AC: 23/7/2020

Item No. 127

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Computer 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)

AC: 23/7/2020
Item No. 127

UNIVERSITY OF MUMBAI

Syllabus for Approval

Date

Sr. No.	Heading	Particulars
1	Title of the Course	**Second Year B.E. Computer 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	~~P.G.~~ / **U.G.**/ ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ / **Semester** (Strike out which is not applicable)
8	Status	**New** / ~~Revised~~ (Strike out which is not applicable)
9	To be implemented from Academic Year	**With effect from Academic Year: 2020-2021**

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
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Dr Anuradha Muzumdar
Dean
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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 by Board of Studies in Computer Engineering

Dear Students and Teachers, we, the members of Board of Studies Computer Engineering, are very happy to present Second Year Computer Engineering syllabus effective from the Academic Year 2020-21 (REV-2019'C' Scheme). We are sure you will find this syllabus interesting and challenging.

Computer Engineering is one of the most sought-after courses amongst engineering students hence there is a continuous requirement of revision of syllabus. The syllabus focuses on providing a sound theoretical background as well as good practical exposure to students in the relevant areas. It is intended to provide a modern, industry-oriented education in Computer Engineering. It aims at producing trained professionals who can successfully acquainted with the demands of the industry worldwide. They obtain skills and experience in up-to-date the knowledge to analysis, design, implementation, validation, and documentation of computer software and systems.

The revised syllabus falls in line with the objectives of affiliating University, AICTE, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements.

The salient features of the revised syllabus are:

1. Reduction in credits to 170 is implemented to ensure that students have more time for extracurricular activities, innovations, and research.
2. Introduction of Skill Based Lab and Mini Project to showcase their talent by doing innovative projects that strengthen their profile and increases the chance of employability.
3. Students are encouraged to take up part of course through MOOCs platform SWAYAM

We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

Board of Studies in Computer Engineering

Prof. Sunil Bhirud : Chairman

Prof. Madhumita Chatterjee : Member

Prof. Sunita Patil : Member

Prof. Leena Raga : Member

Prof. Subhash Shinde : Member

Prof. Meera Narvekar : Member

Prof. Suprtim Biswas : Member

Prof. Sudhir Sawarkar : Member

Prof. Dayanand Ingle : Member

Prof. Satish Ket : Member

Program Structure for Second Year Computer Engineering

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
CSC301	Engineering Mathematics-III	3	--	1*	3	--	1	4
CSC302	Discrete Structures and Graph Theory	3	--	--	3	--	--	3
CSC303	Data Structure	3	--	--	3	--	--	3
CSC304	Digital Logic & Computer Architecture	3	--	--	3	--	--	3
CSC305	Computer Graphics	3	--	--	3	--	--	3
CSL301	Data Structure Lab	--	2	--	--	1	--	1
CSL302	Digital Logic & Computer Architecture Lab	--	2	--	--	1	--	1
CSL303	Computer Graphics Lab	--	2	--	--	1	--	1
CSL304	Skill base Lab course: Object Oriented Programming with Java	--	2+2*	--	--	2	--	2
CSM301	Mini Project – 1 A	--	4$	--	--	2	--	2
Total		**15**	**14**	**1**	**15**	**07**	**1**	**23**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract & oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test 1	Test2	Avg					
CSC301	Engineering Mathematics-III	20	20	20	80	3	25	--	125
CSC302	Discrete Structures and Graph Theory	20	20	20	80	3	--	--	100
CSC303	Data Structure	20	20	20	80	3	--	--	100
CSC304	Digital Logic & Computer Architecture	20	20	20	80	3	--	--	100
CSC305	Computer Graphics	20	20	20	80	3	--	--	100
CSL301	Data Structure Lab	--	--	--	--	--	25	25	50
CSL302	Digital Logic & Computer Architecture Lab	--	--	--	--	--	25	--	25
CSL303	Computer Graphics Lab	--	--	--	--	--	25	25	50
CSL304	Skill base Lab course: Object Oriented Programming with Java	--	--	--	--	--	50	25	75
CSM301	Mini Project – 1 A	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**175**	**100**	**775**

*Should be conducted batch wise and

$ indicates workload of Learner (Not Faculty), Students can form groups with minimum 2 (Two) and not more than 4 (Four), Faculty Load: 1 hour per week per four groups

Program Structure for Second Year Computer 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
CSC401	Engineering Mathematics-IV	3	--	1*	3	--	1	4
CSC402	Analysis of Algorithm	3	--	--	3	--	--	3
CSC403	Database Management System	3	--	--	3	--	--	3
CSC404	Operating System	3	--	--	3	--	--	3
CSC405	Microprocessor	3	--	--	3	--	--	3
CSL401	Analysis of Algorithm Lab	--	2	--	--	1	--	1
CSL402	Database Management System Lab	--	2	--	--	1	--	1
CSL403	Operating System Lab	--	2	--	--	1	--	1
CSL404	Microprocessor Lab	--	2	--	--	1	--	1
CSL405	Skill Base Lab Course: Python Programming	--	2*+2	--	--	2	--	2
CSM401	Mini Project 1-B	--	4$	--	--	2	--	2
Total		**15**	**16**	**1**	**15**	**7**	**1**	**24**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract & oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg.					
CSC401	Engineering Mathematics-IV	20	20	20	80	3	25	--	125
CSC402	Analysis of Algorithm	20	20	20	80	3	--	--	100
CSC403	Database Management System	20	20	20	80	3	--	--	100
CSC404	Operating System	20	20	20	80	3	--	--	100
CSC405	Microprocessor	20	20	20	80	3	--	--	100
CSL401	Analysis of Algorithm Lab	--	--	--	--	--	25	25	50
CSL402	Database Management System Lab	--	--	--	--	--	25	25	50
CSL403	Operating System Lab	--	--	--	--	--	25	25	50
CSL404	Microprocessor Lab	--	--	--	--	--	25	--	25
CSL405	Skill Base Lab Course: Python Programming	--	--	--	--	--	25	--	25
CSM401	Mini Project 1-B	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	**--**	**175**	**100**	**775**

*Should be conducted batchwise and

$ indicates workload of Learner (Not Faculty), Students can form groups with minimum 2 (Two) and not more than 4 (Four), Faculty Load: 1 hour per week per four groups.

Course Code	Course Name	Credits
CSC301	Engineering Mathematics-III	4

Pre-requisite: Engineering Mathematics-I, Engineering Mathematics-II	
Course Objectives: The course aims:	
1	To learn the Laplace Transform, Inverse Laplace Transform of various functions, its applications.
2	To understand the concept of Fourier Series, its complex form and enhance the problem-solving skills.
3	To understand the concept of complex variables, C-R equations with applications.
4	To understand the basic techniques of statistics like correlation, regression, and curve fitting for data analysis, Machine learning, and AI.
5	To understand some advanced topics of probability, random variables with their distributions and expectations.
Course Outcomes: On successful completion, of course, learner/student will be able to:	
1	Understand the concept of Laplace transform and its application to solve the real integrals in engineering problems.
2	Understand the concept of inverse Laplace transform of various functions and its applications in engineering problems.
3	Expand the periodic function by using the Fourier series for real-life problems and complex engineering problems.
4	Understand complex variable theory, application of harmonic conjugate to get orthogonal trajectories and analytic functions.
5	Apply the concept of Correlation and Regression to the engineering problems in data science, machine learning, and AI.
6	Understand the concepts of probability and expectation for getting the spread of the data and distribution of probabilities.

Module		Detailed Contents	Hours
1	**Laplace Transform**		7
	1.1	Definition of Laplace transform, Condition of Existence of Laplace transform.	
	1.2	Laplace Transform (L) of standard functions like $e^{at}, sin(at), cos(at), sinh(at), cosh(at)andt^n, n \geq 0$.	
	1.3	Properties of Laplace Transform: Linearity, First Shifting Theorem, Second Shifting Theorem, Change of Scale, Multiplication by *t*, Division by *t*, Laplace Transform of derivatives and integrals (Properties without proof).	
	1.4	Evaluation of real improper integrals by using Laplace Transformation.	
	1.5	**Self-learning Topics:** Laplace Transform: Periodic functions, Heaviside's Unit Step function, Dirac Delta Function, Special functions (Error and Bessel)	
2	**Inverse Laplace Transform**		7
	2.1	Definition of Inverse Laplace Transform, Linearity property, Inverse Laplace Transform of standard functions, Inverse Laplace transform using derivatives.	
	2.2	Partial fractions method to find Inverse Laplace transform.	
	2.3	Inverse Laplace transform using Convolution theorem (without proof)	
	2.4	**Self-learning Topics:** Applications to solve initial and boundary value	

		problems involving ordinary differential equations.	
3	**Fourier Series:**		7
	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.	
	3.5	**Self-learning Topics:** Orthogonal and orthonormal set of functions, Complex form of Fourier Series, Fourier Transforms.	
4	**Complex Variables:**		7
	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: Determine analytic function *f(z)*when real part (u), imaginary part (v) or its combination (u+v / u-v) is given.	
	4.4	Harmonic function, Harmonic conjugate and Orthogonal trajectories.	
	4.5	**Self-learning Topics:** Conformal mapping, Linear and Bilinear mappings, cross ratio, fixed points and standard transformations.	
5	**Statistical Techniques**		6
	5.1	Karl Pearson's coefficient of correlation (r)	
	5.2	Spearman's Rank correlation coefficient (R) (with repeated and non-repeated ranks)	
	5.3	Lines of regression	
	5.4	Fitting of first- and second-degree curves.	
	5.5	**Self-learning Topics:** Covariance, fitting of exponential curve.	
6	**Probability**		6
	6.1	Definition and basics of probability, conditional probability.	
	6.2	Total Probability theorem and Bayes' theorem.	
	6.3	Discrete and continuous random variable with probability distribution and probability density function.	
	6.4	Expectation, Variance, Moment generating function, Raw and central moments up to 4^{th} order.	
	6.5	**Self-learning Topics:** Skewness and Kurtosis of distribution (data).	

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	Complex Variables and Applications, Brown and Churchill, McGraw-Hill Education.
5	Probability, Statistics and Random Processes, T. Veerarajan, McGraw-Hill Education.
6	Theory and Problems of Fourier Analysis with applications to BVP, Murray Spiegel, Schaum's Outline Series.

Term Work:	
General Instructions:	
1	Batch wise tutorials have to be conducted. The number of students per batch will be as per University pattern for practical.
2	Students must be encouraged to write at least 6 class tutorials on the 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 will be considered as a mini project in Engineering Mathematics. This project will be graded out of 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 Test:	
The assessment consists of two class tests of 20 marks each. The 1stclass test (Internal Assessment I) has to be conducted when approximately 40% of the syllabus is completed. The 2nd class test has to be conducted (Internal Assessment II) when an additional 35% syllabus is completed. The duration of each test will be for one hour.	
End Semester Theory Examination:	
1	The question paper will comprise a total of 6 questions, each carrying 20 marks.
2	Out of the 6 questions, 4 questions have to be attempted.
3	Question 1, based on the entire syllabus, will have 4sub-questions of 5 marks each and is compulsory.
4	Question 2 to Question 6 will have 3 sub-questions, each of 6, 6, and 8 marks, respectively.
5	Each sub-question in (4) will be from different modules of the syllabus.
6	Weightage of each module will be proportional to the number of lecture hours, as mentioned in the syllabus.

Course Code	Course Name	Credits
CSC302	Discrete Structures and Graph Theory	3

Pre-requisite: Basic Mathematics	
Course Objectives: The course aims:	
1	Cultivate clear thinking and creative problem solving.
2	Thoroughly train in the construction and understanding of mathematical proofs. Exercise common mathematical arguments and proof strategies.
3	To apply graph theory in solving practical problems.
4	Thoroughly prepare for the mathematical aspects of other Computer Engineering courses
Course Outcomes: On successful completion, of course, learner/student will be able to:	
1	Understand the notion of mathematical thinking, mathematical proofs and to apply them in problem solving.
2	Ability to reason logically.
3	Ability to understand relations, functions, Diagraph and Lattice.
4	Ability to understand and apply concepts of graph theory in solving real world problems.
5	Understand use of groups and codes in Encoding-Decoding
6	Analyze a complex computing problem and apply principles of discrete mathematics to identify solutions

Module	Detailed Contents		Hours
1	**Logic**		6
	1.1	Propositional Logic, Predicate Logic, Laws of Logic, Quantifiers, Normal Forms, Inference Theory of Predicate Calculus, Mathematical Induction.	
2	**Relations and Functions**		**6**
	2.1	Basic concepts of Set Theory	
	2.2	**Relations:** Definition, Types of Relations, Representation of Relations, Closures of Relations, Warshall's algorithm, Equivalence relations and Equivalence Classes	
	2.3	**Function**s: Definition, Types of functions, Composition of functions, Identity and Inverse function	
3	**Posets and Lattice**		**5**
	3.1	Partial Order Relations, Poset, Hasse Diagram, Chain and Anti chains, Lattice, Types of Lattice, Sub lattice	
4	**Counting**		**6**
	4.1	Basic Counting Principle-Sum Rule, Product Rule, Inclusion-Exclusion Principle, Pigeonhole Principle	
	4.2	Recurrence relations, Solving recurrence relations	
5	**Algebraic Structures**		**8**
	5.1	**Algebraic structures with one binary operation:** Semi group, Monoid, Groups, Subgroups, Abelian Group, Cyclic group, Isomorphism	
	5.2	**Algebraic structures with two binary operations:** Ring	
	5.3	**Coding Theory**: Coding, binary information and error detection, decoding and error correction	
6	**Graph Theory**		**8**
		Types of graphs, Graph Representation, Sub graphs, Operations on Graphs, Walk, Path, Circuit, Connected Graphs, Disconnected Graph, Components, Homomorphism and Isomorphism of Graphs, Euler and Hamiltonian Graphs, Planar Graph, Cut Set, Cut Vertex,	

		Applications.	

