing, study the properties of LDR, Build a simple LED light intensity controller, Linux on Raspberry Pi, Interfaces, and Programming. **Self-learning Topics: Python Programming to interface sensors**	**8**	CO1, CO2, CO5
VI	**Current Trends in sensors and Technology**	**Current Trends in sensors and Technology** Smart Sensors: Introduction, Primary sensors, Excitation, Amplification, Filters, Converters, Compensation, Information Coding/Processing, Data Communication, Standards for Smart Sensor Interface, The Automation Sensor Technologies: Introduction, Film Sensors, Thick Film Sensors, Thin Film Sensors, Semiconductor IC Technology—Standard Methods, Microelectromechanical Systems (MEMS), Nano-sensors Sensor Applications: Onboard Automobile sensors, Home appliances sensors, Aerospace Sensors, Sensors for Environmental Monitoring **Self-learning Topics: Energy Harvesting, Self-powered Wireless Sensing in ground, Ground penetrating sensors**	**9**	CO1, CO2, CO3, CO4, CO5, CO6

Text Books:

1. Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", 2015, 3rd edition, Springer, New York.
2. Jon. S. Wilson, "Sensor Technology Hand Book", 2011, 1st edition, Elsevier, Netherland
3. D. Patranabis – Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003
4. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)",1st Edition, VPT, 2014

References:

1. Edited by Qusay F Hasan, Atta ur rehman Khan, Sajid A madani, "Internet of Things Challenges, Advances, and Application", CRC Press

2. Triethy HL - Transducers in Electronic and Mechanical Designs, Mercel Dekker, 2003
3. Gerd Keiser,"Optical Fiber Communications", 2017, 5th edition, McGraw-Hill Science, Delhi.
4. John G Webster, Halit Eren, "Measurement, Instrumentation and sensor Handbook", 2014, 2nd edition, CRC Press, Taylor and Fransis Group, New York.
5. Adrian McEwen, "Designing the Internet of Things", Wiley Publishers, 2013, ISBN: 978-1-118-43062-0
6. Nathan Ida, "Sensors, Actuators and their Interfaces: A Multidisciplinary Introduction", Second Edition, IET Control, Robotics and Sensors Series 127, 2020

Online References:

Sr. No.	Website Name
3.	https://nptel.ac.in/courses/108/108/108108123/
4.	https://nptel.ac.in/courses/108/108/108108098/
3.	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ee41/
4.	https://nptel.ac.in/courses/108/106/108106165/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Internet of Things: Sem VI								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HIoTC601	**IoT System Design**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HIoTC601	**IoT System Design**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To learn basic principles, concepts, and technologies for internet of things.
2	To understand various architectures of IOT.
3	To train the students to build IoT systems using sensors, single board computers and open source IoT platform for given application.
4	To learn and implement various networking and communication protocols.
5	To design and analyze IoT for given applications.
6	To Evaluate performance of given IoT system.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Able to explain principles, concepts, and technologies for internet of things.	L1, L2
2	Able to identify various building blocks of IoT system	L1,L2
3	Able to analyze and evaluate various networking and communication protocols used in IoT system	L3,L4
4	Able to select appropriate interface for given application	L3
5	Able to design and analyze IoT system for given application	L4,L5
6	Able to evaluate performance of given IOT System	L5

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**

0	**Prerequisite**	Comment (Prerequisite syllabus should not be considered for paper setting) Basics of Embedded System, IoT Sensors, Digital design	**2**	--
I	**Overview of IoT System**	What is IoT System? IoT Impact, Current Trends in IoT, IoT Challenges, Comparing IoT Architectures, A Simplified IoT Architecture, The Core IoT Functional Stack How are IoT Systems different from traditional system Values and Uses of IoT Functional View and Infrastructure view of IoT Systems **Self-learning Topics:** *Understanding the Issues and Challenges of a More Connected World*	**6**	CO1, CO2
II	**Networking Protocols**	OSI Model for the IoT/M2M System Lightweight M2M Communication Protocols, Internet based Communications, IP addressing in IoT, Network Model, TCP & UDP, Client-Server architecture **Self-learning Topics:** *How to choose correct protocol for our network.*	**8**	CO3
III	**Communication Protocols**	IoT Edge to Cloud protocols: HTTP, REST APIs, WebSocket, MQTT, COAP, Comparison of Protocols.M2M Communication Protocols, Bluetooth BR/EDR and Bluetooth low energy. RFID IoT System , RFID IoT Network Architecture, ZigBee IP/ZigBee SE2.0, Wifi(WLAN), Message Communication protocols for connected devices Data exchange formats: JSON & XML, Node-Red, Flow control using Node-Red, learning the different nodes of Node-RED for implementing the Communication Protocols **Self-learning Topics:** *Types of Communication*	**10**	CO3,CO4
IV	**Sensor Interfaces**	Digital Interfaces: UART, Serial Peripheral Interface (SPI), I2C (Inter-Integrated Circuit), Controller Area Network (CAN), Middleware Technologies, Communication Protocols and Models. Practical Components Programming with interface in Arduino, MBed and Raspberry Pi **Self-learning Topics:** *SMART SENSOR INTERFACES*	**10**	CO4
V	**Design principles for prototyping**	Design solution for ubiquitionos and utility, Interface design for user experience, Designing for data privacy, Interfacing – Apps & Webs, Designing for Affordability, Cost v/s Ease of Prototyping, Prototypes and Production, Selection of embedded platform, Prototype and Mass personalization, Open Source v/s Closed Source ,Amplification and Signal Conditioning- Integrated Signal Conditioning- Digital conversion- MCU Control MCUs for Sensor Interface- Techniques and System Considerations- Sensor Integration **Self-learning Topics:** *Principles for Prototyping and moving towards Product Development*	**8**	CO5
VI	**IoT, case studies**	Arduino Programming for Ethernet and Wifi connectivity, Networking and Data logging with Raspberry Pi Applications-Agriculture, Medical, Fire detection, Air pollution prediction, Earthquake early detection; for smart environmental care, smart traveling, Home Automation **Self-learning Topics**: *IoT enabled Business solution in Supply Chain*	**8**	CO6

Text Books:

1. S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press.

2. Adrian McEwen and Hakim Cassimally, —Designing the Internet of Things‖, John Wiley and Sons Ltd, UK, 2014.

3. Milan Milenkovic, Internet of Things: Concepts and System Design, Springer International Publishing,May 2020cation

4. Dr.Raj Kamal,Internet of Things(IoT) , Architecture and Design Principles.McGraw Hill Education.

References:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things
2. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.
3. Editors OvidiuVermesan Peter Friess,'Internet of Things – From Research and Innovation to Market
4. Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies Sensors for the Internet of Things Businesses & Market Trends 2014 -2024',Yole Development Copyrights ,2014

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Internet of Things: Sem VII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HIoTC701	**Dynamic Paradigm in IoT**	**03**	**--**	**--**	**03**	**--**	**--**	**03**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HIoTC701	**Dynamic Paradigm in IoT**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To explore the role of the cloud in Internet of Things deployment.
2	To introduce the usage of different machine learning algorithms on IoT Data.
3	To explore data analytics and data visualization on IoT Data.
4	To explore the role of Fog computing in Internet of Things.
5	To explore design issues and working principles of various security measures and various standards for secure communication in IoT.
6	To develop the ability to integrate IoT with Dev-ops.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Identify the need for the cloud in IoT deployment and describe different Cloud provider's architecture.	L1,L2
2	Use and correlate machine learning techniques on IoT Data.	L3,L4
3	Apply IoT analytics and data visualization.	L3
4	Recognize the use of Fog Computing in the Internet of things.	L1,L2
5	Explain the need of security measures in the Internet of Things.	L4
6	Apply the knowledge of Dev-ops in IoT applications.	L3

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**

0	**Prerequisite**	Basics of Cloud Computing, Basics of Machine learning and primitives of cryptography	**2**	--
I	**IoT and CLOUD**	**Cloud Computing Concept, Grid/SOA and Cloud Computing, Cloud Middleware** **NIST's SPI Architecture and Cloud Standards, The Cloud of Things--** The Internet of Things and Cloud Computing **The Cloud of Things Architecture**-- Four Deployment Models, Vertical Applications, Fifteen Essential Features, Four Technological Pillars, Three Layers of IoT Systems, Foundational Technological Enabler **Cloud Providers and Systems** -- Microsoft Azure IoT, Amazon Web Services, Google's cloud IoTs. **Self-learning Module:** IBM Watson Cloud	**10**	CO1
II	**IoT and Machine Learning**	**Advantages of IoT and Machine Learning Integration, Implementation of Supervised Algorithm-** Regression (Linear and Logistic), SVM for IoT-Neural Network **on case study:** Agriculture and IoT, Smart Home etc. **Self-Learning Module:** Regression, SVM	**6**	CO2
III	**IoT and Data Analytics**	**Defining IoT Analytics, IoT Analytics challenges, IoT analytics for the cloud**-Microsoft Azure overview– Strategies to organize Data for IoT Analytics, Linked Analytics Data Sets, Managing Data lakes, The data retention strategy. **Communicating with Others- Visualization and Dash boarding-** Designing visual analysis for IoT data, creating a dashboard –creating and visualizing alerts. **Self-learning Topics:** Study real time case study on IoT Analytics.	**8**	CO3
IV	**IoT and Fog Computing**	**Fog computing Basics, The Hadoop philosophy for Fog computing, Fog Computing versus Edge Computing versus cloud computing, Open Fog Reference Architecture Application services**-- Application support, Node management and software backplane, Hardware virtualization, Open Fog node security, Network Accelerators Compute, Storage Hardware platform infrastructure, Protocol abstraction, Sensors, actuators, and control systems, Fog Topology. **Self-learning Module:** Amazon Green grass and Lambda (implementation)	**8**	CO4
V	**IoT and it's Security**	Cyber security vernacular Attack and threat terms, Defense terms, Anatomy of IoT cyber attacks – Mirai, Stuxnet, Chain Reaction, Physical and hardware security, Root of Trust, Key management and trusted platform modules, Processor and memory space, Storage security, Network stack – Transport Layer Security, Software defined perimeter, Software-Defined Perimeter architecture, **Self-learning Module:** OWASP-Existing Security attacks and its prevention methods.	**8**	CO5
VI	**IoT and Devops**	Introduction to DevOps, DevOps application - business scenarios, DevOps process -- Source Code Management (SCM), Code review, Configuration Management, Build management, Artifacts repository management, Release management, Test automation, Continuous integration, Continuous delivery, Continuous deployment, Infrastructure as Code, Routine automation, Key application performance monitoring/indicators. DevOps frameworks--DevOps maturity life cycle, DevOps maturity map, DevOps progression	**10**	CO6

		framework/readiness model, DevOps maturity checklists, Agile framework for DevOps process projects, Agile ways of development **Tool for IoT—**Chef and Puppet, Setting up Chef and Puppet, Multi-tier Application Deployment, NETCONF-YANG Case Studies- Steps for IoT device management with NETCONF-YANG, Managing Smart irrigation IoT system with NETCONF-YANG, Managing Home Intrusion Detection IoT system with NETCONF-YANG **Self-learning Topics:** Compare different tool of IoT.		

Text Books:

1. The Internet of Things in the Cloud A Middleware Perspective, Honbo Zhou – CRC Publication.
2. Analytics for the Internet of Things (IoT), Andrew Minteer, Packt Publication 2017
3. Internet of Things- Hands on Approach, Arshdeep Bagha, Vijay Medisetti, Published by Arshdeep Bagha and Vijay Medisetti,2014.
4. Hands-on DevOps, Sricharan Vadapalli, Packt Publication, 2017
5. Internet of things For Architects, Perry Lea Packt Publication,2018

References:

1. Enterprise Cloud Computing, Gautam Shroff, Cambridge,2010
2. Mastering Cloud Computing -Foundations and Applications Programming, Raj Kumar Buyya, Christian Vecchiola, S. Thamarai Selvi, MK Publication, 2013.
3. Machine Learning in Action‖, Peter Harrington, DreamTech Press
4. Introduction to Machine Learning‖, Ethem Alpaydın, MIT Press
5. Learning AWS IoT- Effectively Manage Connected Devices on the AWS Cloud Using Services Such as AWS Greengrass, AWS Button, Predictive Analytics and Machine Learning, Agus Kurniawan, Packt Publication,2018
6. Practical Dev-Ops, Joakim Verona, Packt Publication, 2016

Online References:

Sr. No.	Website Name
1.	https://hub.packtpub.com/25-datasets-deep-learning-iot/
2.	https://data.world/datasets/iot
3.	https://dashboard.healthit.gov/datadashboard/data.php
4.	https://www.data.gov/
5.	https://dev.socrata.com/data/
6.	https://www.kaggle.com/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**

- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Internet of Things: Sem VII								
		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical & Oral	Tutorial	Total
HIoTSBL701	Interfacing & Programming with IoT Lab (SBL)	--	4	--	--	2	--	02

Course Code	Course Title	Examination Scheme						
		Theory Marks				Term Work	Practical/ Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
HIoTSBL701	Interfacing & Programming with IoT Lab (SBL)	--	--	--	--	50	50	100

Lab Objectives:

Sr. No.	Lab Objectives
The Lab aims:	
1	To Understand the definition and significance of the Internet of Things.
2	To Discuss the architecture, operation, and business benefits of an IoT solution.
3	To Examine the potential business opportunities that IoT can uncover.
4	To Explore the relationship between IoT, cloud computing, and DevOps.
5	To Identify how IoT differs from traditional data collection systems.
6	To Explore the interconnection and integration of the physical world and able to design & develop IOT Devices.

Lab Outcomes:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of lab, learner/student will be able to:		
1	Adapt different techniques for data acquisition using various IoT sensors for different applications.	L6
2	Demonstrate the working of actuators based on the collected data.	L2
3	Use different IoT simulators and correlate working of IoT protocols.	L3
4	Adapt different techniques for Integrating IoT services to other third-party Clouds.	L6
5	Execute DevOps methodologies for continuous integration and continuous deployment of IoT application.	L3
6	Implement IoT protocols like MQTT for communication to realize the revolution of internet in mobile devices, cloud and sensor networks.	L3

Prerequisite:

IoT introduction course: Basics of IoT, Introduction to Embedded systems

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. Intel PIV Processor 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card 5. Sensors 6. IoT Kit (Arduino/ARM/Raspberry Pi)	1. Windows or Linux Desktop OS 2. DeVops 3.Python 4. IoT Simulator/Emulator (open source)	1. Internet Connection for installing additional packages if required

This lab will describe the market around the Internet of Things (IoT), the technology used to build these kinds of devices, how they communicate, how they store data, and the kinds of distributed systems needed to support them. Divided into four main modules, we will learn by doing. We will start with simple examples and integrate the techniques we learn into a class project in which we design and build an actual IoT system. The client will run in an emulated ARM environment, communicating using common IoT protocols with a cloud enabled backend system with DevOps integration.

Suggested List of Experiments

Sr. No.	Detailed Content	Hours	LO Mapping
1	To study and implement interfacing of different IoT sensors with Raspberry Pi/Arduino/ModeMCU	**4**	LO1
2	To study and implement interfacing of actuators based on the data collected using IoT sensors. (like led switch ON/OFF, stepper word)	**4**	LO2
3	To study and demonstrate Contiki OS for RPL (like Create 2 border router and 10 REST clients, Access border router from other network (Simulator))	**4**	LO3
4	To study and demonstrate use of IoT simulators (like Beviswise) on any real time device (LED/stepper motor)	**4**	LO3
5	Select any one case study (in a group of 2-3) and perform the experiments 5 to 10. The sample case studies can be as follows: 1. Smart home automation system 2. Healthcare management system 3. Smart traffic management system & so on… Write a program on Raspberry Pi to push and retrieve the data from cloud like thingspeak, thingsboard, AWS, Azure etc.	**8**	LO4
6	To install MySQL database on Raspberry Pi and perform basic SQL queries for analysis data collected.	**6**	LO4
7	To study and implement IoT Data processing using Pandas.	**4**	LO4

8	To study and implement Continuous Integration using Jenkins on IoT data and also perform interfacing of Raspberry Pi into Jenkins.	**6**	LO6
9	To study and implement Continuous Deployment (Infrastructure as a code) for IoT using Ansible.	**6**	LO6
10	To study MQTT Mosquitto server and write a program on Arduino/Raspberry Pi to publish sensor data to MQTT broker.	**6**	LO5

Books / References:

1. Jake VanderPlas,“ Python Data Science Handbook”, O’Reilly publication,2016
2. Joakim Verona,” Practical DevOps”, PACKT publishing, 2016
3.Honbo Zhou,” The internet of things in the cloud”, CRC press, Taylor and Francis group, 2012
4. Perry Lea,” Internet of things for architects”, PACKT publishing, 2018

Online Resources:

Sr. No.	Website Name
1.	https://spoken-tutorial.org/watch/Arduino/Introduction+to+Arduino/English/
2.	https://pythonprogramming.net/introduction-raspberry-pi-tutorials/
3.	https://iotbytes.wordpress.com/basic-iot-actuators/
4.	http://www.contiki-os.org/
5.	https://www.bevywise.com/iot-simulator/
6.	https://mqtt.org/

Term Work:

The Term work shall consist of at least 10 practical based on the above list. The term work Journal must include at least 2 assignments. The assignments should be based on real world applications which cover concepts from all above list**.**

Term Work Marks: 50 Marks (Total marks) = 40 Marks (Experiment) + 5 Marks (Assignments/tutorial/write up) + 5 Marks (Attendance)

Practical & Oral Exam: An Oral & Practical exam will be held based on the above syllabus.