Textbooks:	
1	Bernad Kolman, Robert Busby, Sharon Cutler Ross, Nadeem-ur-Rehman, "Discrete Mathematical Structures", Pearson Education.
2	C. L. Liu "Elements of Discrete Mathematics", second edition 1985, McGraw-Hill Book Company. Reprinted 2000.
3	K. H. Rosen, "Discrete Mathematics and applications", fifth edition 2003, Tata McGraw Hill Publishing Company
References:	
1	Y N Singh, "Discrete Mathematical Structures", Wiley-India.
2	J. L. Mott, A. Kandel, T. P. Baker, "Discrete Mathematics for Computer Scientists and Mathematicians", Second Edition 1986, Prentice Hall of India.
3	J. P. Trembley, R. Manohar "Discrete Mathematical Structures with Applications to Computer Science", Tata McGraw Hill Publishing Company
4	Seymour Lipschutz, Marc Lars Lipson, "Discrete Mathematics" Schaum"s Outline, McGraw Hill Education.
5	Narsing Deo, "Graph Theory with applications to engineering and computer science", PHI Publications.
6	P. K. Bisht, H. S. Dhami, "Discrete Mathematics", Oxford press.

Assessment:	
Internal Assessment Test:	
The assessment consists of two class tests of 20 marks each. The 1st class test (Internal Assessment I) has to be conducted when approximately 40% of the syllabus is completed. The 2nd class test has to be conducted (Internal Assessment II) when an additional 40% syllabus is completed. The duration of each test will be for one hour.	
End Semester Theory Examination:	
1	The question paper will comprise a total of 6 questions, each carrying 20 marks.
2	Out of the 6 questions, 4 questions have to be attempted.
3	Question 1, based on the entire syllabus, will have 4sub-questions of 5 marks each and is compulsory.
4	Question 2 to Question 6 will have 3 sub-questions, each of 6, 6, and 8 marks, respectively.
5	Each sub-question in (4) will be from different modules of the syllabus.
6	Weightage of each module will be proportional to the number of lecture hours, as mentioned in the syllabus.

Useful Links	
1	https://www.edx.org/learn/discrete-mathematics
2	https://www.coursera.org/specializations/discrete-mathematics
3	https://nptel.ac.in/courses/106/106/106106094/
4	https://swayam.gov.in/nd1_noc19_cs67/preview

Course Code	Course Name	Credit
CSC303	Data Structure	03

Pre-requisite: C Programming	
Course Objectives: The course aims:	
1	To understand the need and significance of Data structures as a computer Professional.
2	To teach concept and implementation of linear and Nonlinear data structures.
3	To analyze various data structures and select the appropriate one to solve a specific real-world problem.
4	To introduce various techniques for representation of the data in the real world.
5	To teach various searching techniques.
Course Outcomes:	
1	Students will be able to implement Linear and Non-Linear data structures.
2	Students will be able to handle various operations like searching, insertion, deletion and traversals on various data structures.
3	Students will be able to explain various data structures, related terminologies and its types.
4	Students will be able to choose appropriate data structure and apply it to solve problems in various domains.
5	Students will be able to analyze and Implement appropriate searching techniques for a given problem.
6	Students will be able to demonstrate the ability to analyze, design, apply and use data structures to solve engineering problems and evaluate their solutions.

Module		Detailed Content	Hours
1		**Introduction to Data Structures**	2
	1.1	Introduction to Data Structures, Concept of ADT, Types of Data Structures-Linear and Nonlinear, Operations on Data Structures.	
2		**Stack and Queues**	8
	2.1	Introduction, ADT of Stack, Operations on Stack, Array Implementation of Stack, Applications of Stack-Well form-ness of Parenthesis, Infix to Postfix Conversion and Postfix Evaluation, Recursion.	
	2.2	Introduction, ADT of Queue, Operations on Queue, Array Implementation of Queue, Types of Queue-Circular Queue, Priority Queue, Introduction of Double Ended Queue, Applications of Queue.	
3		**Linked List**	10
	3.1	Introduction, Representation of Linked List, Linked List v/s Array, Types of Linked List - Singly Linked List, Circular Linked List, Doubly Linked List, Operations on Singly Linked List and Doubly Linked List, Stack and Queue using Singly Linked List, Singly Linked List Application-Polynomial Representation and Addition.	
4		**Trees**	11
	4.1	Introduction, Tree Terminologies, Binary Tree, Binary Tree Representation, Types of Binary Tree, Binary Tree Traversals, Binary Search Tree, Operations on Binary Search Tree, Applications of Binary Tree-Expression Tree, Huffman Encoding, Search Trees-AVL, rotations in AVL Tree, operations on AVL Tree, Introduction of B Tree, B+ Tree.	
5		**Graphs**	4

	5.1	Introduction, Graph Terminologies, Representation of Graph, Graph Traversals-Depth First Search (DFS) and Breadth First Search (BFS), Graph Application-Topological Sorting.	
6		**Searching Techniques**	4
	6.1	Linear Search, Binary Search, Hashing-Concept, Hash Functions, Collision resolution Techniques	

Textbooks:	
1	Aaron M Tenenbaum, Yedidyah Langsam, Moshe J Augenstein, "Data Structures Using C", Pearson Publication.
2	Reema Thareja, "Data Structures using C", Oxford Press.
3	Richard F. Gilberg and Behrouz A. Forouzan, "Data Structures: A Pseudocode Approach with C", 2nd Edition, CENGAGE Learning.
4	Jean Paul Tremblay, P. G. Sorenson, "Introduction to Data Structure and Its Applications", McGraw-Hill Higher Education
5	Data Structures Using C, ISRD Group, 2nd Edition, Tata McGraw-Hill.
References:	
1	Prof. P. S. Deshpande, Prof. O. G. Kakde, "C and Data Structures", DreamTech press.
2	E. Balagurusamy, "Data Structure Using C", Tata McGraw-Hill Education India.
3	Rajesh K Shukla, "Data Structures using C and C++", Wiley-India
4	GAV PAI, "Data Structures", Schaum's Outlines.
5	Robert Kruse, C. L. Tondo, Bruce Leung, "Data Structures and Program Design in C", Pearson Edition

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	https://nptel.ac.in/courses/106/102/106102064/
2	https://www.coursera.org/specializations/data-structures-algorithms
3	https://www.edx.org/course/data-structures-fundamentals
4	https://swayam.gov.in/nd1_noc19_cs67/preview

Course Code	Course Name	Credit
CSC304	Digital Logic & Computer Organization and Architecture	3

Pre-requisite: Knowledge on number systems	
Course Objective:	
1	To have the rough understanding of the basic structure and operation of basic digital circuits and digital computer.
2	To discuss in detail arithmetic operations in digital system.
3	To discuss generation of control signals and different ways of communication with I/O devices.
4	To study the hierarchical memory and principles of advanced computing.
Course Outcome:	
1	To learn different number systems and basic structure of computer system.
2	To demonstrate the arithmetic algorithms.
3	To understand the basic concepts of digital components and processor organization.
4	To understand the generation of control signals of computer.
5	To demonstrate the memory organization.
6	To describe the concepts of parallel processing and different Buses.

Module		Detailed Content	Hours
1		**Computer Fundamentals**	**5**
	1.1	Introduction to Number System and Codes	
	1.2	Number Systems: Binary, Octal, Decimal, Hexadecimal,	
	1.3	Codes: Grey, BCD, Excess-3, ASCII, Boolean Algebra.	
	1.4	Logic Gates: AND, OR, NOT, NAND, NOR, EX-OR	
	1.5	Overview of computer organization and architecture.	
	1.6	Basic Organization of Computer and Block Level functional Units, Von-Neumann Model.	
2		**Data Representation and Arithmetic algorithms**	**8**
	2.1	Binary Arithmetic: Addition, Subtraction, Multiplication, Division using Sign Magnitude, 1's and 2's compliment, BCD and Hex Arithmetic Operation.	
	2.2	Booths Multiplication Algorithm, Restoring and Non-restoring Division Algorithm.	
	2.3	IEEE-754 Floating point Representation.	
3		**Processor Organization and Architecture**	**6**
	3.1	Introduction: Half adder, Full adder, MUX, DMUX, Encoder, Decoder(IC level).	
	3.2	Introduction to Flip Flop: SR, JK, D, T (Truth table).	
	3.3	Register Organization, Instruction Formats, Addressing modes, Instruction Cycle, Interpretation and sequencing.	
4		**Control Unit Design**	**6**
	4.1	Hardwired Control Unit: State Table Method, Delay Element Methods.	
	4.2	Microprogrammed Control Unit: Micro Instruction-Format, Sequencing and execution, Micro operations, Examples of microprograms.	
5		**Memory Organization**	**6**
	5.1	Introduction and characteristics of memory, Types of RAM and ROM, Memory Hierarchy, 2-level Memory Characteristic,	
	5.2	Cache Memory: Concept, locality of reference, Design problems based on	

		mapping techniques, Cache coherence and write policies. Interleaved and Associative Memory.	
6		**Principles of Advanced Processor and Buses**	**8**
	6.1	Basic Pipelined Data path and control, data dependencies, data hazards, branch hazards, delayed branch, and branch prediction, Performance measures-CPI, Speedup, Efficiency, throughput, Amdhal's law.	
	6.2	Flynn's Classification, Introduction to multicore architecture.	
	6.3	Introduction to buses: ISA, PCI, USB. Bus Contention and Arbitration.	

Textbooks:	
1	R. P. Jain, "Modern Digital Electronic", McGraw-Hill Publication, 4thEdition.
2	William Stalling, "Computer Organization and Architecture: Designing and Performance", Pearson Publication 10TH Edition.
3	John P Hayes, "Computer Architecture and Organization", McGraw-Hill Publication, 3RD Edition.
4	Dr. M. Usha and T. S. Shrikanth, "Computer system Architecture and Organization", Wiley publication.
References:	
1	Andrew S. Tanenbaum, "Structured Computer Organization", Pearson Publication.
2	B. Govindarajalu, "Computer Architecture and Organization", McGraw-Hill Publication.
3	Malvino, "Digital computer Electronics", McGraw-Hill Publication, 3rdEdition.
4	Smruti Ranjan Sarangi, "Computer Organization and Architecture", McGraw-Hill Publication.

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of 6 questions, each carrying 20 marks.
2	The students need to solve total 4 questions.
3	Question No.1 will be compulsory and based on entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	https://www.classcentral.com/course/swayam-computer-organization-and-architecture-a-pedagogical-aspect-9824
2	https://nptel.ac.in/courses/106/103/106103068/
3	https://www.coursera.org/learn/comparch
4	https://www.edx.org/learn/computer-architecture

Course Code	Course Name	Credits
CSC305	**Computer Graphics**	**3**

Prerequisite: Knowledge of C Programming and Basic Mathematics**.**	
Course Objectives	
1	To equip students with the fundamental knowledge and basic technical competence in the field of Computer Graphics.
2	To emphasize on implementation aspect of Computer Graphics Algorithms.
3	To prepare the student for advance areas and professional avenues in the field of Computer Graphics
Course Outcomes: At the end of the course, the students should be able to	
1	Describe the basic concepts of Computer Graphics.
2	Demonstrate various algorithms for basic graphics primitives.
3	Apply 2-D geometric transformations on graphical objects.
4	Use various Clipping algorithms on graphical objects
5	Explore 3-D geometric transformations, curve representation techniques and projections methods.
6	Explain visible surface detection techniques and Animation.

Module		Detailed Content	Hours
1		**Introduction and Overview of Graphics System:**	**02**
	1.1	Definition and Representative uses of computer graphics, Overview of coordinate system, Definition of scan conversion, rasterization and rendering.	
	1.2	Raster scan & random scan displays, Architecture of raster graphics system with display processor, Architecture of random scan systems.	
2		**Output Primitives:**	**10**
	2.1	Scan conversions of point, line, circle and ellipse: DDA algorithm and Bresenham algorithm for line drawing, midpoint algorithm for circle, midpoint algorithm for ellipse drawing (Mathematical derivation for above algorithms is expected)	
	2.2	Aliasing, Antialiasing techniques like Pre and post filtering, super sampling, and pixel phasing).	
	2.3	Filled Area Primitive: Scan line Polygon Fill algorithm, inside outside tests, Boundary Fill and Flood fill algorithm.	
3		**Two Dimensional Geometric Transformations**	**6**
	3.1	Basic transformations: Translation, Scaling, Rotation	
	3.2	Matrix representation and Homogeneous Coordinates	
	3.3	Composite transformation	
	3.4	Other transformations: Reflection and Shear	
4		**Two-Dimensional Viewing and Clipping**	**7**
	4.1	Viewing transformation pipeline and Window to Viewport coordinate transformation	
	4.2	Clipping operations: Point clipping, Line clipping algorithms: Cohen-Sutherland, Liang: Barsky, Polygon Clipping Algorithms: Sutherland-Hodgeman, Weiler-Atherton.	
5		**Three Dimensional Geometric Transformations, Curves and Fractal Generation**	**8**
	5.1	3D Transformations: Translation, Rotation, Scaling and Reflection	

	5.2	Composite transformations: Rotation about an arbitrary axis	
	5.3	Projections – Parallel, Perspective. (Matrix Representation)	
	5.4	Bezier Curve, B-Spline Curve, Fractal-Geometry: Fractal Dimension, Koch Curve.	
6		**Visible Surface Detection and Animation**	**6**
	6.1	Visible Surface Detection: Classification of Visible Surface Detection algorithm, Back Surface detection method, Depth Buffer method, Area Subdivision method	
	6.2	Animation: Introduction to Animation, Traditional Animation Techniques, Principles of Animation, Key framing: Character and Facial Animation, Deformation, Motion capture	

Textbooks:	
1	Hearn & Baker, "Computer Graphics C version", 2nd Edition, Pearson Publication
2	James D. Foley, Andries van Dam, Steven K Feiner, John F. Hughes, "Computer Graphics Principles and Practice in C", 2nd Edition, Pearson Publication
3	Samit Bhattacharya, "Computer Graphics", Oxford Publication
References:	
1	D. Rogers, "Procedural Elements for Computer Graphics", Tata McGraw-Hill Publications.
2	Zhigang Xiang, Roy Plastock, "Computer Graphics", Schaum"s Outlines McGraw-Hill Education
3	Rajesh K. Maurya, "Computer Graphics", Wiley India Publication.
4	F. S. Hill, "Computer Graphics using OpenGL", Third edition, Pearson Publications.

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of 6 questions, each carrying 20 marks.
2	The students need to solve total 4 questions.
3	Question No.1 will be compulsory and based on entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules

Useful Links	
1	https://www.classcentral.com/course/interactivegraphics-2067
2	https://swayam.gov.in/nd2_ntr20_ed15/preview
3	https://nptel.ac.in/courses/106/106/106106090/
4	https://www.edx.org/course/computer-graphics-2

Lab Code	Lab Name	Credit
CSL301	Data Structures Lab	1

Prerequisite: C Programming Language.	
Lab Objectives:	
1	To implement basic data structures such as arrays, linked lists, stacks and queues
2	Solve problem involving graphs, and trees
3	To develop application using data structure algorithms
4	Compute the complexity of various algorithms.
Lab Outcomes:	
1	Students will be able to implement linear data structures & be able to handle operations like insertion, deletion, searching and traversing on them.
2	Students will be able to implement nonlinear data structures & be able to handle operations like insertion, deletion, searching and traversing on them
3	Students will be able to choose appropriate data structure and apply it in various problems
4	Students will be able to select appropriate searching techniques for given problems.

Suggested Experiments: Students are required to complete at least 10 experiments.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
1*	Implement Stack ADT using array.
2*	Convert an Infix expression to Postfix expression using stack ADT.
3*	Evaluate Postfix Expression using Stack ADT.
4	Applications of Stack ADT.
5*	Implement Linear Queue ADT using array.
6*	Implement Circular Queue ADT using array.
7	Implement Priority Queue ADT using array.
8*	Implement Singly Linked List ADT.
9*	Implement Circular Linked List ADT.
10	Implement Doubly Linked List ADT.
11*	Implement Stack / Linear Queue ADT using Linked List.
12*	Implement Binary Search Tree ADT using Linked List.
13*	Implement Graph Traversal techniques:) Depth First Search b) Breadth First Search
14	Applications of Binary Search Technique.

Useful Links:	
1	www.leetcode.com
2	www.hackerrank.com
3	www.cs.usfca.edu/~galles/visualization/Algorithms.html
4	www.codechef.com

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSL301and CSC303

Lab Code	Lab Name	Credit
CSL302	Digital Logic & Computer Organization and Architecture Lab	1

Prerequisite: C Programming Language.	
Lab Objectives:	
1	To implement operations of the arithmetic unit using algorithms.
2	Design and simulate different digital circuits.
3	To design memory subsystem including cache memory.
4	To demonstrate CPU and ALU design.
Lab Outcomes:	
1	To understand the basics of digital components
2	Design the basic building blocks of a computer: ALU, registers, CPU and memory
3	To recognize the importance of digital systems in computer architecture
4	To implement various algorithms for arithmetic operations.

List of Experiments:	
Sr. No.	**Name of the Experiment**
1	To verify the truth table of various logic gates using ICs.
2	To realize the gates using universal gates
3	Code conversion.
4	To realize half adder and full adder.
5	To implement logic operation using MUX IC.
6	To implement logic operation decoder IC.
7	Study of flip flop IC.
8	To implement ripple carry adder.
9	To implement carry look ahead adder.
10	To implement Booth's algorithm.
11	To implement restoring division algorithm.
12	To implement non restoring division algorithm.
13	To implement ALU design.
14	To implement CPU design.
15	To implement memory design.
16	To implement cache memory design.

Note:	
1	Any Four experiments from Exp. No. 1 to Exp. No. 7 using hardware.
2	Any Six experiments from Exp. No. 8 to Exp. No. 16 using Virtual Lab, expect Exp. No 10,11 and 12.
3	Exp. No. 10 to Exp. No. 12 using Programming language.
Digital Material:	
1	Manual to use Virtual Lab simulator for Computer Organization and Architecture developed by the Department of CSE, IIT Kharagpur.
2	Link http://cse10-iitkgp.virtual-labs.ac.in/

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments on content of theory and practical of "Digital Logic &Computer Organization and Architecture"
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.

4	Total 25 Marks (Experiments: 15-marks, Attendance Theory& Practical: 05-marks, Assignments: 05-marks)

Course Code	Lab Name	Credits
CSL303	Computer Graphics Lab	1

Prerequisite: C Programming Language.	
Lab Objectives:	
1	Understand the need of developing graphics application
2	Learn algorithmic development of graphics primitives like line, circle, polygon etc.
3	Learn the representation and transformation of graphical images and pictures
Lab Outcomes: At the end of the course, the students should be able to	
1	Implement various output and filled area primitive algorithms
2	Apply transformation, projection and clipping algorithms on graphical objects.
3	Perform curve and fractal generation methods.
4	Develop a Graphical application/Animation based on learned concept

Content:

Scan conversions: lines, circles, ellipses. Filling algorithms, clipping algorithms. 2D and 3D transformation Curves Visible surface determination. Simple animations Application of these through exercises in C/C++

List of Suggested Experiments:

Sr. No.	Name of the Experiment
1	Implement DDA Line Drawing algorithm (dotted/dashed/thick)
2	Implement Bresenham's Line algorithm(dotted/dashed/thick)
3	Implement midpoint Circle algorithm.
4	Implement midpoint Ellipse algorithm.
5	Implement Area Filling Algorithm: Boundary Fill, Flood Fill.
6	Implement Scan line Polygon Filling algorithm.
7	Implement Curve: Bezier for n control points, B Spline (Uniform)(at least one)
8	Implement Fractal generation method (anyone)
9	Character Generation: Bit Map method and Stroke Method
10	Implement 2D Transformations: Translation, Scaling, Rotation, Reflection, Shear.
11	Implement Line Clipping Algorithm: Cohen Sutherland / Liang Barsky.
12	Implement polygon clipping algorithm (at least one)
13	Program to perform 3D transformation.
14	Perform projection of a 3D object on Projection Plane: Parallel and Perspective.
15	Perform Animation (such as Rising Sun, Moving Vehicle, Smileys, Screen saver etc.)

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments
3	Mini Project to perform using C /C++/Java/OpenGL/Blender/ any other tool (2/3 students per group). Possible Ideas: Animation using multiple objects, Game development, Graphics editor: Like Paint brush, Text editor etc.
4	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
5	Total 25 Marks (Experiments: 10-marks, Attendance Theory& Practical: 05-marks, Assignments: 05-marks, Mini Project: 5-marks)
Oral & Practical exam	
	Based on the above contents and entire syllabus of CSC305

Lab Code	Lab Name	Credits
CSL304	Skill based Lab Course: Object Oriented Programming with Java	2

Prerequisite: Structured Programming Approach	
Lab Objectives:	
1	To learn the basic concepts of object-oriented programming
2	To study JAVA programming language
3	To study various concepts of JAVA programming like multithreading, exception Handling, packages, etc.
4	To explain components of GUI based programming.
Lab Outcomes: At the end of the course, the students should be able to	
1	To apply fundamental programming constructs.
2	To illustrate the concept of packages, classes and objects.
3	To elaborate the concept of strings, arrays and vectors.
4	To implement the concept of inheritance and interfaces.
5	To implement the concept of exception handling and multithreading.
6	To develop GUI based application.

Module		Detailed Content	Hours
1		**Introduction to Object Oriented Programming**	**2**
	1.1	OOP concepts: Objects, class, Encapsulation, Abstraction, Inheritance, Polymorphism, message passing.	
	1.2	Java Virtual Machine	
	1.3	Basic programming constructs: variables, data types, operators, unsigned right shift operator, expressions, branching and looping.	
2		**Class, Object, Packages and Input/output**	**6**
	2.1	Class, object, data members, member functions Constructors, types, static members and functions Method overloading Packages in java, types, user defined packages Input and output functions in Java, Buffered reader class, scanner class	
3		**Array, String and Vector**	**3**
	3.1	Array, Strings, String Buffer, Vectors	
4		**Inheritance**	**4**
	4.1	Types of inheritance, Method overriding, super, abstract class and abstract method, final, Multiple inheritance using interface, extends keyword	
5		**Exception handling and Multithreading**	**5**
	5.1	Exception handling using try, catch, finally, throw and throws, Multiple try and catch blocks, user defined exception Thread lifecycle, thread class methods, creating threads using extends and implements keyword.	
6		**GUI programming in JAVA**	**6**
	6.1	Applet and applet life cycle, creating applets, graphics class functions, parameter passing to applet, Font and color class. Event handling using event class AWT: working with windows, using AWT controls for GUI design Swing class in JAVA	

		Introduction to JDBC, JDBC-ODBC connectivity, JDBC architecture.	

Textbooks:	
1	Herbert Schildt, 'JAVA: The Complete Reference', Ninth Edition, Oracle Press.
2	E. Balagurusamy, 'Programming with Java', McGraw Hill Education.
References:	
1	Ivor Horton, "Beginning JAVA", Wiley India.
2	Dietal and Dietal, "Java: How to Program", 8th Edition, PHI .
3	"JAVA Programming", Black Book, Dreamtech Press.
4	"Learn to Master Java programming", Staredu solutions
Digital material:	
1	www.nptelvideos.in
2	www.w3schools.com
3	www.tutorialspoint.com
4	https://starcertification.org/Certifications/Certificate/securejava

Suggested List of Programming Assignments/laboratory Work:	
Sr. No.	**Name of the Experiment**
1	Programs on Basic programming constructs like branching and looping
2	Program on accepting input through keyboard.
3	Programs on class and objects
4	Program on method and constructor overloading.
5	Program on Packages
6	Program on 2D array, strings functions
7	Program on String Buffer and Vectors
8	Program on types of inheritance
9	Program on Multiple Inheritance
10	Program on abstract class and abstract methods.
11	Program using super and final keyword
12	Program on Exception handling
13	Program on user defined exception
14	Program on Multithreading
15	Program on Graphics class
16	Program on applet class
17	Program to create GUI application
18	Mini Project based on the content of the syllabus (Group of 2-3 students)

Term Work:	
1	Term work should consist of 15 experiments.
2	Journal must include at least 2 assignments
3	Mini Project based on the content of the syllabus (Group of 2-3 students)
4	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
5	Total 50-Marks (Experiments: 15-marks, Attendance: 05-marks, Assignments: 05-marks, Mini Project: 20-marks, MCQ as a part of lab assignments: 5-marks)

Oral & Practical exam
Based on the entire syllabus of CSL 304: **Skill based Lab Course: Object Oriented Programming with Java**

Course code	Course Name	Credits
CSM301	Mini Project A	02

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	Analyze 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 lifelong 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 shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
4	A logbook 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.

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**
1	Marks awarded by guide/supervisor based on logbook	10
2	Marks awarded by review committee	10
3	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:

1	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.
2	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:

1	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
2	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;

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:

1	Report should be prepared as per the guidelines issued by the University of Mumbai.
2	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 approved by head of Institution.
3	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

Course Code	Course Name	Credits
CSC401	Engineering Mathematics-IV	4

Pre-requisite: Engineering Mathematics-I, Engineering Mathematics-II, Engineering Mathematics-III, Binomial Distribution.	
Course Objectives: The course aims to learn:	
1	Matrix algebra to understand engineering problems.
2	Line and Contour integrals and expansion of a complex valued function in a power series.
3	Z-Transforms and Inverse Z-Transforms with its properties.
4	The concepts of probability distributions and sampling theory for small samples.
5	Linear and Non-linear programming problems of optimization.
Course Outcomes: On successful completion, of course, learner/student will be able to:	
1	Apply the concepts of eigenvalues and eigenvectors in engineering problems.
2	Use the concepts of Complex Integration for evaluating integrals, computing residues & evaluate various contour integrals.
3	Apply the concept of Z- transformation and inverse in engineering problems.
4	Use the concept of probability distribution and sampling theory to engineering problems.
5	Apply the concept of Linear Programming Problems to optimization.
6	Solve Non-Linear Programming Problems for optimization of engineering problems.

Module		Detailed Contents	Hours
1	**Linear Algebra (Theory of Matrices)**		7
	1.1	Characteristic Equation, Eigenvalues and Eigenvectors, and properties (without proof)	
	1.2	Cayley-Hamilton Theorem (without proof), verification and reduction of higher degree polynomials	
	1.3	Similarity of matrices, diagonalizable and non-diagonalizable matrices	
	1.4	**Self-learning Topics:** Derogatory and non-derogatory matrices, Functions of Square Matrix, Linear Transformations, Quadratic forms.	
2	**Complex Integration**		7
	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)	
	2.4	**Self-learning Topics:** Application of Residue Theorem to evaluate real integrations.	
3	**Z Transform**		5
	3.1	Definition and Region of Convergence, Transform of Standard Functions: $\{k^n a^k\}, \{a^{\lvert k\rvert}\}, \{{}^{k+n}_{n}C.\, a^k\}, \{c^k \sin(\alpha k+\beta)\}, \{c^k \sinh \alpha k\}, \{c^k \cosh \alpha k\}$.	
	3.2	Properties of Z Transform: Change of Scale, Shifting Property, Multiplication, and Division by k, Convolution theorem.	
	3.3	Inverse Z transform: Partial Fraction Method, Convolution Method.	
	3.4	**Self-learning Topics:** Initial value theorem, Final value theorem, Inverse of Z Transform by Binomial Expansion	
4	**Probability Distribution and Sampling Theory**		7
	4.1	Probability Distribution: Poisson and Normal distribution	

	4.2	Sampling distribution, Test of Hypothesis, Level of Significance, Critical region, One-tailed, and two-tailed test, Degree of freedom.	
	4.3	Students' t-distribution (Small sample). Test the significance of mean and Difference between the means of two samples. Chi-Square Test: Test of goodness of fit and independence of attributes, Contingency table.	
	4.4	**Self-learning Topics:** Test significance for Large samples, Estimate parameters of a population, Yate's Correction.	
5	**Linear Programming Problems**		6
	5.1	Types of solutions, Standard and Canonical of LPP, Basic and Feasible solutions, slack variables, surplus variables, Simplex method.	
	5.2	Artificial variables, Big-M method (Method of penalty)	
	5.3	Duality, Dual of LPP and Dual Simplex Method	
	5.4	**Self-learning Topics:** Sensitivity Analysis, Two-Phase Simplex Method, Revised Simplex Method.	
6	**Nonlinear Programming Problems**		7
	6.1	NLPP with one equality constraint (two or three variables) using the method of Lagrange's multipliers	
	6.2	NLPP with two equality constraints	
	6.3	NLPP with inequality constraint: Kuhn-Tucker conditions	
	6.4	**Self-learning Topics:** Problems with two inequality constraints, Unconstrained optimization: One-dimensional search method (Golden Search method, Newton's method). Gradient Search method	

References:	
1	Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons.
2	R. K. Jain and S. R. K. Iyengar, "Advanced Engineering Mathematics", Narosa.
3	Brown and Churchill, "Complex Variables and Applications", McGraw-Hill Education.
4	T. Veerarajan, "Probability, Statistics and Random Processes", McGraw-Hill Education.
5	Hamdy A Taha, "Operations Research: An Introduction", Pearson.
6	S.S. Rao, "Engineering Optimization: Theory and Practice", Wiley-Blackwell.
7	Hira and Gupta, "Operations Research", S. Chand Publication.