Internet of Things: Sem VIII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HIoTC801	**Industrial IoT**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HIoTC801	**Industrial IoT**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To learn the concepts of Industry 4.0 and IIOT.
2	To learn reference Architecture of IIOT.
3	To learn Industrial Data Transmission and Industrial Data Acquisition.
4	To learn middleware and WAN technologies.
5	To learn IIOT Block chain and Security.
6	To learn different applications and securities in IIOT.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Understand the concepts of Industry 4.0 and IIOT.	L1,L2
2	Understand reference Architecture of IIOT.	L1,L2
3	Understand Industrial Data Transmission and Industrial Data Acquisition.	L1,L2
4	Understand middleware and WAN technologies in IIOT.	L1,L2
5	Understand the concepts of Blockchain and Security in IIOT.	L1,L2
6	Apply security in IIOT applications.	L3

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	IOT Concepts, Sensor Technology, IOT Stack and Protocols, Design IoT systems, WSN etc.	**02**	--

I	**Introduction**	Overview of Industry 4.0 and Industrial Internet of Things, Industry 4.0: Industrial Revolution: Phases of Development, Evolution of Industry 4.0, Environment impacts of industrial revolution, Industrial Internet, Basics of CPS, CPS and IIOT, Design requirements of Industry 4.0, Drivers of Industry 4.0, Sustainability Assessment of Industries, Smart Business Perspective, Cyber security, Impacts of Industry 4.0, Industrial Internet of Things: Basics, IIOT and Industry 4.0, Industrial Internet Systems, Industrial Sensing, Industrial Processes, IIOT Challenges – Identifying Things within the internet, Discovering Things and the Data they possess, Managing massive amount of data, Navigating Connectivity Outages, IIOT Edge - Leveraging the Power of Cloud Computing, Communicating with Devices on the Edge, Determining a Request/Response Model **Self-learning Topics:** Study real time IIoT challenges in industry.	**06**	CO1
II	**IIOT Reference Architecture**	The IIC Industrial Internet Reference Architecture - Industrial Internet Architecture Framework (IIAF),Industrial Internet Viewpoints -Functional, Operational, Information Application and Business Domain of IIAF. The Three-Tier Topology, Key Functional Characteristics of Connectivity. Software Architectural Style for the Industrial Internet of Things - Software Architecture Practice, Advanced Architectural Styles, Systems of Systems, Challenges of Software Engineering in IIoT, Principles for Software Architecture design in IIoT, The Principled Decomposition, The Architectural Style **Self-learning Topics:** Study IIoT Architecture.	**08**	CO2
III	**Industrial Data Transmission and Industrial Data Acquisition**	Introduction, (Features and Components of - Foundation Fieldbus, Profibus, HART,Interbus, Bitbus, CC-Link, Modbus, Batibus, DigitalSTROM, Controller Area Network, DeviceNet, LonWorks, ISA 100.11a, Wireless HART, LoRa and LoRaWAN) NB-IoT, IEEE 802.11AH, Distributed Control System, PLC, SCADA **Self-learning Topics:** Study SCADA, PLC in detail.	**10**	CO3
IV	**IIOT Middleware and WAN Technologies**	(From Industrial Application Perspective) Examining Middleware Transport Protocols (TCP/IP, UDP, RTP, CoAP), Middleware Software Patterns (Publish Subscribe Pattern, Delay Tolerant Networks), Software Design Concepts – Application Programming Interface – A Technical Perspective, Why Are APIs Important for Business? Web Services,	**10**	CO4

		IIOT Middleware Platforms – Middleware Architecture IIOT WAN Technologies and Protocols - IIoT Device Low-Power WAN Optimized Technologies for M2M, SigFox,LoRaWAN,nWave, Dash7 Protocol, Ingénue RPMA, Low Power Wi-Fi, LTE Category-M, Weightless, Millimeter Radio **Self-learning Topics:** Study different IIoT Middleware and WAN Technologies.		
V	**IIOT Blockchain and Security**	Blockchains and cryptocurrencies in IoT, Bitcoin (blockchain-based), IOTA- distributed ledger (directed a cyclical graph-based), Government regulations and intervention, US Congressional Bill – Internet of Things (IoT) Cyber security Improvement Act of 2017, Other governmental bodies, IoT security best practices, Holistic security. **Self-learning Topics:** Case study on IIoT Block chain and Security.	**08**	CO5
VI	**IIOT Applications and Securities**	The IoT Security Lifecycle- The secure IoT system implementation lifecycle, Implementation and integration, IoT security CONOPS document, Network and security integration, System security verification and validation (V&V), Security training, Secure configurations, Operations and maintenance, Managing identities, roles, and attributes, Security monitoring, Penetration testing, Compliance monitoring, Asset and configuration management, Incident management, Forensics, Dispose, Secure device disposal and zeroization, Data purging, Inventory control, Data archiving and records management Securing the Industrial Internet - Security in Manufacturing, PLCs and DCS, Securing the OT (Operation Technology), Network, System Level: Potential Security Issues, Identity Access Management Develop New Business Models – Adopt Smart Architectures and Technologies, Sensor-Driven Computing, Industrial Analytics, Intelligent Machine Applications, Transform the Workforce Case Studies – Healthcare Applications in Industries – Challenges associated with Healthcare, Introduction, Smart Devices, Advanced technologies used in Healthcare. Inventory Management and Quality Control – Introduction, Inventory Management and IIOT, Quality Control Manufacturing Industry, Automotive Industry and Mining Industry	**08**	CO6

		Self-learning Topics: Study real time IIoT application.		

Text Books:

1. "Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress)
2. "Introduction to Industrial Internet of Things and Industry 4.0",by Sudip Misra, Chandana Roy And Anandarup Mukherjee, CRC Press (Taylor & Francis Group)
3. "Internet **of Things** Principles and Paradigms", by Rajkumar Buyya, Amir Vahid Dastjerdi, ELSEVIER Inc.
4. Internet of things For Architects, Perry Lea Packt Publication,2018

References:

1. "Practical Internet of Things Security", by Brian Russell, Drew Van Duren (Packt Publishing)
2. "Industrial Internet of Things and Communications at the Edge", by Tony Paine, CEO, Kepware Technologies
3. "Architectural Design Principles For Industrial Internet of Things", Hasan Derhamy, Luleå University of Technology, Graphic Production

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc20_cs69/preview
2.	https://www.coursera.org/specializations/developing-industrial-iot
3.	https://www.coursera.org/lecture/advanced-manufacturing-enterprise/the-industrial-internet-of-things-iiot-59EvI
4.	https://www.coursera.org/lecture/industrial-iot-markets-security/segment-12-blockchains-l4aG9

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Waste Technology

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Honours in Waste Technology (With effect from 2022-23)										
Year and Sem	**Course Code and Course Title**	**Teaching Scheme Hours/ Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	**Seminar/ Tutorial.**	**Pract.**	**Internal Assessment**	**End Sem Exam**	**Term Work**	**Oral/ Pract**	**Total**	**Credits**
TE Sem V	**HCWC501: Solid And Hazardous Waste Management**	4	–	–	20	80	–	–	100	4
	Total	**4**	**–**	**–**	**100**		**–**	**–**	**100**	**4**
										Total Credits=04
TE Sem VI	**HCWC601: Liquid Effluent Management**	4	–	–	20	80	–	–	100	4
	Total	**4**	**–**	**–**	**100**		**–**	**–**	**100**	**4**
										Total Credits=04
BE Sem VII	**HCWC701: Waste Volorization I**	4	–	–	20	80	–	–	100	4
	HCWSBL701: Waste Technology .Skill Based Lab -1	–	–	2	–	–	50	50	100	2
	Total	**4**	**–**	**2**	**100**		**50**	**50**	**100**	**6**
										Total Credits=06
BE Sem VIII	**HCWC801: Sustainable Waste Volorization II**	4	–	–	20	80	–	–	100	4
	Total	**4**	**–**	**–**	**100**		**–**	**–**	**100**	**4**
										Total Credits=04
Total Credit for Semester V+VI+VII+VIII=18										

Waste Technology: Semester V		
Course Code	**Course Name**	**Credits**
HCWC501	**SOLID AND HAZARDOUS WASTE MANAGEMENT**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

Theory					Term Work / Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	20	20	80	03 Hrs	--		--	100

Course Objectives:

1. To recognize the relevant, regulations that apply for facilities used for disposal and destruction of waste.
2. To provide in depth knowledge of municipal solid waste management
3. To provide in-depth knowledge of hazardous waste management
4. To provide in-depth knowledge of Physico-chemical processes useful for the treatment of municipal and solid wastes
5. To provide in-depth knowledge of biological processes useful for the treatment of municipal and solid wastes.
6. Know the necessity of environment risk assessment.

Module	Content	Hours
1	**Rules and Regulations** Municipal solid waste (management and handling) rules, hazardous waste (management and handling) rules, biomedical waste handling rules, fly ash rules, recycled plastics usage rules, batteries (management and handling) rules	4
2	**Municipal Solid Waste Management** Need for management, sources, composition, generation rates, collection of waste, separation, transfer and transport of waste, treatment and disposal options, source reduction of wastes, recycling and reuse.	9
3	**Hazardous Waste Management** Need for management, hazardous characterization of waste, compatibility and flammability of chemicals, waste sampling, TCLP tests, fate and transport of chemicals, health effects	9
4	**Physicochemical Treatment of Solid and Hazardous Waste** Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes), physicochemical processes for hazardous wastes (soil vapour extraction, air stripping, chemical oxidation), ground water contamination and remediation	9

5	**Biological Treatment of Solid and Hazardous Waste** Composting, bioreactors, anaerobic decomposition of solid waste, principles of biodegradation of toxic waste, inhibition, co-metabolism, oxidative and reductive processes, slurry phase bioreactor, in-situ remediation. Landfill design for solid and hazardous wastes, leachate collection and removal, landfill covers, incineration	14
6	**Environmental Risk Assessment** Defining risk and environmental risk, methods of risk assessment, case studies	7

Course Outcome:

On completion of the course the students will:

1 understand rules and regulations for handling solid waste.
2 understand principals of municipal solid waste management.
3 understand hazardous waste management.
4 learn physicochemical treatment of solid and hazardous waste.
5 understand biological treatment of solid and hazardous waste.
6 understand environment risk assessment.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only **Four questions need to be solved.**

Test Books/Reference Books:

1 Tchobanoglous G., Theisen H. and Vigil S.A., "Integrated Solid Waste Management", McGraw-Hill International editions.
2 Bhide A.D. and Sundaresan B.B., "Solid Waste Management, Collection, Processing and Disposal", Nagpur.
3 . "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, Government of India.
4 Management and Handling Rules for: municipal solid waste, biomedical waste, hazardous waste and radioactive wastes, Government of India Publications.
5 Solid Waste Management Hand Book – Pavoni

Waste Technology: Semester VI		
Course Code	**Course Name**	**Credits**
HCWC601	**LIQUID EFFLUENT MANAGEMENT**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

Theory					Term Work / Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**--**		**--**	**100**

Course Objectives:

1 To learn how to minimize waste and study available treatment options.
2 To know concept of pollution control.
3 To learn ion exchange process and various adsorption techniques.
4 To study advanced methods for effluent management.
5 To know methods of waste reduction and how to recover byproducts.
6 To learn concepts and design of natural treatment system.

Module	Contents	Hours
1	**Waste Minimization and Treatment options** Methods of waste volume and strength reductions, Waste minimization - 4 R concepts, Waste audit, Classification of treatment and development of treatment flow sheets.	9
2	**Pollution control** Zero discharge concept. Concept of common effluent treatment plant- objectives, types of CETP, technical and financial aspects. Rural wastewater systems – septic tanks, two-pit latrines, ecotoilet, soak pits.	8
3	**Ion Exchange and Adsorption** Ion exchange process, ion exchange resins, exchange capacity, ion exchange, chemistry and reactions, Design of ion exchange units, Disposal of concentrate waste streams. Types of adsorption, adsorption isotherms, activated carbon adsorption kinetics, analysis and design of adsorption column.	9
4	**Advanced methods for effluent management** Ozonation, photocatalysis, wet air oxidation, evaporation, reverse osmosis, biological treatment for toxic waste	9
5	**Waste Reduction/Byproduct recovery**	9

	Waste reduction/ byproduct recovery for sugar, paper mill, petroleum and oil refineries, steel and engineering industries, fertilizer and pesticide industries, organic & inorganic manufacturing industries	
6	**Natural Treatment Systems** Constructed wetland and aquatic treatment systems; Types- free water surface and subsurface constructed wetlands, selection of plants, removal mechanisms, applications, design procedure for constructed wetlands, management of constructed wetlands	8

Course Outcomes:

1 Understand minimizing the waste and available treatment options.
2 Understand concept of pollution control.
3 Understand ion exchange process/design and adsorption techniques.
4 Advanced methods for effluent management.
5 Waste reduction/byproducts recovery for manufacturing industries.
6 Concepts and design of natural treatment system.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only **Four questions need to be solved.**

Text Books and References:

1 Eckenfelder, W.W., Industrial Water Pollution Control, McGraw-Hill, 1999.
2 Arceivala, S.J., Wastewater Treatment for Pollution Control, McGraw-Hill, 1998.
3 Frank Woodard, Industrial waste treatment Handbook, Butterworth Heinemann, New Delhi, 2001

Honours in Waste Technology: Semester VII		
Course Code	**Course Name**	**Credits**
HCWC701	**WASTE VALORIZATION I**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

Theory					Term Work / Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**--**		**--**	**100**

Course Outcomes:

1. To know waste valorization process used for reduce, reuse and recycle.
2. To learn biovalorization of industrial waste.
3. To know concept of biorefineries and related factors.
4. To learn recent trends and vermiculture.
5. To know biovalorisation of agriculture biomass.
6. To study case studies based on waste recycling.

Module	Contents	Hours
1	**Wastes valorization processes:** Preparation for reuse, recycling, and other valorisation processes. Analysis of advantages and limitations.	5
2	**Bio-valorisation of industrial wastes:** Anaerobic bio-valorisation of leather industry solid waste and production of high value-added biomolecules and biofuels, Anaerobic bio-valorisation of pulp and paper mill waste, Bio-valorisation of winery industry waste to produce value-added products, Conversion of textile effluent wastewater into fertilizer using marine cyanobacteria along with different agricultural waste.	12
3	**Biorefineries:** Biorefinery for hydrocarbons and emerging contaminants, Biodesulfurization of petroleum wastes, Microbial leaching of heavy metals from e- waste, opportunities and challenges.	8
4	**Biovalorisation of agricultural biomass:** Recent trends in biorefinery-based valorisation of lignocellulosic biomass, Protein engineering approaches for lignocellulosic ethanol biorefinery, Biovalorization potential of agro forestry/industry biomass for optically pure lactic acid fermentation, Opportunities and challenges, Agro-based sugarcane industry wastes for production of high-value bioproducts	11
5	**Recent trends and vermiculture**	8

	Recent trends and challenges in bioleaching technologies, membrane separation technologies for downstream processing. Definition, scope and importance – common species for culture – environmental requirements – culture methods- applications of vermiculture-Potentials and constraints for composting in India-large scale and decentralized plants.	
6	**Case studies on waste recycling** Recycling technologies for paper, glass, metal, plastic, used lead acid battery, end of life vehicle recycling, electronic waste recycling, waste oil, recycling solvent recovery, drivers and barriers for material recycling, social, legal and economic factors, environmental impacts of waste recycling, design for the environment the life cycle approach.	8

Course Outcomes:

On completion of this course students will

1 understand the waste valorization process to reduce, reuse and recycle.
2 understand Biovalorization of industrial waste
3 understand concept of biorefineries, their opportunities and challenges
4 understand recent trends and vermiculture.
5 understand biovalorisation of agriculture biomass.
6 understand waste recycling using case studies.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total six questions, each carrying 20 marks.
3. Question 1 will be compulsory and should cover maximum contents of the curriculum.
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only Four questions need to be solved.

Text Books/ Reference Books

1 Aarne Veslind and Alan E Rimer (1981), Unit operations in Resource Recovery Engineering , Prentice Hall Inc., London
2 Manser A G R, Keeling A A (1996). Practical handbook of processing and recycling on municipal waste. Pub CRC Lewis London, ISBN 1-56670-164
3 Chiumenti, Chiumenti, Diaz, Savage, Eggerth, and Goldstein, Modern Composting Technologies JG Press October 2005
4 Charles R Rhyner (1995),Waste Management and Resource Recovery, Lewis

Waste Technology: Semester VII		
Course Code	**Course Name**	**Credits**
HCWSBL701	**WASTE TECHNOLOGY SKILL BASED LAB**	**02**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	04	-	--	02	-	02

Theory					Term Work / Practical/Oral		Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	OR/PR	
Test-I	Test-II	Average					
-	-	-	-	----------	50	50	100

Course Objectives:-

Students will able to

1 Understand analyze properties of MSW
2 Understand vermicomposting on a lab scale.
3 Understand aerobic and anaerobic digesting of solid waste.
4 Will know of incineration process and handling of HSW.
5 Understand ecology baseline and impact of waste on environment.
6 Understand process of project report preparation based on case studies.

List of Experiments (minimum eight)

Waste Technology based experiments should be conducted.

1. Determination of pH of MSW
2. Determination of Total Solids, fixed solids and volatile solids
3. Determination of nutrient value (NPK)
4. Lab scale study on vermicomposting
5. Lab scale study of aerobic and anaerobic digesting of solid wastes (Both industrial & Municipal)
6. A Visit to the Hazardous waste Generation or disposal site.
7. Practical knowledge and working of incinerators
8. Visit to Industrial area, especially the handling of Hazardous materials

9. Ecology baseline and impact of waste – disposal on vegetation

10. Preparation of Project report based on a case study of one hospital Study of the source, generation rates and characteristics of hazardous wastes and their regulation, handling, treatment, and disposal. Special emphasis is placed on process design of waste handling, treatment and disposal systems.

Course Outcomes:

At the end of the course the student will be able to:

1 Learn to analyze properties of MSW.
2 To study vermicomposting on a lab scale.
3 To carry out aerobic and anaerobic digesting of solid waste.
4 To acquire knowledge of incineration process and handling of HSW.
5 Learn to analyze ecology baseline and impact of waste.
6 Learn about project report preparation based on case studies.

Term work (25 marks)

Term work should be evaluated based on performance in practical/Assignments.

Practical Journal/Assignments: 20 marks

Attendance: 05 marks

Total: 25 marks

End Semester Oral Practical Examination/orals (25 marks)

- A student will become eligible for Oral practical examination after completing 8 out of 10 experiments/Assignments

Waste Technology: Semester VIII		
Course Code	**Course Name**	**Credits**
HCWC801	**WASTE VALORIZATION II**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

Theory					Term Work/ Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test -II	Aver age						
20	**20**	**20**	**80**	**03 Hrs**	**--**	**-**	**--**	**100**

Course Objective:

1 To know concept of energy from waste.
2 To study devices for converting waste into energy.
3 To undertake case studies based on impact of pollution on environmental and health.
4 To learn biohydrogen processes its applications and briquetting techniques.
5 To know microalgal biovalorization.
6 To learn process of converting biomass to energy.

Module	Contents	Hours
1	**Introduction to Energy from waste** Present status of technologies for conversion of waste into energy, design of waste to energy plants for cities, small townships and villages. Sources of energy generation, Classification of waste as fuel – agro based, forest residue, industrial waste	8
2	**MSW –conversion devices** Incinerators, gasifiers, digestors. , land fill gas generation and utilization, ,Anaerobic Digestion: Biogas production	9
3	**Environmental and health impacts-case studies** Environmental and health impacts of waste to energy conversion, case studies of commercial waste to energy plants, waste to energy- potentials and constraints in India, eco-technological alternatives for waste to energy conversions.	10
4	**Briquetting** Industrial Application of Gasifiers-Utilization and Advantages of Briquetting, environmental and health impacts of incineration; strategies for reducing environmental impacts.	9
5	**Biohydrogen**: Overview on Processes involved, and from Biohydrogen and applications.	8
6	**Microalgal biovalorization:** Conventional and nonconventional approach, Integration of wastewater valorization with microalgae for biofuel production,	8

Course Outcome:

Students will be able to

1 understand the concept of energy from waste.
2 understand various devices to convert energy from waste.
3 understand environmental and health impacts using case studies.
4 understand biohydrogen processes, applications and briquetting techniques.
5 understand concept of microalgal biovalorization.
6 understand process for biomass to energy.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only **Four questions need to be solved.**

Textbooks /References

1 Rada E.C. Waste Management and Valorization: Alternative Technologies., CRC Press, Taylor and Francis Group, 2016.
2 Rathinam N.K. and Sani, R.K. Biovalorisation of Wastes to Renewable Chemicals and Biofuels. Elsevier Inc. 2020.

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Electric Vehicles

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Electric Vehicles (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HCEV501: Vehicular Systems and Dynamics**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HCEV601: EV Drive and Energy Sources**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HCEV701: Automotive Controllers and Auxiliary Systems**	04	--	--	20	80	--	--	100	04
	HSEVBL701: Electric Vehicles Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits =	**06**
BE Sem. VIII	**HCEV801: Electric Vehicle System Design**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

'Electric Vehicle' - SEM-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HCEV501	**Vehicular Systems and Dynamics**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HCEV501	**Vehicular Systems and Dynamics**	20	20	20	80	03	-	100

Course Objectives	1. To study different automotive components and subsystems 2. To explore and compare the transition of automotive domain from ICE to electric vehicles
Course Outcomes	**Upon successful completion of this course, the learner will be able:** 1. To Illustrate the general configuration and identify various components of automobile. 2. To define the functionality and working principles of different types of Automotive Powertrains 3. To illustrate the working of various automotive transmission systems 4. To identify and illustrate the various hybrid electric powertrains and their different modes of operations 5. To explain the basic and state of the art of Electric vehicles and its major parts. 6. To compare and contrast the performance of ICE vehicles, HEVs and EVs.

Module	Contents	Hours
1.	**Vehicle Mechanics:** History of Vehicle Development, General Configuration of Automobile, Body and Chassis Fundamentals: General Packaging, Types of Structural System, Backbone Construction; Body and Chassis Materials. Automotive Powertrain Mechanical, Suspensions system, Steering System, NVH, Control System Integration and Implementation. Front-Wheel Drive (FWD) Powertrains, Rear-Wheel Drive Powertrains (RWD), Multi-Wheel Drive Powertrains (AWD and 4WD)	10
2.	**Transmission Systems:** Transmission gears, Manual Transmission (MT), Automatic Transmission (AT), Automated Manual Transmissions (AMT) and Continuously Variable Transmissions (CVT); Manual Transmissions Powertrain Layout and Manual Transmission Structure, Power Flows and Gear Ratios, Manual Transmission Clutch and its structure. Drivetrain and Differential	10
3.	**Automotive Subsystems:** Automotive Aero-dynamics, Vehicle Power Demand Analysis; Types of suspension and drive, Braking systems; Tyre Mechanics: Tyres and wheels, Tyre characteristics; Vehicle handling & stability; Automotive instrumentation	06
4.	**ICE Performance Characteristics:** Power and torque generation, specific fuel consumption, specific emissions, Efficiencies- fuel conversion efficiency, mechanical efficiency, volumetric efficiency	06

5.	**Hybrid Powertrain:** Series HEVs, Parallel HEVs, Series–Parallel HEVs, Complex HEVs, Operating Modes, Degree of Hybridization, Comparison of HEVs, Plug-in Hybrid Electric Vehicles (PHEVs) Real Life examples of HEVs	10
6.	**Electric Vehicles:** Basics of Electric Vehicles, Current Status and Trends for EVs, Battery Electric Vehicles (BEVs), Fuel-Cell Electric Vehicles (FCEVs), Electric Machines for EV applications, EV Transmission: Single-Speed EV Transmission, Multiple Ratio EV Transmissions. Comparison of ICE vehicle with HEVs and EVs. National Policy for adoption of EVs	10

Text Books:-

1. Vehicle Powertrain Systems by Behrooz Mashadi and David Crolla, Wiley, 2012
2. Automotive Aerodynamics by Joseph Katz, Wiley, 2016
3. Automotive Chassis Engineering, by David C. Barton and John D. Fieldhouse, Springer, 2018
4. Automotive Engineering Powertrain, Chassis System and Vehicle Body Edited by David A. Crolla, Elsevier, 2009
5. Automotive Power Transmission Systems by Yi Zhang and Chris Mi, Wiley, 2018
6. Linear Electric Machines, Drives, and MAGLEVs Handbook, by Ion Boldea, CRC Press. 2013
7. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, and Ali Emadi, CRC Press 2005
8. Electric Vehicle Technology Explained by James Larminie and John Lowry, John Wiley, 2003
9. Electric And Hybrid Vehicles- Design Fundamentals by Iqbal Husain, CRC Press, 2005

Reference Books:-

1. Encyclopaedia of Automotive Engineering edited by David Crolla et al, Wiley, 2014
2. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
3. The Automotive Transmission Book by Robert Fischer, Ferit Küçükay, Gunter Jürgens , Rolf Najork, and Burkhard Pollak, Springer, 2015
4. Noise and Vibration Control in Automotive Bodies by Jian Pang, Wiley, 2019

Website Reference / Video Courses:

1. NPTEL Web course: Fundamentals of Automotive Systems, by Prof. C.S. Shankar Ram, IIT Madras, https://nptel.ac.in/courses/107/106/107106088/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.

4. Remaining question will be randomly selected from all the modules.

'Electric Vehicle' - SEM-VI						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HCEV601	**EV Drive and Energy Sources**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HCEV601	**EV Drive and Energy Sources**	20	20	20	80	03	-	100

Course Objectives	1. To explore and understand various traction motors, power drives and control strategies used in EVs. 2. To get conversant with the energy sources used in EVs and their state of the art. 3. To understand the various battery charging and management systems
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. To identify and assess various traction motors along with their suitability in various EV segments 2. To describe and differentiate various power converters and their control used in EV drives 3. To evaluate the battery specifications using various design considerations for EVs 4. To illustrate different battery charging methods and protocols 5. To explain the impact of large scale integration of EV charging infra in existing grid and its mitigation techniques. 6. To illustrate the need and importance of drive cycles used in testing of automobiles.

Module	Contents	Hours
1.	**Introduction to Traction Motors:** DC Machines- Brushed and Brushless DC motors (BLDC); AC Motors: Induction motors (IM), permanent-magnet ac synchronous motor-surface-permanent-magnet (SPM) motors and interior-permanent-magnet (IPM) motors; PM Materials; Switched Reluctance Motor (SRM); Basic construction details and working principles of each of the machine. In-Wheel Motors Comparison of Traction Machines; Specifications of the motors, Characteristic Curves of a Machines: Constant-Torque Mode, Constant-Power Mode; Efficiency Map; Suitability of each machine in Electric vehicle domain for 2W, 3W, 4 wheeler and large size vehicles. Real life examples; Review of advancement in EV Motors and Drives.	10
2.	**Power Converters for EV drive:** Power Conversion –Basic Principle, review of DC-DC converters, DC-AC Converters used in EV applications; Power topologies for IM, BLDC, PMSM and SRM motors. Traction Drives, Modulation schemes: Sinusoidal Pulse Width Modulation, SPWM with third harmonic injection, Space vector modulation, comparison of modulation techniques. Converter / Inverter Loss calculation, Heat-sinking: passive and active cooling.	08

3.	**Control of Power converters and Motors:** Induction Motor Control: Variable-Voltage Variable-Frequency Control (VVVF), Field-Oriented Control (FOC), Direct Torque Control (DTC); PM Synchronous Motor Control: Field-Oriented Control of PMSM, Flux-Weakening Control of PMSM, Position Sensorless Control of PMSM. SRM motor control: Current chopping control (CCC), Torque-Ripple Minimization Control BLDC Motor Control*:* Trapezoidal back EMF BLDC motor control	10
4.	**Energy Sources for EV:** Overview of energy sources for electric vehicle: Batteries, Fuel Cell, Ultra-capacitor and flywheel energy storage; Hybridization of energy sources for electric and hybrid vehicles; Comparison of sources. Batteries: Lead-acid battery, Nickel-based batteries, Sodium based batteries, lithium batteries Metal/air batteries; Battery parameters, Battery pack formation and testing, SoC & SoH, Estimation of SoC. Battery cell balancing, Battery management System (BMS), Thermal and safety considerations in battery pack design. Voltage and AHr/ kWhr ratings of ES for EV applications: Major design considerations	10
5.	Battery charging Infrastructure: AC and DC charging, CC-CV charging, Pulse charging; On-board and off-board charging; Standards and protocols for charging; Fast DC chargers, Home and Public charging infrastructure; Wireless power transfer (WPT) technologies for EVs, Move-and-charge technology. Charging Infrastructure-standardization and connectivity issues; SAE J1772, CHAdeMo, GB/T, CCS2 battery charging protocols. OCPP protocol Impact on existing power grid, G2V and V2X- Vehicle-to-home (V2H), vehicle-to-vehicle (V2V), and vehicle-to-grid (V2G) energy systems. Renewable Energy Based Charging infra.	10
6.	**EV Drive Cycle Testing:** Need for a driving cycle, different Drive Cycles: NEDC, EUDC, EPA, WLTP, and FTP-75; Testing of EV for range per charge for a given drive cycle	04

Text/Reference Books:-

1. Fundamentals And Applications Of Lithium-Ion Batteries In Electric Drive Vehicles by Jiuchun Jiang and Caiping Zhang, Wiley, 2015
2. Battery Management Systems for Large Lithium-Ion Battery Packs, by Davide Andrea, Artech House Publication, 2010
3. Electric Vehicle Battery Systems by Sandeep Dhameja, Newens, 2002
4. Fundamentals And Applications Of Lithium-Ion Batteries In Electric by Jiuchun Jiang and Caiping Zhang, Wiley, 2015
5. Optimal Charging Control of Electric Vehicles in Smart Grids by Wanrong Tang and Ying Jun Zhang, Springer, 2017
6. Plug In Electric Vehicles in Smart Grids Charging Strategies Edited by Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, Springer 2015
7. Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles edited by Ottorino Veneri, Springer, 2017

8. Solar Powered Charging Infrastructure for Electric Vehicles A Sustainable Development Edited by Larry E. Erickson, Jessica Robinson, Gary Brase, and Jackson Cutsor, CRC Press, 2017
9. Energy Systems for Electric and Hybrid Vehicles Edited by K.T. Chau, IET, 2016
10. Handbook of Automotive Power Electronics and Motor Drive Edited by Ali Emadi, CRC Press, 2005
11. Electric And Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure And The Market by Gianfranco Pistoia, Elsevier, 2013
12. AC Motor Control and Electrical Vehicle Applications, Second Edition by Kwang Hee Nam CRC Press, 2019

Website Reference / Video Courses:

1. NPTEL Web Course: Electric Vehicles - Part 1 by PROF. AMIT KUMAR JAIN Department of Electrical Engineering IIT Delhi; https://nptel.ac.in/courses/108/102/108102121/
2. NPTEL Web Course: Fundamentals of Electric vehicles: Technology & Economics: by Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras, https://nptel.ac.in/courses/108/106/108106170/
3. NPTEL Web Course: Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati, https://nptel.ac.in/courses/108/103/108103009/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'Electric Vehicle' - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HCEV701	**Automotive Controllers and Auxiliary Systems**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HCEV701	**Automotive Controllers and Auxiliary Systems**	20	20	20	80	03	-	100

Course Objectives	1. To Identify functionalities of various automotive controllers and auxiliary systems 2. To study various automotive sensors and actuators 3. To explore details of energy sources management system, thermal management system and overall system integration in EVs/ HEVs
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To illustrate functionality of various auxiliary subsystems used EVs 2. To demonstrate the use of VCUS and ECUS in automobile 3. To describe the need and functionality of automotive sensors / actuators and networking 4. To illustrate the design and management aspects of EV energy sources 5. To describe the various heat losses, and thermal management systems incorporated in EVs 6. To elaborate on System Integration and resource optimization in EVs