Term Work:		
General Instructions:		
1	Batch wise tutorial shave to be conducted. The number of students per batch will be as per University pattern for practical.	
2	Students must be encouraged to write at least 6 class tutorials on the 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 will be considered as a mini project in Engineering Mathematics. This project will be graded out of 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

<u>Assessment</u>:
Internal Assessment Test:
The assessment consists of two class tests of 20 marks each. The 1stclass test (Internal Assessment I) has to be conducted when approximately 40% of the syllabus is completed. The 2nd class test has to be conducted (Internal Assessment II) when an additional 35% syllabus is

completed. The duration of each test will be for one hour.	
End Semester Theory Examination:	
1	The question paper will comprise a total of 6 questions, each carrying 20 marks.
2	Out of the 6 questions, 4 questions have to be attempted.
3	Question 1, based on the entire syllabus, will have 4sub-questions of 5 marks each and is compulsory.
4	Question 2 to Question 6 will have 3 sub-questions, each of 6, 6, and 8 marks, respectively.
5	Each sub-question in (4) will be from different modules of the syllabus.
6	Weightage of each module will be proportional to the number of lecture hours, as mentioned in the syllabus.

Course Code	Course Name	Credit
CSC402	Analysis of Algorithms	3

Prerequisite: Data structure concepts, Discrete structures	
Course Objectives:	
1	To provide mathematical approaches for Analysis of Algorithms
2	To understand and solve problems using various algorithmic approaches
3	To analyze algorithms using various methods
Course Outcomes: At the end of the course learner will be able to	
1	Analyze the running time and space complexity of algorithms.
2	Describe, apply and analyze the complexity of divide and conquer strategy.
3	Describe, apply and analyze the complexity of greedy strategy.
4	Describe, apply and analyze the complexity of dynamic programming strategy.
5	Explain and apply backtracking, branch and bound.
6	Explain and apply string matching techniques.

Module		Detailed Contents	Hours
1		**Introduction**	8
	1.1	Performance analysis, space, and time complexity Growth of function, Big-Oh, Omega Theta notation Mathematical background for algorithm analysis. Complexity class: Definition of P, NP, NP-Hard, NP-Complete Analysis of selection sort, insertion sort.	
	1.2	Recurrences: The substitution method, Recursion tree method, Master method	
2		**Divide and Conquer Approach**	6
	2.1	General method, Merge sort, Quick sort, Finding minimum and maximum algorithms and their Analysis, Analysis of Binary search.	
3		**Greedy Method Approach**	6
	3.1	General Method, Single source shortest path: Dijkstra Algorithm Fractional Knapsack problem, Job sequencing with deadlines, Minimum cost spanning trees: Kruskal and Prim's algorithms	
4		**Dynamic Programming Approach**	9
	4.1	General Method, Multistage graphs, Single source shortest path: Bellman Ford Algorithm All pair shortest path: Floyd Warshall Algorithm, Assembly-line scheduling Problem0/1 knapsack Problem, Travelling Salesperson problem, Longest common subsequence	
5		**Backtracking and Branch and bound**	6
	5.1	General Method, Backtracking: N-queen problem, Sum of subsets, Graph coloring	
	5.2	Branch and Bound: Travelling Salesperson Problem, 15 Puzzle problem	
6		**String Matching Algorithms**	4
	6.1	The Naïve string-matching algorithm, The Rabin Karp algorithm, The Knuth-Morris-Pratt algorithm	

Textbooks:	
1	T. H. Cormen, C.E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to algorithms", 2nd Edition, PHI Publication 2005.
2	Ellis Horowitz, Sartaj Sahni, S. Rajsekaran. "Fundamentals of computer algorithms" University Press.

References:	
1	Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, “Algorithms”, Tata McGraw-Hill Edition.
2	S. K. Basu, “Design Methods and Analysis of Algorithm”, PHI

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved.
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Useful Links	
1	https://nptel.ac.in/courses/106/106/106106131/
2	https://swayam.gov.in/nd1_noc19_cs47/preview
3	https://www.coursera.org/specializations/algorithms
4	https://www.mooc-list.com/tags/algorithms

Course Code:	Course Title	Credit
CSC403	Database Management System	3

Prerequisite: Data Structures	
Course Objectives:	
1	Develop entity relationship data model and its mapping to relational model
2	Learn relational algebra and Formulate SQL queries
3	Apply normalization techniques to normalize the database
4	Understand concept of transaction, concurrency control and recovery techniques.
Course Outcomes:	
1	Recognize the need of database management system
2	Design ER and EER diagram for real life applications
3	Construct relational model and write relational algebra queries.
4	Formulate SQL queries
5	Apply the concept of normalization to relational database design.
6	Describe the concept of transaction, concurrency and recovery.

Module		Content	Hrs
1		**Introduction Database Concepts**	**3**
	1.1	Introduction, Characteristics of databases, File system v/s Database system, Data abstraction and data Independence, DBMS system architecture, Database Administrator	
2		**Entity–Relationship Data Model**	**6**
	2.1	The Entity-Relationship (ER) Model: Entity types: Weak and strong entity sets, Entity sets, Types of Attributes, Keys, Relationship constraints: Cardinality and Participation, Extended Entity-Relationship (EER) Model: Generalization, Specialization and Aggregation	
3		**Relational Model and relational Algebra**	**8**
	3.1	Introduction to the Relational Model, relational schema and concept of keys. Mapping the ER and EER Model to the Relational Model, Relational Algebra-operators, Relational Algebra Queries.	
4		**Structured Query Language (SQL)**	**6**
	4.1	Overview of SQL, Data Definition Commands, Integrity constraints: key constraints, Domain Constraints, Referential integrity , check constraints, Data Manipulation commands, Data Control commands, Set and string operations, aggregate function-group by, having, Views in SQL, joins, Nested and complex queries, Triggers	
5		**Relational-Database Design**	**6**
	5.1	Pitfalls in Relational-Database designs, Concept of normalization, Function Dependencies, First Normal Form, 2NF, 3NF, BCNF.	
6		**Transactions Management and Concurrency and Recovery**	**10**
	6.1	Transaction concept, Transaction states, ACID properties, Transaction Control Commands, Concurrent Executions, Serializability-Conflict and View, Concurrency Control: Lock-based, Timestamp-based protocols, Recovery System: Log based recovery, Deadlock handling	

Textbooks:	
1	Korth, Slberchatz, Sudarshan, Database System Concepts, 6thEdition, McGraw Hill
2	Elmasri and Navathe, Fundamentals of Database Systems, 5thEdition, Pearson Education
3	Raghu Ramkrishnan and Johannes Gehrke, Database Management Systems, TMH
References:	
1	Peter Rob and Carlos Coronel, Database Systems Design, Implementation and Management‖, Thomson Learning, 5thEdition.
2	Dr. P.S. Deshpande, SQL and PL/SQL for Oracle 10g, Black Book, Dreamtech Press.
3	G. K. Gupta, Database Management Systems, McGraw Hill, 2012

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved.
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Useful Links	
1	https://nptel.ac.in/courses/106/105/106105175/
2	https://swayam.gov.in/nd1_noc19_cs46/preview
3	https://www.classcentral.com/course/swayam-database-management-system-9914
4	https://www.mooc-list.com/tags/dbms

Course Code	Course Name	Credit
CSC404	Operating System	03

Prerequisites: Data structures and Computer architecture	
Course Objectives:	
1	1. To introduce basic concepts and functions of operating systems.
2	2. To understand the concept of process, thread and resource management.
3	3. To understand the concepts of process synchronization and deadlock.
4	4. To understand various Memory, I/O and File management techniques.
Course Outcome:	
1	Understand the objectives, functions and structure of OS
2	Analyze the concept of process management and evaluate performance of processscheduling algorithms.
3	Understand and apply the concepts of synchronization and deadlocks
4	Evaluate performance of Memory allocation and replacement policies
5	Understand the concepts of file management.
	Apply concepts of I/O management and analyze techniques of disk scheduling.

Module	Detailed Content		Hours
1	**Operating system Overview**		**4**
	1.1	Introduction, Objectives, Functions and Evolution of Operating System	
	1.2	Operating system structures: Layered, Monolithic and Microkernel	
	1.3	Linux Kernel, Shell and System Calls	
2	**Process and Process Scheduling**		**9**
	2.1	Concept of a Process, Process States, Process Description, Process Control Block.	
	2.2	Uniprocessor Scheduling-Types: Preemptive and Non-preemptive scheduling algorithms (FCFS, SJF, SRTN, Priority, RR)	
	2.3	Threads: Definition and Types, Concept of Multithreading	
3	**Process Synchronization and Deadlocks**		**9**
	3.1	Concurrency: Principles of Concurrency, Inter-Process Communication, Process Synchronization.	
	3.2	Mutual Exclusion: Requirements, Hardware Support (TSL), Operating System Support (Semaphores), Producer and Consumer problem.	
	3.3	Principles of Deadlock: Conditions and Resource, Allocation Graphs, Deadlock Prevention, Deadlock Avoidance: Banker‟s Algorithm, Deadlock Detection and Recovery, Dining Philosophers Problem.	
4	**Memory Management**		**9**
	4.1	Memory Management Requirements, Memory Partitioning: Fixed, Partitioning, Dynamic Partitioning, Memory Allocation Strategies: Best-Fit, First Fit, Worst Fit, Paging and Segmentation, TLB	
	4.2	Virtual Memory: Demand Paging, Page Replacement Strategies: FIFO, Optimal, LRU, Thrashing	
5		**File Management**	**4**

	5.1	Overview, File Organization and Access, File Directories, File Sharing	
6		**I/O management**	**4**
	6.1	I/O devices, Organization of the I/O Function, Disk Organization, I/O Management and Disk Scheduling: FCFS, SSTF, SCAN, CSCAN, LOOK, C-LOOK.	

Textbooks:	
1	William Stallings, Operating System: Internals and Design Principles, Prentice Hall, 8thEdition, 2014, ISBN-10: 0133805913 • ISBN-13: 9780133805918.
2	Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, Operating System Concepts, John Wiley &Sons, Inc., 9thEdition, 2016, ISBN 978-81-265-5427-0
References:	
1	Achyut Godbole and Atul Kahate, Operating Systems, McGraw Hill Education, 3rdEdition
2	Andrew Tannenbaum, Operating System Design and Implementation, Pearson, 3rdEdition.
3	Maurice J. Bach, "Design of UNIX Operating System", PHI
4	Sumitabha Das, "UNIX: Concepts and Applications", McGraw Hill, 4thEdition

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of 6 questions, each carrying 20 marks.
2	The students need to solve total 4 questions.
3	Question No.1 will be compulsory and based on entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules

Useful Links	
1	https://swayam.gov.in/nd1_noc19_cs50/preview
2	https://nptel.ac.in/courses/117/106/117106113/
3	https://www.classcentral.com/course/swayam-introduction-to-operating-systems-6559

Course Code	Course Name	Credits
CSC405	**Microprocessor**	**3**

Prerequisites: Digital Logic and Computer Architecture	
Course objectives:	
1	To equip students with the fundamental knowledge and basic technical competence in thefield of Microprocessors.
2	To emphasize on instruction set and logic to build assembly language programs.
3	To prepare students for higher processor architectures and embedded systems
Course outcomes: On successful completion of course, learner will be able to:	
1	Describe core concepts of 8086 microprocessor.
2	Interpret the instructions of 8086 and write assembly and Mixed language programs.
3	Identify the specifications of peripheral chip.
4	Design 8086 based system using memory and peripheral chips.
5	Appraise the architecture of advanced processors
6	Understand hyperthreading technology

Module	**Detailed Contents**		**Hours**
1	**The Intel Microprocessors 8086 Architecture**		8
	1.1	8086CPU Architecture,	
	1.2	Programmer's Model	
	1.3	Functional Pin Diagram	
	1.4	Memory Segmentation	
	1.5	Banking in 8086	
	1.6	Demultiplexing of Address/Data bus	
	1.7	Functioning of 8086 in Minimum mode and Maximum mode	
	1.8	Timing diagrams for Read and Write operations in minimum and maximum mode	
	1.9	Interrupt structure and its servicing	
2	**Instruction Set and Programming**		**6**
	2.1	Addressing Modes	
	2.2	Instruction set-Data Transfer Instructions, String Instructions, Logical Instructions, Arithmetic Instructions, Transfer of Control Instructions, Processor Control Instructions	
	2.3	Assembler Directives and Assembly Language Programming, Macros, Procedures	
3	**Memory and Peripherals interfacing**		**8**
	3.1	Memory Interfacing - RAM and ROM Decoding Techniques – Partial and Absolute	
	3.2	8255-PPI-Block diagram, CWR, operating modes, interfacing with 8086.	
	3.3	8257-DMAC-Block diagram, DMA operations and transfer modes.	
	3.4	Programmable Interrupt Controller 8259-Block Diagram, Interfacing the 8259 in single and cascaded mode.	
4	**Intel 80386DX Processor**		**7**
	4.1	Architecture of 80386 microprocessor	
	4.2	80386 registers–General purpose Registers, EFLAGS and Control	

		registers	
	4.3	Real mode, Protected mode, virtual 8086 mode	
	4.4	80386 memory management in Protected Mode – Descriptors and selectors, descriptor tables, the memory paging mechanism	
5	**Pentium Processor**		**6**
	5.1	Pentium Architecture	
	5.2	Superscalar Operation,	
	5.3	Integer &Floating-Point Pipeline Stages,	
	5.4	Branch Prediction Logic,	
	5.5	Cache Organization and	
	5.6	MESI protocol	
6	**Pentium 4**		**4**
	6.1	Comparative study of 8086, 80386, Pentium I, Pentium II and Pentium III	
	6.2	Pentium 4: Net burst micro architecture.	
	6.3	Instruction translation look aside buffer and branch prediction	
	6.4	Hyper threading technology and its use in Pentium 4	

Textbooks:	
1	John Uffenbeck, “8086/8088 family: Design Programming and Interfacing”, PHI.
2	Yu-Cheng Liu, Glenn A. Gibson, “Microcomputer System: The 8086/8088 Family, Architecture, Programming and Design”, Prentice Hall
3	Walter A. Triebel, “The 80386DX Microprocessor: hardware, Software and Interfacing”, Prentice Hall
4	Tom Shanley and Don Anderson, “Pentium Processor System Architecture”, Addison-Wesley.
5	K. M. Bhurchandani and A. K. Ray, “Advanced Microprocessors and Peripherals”, McGraw Hill
References:	
1	Barry B. Brey, “Intel Microprocessors”, 8thEdition, Pearson Education India
2	Douglas Hall, “Microprocessor and Interfacing”, Tata McGraw Hill.
3	Intel Manual
4	Peter Abel, “IBM PC Assembly language and Programming”, 5th Edition, PHI
5	James Antonakons, “The Pentium Microprocessor”, Pearson Education

Assessment:
Internal Assessment Test:
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.
End Semester Theory Examination:
1 Question paper will comprise of 6 questions, each carrying 20 marks.
2 The students need to solve total 4 questions.
3 Question No.1 will be compulsory and based on entire syllabus.
4 Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	https://swayam.gov.in/nd1_noc20_ee11/preview
2	https://nptel.ac.in/courses/108/105/108105102/
3	https://www.classcentral.com/course/swayam-microprocessors-and-microcontrollers-9894
4	https://www.mooc-list.com/tags/microprocessors

Course Name	Lab Name	Credit
CSL401	**Analysis of Algorithms Lab**	**1**

Prerequisite: Basic knowledge of programming and data structure	
Lab Objectives:	
1	To introduce the methods of designing and analyzing algorithms
2	Design and implement efficient algorithms for a specified application
3	Strengthen the ability to identify and apply the suitable algorithm for the given real-world problem.
4	Analyze worst-case running time of algorithms and understand fundamental algorithmic problems.
Lab Outcomes: At the end of the course, the students will be able to	
1	Implement the algorithms using different approaches.
2	Analyze the complexities of various algorithms.
3	Compare the complexity of the algorithms for specific problem.