Module	Contents	Hours
1.	**Introduction:** Review of Automotive electrical, electronic, communication and thermal subsystems; Review of Energy Storage (Power Plant) system, Main Traction Inverter, On-Board Charger (OBC), LV Auxiliary Power Source, HV Battery Disconnect; Vehicle Control Unit (VCU) and ECUs. Braking Systems: Energy Consumption in Braking, Braking Power and Energy on Front and Rear Wheels, Brake System of EVs and HEVs, Series Brake-Optimal Feel, Series Brake-Optimal Energy Recovery; Parallel Brake; Antilock Brake System (ABS); Fundamentals of Regenerative Braking. Steering System: In-car system networking, Steering ratio characteristic, Steering Stabilization, Over-steer, understeer, Electric-Power-Assisted Steering (EPAS); Autonomous vehicles, Principle of object detection.	12
2.	**Vehicle Control Unit and Electronic Control Unit:** VCU functionality: Inverter control, battery management, charging control, vehicle functions in transmission and engine control; Advanced Driver Assistance System (ADAS); Electronic control units (ECUs): Various Section ECUs and their networking; Body and Lighting ECU (Key-less Entry, Sonar, HID, LED Lamps), Body ECU (Airbag).	08

3.	**Automotive sensors / actuators and networking:** Radar Sensor Detectors for Vehicle Safety Systems; Airborne Ultrasonic Imaging: SONAR Based Image Generation for Autonomous Vehicles, Motor angle sensor, Steering angle sensor, Tyre Pressure Monitoring Systems (TPMS); In Vehicle communication system: CAN, LIN, Ethernet, Flexray	10
4.	**Energy Storage (Power Plant) Management system:** Battery cell packaging, Battery Management System (BMS), Design of battery pack and safety considerations; High voltage cabling and cut-outs; Battery pack installation. Use of Battery-UC Hybrid source; Fuel Cell (FC): FC management and Hydrogen storage in EV.	10
5.	**Thermal Management System:** Heat Calculation in various subsystems; HVAC system: HVAC compressor drive; Liquid cooling system for Battery, Electric drive and On board charger. Design considerations for thermal management system	06
6.	**System Integration and Implementation:** Vehicular Power Control Strategy and Energy Management: A Generic Framework, Definition, and Needs, Methodologies for Optimization, Cost Function Optimization, Benefits of Energy Management.	06

Text/Reference Books:-

1. Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles by John G. Hayes and G. Abas Goodarzi, Wiley, 2018.
2. Handbook of Automotive Power Electronics and Motor Drive Edited by Ali Emadi, CRC Press, 2005
3. Encyclopaedia of Automotive Engineering edited by David Crolla *et al.*, Wiley, 2014
4. Electric and Hybrid Vehicles Technologies, Modeling and Control: A Mechatronic Approach by Amir Khajepour, Saber Fallah and Avesta Goodarzi, Wiley, 2014.
5. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, Second Edition Chris Mi and M. Abul Masrur, Wiley 2018.
6. Autonomous Vehicles Intelligent Transport Systems And Smart Technologies edited by Nicu Bizon, Lucian Dascalescu and Naser Mahdavi Tabatabaei, Nova Publishers, 2014
7. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles by Sheldon S. Williamson, Springer, 2013
8. Electric and Hybrid Buses for Urban Transport Energy Efficiency Strategies, by Bogdan Ovidiu Varga, Calin Iclodean and Florin Mariasiu, Springer, 2016

Website Reference / Video Courses:

1. NPTEL Web Course: Electric Vehicles - Part 1 by PROF. AMIT KUMAR JAIN Department of Electrical Engineering IIT Delhi; https://nptel.ac.in/courses/108/102/108102121/
2. NPTEL Web Course: by Fundamentals of Electric vehicles: Technology & Economics: Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur,Prof. Kaushal Kumar Jha andProf. L Kannan, IIT Madras, https://nptel.ac.in/courses/108/106/108106170/
3. NPTEL Web Course: Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati, https://nptel.ac.in/courses/108/103/108103009/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'Electric Vehicle' - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical/ Tutorial	Theory	Practical/ Tutorial	Total
HCEVSBL701	**Electric Vehicles Lab**		04	--	04	04

Course code	Course Name				Examination Scheme				
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)			
		Test 1	Test 2	Avg.					
HCEVSBL701	**Electric Vehicles Lab**	-	-	-	-	-	50	50	100

Course Objectives	1. To provide hands-on with various major components used in EV/HEVs 2. To explore EV drives & control implementation along with analysis using simulation tool or with hardware. 3. To study various auxiliary systems commonly used in EV.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Compare and contrast conventional vehicles and EV/HEVs. 2. Illustrate operations and features of Conventional, hybrid electric vehicle and electrical vehicle Powertrains. 3. Describe the working of EV drives used for different kinds of electric motors. 4. Illustrate battery characteristics and working of BMS. 5. Describe the operation of On-board and Off-board EV chargers 6. Demonstrate the use of simulations tools along with hardware implementation for evaluation of EV subsystems.

Contents

Electric Vehicles Lab: Experimental study based on the following topics

1. Conventional and electrical vehicle sub-systems and components
2. Conventional, hybrid electric vehicle and electrical vehicle Powertrains
3. Motor performance test - for BLDC /PMSM/ IM/SRM motors;
4. EV drive for BLDC/PMSM/IM /SRM motors
5. Battery cell and module- characterization
6. Battery Management System (BMS)
7. On-board and Off-board charger for EV
8. Study of Automotive Electronics-HVAC control, Steering Control, VCU; 2/3 or 4 Wheeler EV.

(or any other experiments based on EV/HEV related systems/ subsystems)

Use of software tools:

Use of tools like ADVISOR, MATLAB, SEMIKRON SEMISEL, Python, C, Java platforms (or similar) etc. for the following

1. Simulation/ Emulation of Vehicle performance analysis for Conventional and Electrical Vehicle
2. Design simulation of a battery pack with given specifications and constraints.

3. Simulation/ Emulation of BLDC motor drive for performance analysis
4. Simulation/ Emulation of PMSM motor drive for performance analysis
5. Simulation/ Emulation of IM motor drive for performance analysis
6. Simulation/ Emulation of SRM motor drive for performance analysis
7. Simulation/ Emulation of On board and Off board charger.
8. Simulation/ Emulation of regenerative breaking.

(or any other simulation based on EV/HEV related systems/ subsystems)

Visit to industrial/ manufacturing facility:

1. Visit to EV manufacturing facility.
2. Visit to Battery pack /BMS design facility
3. Visit to battery Charger facility
4. Visit to Automotive Research Association of India (ARAI), Pune EV COE

(or a visit to any facility / industry / research institute carrying out work in the domain of EV)

Course Project

Course project to be carried out to design /fabricate/ program one of the vehicular sub-systems used in EV

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below. The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. https://www.vlab.co.in/broad-area-mechanical-engineering - Energy Storage Labs, Solar Energy lab, Wind Energy Lab

Term work:

Term work shall consist of minimum eight experiments, at least one plant visit, and one course project. The distribution of marks shall be as follows:

Experiments Performance	: 20 marks
Attendance	: 05 marks
Plant Visit report	: 10 marks
Course Project report	: 10 Marks
Journal & Attendance	: 10 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire lab work of HCEVSBL701-Electric Vehicles Lab

'Electric Vehicle' - SEM-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HCEV801	**Electric Vehicle System Design**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HCEV801	**Electric Vehicle System Design**	20	20	20	80	03	-	100

Course Objectives	1. To illustrate the design philosophies used in the EV domain. 2. To explore the selection of power and control architecture of EV drives 3. To study the design aspects of EV battery packs and other auxiliary systems
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. To select and size the electric motor for a particular EV application and performance criteria 2. To select and size the battery pack to meet desired EV performance and 3. To design the EV drive system with functional safety considerations. 4. To illustrate the use of hybrid energy source for EV performance improvement 5. To illustrate the design aspects of Automotive Subsystem 6. To design the EV chargers and charging infrastructure

Module	Contents	Hours
1.	**Selection/ Sizing of EV Electric Motors:** Electric Vehicle modelling, Tractive force calculations, Design considerations for 2W, 3W and 4W EVs; Torque, power and Speed requirement, Traction Limit, Maximum Acceleration Limit, Maximum Grade Limit, Vehicle Power Demand Vehicle Performance Envelope, and Vehicle Power Envelope; Vehicle Power Demand during Driving Cycles. Design considerations for EV motors and their cooling system. Application Examples of EV /HEV motors with vehicles and motor specifications.	08
2.	**Selection/ Sizing of Battery pack and other Energy Resource:** Selection of type of Battery pack for 2W, 3W and 4W EVs; Battery pack sizing: Design considerations: Range per charge, range anxiety, EV motor power requirement; Impact of road conditions, environmental conditions and traffic conditions. High-Voltage Cabling and Disconnects, Safety in Battery Design, Testing for safety. Accelerated Reliability Testing of Electric Vehicles, Battery Cycle Life versus Peak Power and Rest Period. Selection and sizing of Fuel cell for FCEV, design considerations; Battery-ultra-capacitor hybrid combination sizing, performance analysis. Design considerations for Ultra-capacitor based EV, requirement of charging infra. Flywheel selection and sizing for EV/HEV applications.	12
3.	**Automotive Subsystem Design:** Electronic Control Unit (ECU) and its Control Features, Communications between ECUs, Control Software Development: Software-in-the-Loop (SIL) Simulation and Hardware-in-the-Loop (HIL) Simulation.	06

	Acceleration and braking control, regenerative braking; Automotive Steering Systems. Design considerations of HVAC controller	
4.	**EV System integration:** EMC design on ECU level, EMC design on system level and in special subsystems, Radiated emissions and Conducted emissions, EMI EMC measurements.	06
5.	**Design of Charging Infrastructure:** Design considerations for AC charger: vehicle interface and charging protocol design. applicable charging standards Design of On-Board Charger (OBC)-Schematic, power topology and control, Power capacities, regenerative braking control. Design considerations of DC fast charger: vehicle interface and charging protocol design. Connectivity and applicable charging standards Installation guidelines and grid requirement for charger installations.	12
6.	**Design with Functional Safety of Automotive Electronics:** Functional Safety requirements of Automotive Electronics; ASIL identification and safety goal finalization, ISO 26262. Energy Storage integrity / protection: rupture and toxic gas management; low energy stranding, Unintended vehicle movement, shock protection, and Elimination of potential thermal/ explosive event. Hazard and Risk Analysis (HARA) for different situations, Testing of vehicles for compliance of safety norms	08

Text/Reference Books:-

1. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
2. Electric Vehicle Machines And Drives Design, Analysis and Application by K. T. Chau, IEEE Press, and Wiley, 2015
3. EMC and Functional Safety of Automotive Electronics by Kai Borgeest, IET, 2018

Website Reference / Video Courses:

1. NPTEL Web Course: Electric Vehicles - Part 1 by PROF. AMIT KUMAR JAIN Department of Electrical Engineering IIT Delhi; https://nptel.ac.in/courses/108/102/108102121/
2. NPTEL Web Course: Fundamentals of Electric vehicles: Technology & Economics, by Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras, https://nptel.ac.in/courses/108/106/108106170/
3. NPTEL Web Course: Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati, https://nptel.ac.in/courses/108/103/108103009/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Microgrid Technology

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Microgrid Technology (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HCMT501: Futuristic Power Systems**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HCMT601: Power Electronic Converters for Energy Sources**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HCMT701: Microgrid Power and Control Architecture**	04	--	--	20	80	--	--	100	04
	HCMTSBL701: Microgrid and RES Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits =	**06**
BE Sem. VIII	**HCMT801: Microgrid System Design**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

'Microgrid Technology - SEM-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HCMT501	**Futuristic Power Systems**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HCMT501	**Futuristic Power Systems**	20	20	20	80	03	-	100

Course Objectives	1. To explore the state of the art and future trends in power systems. 2. To understand the technical, economic and social challenges in power system evolution. 3. To realize the role and importance of Microgrids if futuristic power systems.
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To solicit the importance of large scale renewable energy integration with existing grid infrastructure. 2. To understand the importance and utility of Energy storage systems in futuristic power systems. 3. To explore large scale micro-grid deployment with RES and ESS integration. 4. To understand the role of communication and IT Infrastructure in power system and related challenges. 5. To explore the potential of Microgrids and its importance in Indian context.

Module	Contents	Hours
1.	**Introduction:** Present status of worldwide scenario of electricity generation, transmission and distribution; Energy infrastructure-Resilience and Security; Social, Technical and economic challenges; Major trends driving power system evolution; State of the art technologies in power system.	06
2.	**Renewable Energy Integration:** Review of renewable energy (RE) resources and systems: Solar- PV, Solar Thermal, Wind, Biomass, Micro-hydro and Fuel Cell, comparison of various RE resources; Renewable Energy Policies and present status of integration with existing grid; Large scale integration of renewable energy-Technical challenges, enabling technologies, International requirements; Renewable energy forecasting	12
3.	**Energy Storage Systems (ESS):** Review of energy storage components: Battery, VRB, Ultra-capacitor, Fuel Cells, Pumped Hydro-Storage and flywheels, comparison of ESS technologies; Importance of ESS in futuristic power systems; Aggregated ESS, Distributed ESS; Applications of ESS: Energy Management (Load Leveling and Peak Shifting), Fluctuation Suppression (Intermittency Mitigation), Uninterruptible Power System Low-Voltage Ride Through; Placement of the ESS to Improve Power Quality, Voltage Regulation Using ESS, ESS as Spinning Reserve.	12
4.	**Micro-grid and Smart-grid** Micro-grid evolution: Micro-grid concept, importance in futuristic power system, basic architectures and control, objectives and state of the art technologies; Microgrid as a building block of Smart-grid; Smart-grid concept, Smart Grid versus conventional electrical networks, Smart-grid infrastructure, Smart Grid communication system and its cyber security, International standard IEC 61850 and its application to Smart-grid;	12

	Microgrids /smart grid and Electric Vehicles integration. Technical, Economic, Environmental and Social Benefits of Microgrid Operation.	
5.	**Communication and IT infrastructure:** Requirements of Communication and IT infrastructure in futuristic power systems: various communication protocols, comparison of performance; IEEE standard: IEEE 802.11 Mesh Networking, IEEE 802.15.4-Wireless Sensor Networks; Communications Technologies for Smart metering; Cyber security issues and mitigation techniques.	05
6.	**Microgrids in India:** Microgrids for Rural Electrification, Review of Microgrid Best Practices through Case Studies: Strategic Planning, Operations: Commercial and Financial Considerations; Technical and Social Context.	05

Text Books:-

1. Microgrids Architectures and Control Edited by Nikos Hatziargyriou, IEEE and Wiley, 2014
2. Energy Storage for Sustainable Microgrid by David Wenzhong Gao, Elsevier, 2015
3. Introduction to the Smart Grid- Concepts, Technologies and Evolution by Salman K. Salman, IET, 2017
4. Energy Storage Systems and Components by Alfred Rufer, CRC Press, 2018

Reference Books:-

1. Energy Efficiency and Renewable Energy Handbook Edited by D. Yogi Goswami and Frank Kreith, 2nd Edition-2016, CRC
2. Clean Energy Microgrids, Edited by Shin'ya Obara and Jorge Morel IET, 2017
3. Hybrid-Renewable Energy Systems in Microgrids- Integration, Developments and Control edited by Hina Fathimaby *et al*., Elsevier WoodHead Publishing, 2018
4. Smart Microgrids: Lessons from Campus Microgrid Design and Implementation edited by Hassan Farhangi, CRC Press 2017

Website Reference / Video Courses:

1. NPTEL Web Course on: DC Microgrid And Control System Prof. Avik Bhattacharya, IIT Roorkee
2. NPTEL Web Course on Electronics and Distributed Generation Dr. Vinod John Department of Electrical Engineering IISc Bangalore
3. NPTEL Web Course on Introduction to Smart Grid, PROF. N.P. PADHY Department of Electrical Engineering IIT Roorkee PROF. PREMALATA JENA Department of Electrical Engineering
4. NPTEL Web Course on Electric vehicles and Renewable energy, Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'Microgrid Technology - SEM-VI						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HCMT601	**Power Electronic Converters for Energy Sources**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HCMT601	**Power Electronic Converters for Energy Sources**	20	20	20	80	03	-	100

Course Objectives	1. To illustrate the design philosophies used in the domain of microgrid power converters. 2. To explore the control implementations in power converters for voltage, current and power regulation for various DC and AC energy sources
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Select and size various passive and active components for power converters 2. Design power converters used with DC energy resources with their control implementation 3. Design power converters used with AC energy resources with their control implementation 4. Understand the design considerations of power conditioning unit for ESS, SPV and Wind applications. 5. Understand the design and selection aspects of various auxiliary systems and components used in PCUs

Module	Contents	Hours
1.	**Selection of components for Power Electronics Converters (PEC):** Selection and Sizing of capacitors and magnetic components for PECs, design of Magnetic Components; Selection and sizing of Power Devices, Commonly used software tools for selection and sizing; Heatsink- selection and sizing.	06
2.	**Design and Control of DC-DC Converters:** Design of Buck and Boost converters, Design examples; Design of Bidirectional Converters. Design of gate driver circuits; Review of DC-DC converter modelling; Closed loop PI controller design for buck and boost converters; Current control mode and voltage control mode.	10
3.	**Design and Control of DC-AC converters:** Design of Inverter for standalone applications; Design of grid connected Inverter with different grid synchronization strategies- ZCD, PLL; Strategies for Control of voltage, current and power output.	10
4.	**Design of PCU for SPV and Wind Application:** Various topologies of Power Converter Unit (PCU) for SPV and Wind energy systems. Design considerations of PCU for SPV and Wind energy Systems and Design Examples.	10
5.	**Design of PCU for ESS Applications:** Design consideration for BDC converter based PCU for batteries and Ultra-capacitors.	08
6.	**Design of Auxiliary System and Interfaces:**	08

	Design of current and voltage sensor interfaces; Design considerations for auxiliary power supplies; Design of protection and snubber components: Introduction to Digital Signal Processors (DSP) and microcontroller interfaces	

Text Books:-

1. Microgrids Design and Implementation edited by Antonio Carlos Zambroni de Souza and Miguel Castilla, Springer, 2019
2. Power Electronic Converters for Microgrids by Suleiman M. Sharkh, Mohammad A. Abusara, Georgios I. Orfanoudakis Babar Hussain, IEEE and Wiley, 2014
3. Microgrids Architectures and Control Edited by Nikos Hatziargyriou, IEEE and Wiley, 2014
4. Energy Storage for Sustainable Microgrid by David Wenzhong Gao, Elsevier, 2015
5. Control Circuits In Power Electronics Practical Issues In Design And Implementation Edited by Miguel Castilla, IET, 2016
6. Control and Dynamics in Power Systems and Microgrids by Lingling Fan, CRC Press, 2017
7. Integrated Power Electronic Converters and Digital Control, by Ali Emadi, Alireza Khaligh, Zhong Nie, and Young Joo, Lee 2009, CRC Press.

Reference Books:-

1. Cooperative Synchronization in Distributed Microgrid Control by Ali Bidram, Vahidreza Nasirian Ali Davoudi, and Frank L. Lewis, Springer, 2017
2. Hybrid-Renewable Energy Systems in Microgrids- Integration, Developments and Control edited by Hina Fathimaby et al., Elseiver WoodHead Publishing, 2018
3. Smart Microgrids- Lessons from Campus Microgrid Design and Implementation edited by Hassan Farhangi, CRC Press 2017
4. Energy Storage Systems and Components by Alfred Rufer, CRC Press, 2018

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'Microgrid Technology - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HCMT701	**Microgrid Power and Control Architecture**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HCMT701	**Microgrid Power and Control Architecture**	20	20	20	80	03	-	100

Course Objectives	1. To study various power and control architectures adopted in DC and AC Microgrids. 2. To explore various control strategies used in power control 3. To take insight into operations stability and protection issues related to Microgrids
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Understand various types Microgrids based on applications, power and control architecture. 2. Illustrate various power control strategies adopted in DC, AC and Hybrid Microgrids 3. Compare and contrast various control architectures used DC, AC and Hybrid Microgrids 4. Illustrate the various operational challenges in Microgrids 5. Comprehend the various aspects related to the stability in Microgrids 6. Understand the protection challenges in Microgrids along with various protection methods to overcome these challenges,

Module	Contents	Hours
1.	<u>Microgrid Power Architecture:</u> Types of Microgrid system, AC and DC and Hybrids Microgrids, Application based Suitability of Microgrid type; Review of power architecture of various Microgrids deployed world-wide. Comparison of various Microgrid power architectures.	08
2.	<u>AC Microgrid and Control Architecture:</u> Black-start operation, Grid Synchronisation- various Grid synchronization methods, Grid forming and grid following operations; Power Control- Real and reactive power control in AC Microgrid, simple droop control and other variants of droop control, Unit Power Flow Control, Feeder power flow control and Mixed mode control, source optimization; Centralized, decentralised, distributed and hierarchical control architecture, Local and system / supervisory level control strategies, Multi Agent System (MAS) Based Control; Control approaches used in AC Microgrids deployed worldwide. Microgrid standards IEEE 1547 series. Communication in AC Microgrids	12
3.	<u>DC Microgrid and Control Architecture:</u> Power sharing in DC Microgrids, source optimization; Control approaches: Centralized, decentralised, distributed and hierarchical control architecture. Control approaches used in hybrid Microgrids. Communication in DC/Hybrid Microgrids	08

4.	Operational Control in Microgrids: Energy management in Microgrids, coordinated control, load management, grid synchronisation and islanding, Anti-islanding schemes; Various Architectural and Operational Challenges in Microgrid, Optimal operation of Microgrids.	08
5.	Microgrid Stability Steady-state and dynamic stability in AC and DC Microgrids, Methods to improve the stability in Microgrids; introduction to small signal and large signal stability analysis in Microgrids.	06
6.	Protection in Microgrids Fault scenarios in DC and AC Microgrids, Protection in DC and AC Microgrids, adaptive protection, Fault current source (FCS) based protection; Protection challenges in islanded and autonomous modes of operation and ways to mitigate.	10

Text/Reference Books:-

1. Microgrids Design and Implementation edited by Antonio Carlos Zambroni de Souza and Miguel Castilla, Springer, 2019
2. Microgrids Architectures and Control Edited by Nikos Hatziargyriou, IEEE and Wiley, 2014
3. Cooperative Synchronization in Distributed Microgrid Control by Ali Bidram, Vahidreza Nasirian Ali Davoudi, and Frank L. Lewis, Springer, 2017
4. Control Circuits In Power Electronics Practical Issues In Design And Implementation Edited by Miguel Castilla, IET, 2016
5. Control and Dynamics in Power Systems and Microgrids by Lingling Fan, CRC Press, 2017
6. Hybrid-Renewable Energy Systems in Microgrids- Integration, Developments and Control edited by Hina Fathimaby et al., Elseiver WoodHead Publishing, 2018
7. Urban DC Microgrid Intelligent Control and Power Flow Optimization by Manuela Sechilariu and Fabrice Locment, 2016 Elsevier
8. Integrated Power Electronic Converters and Digital Control, by Ali Emadi, Alireza Khaligh, Zhong Nie, and Young Joo, Lee 2009, CRC Press.
9. Island Power Systems by Lukas Sigrist, Enrique Lobato, Francisco M. Echavarren Ignacio Egido, and Luis Rouco, CRC Press, 2016

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2. NPTEL Web Course on Electronics and Distributed Generation Dr. Vinod John Department of Electrical Engineering IISc Bangalore
3. NPTEL Web Course on Introduction to Smart Grid, PROF. N.P. PADHY Department of Electrical Engineering IIT Roorkee PROF. PREMALATA JENA Department of Electrical Engineering
4. NPTEL Web Course on Electric vehicles and Renewable energy, Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

Microgrid Technology - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
HCMTSBL701	**Microgrid and RES Lab**	--	04	--	04	04

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)			
		Test 1	Test 2	Avg.					
HCMTSBL701	**Microgrid and RES Lab**	--	--	--	--	--	50	50	100

Course Objectives	1. To provide hands-on with power converters used in AC, DC Microgrids 2. To explore various control implementation incorporated in Microgrids in simulation or with hardware 3. To study various auxiliary systems commonly used in Microgrids.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Test the various power converters used AC, DC Microgrids 2. Illustrate various operational modes of power converters 3. Illustrate various operational modes of Microgrid. 4. Describe the working of various auxiliary system interfaces (communication / sensors) 5. Analyse the steady-state and transient behaviour of Microgrid 6. Demonstrate the design the Microgrid and its sub-systems.

Contents

Microgrid / RES Lab: Experimental Setups (Any Five of the following)

1. Testing of Power Conversion Unit for DC Microgrid
2. Testing of Power Conversion Unit for AC Microgrid
3. DC Microgrid: Power Sharing between the sources
4. AC Microgrid: Power Sharing between the sources
5. Grid Connected Inverter
6. Grid Forming Inverter
7. Grid Interactive Inverter
8. Solar MPPT Control
9. Islanding detection
10. Island mode of operation of DC or AC Microgrid
11. Data transfer through Microgrid Communication Interfaces
12. Standalone Microgrid operation
13. Voltage and current sensing circuits
14. DSP / Microcontroller interface circuits
15. DSP / Microcontroller programming for converter control.

(or any other experiments based on Microgrid related systems/ subsystems)

Use of software tools: (Any three of the following)

Use of tools like MATLAB, Scilab, PSIM, LTSPice, python, C, Java platforms etc. for the following

1. Simulation/ Emulation of DC Microgrid with steady state performance analysis.
2. Simulation/ Emulation of AC Microgrid with steady state performance analysis.
3. Simulation/ Emulation of DC Microgrid ith transient performance analysis.
4. Simulation/ Emulation of AC Microgrid with transient performance analysis.
5. Microgrid Stability analysis with study of impact of ESS on stability

(or any other simulations based on Microgrid related systems/ subsystems)

Plant Visit:

Visit to existing Microgrid facility or a Solar PV/ Wind Installation or a power converters manufacturing / research facility.

Course Project

Course project to be carried out to design /fabricate/ program one of the PCU used in Microgrid.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below. The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. https://www.vlab.co.in/broad-area-mechanical-engineering - Energy Storage Labs, Solar Energy lab, Wind Energy Lab

Term work:

Term work shall consist of minimum eight experiments, at least one plant visit, and one course project. The distribution of marks shall be as follows:

Experiments Performance	: 20 marks
Attendance	: 05 marks
Plant Visit report	: 10 marks
Course Project report	: 10 Marks
Journal & Attendance	: 10 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire lab work of HCMTSBL701-Microgrid and RES Lab

'Microgrid Technology - SEM-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HCMT801	**Microgrid System Design**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HCMT801	**Microgrid System Design**	20	20	20	80	03	-	100

Course Objectives	1. To illustrate the design philosophies used in the domain of Microgrid. 2. To explore the selection of power and control architecture of Microgrids 3. To study the design aspects of AC Microgrid, DC Microgrid and their auxiliary systems
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Select and size various Microgrid energy resources 2. Select the power and control architecture of the Microgrid 3. Select and design the Microgrid's communication architecture. 4. Illustrate the design aspects DC Microgrids with their control strategies. 5. Illustrate the design aspects AC Microgrids with their control strategies. 6. Illustrate the implementation of the Microgrid islanding detection and anti-islanding scheme/ blackstart operation

Module	Contents	Hours
1.	**Selection/ Sizing of Microgrid Energy Resources** Factors affecting the selection and sizing of energy resources for Microgrid applications, dependency on type of loads connected, Selection/ Sizing: Renewable energy resources, Energy Storage components. Hybrid combination of RES and ESS.	07
2.	**Selection of Power and Control Architecture:** Factors affecting the selection of Microgrid power and control architecture; Design Consideration for control implementation; Sensors: Selection of sensors and design of sensor Interfaces, design of control Interfaces. Design considerations for DSP/ Microcontroller interfaces	07
3.	**Selection and Design of Communication Architecture** Design considerations for selection of communication network for Microgrid applications; Design and implementation of communication links/ interfaces. Microg4controller programming for Data transfer on communication network. Practical design considerations for Communication networks.	08
4.	**Design of DC Microgrid** Design DC Power Conditioning Units for RES and ESS, Unidirectional and Bidirectional Converter design, implementation of Control loop with DSP; Programming for Power sharing and Energy Management algorithms; Design of Protection system for DC Microgrid	12

5.	**Design of AC Microgrid** Design AC Power Conditioning Units for RES and ESS, Unidirectional and Bidirectional Converter design, implementation of Control loop with DSP; Grid Synchronization. Programming for Power sharing and Energy Management algorithms; Design of Protection system for AC Microgrid.	12
6.	**Islanding in Microgrids** Selection and implementation of Islanding detection and anti-islanding scheme; Black-start and Autonomous operations in Microgrids;	06

Text Books:-

1. Microgrids Design and Implementation edited by Antonio Carlos Zambroni de Souza and Miguel Castilla, Springer, 2019
2. Microgrids Architectures and Control Edited by Nikos Hatziargyriou, IEEE and Wiley, 2014
3. Power Electronic Converters For Microgrids by Suleiman M. Sharkh, Mohammad A. Abusara, Georgios I. Orfanoudakis Babar Hussain, IEEE and Wiley, 2014

Reference Books:-

1. Energy Storage for Sustainable Microgrid by David Wenzhong Gao, Elsevier, 2015
2. Cooperative Synchronization in Distributed Microgrid Control by Ali Bidram, Vahidreza Nasirian Ali Davoudi, and Frank L. Lewis, Springer, 2017
3. Energy Efficiency and Renewable Energy Handbook Edited by D. Yogi Goswami and Frank Kreith, 2nd Edition-2016, CRC
4. Control Circuits In Power Electronics Practical Issues In Design And Implementation Edited by Miguel Castilla, IET, 2016
5. Hybrid-Renewable Energy Systems in Microgrids- Integration, Developments and Control edited by Hina Fathimaby et al., Elseiver WoodHead Publishing, 2018
6. Urban DC Microgrid Intelligent Control and Power Flow Optimization by Manuela Sechilariu and Fabrice Locment, 2016 Elsevier
7. Integrated Power Electronic Converters and Digital Control, by Ali Emadi, Alireza Khaligh, Zhong Nie, and Young Joo, Lee 2009, CRC Press.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

Robotics

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Robotics (With effect from 2022-23)										
Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar /Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	HXXC501: Industrial Robotics	04	--	--	20	80	--	--	100	04
	Total	04	-	--	100		-	-	100	04
Tota l Credits = 04										
TE Sem VI	HXXC601: Mechatronics &IoT	04	--	--	20	80	--	--	100	04
	Total	04	-	-	100		-	-	100	04
Total Credits = 04										
BE Sem VII	HXXC701: Artificial Intelligence & Data Analysis	04	--	--	20	80	--	--	100	04
	HXXSBL701: Lab-1	--	--	04	--	--	50	50	100	02
	Total	04	-	04	100		50	50	200	06
Total Credits = 06										
BE Sem VIII	HXXC801: Autonomous Vehicle	04	-	--	20	80	--	--	100	04
	Total	04	-	-	100		-	-	100	04
Total Credits = 04										
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Robotics - SEM-VI		
Course Code	Course Name	Credits
HRC501	**Industrial Robotics**	4

Course Objectives:

1. To acquaint with significance of robotic system in agile and automated manufacturingprocesses.
2. To make conversant with robotic elements/ peripherals, their selection and interface with manufacturing equipment's.
3. To study the basics of robot kinematics

Course Outcomes: Upon successful completion the course, learner will be able to

1. Acquire skills in understanding robot language and programming.
2. Acquire skill in robot task planning for problem solving.
3. Develop skills in understanding various sensors, robot peripherals and their use & deployment in manufacturing system.
4. Develop skills in identifying areas in manufacturing where robotics can be deployedfor enhancing productivity.