Description		
Implementation can be in any language.		
Suggested Practical List:		
Sr No		**Suggested Experiment List**
1		**Introduction**
	1.1	Selection sort, Insertion sort
2		**Divide and Conquer Approach**
	2.1	Finding Minimum and Maximum, Merge sort, Quick sort, Binary search
3		**Greedy Method Approach**
	3.1	Single source shortest path- Dijkstra Fractional Knapsack problem Job sequencing with deadlines Minimum cost spanning trees-Kruskal and Prim's algorithm
4		**Dynamic Programming Approach**
	4.1	Single source shortest path- Bellman Ford All pair shortest path- Floyd Warshall 0/1 knapsack Travelling salesperson problem Longest common subsequence
5		**Backtracking and Branch and bound**
	5.1	N-queen problem Sum of subsets Graph coloring
6		**String Matching Algorithms**
	6.1	The Naïve string-matching Algorithms The Rabin Karp algorithm The Knuth-Morris-Pratt algorithm

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments on content of theory and practical of "Analysis of Algorithms"
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory& Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSC402: Analysis of Algorithms

Lab Code	Lab Name	Credit
CSL402	Database Management system Lab	1

Prerequisite: Discrete Structures	
Lab Objectives:	
1	To explore design and develop of relational model
2	To present SQL and procedural interfaces to SQL comprehensively
3	To introduce the concepts of transactions and transaction processing
Lab Outcomes: At the end of the course, the students will be able to	
1	Design ER /EER diagram and convert to relational model for the realworld application.
2	Apply DDL, DML, DCL and TCL commands
3	Write simple and complex queries
4	UsePL / SQL Constructs.
5	Demonstrate the concept of concurrent transactions execution and frontend-backend connectivity

Suggested List of Experiments	
Sr. No.	**Title of Experiment**
1	Identify the case study and detail statement of problem. Design an Entity-Relationship (ER) / Extended Entity-Relationship (EER) Model.
2	Mapping ER/EER to Relational schema model.
3	Create a database using Data Definition Language (DDL) and apply integrity constraints for the specified System
4	Apply DML Commands for the specified system
5	Perform Simple queries, string manipulation operations and aggregate functions.
6	Implement various Join operations.
7	Perform Nested and Complex queries
8	Perform DCL and TCL commands
9	Implement procedure and functions
10	Implementation of Views and Triggers.
11	Demonstrate Database connectivity
12	Implementation and demonstration of Transaction and Concurrency control techniques using locks.

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments on content of theory and practical of “Database Management System”
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory& Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	

Course Code	Course Name	Credit
CSL403	Operating System Lab	01
	Based on the entire syllabus of CSC403: Database Management System	

Prerequisite: Knowledge on Operating system principles	
Lab Objectives:	
1	To gain practical experience with designing and implementing concepts of operating systems such as system calls, CPU scheduling, process management, memory management, file systems and deadlock handling using C language in Linux environment.
2	To familiarize students with the architecture of Linux OS.
3	To provide necessary skills for developing and debugging programs in Linux environment.
4	To learn programmatically to implement simple operation system mechanisms
Lab Outcomes: At the end of the course, the students will be able to	
1	Demonstrate basic Operating system Commands, Shell scripts, System Calls and API wrt Linux
2	Implement various process scheduling algorithms and evaluate their performance.
3	Implement and analyze concepts of synchronization and deadlocks.
4	Implement various Memory Management techniques and evaluate their performance.
5	Implement and analyze concepts of virtual memory.
6	Demonstrate and analyze concepts of file management and I/O management techniques.

Suggested List of Experiments		
Sr. No.		**Content**
1		**Explore Linux Commands**
	1.1	**Explore usage of basic Linux Commands and system calls for file, directory and process management.** For eg: (mkdir, chdir, cat, ls, chown, chmod, chgrp, ps etc. system calls: open, read, write, close, getpid, setpid, getuid, getgid, getegid, geteuid. sort, grep, awk, etc.)
2		**Linux shell script**
	2.1	Write shell scripts to do the following: a. Display OS version, release number, kernel version b. Display top 10 processes in descending order c. Display processes with highest memory usage. d. Display current logged in user and log name. Display current shell, home directory, operating system type, current path setting, current working directory.
3		**Linux- API**
	3.1	Implement any one basic commands of linux like ls, cp, mv and others using kernel APIs.
4		**Linux- Process**
	4.1	a. Create a child process in Linux using the fork system call. From the child process obtain the process ID of both child and parent by using getpid and getppid system call. b. Explore wait and waitpid before termination of process.
5		**Process Management: Scheduling**

	5.1	a. Write a program to demonstrate the concept of non-preemptive scheduling algorithms. b. Write a program to demonstrate the concept of preemptive scheduling algorithms
6		**Process Management: Synchronization**
	6.1	**a.** Write a C program to implement solution of Producer consumer problem through Semaphore
7		**Process Management: Deadlock**
	7.1	a. Write a program to demonstrate the concept of deadlock avoidance through Banker's Algorithm b. Write a program demonstrate the concept of Dining Philospher's Problem
8		**Memory Management**
	8.1	a. Write a program to demonstrate the concept of MVT and MFT memory management techniques b. Write a program to demonstrate the concept of dynamic partitioning placement algorithms i.e. Best Fit, First Fit, Worst-Fit etc.
9		**Memory Management: Virtual Memory**
	9.1	a. Write a program to demonstrate the concept of demand paging for simulation of Virtual Memory implementation b. Write a program in C demonstrate the concept of page replacement policies for handling page faults eg: FIFO, LRU etc.
10		**File Management & I/O Management**
	10.1	a. Write a C program to simulate File allocation strategies typically sequential, indexed and linked files b. Write a C program to simulate file organization of multi-level directory structure. **c.** Write a program in C to do disk scheduling - FCFS, SCAN, C-SCAN

Term Work:	
1	Term work should consist of 10 experiments covering all modules.
2	Journal must include at least 2 assignments on content of theory and practical of "Database Management System"
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory& Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSC405: Operating System.

Lab Code	Lab Name	Credits
CSL404	**Microprocessor Lab**	**1**

Prerequisite: Basic knowledge digital integrated circuits	
Lab Objectives:	
1	To emphasize on use of Assembly language program.
2	To prepare students for advanced subjects like embedded system and IOT.
Lab Outcomes: At the end of the course, the students will be able to	
1	Use appropriate instructions to program microprocessor to perform various task
2	Develop the program in assembly/ mixed language for Intel 8086 processor
3	Demonstrate the execution and debugging of assembly/ mixed language program

Suggested List of Experiments:	
Sr. No.	**Title of Experiments**
1	Use of programming tools (Debug/TASM/MASM/8086kit) to perform basic arithmetic operations on 8-bit/16-bit data
2	Code conversion (Hex to BCD and BCD to Hex)/ (ASCII to BCD and BCD to ASCII)
3	Assembly programming for 16-bit addition, subtraction, multiplication and division (menu based)
4	Assembly program based on string instructions (overlapping/non-overlapping block transfer/ string search/ string length)
5	Assembly program to display the contents of the flag register.
6	Any Mixed Language programs.
7	Assembly program to find the GCD/ LCM of two numbers
8	Assembly program to sort numbers in ascending/ descending order
9	Any program using INT 10H
10	Assembly program to find minimum/ maximum number from a given array.
11	Assembly Program to display a message in different color with blinking
12	Assembly program using procedure.
13	Assembly program using macro.
14	Program and interfacing using 8255.
15	Program and interfacing of ADC/ DAC/ Stepper motor.

Term Work:	
1	Term work should consist of 10 experiments, out of theses at least one experiment on hardware interfacing.
2	Journal must include at least 2 assignments on content of theory and practical of "Microprocessor"
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory& Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSL501and CSC501syllabus.

Lab Code	Lab Name	Credit
CSL405	Skill Base Lab Course: Python Programming	2

Prerequisite: Knowledge of some programming language like C, Java	
Lab Objectives:	
1	Basics of Python programming
2	Decision Making, Data structure and Functions in Python
3	Object Oriented Programming using Python
4	Web framework for developing
Lab Outcomes: At the end of the course, the students will be able to	
1	To understand basic concepts in python.
2	To explore contents of files, directories and text processing with python
3	To develop program for data structure using built in functions in python.
4	To explore django web framework for developing python-based web application.
5	To understand Multithreading concepts using python.

Module		Detailed Content	Hours
1		**Python basics**	**5**
	1.1	Data types in python, Operators in python, Input and Output, Control statement, Arrays in python, String and Character in python, Functions, List and Tuples, Dictionaries Exception, Introduction to OOP, Classes, Objects, Interfaces, Inheritance	
2		**Advanced Python**	**4**
	2.1	Files in Python, Directories, Building Modules, Packages, Text Processing, Regular expression in python.	
3		**Data Structure in Python**	**3**
	3.1	Link List, Stack, Queues, Dequeues	
4		**Python Integration Primer**	**4**
	4.1	Graphical User interface, Networking in Python, Python database connectivity, Introduction to Django	
5		**Multithreading**	**4**
	5.1	Thread and Process, Starting a thread, Threading module, Synchronizing threads, Multithreaded Priority Queue	
6		**NumPy and Pandas**	**6**
	6.1	Creating NumPy arrays, Indexing and slicing in NumPy, creating multidimensional arrays, NumPy Data types, Array Attribute, Indexing and Slicing, Creating array views copies, Manipulating array shapes I/O	
	6.2	Basics of Pandas, Using multilevel series, Series and Data Frames, Grouping, aggregating, Merge Data Frames	

Textbooks:	
1	Dr. R. Nageswara Rao, “Core Python Programming”, Dreamtech Press
2	Beginning Python: Using Python 2.6 and Python 3.1. James Payne, Wrox Publication
3	Anurag Gupta, G. P. Biswas, “Python Programming”, McGraw-Hill
4	E. Balagurusamy, “Introduction to computing and problem-solving using python”, McGraw Hill Education
References:	
1	Learn Python the Hard Way, 3rd Edition, Zed Shaw's Hard Way Series

2	Laura Cassell, Alan Gauld, “Python Projects”, Wrox Publication

Digital material:

1	"The Python Tutorial",http://docs.python.org/release/3.0.1/tutorial/
2	Beginning Perl,https://www.perl.org/books/beginning-perl/
3	http://spoken-tutorial.org
4	https://starcertification.org/Certifications/Certificate/python

Suggested experiments using Python:	
Sr. No.	**Title of Experiments**
1	Exploring basics of python like data types (strings, list, array, dictionaries, set, tuples) and control statements.
2	Creating functions, classes and objects using python. Demonstrate exception handling and inheritance.
3	Exploring Files and directories a. Python program to append data to existing file and then display the entire file b. Python program to count number of lines, words and characters in a file. c. Python program to display file available in current directory
4	Creating GUI with python containing widgets such as labels, textbox, radio, checkboxes and custom dialog boxes.
5	Menu driven program for data structure using built in function for link list, stack and queue.
6	Program to demonstrate CRUD (**create, read, update and delete)** operations on database (SQLite/ MySQL) using python.
7	Creation of simple socket for basic information exchange between server and client.
8	Creating web application using Django web framework to demonstrate functionality of user login and registration (also validating user detail using regular expression).
9	Programs on Threading using python.
10	Exploring basics of NumPy Methods.
11	Program to demonstrate use of NumPy: Array objects.
12	Program to demonstrate Data Series and Data Frames using Pandas.
13	Program to send email and read content of URL.

Term Work:	
1	Term work should consist of 12 experiments.
2	Journal must include at least 2 assignments
3	Mini Project based on the content of the syllabus (Group of 2-3 students)
4	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
5	Total 25 Marks (Journal: 10-marks, Attendance: 05-marks, and Mini Project: 10-marks)

Course code	Course Name	Credits
CSM401	Mini Project B	02

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	Analyze 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 lifelong 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 shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
4	A logbook 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.

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**
1	Marks awarded by guide/supervisor based on logbook	10
2	Marks awarded by review committee	10
3	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:

1	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.
2	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:

1	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
2	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;

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:

1	Report should be prepared as per the guidelines issued by the University of Mumbai.
2	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 approved by head of Institution.
3	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

AC: 29/06/2021

Item No: 6.15

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Computer 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)

AC: 29/06/2021

Item No: 6.15

UNIVERSITY OF MUMBAI

Sr. No.	Heading	Particulars
1	Title of the Course	**Third Year Engineering (Computer Engineering)**
2	Eligibility for Admission	**After Passing Second Year Engineering as per the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ / **U.G.**/ ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ / **Semester** (Strike out which is not applicable)
8	Status	~~**New**~~ / Revised (Strike out which is not applicable)
9	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

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
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 2021-22. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2022-23, 2023-24, respectively.