Module	Details	Hours
1.	Introduction Automation, robotics, Robotic system & Anatomy,Classification and Future Prospects	2
2.	**Drives** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators and Power Transmission system. **Robot & its Peripherals** **End Effecters:** Type mechanical and other grippers, Tool as end effecter. **Sensors:** Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Vision systems and Equipment	10
3.	**Machine vision** Introduction, Low level & High level Vision, Sensing & Digitizing, Image Processing & analysis, Segmentation, Edge detection, Object Description & recognition, interpretationand Applications. **Programming for Robots** Method, Robot Programme as a path in space, Motion interpolation, motion & task level Languages, Robot languages, Programming in suitable languages and characteristics ofrobot.	10
4.	**Robot Kinematics** Forward, reverse & Homogeneous Transformations, Manipulator Path control and Robot Dynamics. **Introduction to wheeled and legged robots including humanoids**	10
5.	**Robot Intelligence & Task Planning** Introduction, State space search, Problem reduction, use of predictive logic, Means. Ends Analysis, Problem solving, Robot learning and Robot task planning.	10

6.	**Robot application in manufacturing Material transfer, machine loading & un loading, processing operation, Assembly & inspectors, robotic Cell design & control, Social issues & Economics of Robotics.**	10

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

1. Weightage of each module in end semester examination will be proportional to the numberof respective lecture hours mentioned in the curriculum.
2. Question paper will comprise of total six questions, each carrying 20 marks
3. Question 1 will be compulsory and should cover maximum contents of the curriculum
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3then part (b) will be from any module other than module 3)
5. Only four questions need to be solved

Text/References

1. Industrial Robotics, Technology, Programming & Applications, Grover, Weiss, Nagel, Ordey,Mc Graw Hill.
2. Robotics: Control, Sensing, Vision & Intelligence, Fu, Gonzalex, Lee, Mc Graw Hill.
3. Robotic technology & Flexible Automation, S R Deb. TMH.
4. Robotics for Engineers, Yoram Koren , Mc Graw hill.
5. Fundamentals of Robotics, Larry Health.
6. Robot Analysis & Control, H Asada, JJE Slotine.
7. Robot Technology, Ed. A Pugh, Peter Peregrinus Ltd. IEE, UK. 8. Handbook of IndustrialRobotics, Ed. Shimon. John Wiley
8. Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza, “Introduction to AutonomousMobile Robots”, Bradford Company Scituate, USA

Robotics - SEM-VI		
Course Code	**Course Name**	**Credits**
HRC601	**Mechatronics & IoT**	**4**

Course Objectives:

1. To associate a mechatronic System with IOT
2. To relate data analytics with IOT
3. To understand Cloud Computing in IOT

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Describe a Mechatronic System
2. Demonstrate the use of a Micro-controller
3. Understand an IOT System
4. Identify Wireless Technologies Supporting IOT
5. Use Data Analytics in conjunction with IOT &Cloud

Module	Details	Hours
1.	Introduction to Mechatronics: Traditional and Mechatronics Design, Mechatronics Key Elements, Basic Components of Mechatronic Systems , Integrated Design issues in Mechatronics, Mechatronics Design Process, Mechatronics System in Factory, Home and Business Applications, Objectives, Advantages and Disadvantages of Mechatronics	6
2.	Overview of Micro-processor ad Micro-controller: 8051 Micro-controllers, Functional Block Diagram and Architecture, Instruction set and Assembly Language Programming, Analog and Data Acquisition , Digital I/O interfacing, Special Function interfacing, Signal Conditioning, Special Utility Support hardware Interfacing of HEX – Keyboards, LCD Display, ADC, DAC andStepper Motor with 8051 Micro-controller	10
3.	Introduction and application to Internet of Things: Need of IoT, history of IOT, Objects of IOT, Level of IOT, Technologies in IOT, Introduction to Arduino and Raspberry Pi, understanding its components, recognizing the Input/Output, GPIO Connectivity	10
4.	Wireless Technologies Supporting IoT: Protocol Standardization for IoT, Machine to machine (M2M) and WSN protocols, Basics of RFID , RFID Protocols, Issues with IOT Saudization, Protocols – IEEE 802.15.4, Zigbee, IPv6 Technologies for IOT	10
5.	Data Analytics for IOT: Introduction Apache Hadoop, Using Hadoop MapReduce for Batch Data Analysis, Apache Oozie, Apache Spark, Apache Storm, Using Apache Storm for Real Tie Data Analysis, Structural Health Monitoring, Case Study: Chef Case Study, puppet Case Study	10
6.	Introduction to Cloud Computing, Difference between Cloud Computing and FOG Computing: The Next Evolution of Cloud Computing, Role of Cloud Computing in IOT, Connecting IoT to Cloud, Cloud Storage for IoT Challenge in Integration of IoT with Cloud	8

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

1. Weightage of each module in end semester examination will be proportional to the numberof respective lecture hours mentioned in the curriculum.
2. Question paper will comprise of total six questions, each carrying 20 marks
3. Question 1 will be compulsory and should cover maximum contents of the curriculum
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3then part (b) will be from any module other than module 3)
5. Only four questions need to be solved

Text/Reference Books:

1. Bolton, William. Mechatronics: electronic control systems in mechanical and electricalengineering. Pearson Education, 2003.
2. De Silva, Clarence W. Mechatronics: an integrated approach. CRC press, 2004.
3. Ayala, Kenneth J. The 8051 microcontrollers. Thomson Delmar Learning, 2005.
4. Zhang, Dan, and Bin Wei, eds. Mechatronics and Robotics Engineering for Advanced andIntelligent Manufacturing. Springer International Publishing, 2017.
5. Greengard, Samuel. The internet of things. MIT press, 2021.
6. Chaouchi, Hakima, ed. The internet of things: Connecting objects to the web. John Wiley &Sons, 2013.
7. Hintz, Kenneth, and Daniel Tabak. Microcontrollers: architecture, implementation, andprogramming. McGraw-Hill, Inc., 1992.

Robotics - SEM-VII		
Course Code	**Course Name**	**Credits**
HRC701	**Artificial Intelligence andData Analytics**	**04**

Course Objectives:

1. To gain perspective of AI, its foundations, agent architectures and properties of theenvironment.
2. To understand the basic principles of AI towards problem solving, inference, perception,knowledge representation, and learning.
3. To investigate probabilistic reasoning under uncertain and incomplete information.
4. To gain the perspective of the concepts of data Mining, modelling and visualization, data warehousing.
5. To understand various machine learning algorithms.

Course Outcomes: Upon successfully completion of this course, learner will able to...

1. Demonstrate knowledge of the building blocks of AI, intelligent agents and knowledgepresentation systems.
2. Explain artificial intelligence planning, reasoning, uncertainty handing and expert systems.
3. Describe the concept of data mining, big data, data analytics, business intelligence.
4. Comprehend and implement data mining and machine learning algorithms.

Module	Contents	Hours.
01	**Introduction to Artificial Intelligence (AI):** A. I. Representation, Representation of knowledge, knowledge base systems, state space search, production systems, problem characteristics, types of production systems, Intelligent Agents and Environments, nature of environments, structure of agents **Knowledge and Reasoning:** Knowledge Representation Systems, Properties of Knowledge Representation Systems, Propositional Logic (PL), First Order Logic: Syntax and Semantic, Inference in FOL, Forward v/s Backward Chaining	**6**
02	**Planning:** Introduction to Planning, Planning with State Space Search, Partial Ordered planning, Hierarchical Planning, Conditional Planning, Brief introduction to single layer and multiplayer networks **Reasoning Under Uncertainty:** Handling Uncertain Knowledge, Random Variables, Prior and Posterior Probability, Inference using Full Joint Distribution, Bayes' Rule and its use, Bayesian Belief Networks, Reasoning in Belief Networks **Introduction to Expert Systems:** Components of Expert System: Knowledge base, Inference engine, user interface, workingmemory, Development of Expert Systems	**10**

03	**Introduction to Data Mining:** What is Data Mining; Kind of patterns to be mined; Technologies used; Major issues in Data Mining, associative Rule Mining **Introduction to Big Data:** Big Data characteristics, types of Big Data, Traditional vs. Big Data business approach, Case Studies ofBig Data Solutions, Introduction to parallel Processing (MPP) architecture, Hadoop/HDFS and cloud based solutions **Introduction to Business Intelligence:** Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	**8**
04	**Data Pre-processing:** Notion of data quality. Typical pre-processing operations: combining values into one, handling incomplete/ incorrect / missing values, recoding values, sub setting, sorting, transforming scale, determining percentiles, removing noise, removing inconsistencies, transformations, standardizing, normalizing - min-max normalization, z-score standardization. **Data Modeling and visualization:** Logic driven modeling, data driven modeling, basic what-if spreadsheet models **Data Warehousing:** What is a data warehouse, need for a data warehouse, architecture, data marts, OLTP vs OLAP	**10**
05	**Machine Learning:** Supervised and Unsupervised Learning, Concepts of Classification, Clustering and prediction **Performance Measures:** Measuring Quality of model- ConfusionMatrix, Accuracy, Recall, Precision, Specificity, F1 Score, RMSE	**8**
06	**Classification:** Rule based classification, classification by BayesianBelief networks, Hidden Markov Models. **Clustering:** Hebbian Learning rule, Expectation -Maximizationalgorithm for clustering **Dimensionality Reduction:** Principal Component Analysis FeatureSelection and Feature Extraction **Time Series Analysis and Forecasting:** Time series patterns,forecast accuracy, moving averages and exponential smoothing	**10**

<u>Assessment</u>:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

1. Weightage of each module in end semester examination will be proportional to the numberof respective lecture hours mentioned in the curriculum.
2. Question paper will comprise of total six questions, each carrying 20 marks
3. Question 1 will be compulsory and should cover maximum contents of the curriculum
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3then part (b) will be from any module other than module 3)
5. Only four questions need to be solved

Text Books:

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach —SecondEdition" Pearson Education.
2. Elaine Rich and Kevin Knight —Artificial Intelligence‖ Third Edition, Tata McGraw-HillEducation Pvt. Ltd., 2008.
3. George F Luger "Artificial Intelligence" Low Price Edition, Pearson Education, Fourth edition.
4. Deepak Khemani, A first course in Artificial Intelligence, Mc GrawHill
5. P. N. Tan, M. Steinbach, Vipin Kumar, "Introduction to Data Mining", Pearson Education.
6. G. Shmueli, N.R. Patel, P.C. Bruce, "Data Mining for Business Intelligence: Concepts, Techniques, and Applications in Microsoft Office Excel with XLMiner", 2nd Edition, Wiley India.
7. Ethem Alpaydın, "Introduction to Machine Learning", MIT Press
8. Peter Flach, "Machine Learning", Cambridge University Press

Reference Books:

1. Tom M. Mitchell, "Machine Learning", McGraw Hill
2. Kevin P. Murphy, "Machine Learning — A Probabilistic Perspective", MIT Press
3. Stephen Marsland, "Machine Learning an Algorithmic Perspective", CRC Press
4. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning", CambridgeUniversity Press
5. Peter Harrington, "Machine Learning in Action", DreamTech Press
6. D. W. Patterson, Artificial Intelligence and Expert Systems, Prentice Hall.
7. Saroj Kaushik "Artificial Intelligence", Cengage Learning.

Links for online NPTEL/SWAYAM courses:

https://onlinecourses.nptel.ac.in/noc19_me71/previewhttps://onlinecourses.nptel.ac.in/noc22_cs56/preview

https://onlinecourses.nptel.ac.in/noc22_cs29/preview https://onlinecourses.nptel.ac.in/noc22_cs08/preview

Robotics - SEM-VII		
Course Code	**Course Name**	**Credits**
HRSBL701	**Robotics and Automation Lab**	**2**

Course Objectives:

1. To learn the implementation of image processing algorithms.
2. To acquaint with programming of robots.
3. To acquaint with data acquisition over cloud environment
4. To demonstrate the working of machine learning algorithms for data prediction.

Course Outcomes: learner will able to...

1. Develop simple image processing algorithms.
2. Program robots for simple and inverse kinematics and trajectory planning.
3. Acquire sensor data over cloud using microcontroller.
4. Perform predictive data analysis using clustering, classification and regression models.

List of Experiments:

1. Edge detection / segmentation using image processing
2. programming the robots to solve direct and inverse kinematics problems
3. Trajectory planning for Robots
4. Acquisition of sensor data over cloud using microcontroller
5. Implementation of Clustering algorithm (K-means / K-medoids)
6. Data Classification using data prediction tool (classification tree / artificial neural networks,Support Vector Machines etc.) (Any One)
7. Linear Regression using data predictive tool (multiple regression / artificial neural networksetc.) (Any One)
8. PLC to operate actuators for automation application

Assessment:

Term Work

Term work shall consist of the experiments as mentioned above.The

distribution of marks for term work shall be as follows:

1. Laboratory work (Experiments): 20 marks
2. Attendance: 05 marks

Robotics - SEM-VIII		
Course Code	**Course Name**	**Credits**
HRC801	**Autonomous Vehicle Systems**	**4**

Course Objectives:

1. To comprehend fundamental aspects of Autonomous Vehicles.
2. To Acquire knowledge of levels of automation of autonomous systems.
3. To Understand the Connectivity Aspects of autonomous automobiles

Course Outcomes: The student will be able to

1. Gain perspective of autonomous systems
2. Understand Automotive Electronics and the operation of ECUs.
3. Discuss about the use of computer vision and learning algorithms in vehicles.
4. Learn Localization, Perception, Prediction planning and control.
5. Summarize the aspects of connectivity
6. Understand cloud platform and ROS.

Module	Details	Hours
1	**An over view of autonomous driving technologies**: Algorithms, client systems, cloud Platforms	6
2	**Overview of Automotive Electronics**: Control Systems for Autonomous vehicles, Electronic Engine control, Chassis and Powertrain Electronics, Vehicle motion control, Instrumentation andTelematics & ADAS	8
3	**Sensing Technologies** Radar & Sonar, Camera, Lidar, GNSS.GPS/IMU Use of Sensor Data, Sensor Fusion and Kalman Filters	8
4	**Computer Vision and Deep Learning** Computer Vision Fundamentals -Advanced Computer Vision , Neural Networks for Image Processing , TensorFlow ,Convolutional Neural Networks	10
5	**Levels of Automation** Localization - GNSS, LiDAR, Wheel and Visual Odometry, sensorfusion Perception – Detection and Tracking, DrivingPerception and deeplearning Prediction and Routing- Trffic prediction and Lane level routing Decision, Planning and Control- Motion Planning,Feed back control Cloud System- Operating systems-ROS, Cloud Platforms	12
6	**Connected Car Technology:** Connectivity Fundamentals - DSRC (Direct Short Range Communication), Connectivity types -Vehicle-to-Vehicle, Vehicle-to-Roadside and Vehicle-to-Infrastructure, Vehicle-to-pedestrian, Vehicle- to-clous, Vehicle-to-everything, Applications -Security Issues Technical Issues, Security Issues, Moral and Legal Issues.	8

Text Books:

1. Shaoshan Liu, Liyun Li, “Creating Autonomous Vehicle Systems”, Morgan and Claypool Publishers,2017.
2. Liu, Shaoshan. Engineering autonomous vehicles and robots: the DragonFly modular-based approach. John Wiley & Sons, 2020.
3. Hong Cheng, “Autonomous Intelligent Vehicles: Theory, Algorithms and Implementation”, Springer,2011.
4. Williams. B. Ribbens: “Understanding Automotive Electronics”, 7th Edition, Elsevier Inc,2012.

Reference Books:

1. Marcus Maurer, J.Christian Gerdes, “Autonomous Driving: Technical, Legal andSocial Aspects”Springer, 2016.
2. Ronald.K.Jurgen, “Autonomous Vehicles for Safer Driving”, SAE International, 2013.
3. James Anderson, KalraNidhi, Karlyn Stanly, “Autonomous Vehicle Technology:A Guide forPolicymakers”, Rand Co, 2014.
4. Lawrence. D. Burns, Chrostopher Shulgan, “Autonomy – The quest to build thedriverless car andhow it will reshape our world”, Harper Collins Publishers, 2018

UNIVERSITY OF MUMBAI

Syllabus

Honours/Minor Degree Program

In

3D Printing

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Honours* in 3D Printing (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HC3DP501: Introduction to CAD**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HC3DP601: 3D Printing: Introduction & Processes**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HC3DP701: Applications of 3D Printing**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VIII	**HC3DP801: 3D Printing in Medical Technology**	04	-	--	20	80	--	--	100	04
	H3DPSBL801: Skill Based Lab – Digital Fabrication	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits =	**06**
Total Credits for Semesters V, VI, VII &VIII = 04+04+04+06 = 18										

'3D Printing' :SEM-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HC3DP501	**Introduction to CAD**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HC3DP501	**Introduction to CAD**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To impart the 3D modelling skills for development of 3D models of basic engineering components. 2. To familiarize with basic concepts of computer graphics. 3. To familiarize with basic concepts of additive and subtractive manufacturing process.
Course Outcomes	**Upon successful completion of this course, the learner will be able:** 1. Illustrate basic understanding of design. 2. Create the CAM Toolpath for specific given operations. 3. Illustrate basic understanding of types of CAD model creation. 4. Generate assembly models of given objects using assembly tools of a modelling software. 5. Identify suitable computer graphics techniques for 3D modelling. 6. Transform, manipulate objects & store and manage data.

Module	Contents	Hours
1.	**Design thinking:** Identification of need, Embodiment of design, Generation of ideas and research topics	5
2.	**Subtractive Manufacturing:** Introduction to NC/CNC/DNC machines **Additive Manufacturing:** Introduction to 3D Printing, Limitations of Subtractive manufacturing, Digital fabrication	8
3.	**CAD Introduction:** History & Scope of CAD, CAD hardware and software, Advantages, Disadvantages and Applications of CAD	7

4.	**Introduction to 2D modelling:** CAD models Creation, Types and uses of models from different perspectives **Introduction to assembly drawing:** Types of assembly drawings, part drawings, drawings for catalogues and instruction manuals, patent drawings, drawing standards	12
5.	**Computer Graphics:** Overview of 2D and 3D Computer Graphics, Parametric representation of curves: Synthetic Curves - Bezier curves, Hermite Curves, B-spline curves **Geometric Modelling:** Wire Frame Modelling, Solid Modelling, Surface Modelling, Parametric Modelling, Feature based Modelling, Constraint Based Modelling.	12
6.	**Geometric Transformation:** 2D & 3D Transformations (Translation, Rotation, & Scaling & Reflection), Concatenations	8

Text/Reference Books:-

1. Machine Drawing by N.D. Bhatt.
2. A textbook of Machine Drawing by Laxminarayan and M.L.Mathur, Jain brothers Delhi
3. CAD/ CAM, Theory & Practice, Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications
4. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
5. CAD/CAM Computer Aided and Manufacturing, Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition
6. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.
7. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
8. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.