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

ncorporation 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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Associate Dean
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Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preface by Board of Studies in Computer Engineering

Dear Students and Teachers, we, the members of Board of Studies Computer Engineering, are very happy to present Third Year Computer Engineering syllabus effective from the Academic Year 2021-22 (REV-2019'C' Scheme). We are sure you will find this syllabus interesting, challenging, fulfill certain needs and expectations.

Computer Engineering is one of the most sought-after courses amongst engineering students. The syllabus needs revision in terms of preparing the student for the professional scenario relevant and suitable to cater the needs of industry in present day context. The syllabus focuses on providing a sound theoretical background as well as good practical exposure to students in the relevant areas. It is intended to provide a modern, industry-oriented education in Computer Engineering. It aims at producing trained professionals who can successfully acquainted with the demands of the industry worldwide. They obtain skills and experience in up-to-date the knowledge to analysis, design, implementation, validation, and documentation of computer software and systems.

The revised syllabus is finalized through a brain storming session attended by Heads of Departments or senior faculty from the Department of Computer Engineering of the affiliated Institutes of the Mumbai University. The syllabus falls in line with the objectives of affiliating University, AICTE, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements.

The salient features of the revised syllabus are:

1. Reduction in credits to 170 is implemented to ensure that students have more time for extracurricular activities, innovations, and research.
2. The department Optional Courses will provide the relevant specialization within the branch to a student.
3. Introduction of Skill Based Lab and Mini Project to showcase their talent by doing innovative projects that strengthen their profile and increases the chance of employability.
4. Students are encouraged to take up part of course through MOOCs platform SWAYAM

We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

Board of Studies in Computer Engineering

Prof. Sunil Bhirud	: Chairman
Prof. Sunita Patil	: Member
Prof. Leena Raga	: Member
Prof. Subhash Shinde	: Member
Prof. Meera Narvekar	: Member
Prof. Suprtim Biswas	: Member
Prof. Sudhir Sawarkar	: Member
Prof. Dayanand Ingle	: Member
Prof. Satish Ket	: Member

Program Structure for Third Year Computer Engineering

UNIVERSITY OF MUMBAI (With Effect from 2021-2022)

Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
CSC501	Theoretical Computer Science	3	--	3	--	3
CSC502	Software Engineering	3	--	3		3
CSC503	Computer Network	3	--	3	--	3
CSC504	Data Warehousing & Mining	3	--	3	--	3
CSDLO501x	Department Level Optional Course- 1	3	--	3	--	3
CSL501	Software Engineering Lab	--	2	--	1	1
CSL502	Computer Network Lab	--	2	--	1	1
CSL503	Data Warehousing & Mining Lab	--	2	--	1	1
CSL504	Business Comm. & Ethics II	--	2*+2	--	2	2
CSM501	Mini Project: 2 A	--	4$	--	2	2
Total		**15**	**14**	**15**	**07**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract &oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
CSC501	Theoretical Computer Science	20	20	20	80	3	25	--	125
CSC502	Software Engineering	20	20	20	80	3	--	--	100
CSC503	Computer Network	20	20	20	80	3	--	--	100
CSC504	Data Warehousing & Mining	20	20	20	80	3	--	--	100
CSDLO501x	Department Level Optional Course -1	20	20	20	80	3	--	--	100
CSL501	Software Engineering Lab	--	--	--	--	--	25	25	50
CSL502	Computer Network Lab	--	--	--	--	--	25	25	50
CSL503	Data Warehousing & Mining Lab	--	--	--	--	--	25	25	50
CSL504	Business Comm. & Ethics II	--	--	--	--	--	50	--	50
CSM501	Mini Project : 2A	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	--	**175**	**100**	**775**

* Theory class to be conducted for full class and $ indicates workload of Learner (Not Faculty), students can form groups with minimum 2(Two) and not more than 4(Four). Faculty Load: 1hour per week per four groups.

Program Structure for Computer Engineering

UNIVERSITY OF MUMBAI (With Effect from 2021-2022)

Department Optional Courses

Department Level Optional Courses	Semester	Code & Course
Department Level Optional Course -1	V	CSDLO5011: Probabilistic Graphical Models CSDLO5012: Internet Programming CSDLO5013: Advance Database Management System

Course Code	Course Name	Credits
CSC501	Theoretical Computer Science	3

Prerequisite: Discrete Structures	
Course Objectives:	
1.	Acquire conceptual understanding of fundamentals of grammars and languages.
2.	Build concepts of theoretical design of deterministic and non-deterministic finite automata and push down automata.
3.	Develop understanding of different types of Turing machines and applications.
4.	Understand the concept of Undecidability.
Course Outcomes: At the end of the course, the students will be able to	
1.	Understand concepts of Theoretical Computer Science, difference and equivalence of DFA and NFA , languages described by finite automata and regular expressions.
2.	Design Context free grammer, pushdown automata to recognize the language.
3.	Develop an understanding of computation through Turing Machine.
4.	Acquire fundamental understanding of decidability and undecidability.

Module No.	Unit No.	Topics	Theory Hrs.
1.0		**Basic Concepts and Finite Automata**	**09**
	1.1	Importance of TCS, Alphabets, Strings, Languages, Closure properties, Finite Automata (FA) and Finite State machine (FSM).	
	1.2	Deterministic Finite Automata (DFA) and Nondeterministic Finite Automata (NFA): Definitions, transition diagrams and Language recognizers, Equivalence between NFA with and without ε- transitions, NFA to DFA Conversion, Minimization of DFA, FSM with output: Moore and Mealy machines, Applications and limitations of FA.	
2.0		**Regular Expressions and Languages**	**07**
	2.1	Regular Expression (RE),Equivalence of RE and FA, Arden‘s Theorem, RE Applications	
	2.2	Regular Language (RL), Closure properties of RLs, Decision properties of RLs, Pumping lemma for RLs.	
3.0		**Grammars**	**08**
	3.1	Grammars and Chomsky hierarchy	
	3.2	Regular Grammar (RG), Equivalence of Left and Right linear grammar, Equivalence of RG and FA.	

	3.3	**Context Free Grammars (CFG)** Definition, Sentential forms, Leftmost and Rightmost derivations, Parse tree, Ambiguity, Simplification and Applications, Normal Forms: Chomsky Normal Forms (CNF) and Greibach Normal Forms (GNF), Context Free language (CFL) - Pumping lemma, Closure properties.	
4.0		**Pushdown Automata(PDA)**	**04**
	4.1	Definition, Language of PDA,PDA as generator, decider and acceptor of CFG, Deterministic PDA , Non-Deterministic PDA, Application of PDA.	
5.0		**Turing Machine (TM)**	**09**
	5.1	Definition, Design of TM as generator, decider and acceptor, Variants of TM: Multitrack, Multitape, Universal TM, Applications, Power and Limitations of TMs.	
6.0		**Undecidability**	**02**
	6.1	Decidability and Undecidability, Recursive and Recursively Enumerable Languages, Halting Problem, Rice's Theorem, Post Correspondence Problem.	
		Total	**39**

Text Books:	
1.	John E. Hopcroft, Rajeev Motwani, Jeffery D. Ullman, ***"Introduction to Automata Theory, Languages and Computation"***, 3rd Edition, Pearson Education, 2008.
2.	Michael Sipser, **"Theory of Computation"**, 3rd Edition, Cengage learning. 2013.
3.	Vivek Kulkarni, ***"Theory of Computation",*** Illustrated Edition, Oxford University Press, (12 April 2013) India.
Reference Books:	
1.	J. C. Martin, ***"Introduction to Languages and the Theory of Computation"*****,** 4th Edition, Tata McGraw Hill Publication, 2013.
2.	Kavi Mahesh, ***"Theory of Computation: A Problem Solving Approach"***, Kindle Edition, Wiley-India, 2011.

Assessment:	
Internal Assessment:	
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.
Term work:	
1.	Term Work should consist of at least 06 assignments (at least one assignment on each module).

2.	Assignment (best 5 assignments)	20 marks
	Attendance	5 marks
3.	It is recommended to use JFLAP software (www.jflap.org) for better teaching and learning processes.	

End Semester Theory Examination:	
1.	Question paper will comprise of 6 questions, each carrying 20 marks.
2.	The students need to solve total 4 questions.
3.	Question No.1 will be compulsory and based on entire syllabus.
4.	Remaining questions (Q.2 to Q.6) will cover all the modules of syllabus.

Useful Links:	
1.	www.jflap.org
2.	https://nptel.ac.in/courses/106/104/106104028/
3.	https://nptel.ac.in/courses/106/104/106104148/

Course Code:	Course Title	Credit
CSC502	Software Engineering	3

Prerequisite: Object Oriented Programming with Java , Python Programming	
Course Objectives:	
1	To provide the knowledge of software engineering discipline.
2	To apply analysis, design and testing principles to software project development.
3	To demonstrate and evaluate real world software projects.
Course Outcomes: On successful completion of course, learners will be able to:	
1	Identify requirements & assess the process models.
2	Plan, schedule and track the progress of the projects.
3	Design the software projects.
4	Do testing of software project.
5	Identify risks, manage the change to assure quality in software projects.

Module		Content	Hrs
1		**Introduction To Software Engineering and Process Models**	**7**
	1.1	Software Engineering-process framework, the Capability Maturity Model (CMM), Advanced Trends in Software Engineering	
	1.2	Prescriptive Process Models: The Waterfall, Incremental Process Models, Evolutionary Process Models: RAD & Spiral	
	1.3	Agile process model: Extreme Programming (XP), Scrum, Kanban	
2		**Software Requirements Analysis and Modeling**	**4**
	2.1	Requirement Engineering, Requirement Modeling, Data flow diagram, Scenario based model	
	2.2	Software Requirement Specification document format(IEEE)	
3		**Software Estimation Metrics**	**7**
	3.1	Software Metrics, Software Project Estimation (LOC, FP, COCOMO II)	
	3.2	Project Scheduling & Tracking	
4		**Software Design**	**7**
	4.1	Design Principles & Concepts	
	4.2	Effective Modular Design, Cohesion and Coupling, Architectural design	
5		**Software Testing**	**7**
	5.1	Unit testing, Integration testing,Validation testing, System testing	
	5.2	Testing Techniques, white-box testing: Basis path, Control structure testing black-box testing: Graph based, Equivalence, Boundary Value	
	5.3	Types of Software Maintenance, Re-Engineering, Reverse Engineering	
6		**Software Configuration Management, Quality Assurance and Maintenance**	**7**
	6.1	Risk Analysis & Management: Risk Mitigation, Monitoring and Management Plan (RMMM).	
	6.2	Quality Concepts and Software Quality assurance Metrics, Formal Technical Reviews, Software Reliability	
	6.3	The Software Configuration Management (SCM) ,Version Control and Change Control	
			39

Textbooks:	
1	Roger Pressman, "***Software Engineering: A Practitioner's Approach"***, 9th edition , McGraw-Hill Publications, 2019
2	Ian Sommerville, ***"Software Engineering"***, 9th edition, Pearson Education, 2011
3	Ali Behfrooz and Fredeick J. Hudson, ***"Software Engineering Fundamentals"***, Oxford University Press, 1997
4	Grady Booch, James Rambaugh, Ivar Jacobson, ***"The unified modeling language user guide"***, 2nd edition, Pearson Education, 2005
References:	
1	Pankaj Jalote, ***"An integrated approach to Software Engineering"***, 3rd edition, Springer, 2005
2	Rajib Mall, ***"Fundamentals of Software Engineering"***, 5th edition, Prentice Hall India, 2014
3	Jibitesh Mishra and Ashok Mohanty, ***"Software Engineering"***, Pearson , 2011
4	Ugrasen Suman, ***"Software Engineering – Concepts and Practices"***, Cengage Learning, 2013
5	Waman S Jawadekar, ***"Software Engineering principles and practice"***, McGraw Hill Education, 2004

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and the second-class test when an additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All question carries equal marks
3	Only Four questions need to be solved.
4	In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Useful Links	
1	https://nptel.ac.in/courses/106/105/106105182/
2	https://onlinecourses.nptel.ac.in/noc19_cs69/preview
3	https://www.mooc-list.com/course/software-engineering-introduction-edx

Course Code:	Course Title	Credit
CSC503	Computer Network	3

Prerequisite: None	
Course Objectives:	
1	To introduce concepts and fundamentals of data communication and computer networks.
2	To explore the inter-working of various layers of OSI.
3	To explore the issues and challenges of protocols design while delving into TCP/IP protocol suite.
4	To assess the strengths and weaknesses of various routing algorithms.
5	To understand various transport layer and application layer protocols.
Course Outcomes: On successful completion of course, learner will be able to	
1	Demonstrate the concepts of data communication at physical layer and compare ISO - OSI model with TCP/IP model.
2	Explore different design issues at data link layer.
3	Design the network using IP addressing and sub netting / supernetting schemes.
4	Analyze transport layer protocols and congestion control algorithms.
5	Explore protocols at application layer

Module		Content	Hrs
1		**Introduction to Networking**	**4**
	1.1	Introduction to computer network, network application, network software and hardware components (Interconnection networking devices), Network topology, protocol hierarchies, design issues for the layers, connection oriented and connectionless services	
	1.2	Reference models: Layer details of OSI, TCP/IP models. Communication between layers.	
2		**Physical Layer**	**3**
	2.1	Introduction to Communication Electromagnetic Spectrum	
	2.2	Guided Transmission Media: Twisted pair, Coaxial, Fiber optics.	
3		**Data Link Layer**	**8**
	3.1	DLL Design Issues (Services, Framing, Error Control, Flow Control), Error Detection and Correction(Hamming Code, CRC, Checksum) , Elementary Data Link protocols , Stop and Wait, Sliding Window(Go Back N, Selective Repeat)	
	3.2	**Medium Access Control sublayer** Channel Allocation problem, Multiple access Protocol(Aloha, Carrier Sense Multiple Access (CSMA/CD)	
4		**Network layer**	**12**
	4.1	Network Layer design issues, Communication Primitives: Unicast, Multicast, Broadcast. IPv4 Addressing (classfull and classless), Subnetting, Supernetting design problems ,IPv4 Protocol, Network Address Translation (NAT), IPv6	
	4.2	**Routing algorithms :** Shortest Path (Dijkastra's), Link state routing, Distance Vector Routing	
	4.3	**Protocols** - ARP,RARP, ICMP, IGMP	