Website Reference / Video Courses:

1. https://nptel.ac.in/courses/112/102/112102101/
2. https://nptel.ac.in/courses/106/102/106102065/
3. https://nptel.ac.in/courses/106/102/106102065/
4. https://nptel.ac.in/courses/112/102/112102103/
5. https://nptel.ac.in/courses/112/105/112105211/
6. https://nptel.ac.in/courses/112/104/112104265/
7. https://www.youtube.com/watch?v=2cCMty9v3Tg
8. https://www.youtube.com/watch?v=2zPh26Q1BT8

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'3D Printing' - SEM-VI						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
HC3DP601	**3D Printing: Introduction & Processes**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HC3DP601	**3D Printing: Introduction & Processes**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To familiarise with importance of Rapid Prototyping. 2. To study programming aspects of subtractive manufacturing process. 3. To familiarize with basic process of additive manufacturing in particularly 3D printing.
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Illustrate understanding of various cost-effective alternatives for manufacturing productsand select the feasible RP process for specific technical applications 2. Build and create data for 3D printing of any given object using liquid based rapid prototypingand tooling processes 3. Build and create data for 3D printing of any given object using solid based rapid prototypingand tooling processes 4. Build and create data for 3D printing of any given object using powder based rapid prototyping and tooling processes 5. Select an appropriate material and tools to develop a given product using rapid prototypingmachine 6. Select proper rapid prototyping and reverse engineering techniques for specific technical applications. 7. Demonstrate basics of virtual reality

Module	Contents	Hours
1.	**Additive Manufacturing:** Introduction to AM, Classification of AM Processes, Advantages & disadvantages, AM Applications; in Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, and bio fabrication.	9

2.	**Liquid based systems:** **Stereo lithography apparatus (SLA):** Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. **Solid ground curing (SGC):** Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.	9
3.	**Solid based systems:** **Laminated object manufacturing (LOM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. **Fused Deposition Modeling (FDM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.	8
4.	**Powder Based Systems:** **Selective laser sintering (SLS):** Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. **Three-dimensional printing (3DP):** Models and specification, process, working principle, applications, advantages and disadvantages, case studies. **Electron Beam Melting (EBM):** Models and specification, process, working principle, applications, advantages and disadvantages, case studies.	8
5.	**Materials for Additive manufacturing** Types of material: polymers, metals, ceramics and composites, liquid-based materials, photo polymer development, solid based materials, powder-based materials. **Material properties** Colour, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties.	10
6.	**Reverse Engineering** Introduction to Digitizing Methods, Contact type and Non-contact type, Brief introduction to the types of medical imaging. Virtual reality: Definition, features of VR, Technologies used in VR, Introduction to Augmented reality	8

Text/Reference Books:-

1. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
2. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
3. Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Hauge, P M, Dickens, Wiley

4. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley
5. Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography by Paul F. Jacobs, McGraw Hill
6. Rapid Manufacturing by Pham D T and Dimov S S, Springer Verlog
7. "Rapid Prototyping" Chee Kai Chua, World Scientific Publishing

Website Reference / Video Courses:

NPTEL Web Course:

1. Rapid Manufacturing, By Prof. J. Ramkumar, Prof. Amandeep Singh, IIT Kanpur, https://onlinecourses.nptel.ac.in/noc20_me50/preview
2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'3D Printing' - SEM-VII						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
HC3DP701	**Applications of 3D Printing**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HC3DP701	**Applications of 3D Printing**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To familiarise with applications of 3D Printing technologies. 2. To acquaint with the process of using biomedical data for 3D modelling. 3. To familiarize with basic process of additive manufacturing in different industries.
Course Outcomes	**Upon successful completion of this course, the learner will be able:** 1. To understand the perspectives for 3D printing in Jewellery industries for selection of an appropriate material and tools to develop a given product using rapid prototyping techniques. 2. Develop 3D model using various types of available biomedical data. 3. To understand the perspectives for 3D printing in Aerospace industries for selection of an appropriate material and tools to develop a given product using rapid prototyping techniques. 4. Illustrate understanding of various cost-effective alternatives for manufacturing products. 5. Use rapid prototyping and tooling concepts in any real-life applications. 6. Contribute towards the Product Development at the respective domain in the industry

Module	Contents	Hours
1.	**Applications in Jewellery Industries** **Introduction to 3D Printing Jewellery:** Steps Involved in Jewellery 3D Printing, Why 3D Printing for Jewellery Making, Techniques Involved in Jewellery 3D Printing, 3D Printing Processes for Jewellery Designing, Challenges with Jewellery 3D Printing, 3D Printing vs Traditional Methods, Types of Jewellery can be 3D Printed, **3D Printers for Jewellery Making –** How They Work & Which to Choose	10
2.	**Medical Applications in Additive manufacturing** Presurgical Planning Models, Mechanical Bone Replicas, Teaching Aids and Simulators, Customized Surgical Implants, Prosthetics and Orthotics', Anthropology, Forensics	8

3.	**Applications in Aerospace Industries** Use of AM in Aerospace, Metal AM in Aerospace, Super alloys, Non-Destructive Evaluation, Space technology	8
4.	**Applications in Tooling** **Methods of Rapid tooling:** Direct Soft Tooling, Indirect Soft Tooling, Direct Hard Tooling, Indirect Hard Tooling.	9
5.	**Applications in various industries** Automotive, Défense, Coin industries, Household appliance, Toy industry, Ship building, Un-manned Aerial Vehicles (UAV), Furniture, Construction and food	9
6.	**Applications in Design** Design for Additive Manufacturing (DFAM), Topology optimization for AM, Generative design **Applications in Engineering, Analysis and Planning**	8

Text/Reference Books:-

1. Makers: The New Industrial Revolution (Telord 1403), by Chris Anderson
2. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
3. 3D Printing in Aerospace and Defense Standard Requirements, by Gerardus Blokdyk
4. Additive Manufacturing for the Aerospace Industry, by Francis Froes, Rodney Boyer
5. 3D Printing in Medicine, 1st Edition - April 1, 2017, by Deepak Kalaskar
6. An Update on Medical 3D Printing Hardcover – 1 January 2019, by Dr Raju Vaishya, Dr Abid Haleem, Dr Lalit Maini
7. 3D Printing in Medicine: A Practical Guide for Medical Professionals Hardcover – Import, 12 October 2017, by Frank J. Rybicki, Gerald T. Grant
8. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
9. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
10. Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Hauge, P M, Dickens, Wiley
11. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley

Website Reference / Video Courses:

NPTEL Web Course:

1. Rapid Manufacturing, By Prof. J. Ramkumar, Prof. Amandeep Singh, IIT Kanpur, https://onlinecourses.nptel.ac.in/noc20_me50/preview
2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

‘3D Printing’ - SEM-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HC3DP801	**3D Printing in Medical Technology**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HC3DP801	**3D Printing in Medical Technology**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To acquaint with the process of using biomedical data for 3D modeling. 2. To familiarize with basic process of additive manufacturing in particularly 3D printing
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Describe the creation of highly accurate physical models of human anatomy 2. Identify medical imaging for human body 3. Understand the modelling based on Biomedical data 4. Build and create data for 3D printing of any given object using rapid prototyping and tooling processes. 5. Illustrate the understanding of different manufacturing processes 6. To Identify the processes and tooling concepts in Biomedical

Module	Contents	Hours
1.	**Introduction** Stages of the medical modelling process, The human form, Basic anatomical terminology, technical terminology	8
2.	**Introduction to medical imaging** Computed tomography (CT), Cone beam CT (CBCT), Magnetic resonance (MR), Noncontact surface scanning, Medical scan data, Point cloud data	10
3.	**Working with medical scan data** Pixel data operations, Using CT data: a worked example, Point cloud data operations, Two-dimensional formats, Pseudo 3D formats, True 3D formats, File management and exchange	12
4.	**Physical reproduction** Basic principles of medical modelling: orientation, sectioning, separating and joining, trapped volumes	8

5.	Introduction to Additive manufacturing processes used for Bio-Modelling, Computer numerical controlled machining, Cleaning and Sterilizing medical models	8
6.	**Case Studies based on Bio-Modelling & Future Development**	6

Text/Reference Books:-

1. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
2. 3D Printing in Medicine, 1st Edition - April 1, 2017, by Deepak Kalaskar
3. An Update on Medical 3D Printing Hardcover – 1 January 2019, by Dr Raju Vaishya, Dr Abid Haleem, Dr Lalit Maini
4. 3D Printing in Medicine: A Practical Guide for Medical Professionals Hardcover – Import, 12 October 2017, by Frank J. Rybicki, Gerald T. Grant
5. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
6. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
7. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley

Website Reference / Video Courses:

NPTEL Web Course:

1. Rapid Manufacturing, By Prof. J. Ramkumar, Prof. Amandeep Singh, IIT Kanpur, https://onlinecourses.nptel.ac.in/noc20_me50/preview
2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

‘3D Printing’ - SEM-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical/ Tutorial	Theory	Practical/ Tutorial	Total
H3DPSBL701	**Skill Based Lab – Digital Fabrication**		**04**	**--**	**04**	**04**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)			
		Test 1	Test 2	Avg.					
H3DPSBL801	**Skill Based Lab – Digital Fabrication**	**-**	**-**	**-**	**-**	**-**	**50**	**50**	**100**

Course Objectives	1. To impart the geometric modeling skills for development of 3D models of engineering components. 2. To familiarize with production drawings with important features like GD &T, surface finish, heat treatments etc. 3. To familiarize with additive manufacturing process 4. To acquaint with basic process of 3D modeling using biomedical data.
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Illustrate basic understanding of types of CAD model creation. 2. Build geometric model of a given object using 3D modeling software 3. Generate assembly models of given objects using assembly tools of a modeling software 4. Demonstrate CAM Tool path and prepare NC- G code 5. Develop 3D model using available biomedical data 6. Build any given real life object using 3D printing process

Module	Contents	Hours
1.	Geometric modeling of an Engineering component, demonstrating skills in sketching commands of creation (line, arc, circle etc.) modification (Trim, move, rotate etc.) and viewing using (Pan, Zoom, Rotate etc.)	06
2.	Demonstrating modeling skills using commands like Extrude, Revolve, Sweep, Blend, Loft etc. Mesh of curves, free form surfaces etc. Feature manipulation using Copy, Edit, Pattern, Suppress, History operations etc.	04

3.	Assembly: Constraints, Exploded views, interference check. Drafting (Layouts, Standard & Sectional Views, Detailing & Plotting).	04
4.	Solid modeling of any engineering component using any 3D modeling software.	04
5.	Non - Contact Scanning – Generation of CAD model using 3D scanning equipment.	04
6.	Reverse Engineering of a legacy component – Selection of components, 3D scanning, CAD model verification, 3D print of CAD model.	04
7.	Modeling of a component using 3D modelling software and development of G – Code output using Fractal Software.	06
8.	Design an object with free form surface using Autodesk Fusion 360 and development of G – Code output using Fractal Software.	04
9.	Segmentation in Slicer's Segment Editor module for the purpose of 3D printing.	04
10.	Creation of 3D model from 2D images using any image processing software and printing it. (3D Slicer open source) (Application: Any body organ like Heart, Gallbladder etc. as per available Dicom files)	04
11.	Development of physical 3D mechanical structure using any one of the Additive manufacturing processes – Material to be used Metal	06
12.	Development of physical 3D mechanical structure using any one of the Additive manufacturing processes - Material to be used Plastic	04

Text/Reference Books:-

1. Machine Drawing by N.D. Bhatt.
2. A textbook of Machine Drawing by Laxminarayan and M.L.Mathur, Jain brothers Delhi
3. Machine Drawing by K.I. Narayana, P. Kannaiah, K.Venkata Reddy
4. Medical Modelling - The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd
5. Biomaterials, artificial organs and tissue engineering, Edited by Larry L. Hench and Julian R. Jones, Woodhead Publishing and Maney Publishing, CRC Press 2005
6. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.

Website Reference / Video Courses:

1. https://www.autodesk.in/products/fusion-360/learn-support
2. https://knowledge.autodesk.com/support/inventor

3. https://www.slicer.org/wiki/Documentation/4.10/Training

Term work:

Term work shall consist of all twelve experiments.The distribution of marks shall be as follows:

Experiments Performance	: 20 marks
Course Project	: 20 marks
Attendance	: 10 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire lab work of **H3DPSBL801 - Skill Based Lab – DigitalFabrication**

UNIVERSITY OF MUMBAI

Syllabus for

Honours/Minor Degree Program

In

Industrial Automation

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai
Industrial Automation
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar /Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Pract. and Oral	Total	Credits
TE Sem V	**HIAC501: Fundamentals of Industrial Automation**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HIAC601: Industrial Internet of Thing (IIOT)**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem VII	**HIAC701: AI and ML for Automation**	04	--	--	20	80	-	-	100	04
	HIAL701: AI and ML for Automation-Lab	-	-	04	-	-	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**100**		**200**	**06**
									Total Credits = 06	
BE Sem VIII	**HIAC801: Applied Predictive Analytics**	04	--	--	20	80	-	-	100	04
	Total	**04**	**-**	**-**	**100**		**-**		**100**	**04**
									Total Credits = 04	
Total Credits for Semesters V, VI, VII &VIII = 04+04+06+04 = 18										

Industrial Automation : SEM V								
Course code	**Course Name**	**Teaching scheme**			**Credit assigned**			
HIAC 501	**Fundamentals of Industrial Automation**	**Theory**	**Pract.**	**Tut.**	**Theory**	**Pract**	**Tut.**	**Total**
		4	**-**	-	**4**	**-**	-	**4**

Course Code	**Course Name**	**Examination scheme**							
		Theory (out of 100)				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC 501	**Fundamentals of Industrial Automation**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course objective	1. To impart knowledge of Industrial Automation. 2. To make the students learn industrial sensors. 3. To make the students learn various actuators. 4. To make the students learn about controller strategy and various automation tools like PLC. 5. To give the students an overview of DCS and HMI. 6. To give students an overview of communication protocols.
Course Outcome	The students will able to 1. Recognize Industrial automation. 2. Select and configure industrial sensors. 3. Comprehend and work with various actuators. 4. Know various automation tools. 5. Work with DCS and HMI. 6. Select various communication protocols.

Pre requisites: Sensors and Transducers basics			
Module	**Contents**	**Hours.**	**CO**
1	**Introduction** Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, types of Automation, Hierarchical level in automation, Advanced automation functions, Automated flow lines and transfer mechanisms. Material handling and identification technologies, Conveyor system, Automated guided vehicle system, Automated storage systems, Automatic Identification Methods.	6	CO1
2	**Sensors** Introduction to Industrial Measurement, overview of sensors, classification, sensor characteristics, physical principles of sensing, sensor Materials and Technologies. Inductive sensors, capacitive sensors, vision sensors, ultrasonic sensors, Electronic SMART Digital remote sensor , Robotic sensors, Tactile sensing, Proximity sensors, Range sensor, Position sensors, Fibre optic sensors, Guided microwave sensor, wireless sensors, Electrical characteristics of sensors, specifications of sensors, performance testing, selection guidelines.	8	CO2
3	**Actuators** Pneumatic and hydraulic-directional and pressure control valves, cylinders, servo proportional control valves, rotary actuators. Electrical actuation: A.C and DC motors, stepper motors, mechanical switches and solid state switches. Mechanical Actuation: types of motion, kinematic chain, cams, gears, ratchets and pawl, belt and chain drives, bearings, mechanical aspects of motor selection, piezoelectric actuators, magneto-strictive actuators, memory metal actuators. Selection Criteria of Actuators	8	CO3
4	**Controller strategy / Automation Tools. PLC** Overview and Features, Types, specifications, PLC Architecture, PLC working, PLC SCAN, new trends in PLC, PLC programming Languages, PLC instructions set, Development of Ladder programme, case study Example, PLC Applications, Overview of Motion control.PLC Installation and wiring. **SCADA** Overview, SCADA Architecture, SCADA-Hardware functions, New trends in scada systems, applications, case study examples.	10	CO4

5	**DCS & HMI** DCS: Overview and Features of DCS, DCS Architecture, Hardware elements, working of DCS, DCS displays, DCS interfacing with PLC , DCS wiring diagram. Applications and suppliers. HMI : Overview, need, Types, wiring practice, Data Handling , configuration and interfacing with **PLC & PC, Communication standards. ASM Graphics**	10	**CO5**
6	**Communication protocols** Overview of sensor networks, AS interface,CAN, HART, FF, Profibus, Interbus, Mbus, Wireless sensor network, networks-IEEE, Zigbee, sensor interfaces.	6	**CO6**

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will consist of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 or 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weight age of each module will be proportional to number of respective Lecture hours as mentioned in the syllabus.

Text Books Recommended:

1. Jacob K Freden; Handbook of Modern sensors, Springer, 5th Edition
2. Tony Kuphaldt; Lessons in industrial instrumentation, version 4
3. Walt Boyes; Instrumentation Reference book , Fourth Edition.
4. William C Dunn; Fundamentals of Industrial Instrumentation and process control, McGraw Hill.
5. C.L.Albert and D.A. Coggan, Fundamentals of Industrial Control, ISA, 1992.
6. Bela G. Liptak, Instrument Engineer's HandBook – Process Measurement and Analysis, ISA CRC Press , 4th Edition, 2003.
7. Andrew Williams, Applied instrumentation in the process industries, 2nd Edition, Vol. 1 & 3, Gulf publishing company.
8. Douglas. M.Considine; Process Instruments & Control Handbook, McGraw-Hill
9. S C Mukhopadhyay; Intelligent sensing, Instrumentation and Measurement, Springer.

Industrial Automation : Sem. VI								
Course code	**Course Name**	**Teaching scheme**			**Credit assigned**			
HIAC601	**Industrial Internet of Thing (IIOT)**	**Theory**	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
		4	**-**	-	**4**	**-**	-	**4**

Course Code	**Course Name**	**Examination scheme**							
		Theory (out of 100)				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC601	**Industrial Internet of Thing (IIOT)**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course objective	1. Introduce how IoT has become a game changer in the new economy where the customers are looking for integrated value 2. Bring the IoT perspective in thinking and building solutions 3. Introduce the tools and techniques that enable IoT solution and Security aspects.
Course Outcome	The students will able to 1. Describe IOT, IIOT 2. Design and develop the real-life IoT applications using off the shelf hardware and software 3. Know various IoT Layers and their relative importance 4. Recognize various IoT platforms and Security 5. Realize the importance of Data Analytics in IoT 6. Design and thinking concepts of IIoT

Prerequisites: Microcontroller based Architecture and Programming			
Module	**Content**	**Hours**	**CO**
1	**Introduction:** Introduction of Industry 4.0, Elements of industry 4.0, Introduction to IOT, what is IIOT? IOT Vs. IIOT, History of IIOT, Components of IIOT - Sensors, Interface, Networks, People &Process, Hype cycle, IOT Market, Trends& future Real-life examples, Key terms – IOT Platform, Interfaces, API, clouds, Role of IIOT in Manufacturing Processes Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges & Benefits in implementing IIOT	6	CO1
2	**Architectures:** Overview of IOT components; Various Architectures of IOT and IIOT, Advantages & disadvantages, Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT	8	CO2
3	**Sensor and Interfacing:** Introduction to sensors, Transducers, Classification, Roles of sensors in IIOT, Various types of sensors, Design of sensors, sensor architecture, special requirements for IIOT sensors, Role of actuators, types of actuators, IT and OT Integration.	10	CO3
4	**Protocols and Cloud:** Need of protocols; Types of Protocols, Wi-Fi, Wi-Fi direct, Zigbee, Z wave, BACnet, BLE, Modbus, SPI , I2C, IIOT protocols –COAP, MQTT,6lowpan, lwm2m, AMPQ IIOT cloud platforms: Overview of cots cloud platforms, Predix, thingworks, azure etc. Data analytics, cloud services, Business models: Saas, Paas, Iaas.	8	CO4
5	**Cyber security for industry, Privacy, and Governance** Cyber physical system, cyber security life cycle, cyber security guidelines, standard IEC 62443 Introduction to web security, Conventional web technology and relationship with IIOT, Vulnerabilities of IoT, Privacy, Security requirements, Threat analysis, Trust, IoT security tomography and layered attacker model, Identity establishment, Access control, Message integrity, non-repudiation and availability, Security model for IoT.	8	CO5
6	**IOT Analytics and CASE study:** Role of Analytics in IOT, Data visualization Techniques, Introduction to R Programming, Statistical Methods. Internet of Things Applications: Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Home Automation, Smart Cards, Plant Automation,	8	CO6

	Real life examples of IIOT in Manufacturing Sector.		

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will consist of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 or 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weight age of each module will be proportional to number of respective Lecture hours as mentioned in the syllabus.

Text Books:

1. Daniel Minoli, Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications, ISBN: 978-1-118-47347-4, Willy Publications 2. Bernd Scholz-Reiter,Florian
2. Michahelles, Architecting the Internet of Things, ISBN 978-3- 642-19156-5 e-ISBN 978-3-642-19157-2,Springer

Reference Books:

1. Hakima Chaouchi, The Internet of Things Connecting Objects to the Web, ISBN : 978-1- 84821-140-7, Willy Publications
2. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2nd Edition, Willy Publications
3. Inside the Internet of Things (IoT), Deloitte University Press
4. Internet of Things- From Research and Innovation to Market Deployment; By Ovidiu & Peter; River Publishers Series
5. Five thoughts from the Father of the Internet of Things; by ByPhil Wainewright - Kevin Ashton
6. How Protocol Conversion Addresses IIoT Challenges: White Paper By Red Lion.

Industrial Automation: Sem. VII								
Subject Code	Subject Name	Teaching Scheme			Credit Assigned			
		Th	Pract.	Tut.	Th	Pract.	Tut.	Total
HIAC701	Artificial Intelligence and Machine Learning for Automation	4	-	-	4	-	-	4

Sub Code	Subject Name	Examination scheme							
		Theory				Term work	Pract. and Oral	Oral	Total
		Internal Assessment			End sem Exam				
		Test1	Test2	Avg.					
HIAC701	Artificial Intelligence and Machine Learning for Automation	20	20	20	80	-	-	-	100

Course Objectives	1. To familiarize student with basic concepts of Artificial Intelligence and Machine learning. 2. To provide understanding of the concepts of regression, classification, clustering and deep learning algorithms. 3. To introduce the students to various applications of Artificial Intelligence and Machine learning for industrial automation
Course Outcomes	Students will be able to: 1. Introduce concepts of Artificial Intelligence and Machine learning 2. Explicate statistical tools and development of database for AI/ML. 3. Analyze the various algorithms for Regression, Classification and Clustering. 4. Evaluate metrics for ML/AI algorithms. 5. Examine the algorithms for deep learning. 6. Explain examples of ML/AI algorithms for industrial automation.

Details of Syllabus:

Module	Contents	Hrs.	CO Mapping
1.	**Introduction to Artificial Intelligence:** Evolution, definition, types, application examples, benefits/advantages, limitations/issues, comparison.	**06**	**CO1**
2.	**Review of statistical concepts:** Mean, variance, covariance, standard deviation, random variable, probability distribution, probability distribution function, normal distribution, binomial distribution, poisson distribution, central limit theorem, vector norms, principal component analysis. **Data collection and preparation:**	**08**	**CO2**

	Collecting, cleaning, normalization, standardization, missing data, underfitting and overfitting, neglecting outliers, annotation, labelling. Data Splitting: Training, Validation, and Test Datasets. Public datasets for machine learning.		
3.	**Regression:** Simple Linear regression, Multiple Linear Regression, Polynomial Regression, Logistic regression. **Classifiers:** k-Nearest Neighbours, Decision trees, naïve Bayes, SVM for Linearly separable data, Kernel SVM for Non-Linearly separable data. **Clustering:** k-means clustering.	**10**	**CO3**
4.	**Evaluation Metrics**: True Positive, True Negative, False Positive, False Negative, accuracy, precision, recall or True Positive Rate, False Positive Rate, Receiver Operating Characteristic, Area Under the Curve, Confusion matrix, F-score.	**04**	**CO4**
5.	**Deep Learning:** Multilayer Perceptron (MLP), Convolutional Neural Network (CNN), Recurrent Neural Network (RNN)	**08**	**CO5**
6.	**Application in Industrial Automation**: **Robotics, Factory automation, Process control, Electrical Engineering** Challenges, Data Screening, Feature Engineering, Projected improvement, Model Design, Limitations, Future scope, References.	**12**	**CO6**

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on Minimum 02 Modules) and the other is either a class test or assignment on live problems or Course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 or 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Harrington, Peter. *Machine learning in action*. Simon and Schuster, 2012.
2. Zheng, Alice, and Amanda Casari. *Feature engineering for machine learning: principles and techniques for data scientists*. " O'Reilly Media, Inc.", 2018.
3. Jiang, Hui. *Machine Learning Fundamentals: A Concise Introduction*. Cambridge University Press, 2021.
4. Huyen, C. *"Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications"*, O'Reilly Media, 2022.
5. Gupta, Itisha, and Garima Nagpal. *Artificial Intelligence and Expert Systems*. Stylus Publishing, LLC, 2020.

Reference Books:

1. Pandey, Yogendra Narayan, et al. *Machine Learning in the Oil and Gas Industry*. apress, Texas, 2020.
2. Bangert, Patrick, ed. *Machine learning and data science in the oil and gas industry: Best practices, tools, and case studies*. Gulf Professional Publishing, 2021.
3. Das, Santosh Kumar, et al., eds. *Machine learning algorithms for industrial applications*. Cham: Springer, 2021.

Industrial Automation: SEM VII								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Th	Pract.	Tut.	Th	Pract.	Tut.	Total
HIAL701	Artificial Intelligence and Machine Learning for Automation Lab	-	4	-	-	4	-	2

Subject Code	Subject Name	Examination scheme							
		Theory (out of 100)				Term work	Pract. and Oral	Oral	Total
		Internal Assessment			End sem Exam				
		Test1	Test2	Avg.					
HIAL701	Artificial Intelligence and Machine Learning for Automation Lab	--	--	--	--	50	50		100

Course Objectives	1. To familiarize student with basic concepts of Artificial Intelligence and Machine learning. 2. To provide understanding of the concepts of regression, classification, clustering and deep learning algorithms. 3. To introduce the students to various applications of Artificial Intelligence and Machine learning for industrial automation
Course Outcomes	Students will be able to 1. Write programs based on data compression and dimensionality reduction. 2. Write programs for regression, classification and clustering. 3. Calculate evaluation metrics for various algorithms. 4. Write programs based on deep learning algorithms. 5. Demonstrate working of AI/ML in Robotics and Factory automation. 6. Validate working of AI/ML in Process control and Electrical Engineering.

Syllabus: Same as that of Subject HIAC701.

List of the Laboratory Experiments:

Sr. No.	Contents	CO Mapping
1.	Write a python program to perform PCA for dimension reduction or data compression.	CO1
2.	Develop/download database of any industrial machine/system. Explain hardware system used for data collection. Explain specifications/characteristics of collected data.	CO2
3.	Write a python program to implement linear regression with one variable, two variables for given dataset.	CO2
4.	Demonstrate the working of SVM classifier for a linearly separable data set.	CO2
5.	Demonstrate the working of Kernel SVM classifier for a non-linearly separable data set.	CO2
6.	Demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.	CO2
7.	Calculate evaluation metrics such as accuracy, precision, recall, confusion matrix, F-score, etc for regression, classification and clustering algorithms.	CO3
8.	Calculate evaluation metrics such as Receiver Operating Characteristic, Area Under the Curve, etc for regression, classification and clustering algorithms.	CO3
9.	Implement multilayer Perceptron (MLP) for predicting stock price. Time series forecasting.	CO4
10.	Implement Convolutional Neural Network (CNN) to recognize hand-written digits dataset.	CO4
11.	Implement Recurrent Neural Network (RNN) for speech recognition.	CO4
12.	Case study or mini project on application of AI/ML in Robotics.	CO5
13.	Case study or mini project on application of AI/ML in Factory automation.	CO5
14.	Case study or mini project on application of AI/ML in Process control.	CO6
15.	Case study or mini project on application of AI/ML in Electrical Engineering.	CO6

Any other experiment based on syllabus which will help students to understand topic/concept.

Practical and Oral Examination:

Practical and Oral examination will be based on entire syllabus.

Term Work:

Term work shall consist of minimum 12 experiments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments): 20 Marks
Laboratory work (programs / journal): 20 Marks
Attendance: 10 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Industrial Automation: SEM VIII								
Subject code	**Subject Name**	**Teaching scheme**			**Credit assigned**			
		Theory	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
HIAC801	**Applied Predictive Analytics**	**4**	**-**	-	**4**	**-**	-	**4**

Sub Code	**Subject Name**	**Examination scheme**							
		Theory (out of 100)				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC801	**Applied Predictive Analytics**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course objective	1. To deliver Knowledge of core operations in Energy Vertical Solving complex issues analyzing available data in Operations, Maintenance, Reliability, Safety, Procurement, Inventory etc., 2. To introduce forecasting and predictive techniques.
Course Outcome	The students will able to 1. Identify the use of analytics and its tools 2. Interpret data and preparation of data 3. Use descriptive modeling techniques 4. Practice predictive modeling techniques such as decision tree, logistic regression and neural network 5. Apply and build models using clustering, regression and classification techniques and its corresponding algorithms 6. Discuss the case studies of Predictive Analytics and Predictive Maintenance

Pre requisites: Data Science concepts

Module	**Content**	**Hours.**	**CO**
1	**Overview of Predictive Analytics:** What and Why Analytics, Predictive Analytics? Supervised vs. Unsupervised Learning, Parametric vs. Non-Parametric Models, Business Intelligence, Predictive Analytics vs. Business Intelligence, Predictive Analytics vs. Statistics, Statistics and Analytics, Predictive Analytics and Statistics Contrasted, Predictive Analytics vs. Data Mining, Challenges in Using Predictive Analytics. Concept of hb	06	CO1
2	**Data Understanding and Data Preparation:**	08	CO2

	Single Variable Summaries, Applying Simple Statistics in Data Understanding, Categorical Variable Assessment, Data Visualization in One Dimension, Two or Higher Dimensions. Data Preparation, Fixing Missing Data, Feature Creation, Simple Variable Transformations, Fixing Skew, Binning Continuous Variables, Numeric Variable Scaling, Nominal Variable Transformation, Ordinal Variable Transformations, Date and Time Variable Features, Multidimensional Features		
3	**Descriptive Modeling:** Data Preparation, Issues with Descriptive Modeling, Principal Component Analysis, The PCA Algorithm, Applying PCA to New Data, PCA for Data Interpretation, Additional Considerations before Using PCA, The Effect of Variable Magnitude on PCA Models, Clustering Algorithms, The K-Means Algorithm, Data Preparation for K-Means	07	CO3
4	**Predictive Modeling:** Decision Trees, The Decision Tree Landscape, Building Decision Trees, Logistic Regression, Interpreting Logistic Regression Models, Other Practical Considerations for Logistic Regression, Neural Networks, Building Blocks: The Neuron, Neural Network Training, The Flexibility of Neural Networks, Neural Network Settings, Neural Network Pruning, Interpreting Neural Networks, Neural Network Decision Boundaries, Other Practical Considerations for Neural Networks	9	CO4
5	**Predictive Modeling:** K-Nearest Neighbor, the k-NN Learning Algorithm, Distance Metrics for k-NN, Other Practical Considerations for k-NN, Naïve Bayes, Bayes' Theorem, The Naïve Bayes Classifier Interpreting Naïve Bayes Classifiers, Other Practical Considerations for Naïve Bayes, Regression Models, Linear Regression, Linear Regression Assumptions, Variable Selection in Linear Regression, Interpreting Linear Regression Models, Using Linear Regression for Classification, Other Regression Algorithms	9	CO5
6	**Assessing Predictive Models:** Batch Approach to Model Assessment, Percent Correct Classification, Rank-Ordered Approach to Model Assessment, Assessing Regression Models. **Case studies:** Quality Prediction in a Mining Process, predicting the consumption of electricity in the coming future (refer Kaggle data set) **Predictive Maintenance:** Find a defect in the production, Sensor Fault Detection(refer Kaggle data set), Boiler Fault Detection ((refer https://ieee-dataport.org/)	9	CO6

Text Books:

1. Dean Abbott, "Applied Predictive Analytics: Principles and Techniques for the Professional Data Analyst" ,

   ISBN: 978-1-118-72796-6

2. P. Kaliraj, T. Devi, “Big Data Applications in Industry 4.0”, ISBN 9781032008110, Published February 10, 2022 by Auerbach Publications
3. Mahir Oner, Sultan Ceren Oner, “Data Analytics in Industry 4.0: In the Perspective of Big Data”.

Reference Books:

1. Gareth James, Daniela Witten, Trevor Hastie Robert Tibshirani. “An Introduction to Statistical Learning with Applications in R”
2. Joel Grus, “Data science from scratch”, Orielly publication, ISBN: 9781492041139, May 2019
3. David Roi Hardoon, Galit Shmueli, “Getting Started with Business Analytics: Insightful Decision-Making”, CRC Press,SBN 9781498787413
4. James R Evans, “Business Analytics”, Pearson publication, ISBN: 9780135231678