	4.4	**Congestion control algorithms:** Open loop congestion control, Closed loop congestion control, QoS parameters, Token & Leaky bucket algorithms	
5		**Transport Layer**	**6**
	5.1	**The Transport Service**: Transport service primitives, Berkeley Sockets, Connection management (Handshake), UDP, TCP, TCP state transition, TCP timers	
	5.2	TCP Flow control (sliding Window), TCP Congestion Control: Slow Start	
6		**Application Layer**	**6**
	6.1	DNS: Name Space, Resource Record and Types of Name Server. HTTP, SMTP, Telnet, FTP, DHCP	

Textbooks:	
1	A.S. Tanenbaum, **Computer Networks**,4th edition Pearson Education
2	B.A. Forouzan, **Data Communications and Networking**, 5th edition, TMH
3	James F. Kurose, Keith W. Ross, **Computer Networking, A Top-Down Approach Featuring the Internet**,6th edition, Addison Wesley
References:	
1	S.Keshav,**An Engineering Approach To Computer Networking**, Pearson
2	Natalia Olifer & Victor Olifer,**Computer Networks: Principles, Technologies & Protocols for Network Design**, Wiley India, 2011.
3	Larry L.Peterson, Bruce S.Davie, **Computer Networks: A Systems Approach**, Second Edition ,The Morgan Kaufmann Series in Networking

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved.
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Useful Links	
1	https://www.netacad.com/courses/networking/networking-essentials
2	https://www.coursera.org/learn/computer-networking
3	https://nptel.ac.in/courses/106/105/106105081
4	https://www.edx.org/course/introduction-to-networking

Course Code:	Course Title	Credit
CSC504	Data Warehousing and Mining	3

Prerequisite: Database Concepts	
Course Objectives:	
1.	To identify the significance of Data Warehousing and Mining.
2.	To analyze data, choose relevant models and algorithms for respective applications.
3.	To study web data mining.
4.	To develop research interest towards advances in data mining.
Course Outcomes: At the end of the course, the student will be able to	
1.	Understand data warehouse fundamentals and design data warehouse with dimensional modelling and apply OLAP operations.
2.	Understand data mining principles and perform Data preprocessing and Visualization.
3.	Identify appropriate data mining algorithms to solve real world problems.
4.	Compare and evaluate different data mining techniques like classification, prediction, clustering and association rule mining
5.	Describe complex information and social networks with respect to web mining.

Module	Content	Hrs
1	**Data Warehousing Fundamentals**	8
	Introduction to Data Warehouse, Data warehouse architecture, Data warehouse versus Data Marts, E-R Modeling versus Dimensional Modeling, Information Package Diagram, Data Warehouse Schemas; Star Schema, Snowflake Schema, Factless Fact Table, Fact Constellation Schema. Update to the dimension tables. Major steps in ETL process, OLTP versus OLAP, OLAP operations: Slice, Dice, Rollup, Drilldown and Pivot.	
2	**Introduction to Data Mining, Data Exploration and Data Pre-processing**	8
	Data Mining Task Primitives, Architecture, KDD process, Issues in Data Mining, Applications of Data Mining, Data Exploration: Types of Attributes, Statistical Description of Data, Data Visualization, Data Preprocessing: Descriptive data summarization, Cleaning, Integration & transformation, Data reduction, Data Discretization and Concept hierarchy generation.	
3	**Classification**	6
	Basic Concepts, Decision Tree Induction, Naïve Bayesian Classification, Accuracy and Error measures, Evaluating the Accuracy of a Classifier: Holdout & Random Subsampling, Cross Validation, Bootstrap.	
4	**Clustering**	6
	Types of data in Cluster analysis, Partitioning Methods (*k*-Means, *k*-Medoids), Hierarchical Methods (Agglomerative, Divisive).	
5	**Mining frequent patterns and associations**	6
	Market Basket Analysis, Frequent Item sets, Closed Item sets, and Association Rule, Frequent Pattern Mining, Apriori Algorithm, Association Rule Generation, Improving the Efficiency of Apriori, Mining Frequent Itemsets without candidate generation, Introduction to Mining Multilevel Association Rules and Mining Multidimensional Association Rules.	

6	**Web Mining**	**5**
	Introduction, Web Content Mining: Crawlers, Harvest System, Virtual Web View, Personalization, Web Structure Mining: Page Rank, Clever, Web Usage Mining.	

Textbooks:	
1	Paulraj Ponniah, ***" Data Warehousing: Fundamentals for IT Professionals"***, Wiley India.
2	Han, Kamber, ***"Data Mining Concepts and Techniques"***, Morgan Kaufmann 2nd edition.
3	M.H. Dunham, ***"Data Mining Introductory and Advanced Topics"***, Pearson Education.
References:	
1	Reema Theraja, ***"Data warehousing"***, Oxford University Press 2009.
2	Pang-Ning Tan, Michael Steinbach and Vipin Kumar, ***"Introduction to Data Mining"***, Pearson Publisher 2nd edition.
3	Ian H. Witten, Eibe Frank and Mark A. Hall, ***"Data Mining"***, Morgan Kaufmann 3rd edition.

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example, If Q.2 part (a) from module 3 then part (b) can be from any module other than module 3)
4	Only Four questions need to be solved.
5	In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.
Useful Links	
1	https://onlinecourses.nptel.ac.in/noc20_cs12/preview
2	https://www.coursera.org/specializations/data-mining

Course Code:	Course Title	Credit
CSDLO5011	**Probabilistic Graphical Models**	3

Prerequisite: Engineering Mathematics, Discrete Structure	
Course Objectives:	
1	To give comprehensive introduction of probabilistic graphical models
2	To make inferences, learning, actions and decisions while applying these models
3	To introduce real-world trade-offs when using probabilistic graphical models in practice
4	To develop the knowledge and skills necessary to apply these models to solve real world problems.
Course Outcomes: At the end of the course, the student will be able to	
1	Understand basic concepts of probabilistic graphical modelling.
2	Model and extract inference from various graphical models like Bayesian Networks, Markov Models
3	Perform learning and take actions and decisions using probabilistic graphical models
4	Represent real world problems using graphical models; design inference algorithms; and learn the structure of the graphical model from data.
5	Design real life applications using probabilistic graphical models.

Module		Content	Hrs
1.		**Introduction to Probabilistic Graphical Modeling**	**5**
	1.1	Introduction to Probability Theory: Probability Theory, Basic Concepts in Probability, Random Variables and Joint Distribution, Independence and Conditional Independence, Continuous Spaces, Expectation and Variances	
	1.2	Introduction to Graphs: Nodes and Edges, Subgraphs, Paths and Trails, Cycles and Loops	
	1.3	Introduction to Probabilistic Graph Models: Bayesian Network, Markov Model, Hidden Markov Model	
	1.4	Applications of PGM	
2.		**Bayesian Network Model and Inference**	**10**
	2.1	Directed Graph Model: Bayesian Network-Exploiting Independence Properties, Naive Bayes Model, Bayesian Network Model, Reasoning Patterns, Basic Independencies in Bayesian Networks, Bayesian Network Semantics, Graphs and Distributions. Modelling: Picking variables, Picking Structure, Picking Probabilities, D-separation	
	2.2	Local Probabilistic Models: Tabular CPDs, Deterministic CPDs, Context Specific CPDs, Generalized Linear Models.	

	2.3	Exact inference variable elimination: Analysis of Complexity, Variable Elimination, Conditioning, Inference with Structured CPDs.	
3.		**Markov Network Model and Inference**	**8**
	3.1	**Undirected Graph Model :** Markov Model-Markov Network, Parameterization of Markov Network, Gibb's distribution, Reduced Markov Network, Markov Network Independencies, From Distributions to Graphs, Fine Grained Parameterization, Over Parameterization	
	3.2	Exact inference variable elimination: Graph Theoretic Analysis for Variable Elimination, Conditioning	
4.		**Hidden Markov Model and Inference**	**6**
	4.1	Template Based Graph Model : HMM- Temporal Models, Template Variables and Template Factors, Directed Probabilistic Models, Undirected Representation, Structural Uncertainty.	
5.		**Learning and Taking Actions and Decisions**	**6**
	5.1	Learning Graphical Models: Goals of Learning, Density Estimation, Specific Prediction Tasks, Knowledge Discovery. Learning as Optimization: Empirical Risk, over fitting, Generalization, Evaluating Generalization Performance, Selecting a Learning Procedure, Goodness of fit, Learning Tasks. Parameter Estimation: Maximum Likelihood Estimation, MLE for Bayesian Networks	
	5.2	Causality: Conditioning and Intervention, Correlation and Causation, Causal Models, Structural Causal Identifiability, Mechanisms and Response Variables, Learning Causal Models. Utilities and Decisions: Maximizing Expected Utility, Utility Curves, Utility Elicitation. Structured Decision Problems: Decision Tree	
6.		**Applications**	**4**
	6.1	Application of Bayesian Networks: Classification, Forecasting, Decision Making	
	6.2	Application of Markov Models: Cost Effectiveness Analysis, Relational Markov Model and its Applications, Application in Portfolio Optimization	
	6.3	Application of HMM: Speech Recognition, Part of Speech Tagging, Bioinformatics.	

Textbooks:	
1.	Daphne Koller and Nir Friedman, **"Probabilistic Graphical Models: Principles and Techniques"**, Cambridge, MA: The MIT Press, 2009 (ISBN 978-0-262-0139-2).
2.	David Barber, **"Bayesian Reasoning and Machine Learning"**, Cambridge University Press, 1st edition, 2011.
References:	

1.	Finn Jensen and Thomas Nielsen, **"Bayesian Networks and Decision Graphs (Information Science and Statistics)"**, 2nd Edition, Springer, 2007.
2.	Kevin P. Murphy, **"Machine Learning: A Probabilistic Perspective"**, MIT Press, 2012.
3.	Martin Wainwright and Michael Jordan, M., **"Graphical Models, Exponential Families, and Variational Inference"**, 2008.

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first class test is to be m onducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1.	Question paper will comprise of total six questions.
2.	All question carries equal marks
3.	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4.	Only Four question need to be solved.
5.	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Useful Links

1.	https://www.coursera.org/specializations/probabilistic-graphical-models
2.	https://www.mooc-list.com/tags/probabilistic-graphical-models
3.	https://scholarship.claremont.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=2690&context=cmc_theses
4.	https://www.upgrad.com/blog/bayesian-networks/
5.	https://www.utas.edu.au/__data/assets/pdf_file/0009/588474/TR_14_BNs_a_resource_guide.pdf
6.	https://math.libretexts.org/Bookshelves/Applied_Mathematics/Book%3A_Applied_Finite_Mathematics_(Sekhon_and_Bloom)/10%3A_Markov_Chains/10.02%3A_Applications_of_Markov_Chains/10.2.01%3A_Applications_of_Markov_Chains_(Exercises)
7.	https://link.springer.com/chapter/10.1007/978-3-319-43742-2_24
8.	https://homes.cs.washington.edu/~pedrod/papers/kdd02a.pdf
9.	https://core.ac.uk/download/pdf/191938826.pdf
10.	https://cs.brown.edu/research/pubs/theses/ugrad/2005/dbooksta.pdf

11.	https://web.ece.ucsb.edu/Faculty/Rabiner/ece259/Reprints/tutorial%20on%20hmm%20and%20applications.pdf
12.	https://mi.eng.cam.ac.uk/~mjfg/mjfg_NOW.pdf
13.	http://bioinfo.au.tsinghua.edu.cn/member/jgu/pgm/materials/Chapter3-LocalProbabilisticModels.pdf

Suggested List of Experiments:	
Sr. No	**Experiment**
1.	Experiment on Probability Theory
2.	Experiment on Graph Theory
3.	Experiment on Bayesian Network Modelling
4.	Experiment on Markov Chain Modeling
5.	Experiment on HMM
6.	Experiment on Maximum Likelihood Estimation
7.	Decision Making using Decision Trees
8.	Learning with Optimization
**** Suggestion: Laboratory work based on above syllabus can be incorporated along with mini project in CSM501: Mini-Project.**	

Course Code:	Course Title	Credit
CSDLO5012	Internet Programming	3

Prerequisite: Data Structures	
Course Objectives:	
1	To get familiar with the basics of Internet Programming.
2	To acquire knowledge and skills for creation of web site considering both client and server-side programming
3	To gain ability to develop responsive web applications
4	To explore different web extensions and web services standards
5	To learn characteristics of RIA
6	To learn React js
Course Outcomes:	
1	Implement interactive web page(s) using HTML and CSS.
2	Design a responsive web site using JavaScript
3	Demonstrate database connectivity using JDBC
4	Demonstrate Rich Internet Application using Ajax
5	Demonstrate and differentiate various Web Extensions.
6	Demonstrate web application using Reactive Js

Module		Content	Hrs
1		**Introduction to Web Technology**	**10**
	1.1	**Web Essentials**: Clients, Servers and Communication, The Internet, Basic Internet protocols, World wide web, HTTP Request Message, HTTP Response Message, Web Clients, Web Servers **HTML5** – fundamental syntax and semantics, Tables, Lists, Image, HTML5 control elements, Semantic elements, Drag and Drop, Audio – Video controls **CSS3** – Inline, embedded and external style sheets – Rule cascading, Inheritance, Backgrounds, Border Images, Colors, Shadows, Text, Transformations, Transitions, Animation, Basics of Bootstrap.	
2		**Front End Development**	**7**
	2.1	Java Script: An introduction to JavaScript–JavaScript DOM Model-Date and Objects-Regular Expressions- Exception Handling-Validation-Built-in objects-Event Handling, DHTML with JavaScript-JSON introduction – Syntax – Function Files – Http Request –SQL.	
3.		**Back End Development**	**7**
	3.1	**Servlets**: Java Servlet Architecture, Servlet Life Cycle, Form GET and POST actions, Session Handling, Understanding Cookies, Installing and Configuring Apache Tomcat Web Server, **Database Connectivity**: JDBC perspectives, JDBC program example **JSP:** Understanding Java Server Pages, JSP Standard Tag Library (JSTL), Creating HTML forms by embedding JSP code.	
4		**Rich Internet Application (RIA)**	**4**
	4.1	Characteristics of RIA, **Introduction to AJAX**: AJAX design basics, AJAX vs Traditional Approach, Rich User Interface using Ajax, jQuery framework with AJAX.	
5		**Web Extension: PHP and XML**	**6**
	5.1	XML –DTD (Document Type Definition), XML Schema, Document Object Model, Presenting XML, Using XML Parsers: DOM and SAX, XSL-eXtensible Stylesheet Language	

	5.2	**Introduction to PHP**- Data types, control structures, built in functions, building web applications using PHP- tracking users, PHP and MySQLdatabase connectivity with example.	
6		**React js**	**5**
	6.1	Introduction, React features, App "Hello World" Application, Introduction to JSX, Simple Application using JSX.	
			39

Textbooks:	
1	Ralph Moseley, M.T. Savliya, "Developing Web Applications", Willy India, Second Edition, ISBN: 978-81-265-3867-6
2	"Web Technology Black Book", Dremtech Press, First Edition, 978-7722-997
3	Robin Nixon, "Learning PHP, MySQL, JavaScript, CSS & HTML5" Third Edition, O'REILLY, 2014. (http://www.ebooksbucket.com/uploads/itprogramming/javascript/Learning_PHP_MySQL_Javascript_CSS_HTML5__Robin_Nixon_3e.pdf)
4	Dana Moore, Raymond Budd, Edward Benson,Professional Rich Internet Applications: AJAX and Beyond Wiley publications. https://ebooks-it.org/0470082801-ebook.htm
5.	Alex Banks and Eve Porcello, Learning React Functional Web Development with React and Redux,OREILLY, First Edition
References:	
1	Harvey & Paul Deitel& Associates, Harvey Deitel and Abbey Deitel, Internet and World Wide Web - How To Program, Fifth Edition, Pearson Education, 2011.
2	Achyut S Godbole and AtulKahate, —Web Technologies, Second Edition, Tata McGraw Hill, 2012.
3	Thomas A Powell, Fritz Schneider, —JavaScript: The Complete Reference, Third Edition, Tata McGraw Hill, 2013
4	David Flanagan, —JavaScript: The Definitive Guide, Sixth Edition, O'Reilly Media, 2011
5	Steven Holzner —The Complete Reference - PHP, Tata McGraw Hill, 2008
6	Mike Mcgrath—PHP & MySQL in easy Steps, Tata McGraw Hill, 2012.

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The firstclass test is to be conducted when approx. 40% syllabus is completed and the secondclass test when an additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed 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	In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Useful Links	
1	https://books.goalkicker.com/ReactJSBook/
2	https://www.guru99.com/reactjs-tutorial.html
3	www.nptelvideos.in
4	www.w3schools.com
5	https://spoken-tutorial.org/
6	www.coursera.org
The following list can be used as a guideline for mini project:	

1	Create Simple web page using HTML5
2	Design and Implement web page using CSS3 and HTML5
3	Form Design and Client-Side Validation using: a. Javascript and HTML5, b. Javascript and Jquery
4	Develop interactive web pages using HTML 5 with JDBC database connectivity
5	Develop simple web page using PHP
6	Develop interactive web pages using PHP with database connectivity MYSQL
7	Develop XML web page using DTD, XSL
8	Implement a web page using Ajax and PHP
9	Case study based on Reactive js
10	Installation of the React DOM library.
*** Suggestion: Laboratory work based on above syllabus can be incorporated as mini project in CSM501: Mini-Project.**	

Course Code:	Course Title	Credit
CSDLO5013	Advance Database Management System	3

Prerequisite: Database Management System	
Course Objectives:	
1	To provide insights into distributed database designing
2	To specify the various approaches used for using XML and JSON technologies.
3	To apply the concepts behind the various types of NoSQL databases and utilize it for Mongodb
4	To learn about the trends in advance databases
Course Outcomes: After the successful completion of this course learner will be able to:	
1	Design distributed database using the various techniques for query processing
2	Measure query cost and perform distributed transaction management
3	Organize the data using XML and JSON database for better interoperability
4	Compare different types of NoSQL databases
5	Formulate NoSQL queries using Mongodb
6	Describe various trends in advance databases through temporal, graph based and spatial based databases

Module		Content	Hrs
1		**Distributed Databases**	**3**
	1.1	Introduction, Distributed DBMS Architecture, Data Fragmentation, Replication and Allocation Techniques for Distributed Database Design.	
2		**Distributed Database Handling**	**8**
	2.1	Distributed Transaction Management – Definition, properties, types, architecture Distributed Query Processing - Characterization of Query Processors, Layers/ phases of query processing.	
	2.2	Distributed Concurrency Control- Taxonomy, Locking based, Basic TO algorithm, Recovery in Distributed Databases: Failures in distributed database, 2PC and 3PC protocol.	
3		**Data interoperability – XML and JSON**	**6**
	3.1	XML Databases: Document Type Definition, XML Schema, Querying and Transformation: XPath and XQuery.	
	3.2	Basic JSON syntax, (Java Script Object Notation),JSON data types, Stringifying and parsing the JSON for sending & receiving, JSON Object retrieval using key-value pair and JQuery, XML Vs JSON	
4		**NoSQL Distribution Model**	**10**
	4.1	NoSQL database concepts: NoSQL data modeling, Benefits of NoSQL, comparison between SQL and NoSQL database system.	
	4.2	Replication and sharding, Distribution Models Consistency in distributed data, CAP theorem, Notion of ACID Vs BASE, handling Transactions, consistency and eventual consistency	
	4.3	Types of NoSQL databases: Key-value data store, Document database and Column Family Data store, Comparison of NoSQL databases w.r.t CAP theorem and ACID properties.	
5		**NoSQL using MongoDB**	**6**

	5.1	NoSQL using MongoDB: Introduction to MongoDB Shell, Running the MongoDB shell, MongoDB client, Basic operations with MongoDB shell, Basic Data Types, Arrays, Embedded Documents	
	5.2	Querying MongoDB using find() functions, advanced queries using logical operators and sorting, simple aggregate functions, saving and updating document. MongoDB Distributed environment: Concepts of replication and horizonal scaling through sharding in MongoDB	
6		**Trends in advance databases**	**6**
	6.1	**Temporal database:** Concepts, time representation, time dimension, incorporating time in relational databases.	
	6.2	**Graph Database:** Introduction, Features, Transactions, consistency, Availability, Querying, Case Study Neo4J	
	6.3	**Spatial database:** Introduction, data types, models, operators and queries	
			39

Textbooks:	
1	Korth, Siberchatz,Sudarshan, "Database System Concepts", 6th Edition, McGraw Hill
2	Elmasri and Navathe, "Fundamentals of Database Systems", 5th Edition, Pearson Education
3	Ozsu, M. Tamer, Valduriez, Patrick, "Principles of distributed database systems",3rd Edition, Pearson Education, Inc.
4	PramodSadalge, Martin Fowler, NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Addison Wesely/ Pearson
5	Jeff Friesen , Java XML and JSON,Second Edition, 2019, après Inc.
References:	
1	Peter Rob and Carlos Coronel,Database Systems Design, Implementation and Management, Thomson Learning, 5th Edition.
2	Dr. P.S. Deshpande, SQL and PL/SQL for Oracle 10g, Black Book, Dreamtech Press.
3	Adam Fowler, NoSQL for dummies, John Wiley & Sons, Inc.
4	Shashank Tiwari, Professional NOSQL, John Willy & Sons. Inc
5	Raghu Ramkrishnan and Johannes Gehrke, Database Management Systems, TMH
6	MongoDB Manual : https://docs.mongodb.com/manual

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved.
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.
NOTE: Suggested that in Mini Projects (CSM501) can be included NoSQL databases for implementation as a backend.	

Useful Links	
1	https://cassandra.apache.org
2	https://www.mongodb.com
3	https://riak.com
4	https://neo4j.com
5	https://martinfowler.com/articles/nosql-intro-original.pdf

Lab Code	Lab Name	Credit
CSL501	Software Engineering Lab	1

Prerequisite: Object Oriented Programming with Java , Python Programming	
Lab Objectives:	
1	To solve real life problems by applying software engineering principles
2	To impart state-of-the-art knowledge on Software Engineering
Lab Outcomes: On successful completion of laboratory experiments, learners will be able to :	
1	Identify requirements and apply software process model to selected case study.
2	Develop architectural models for the selected case study.
3	Use computer-aided software engineering (CASE) tools.

Suggested List of Experiments - Assign the case study/project as detail statement of problem to a group of two/three students. Laboratory work will be based on course syllabus with minimum 10 experiments. Open source computer-aided software engineering (CASE) tools can be used for performing the experiment.

Sr. No.	Title of Experiment
1	Application of at least two traditional process models.
2	Application of the Agile process models.
3	Preparation of software requirement specification (SRS) document in IEEE format.
4	Structured data flow analysis.
5	Use of metrics to estimate the cost.
6	Scheduling & tracking of the project.
7	Write test cases for black box testing.
8	Write test cases for white box testing.
9	Preparation of Risk Mitigation, Monitoring and Management Plan (RMMM).
10	Version controlling of the project.

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments on content of theory and practical of "Software Engineering"
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSC502 and CSL501 syllabus

Lab Code	Lab Name	Credit
CSL502	Computer Network Lab	1

Prerequisite: None	
Lab Objectives:	
1	To practically explore OSI layers and understand the usage of simulation tools.
2	To analyze, specify and design the topological and routing strategies for an IP based networking infrastructure.
3	To identify the various issues of a packet transfer from source to destination, and how they are resolved by the various existing protocols
Lab Outcomes: On successful completion of lab, learner will be able to	
1	Design and setup networking environment in Linux.
2	Use Network tools and simulators such as NS2, Wireshark etc. to explore networking algorithms and protocols.
3	Implement programs using core programming APIs for understanding networking concepts.

Suggested List of Experiments	
Sr. No.	**Title of Experiment**
1.	Study of RJ45 and CAT6 Cabling and connection using crimping tool.
2.	Use basic networking commands in Linux (ping, tracert, nslookup, netstat, ARP, RARP, ip, ifconfig, dig, route)
3.	Build a simple network topology and configure it for static routing protocol using packet tracer. Setup a network and configure IP addressing, subnetting, masking.
4.	Perform network discovery using discovery tools (eg. Nmap, mrtg)
5.	Use Wire shark to understand the operation of TCP/IP layers: ● Ethernet Layer: Frame header, Frame size etc. ● Data Link Layer: MAC address, ARP (IP and MAC address binding) ● Network Layer: IP Packet (header, fragmentation), ICMP (Query and Echo) ● Transport Layer: TCP Ports, TCP handshake segments etc. ● Application Layer: DHCP, FTP, HTTP header formats
6.	Use simulator (Eg. NS2) to understand functioning of ALOHA, CSMA/CD.
7.	Study and Installation of Network Simulator (NS3)
8.	a. Set up multiple IP addresses on a single LAN. b. Using nestat and route commands of Linux, do the following: ● View current routing table ● Add and delete routes ● Change default gateway c. Perform packet filtering by enabling IP forwarding using IPtables in Linux.
9	Design VPN and Configure RIP/OSPF using Packet tracer.
10.	Socket programming using TCP or UDP
11.	Perform File Transfer and Access using FTP
12.	Perform Remote login using Telnet server

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments on content of theory and practical of "Computer Network"
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory& Practical: 05-marks,

	Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSC503: Computer Network

Useful Links	
1	https://www.netacad.com/courses/packet-tracer/introduction-packet-tracer
2	https://www.coursera.org/projects/data-forwarding-computer-networks
3	https://www.edx.org/course/ilabx-the-internet-masterclass

Lab Code	Lab Name	Credit
CSL503	Data Warehousing and Mining Lab	1

Prerequisite: Database Concepts	
Lab Objectives:	
1.	Learn how to build a data warehouse and query it.
2.	Learn about the data sets and data preprocessing.
3.	Demonstrate the working of algorithms for data mining tasks such Classification, clustering, Association rule mining & Web mining
4.	Apply the data mining techniques with varied input values for different parameters.
5.	Explore open source software (like WEKA) to perform data mining tasks.
Lab Outcomes: At the end of the course, the student will be able to	
1.	Design data warehouse and perform various OLAP operations.
2.	Implement data mining algorithms like classification.
3.	Implement clustering algorithms on a given set of data sample.
4.	Implement Association rule mining & web mining algorithm.

Suggested List of Experiments	
Sr. No.	**Title of Experiment**
1	One case study on building Data warehouse/Data Mart • Write Detailed Problem statement and design dimensional modelling (creation of star and snowflake schema)
2	Implementation of all dimension table and fact table based on experiment 1 case study
3	Implementation of OLAP operations: Slice, Dice, Rollup, Drilldown and Pivot based on experiment 1 case study
4	Implementation of Bayesian algorithm
5	Implementation of Data Discretization (any one) & Visualization (any one)
6	Perform data Pre-processing task and demonstrate Classification, Clustering, Association algorithm on data sets using data mining tool (WEKA/R tool)
7	Implementation of Clustering algorithm (K-means/K-medoids)
8	Implementation of any one Hierarchical Clustering method
9	Implementation of Association Rule Mining algorithm (Apriori)
10	Implementation of Page rank/HITS algorithm

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 1 assignment on content of theory and practical of "Data Warehousing and Mining"
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance (Theory & Practical): 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSC504 : Data Warehousing and Mining

Course Code	Course Name	Credit
CSL504	Business Communication & Ethics II	02

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	To discern and develop an effective style of writing important technical/business documents.
2	To investigate possible resources and plan a successful job campaign.
3	To understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement.
4	To develop creative and impactful presentation skills.
5	To analyze personal traits, interests, values, aptitudes and skills.
6	To understand the importance of integrity and develop a personal code of ethics.
Course Outcomes: At the end of the course, the student 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.

Module	Contents	Hours
1	**ADVANCED TECHNICAL WRITING: PROJECT/PROBLEM BASED LEARNING (PBL)**	**06**
	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) **Parts of a Long Formal Report:** Prefatory Parts (Front Matter), Report Proper (Main Body), Appended Parts (Back Matter) **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 **Definition, Purpose & Types of Proposals:** Solicited (in conformance with RFP) & Unsolicited Proposals, Types (Short and Long proposals) **Parts of a Proposal:** Elements, Scope and Limitations, Conclusion **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**
	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) **Statement of Purpose:** Importance of SOP, Tips for Writing an Effective SOP **Verbal Aptitude Test:** Modelled on CAT, GRE, GMAT exams **Group Discussions:** Purpose of a GD, Parameters of Evaluating a GD, Types of GDs (Normal, Case-based & Role Plays), GD Etiquettes **Personal Interviews:** Planning and Preparation, Types of Questions, Types of Interviews (Structured, Stress, Behavioural, Problem Solving & Case-based), Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	
3	**BUSINESS MEETINGS**	**02**
	Conducting Business Meetings: Types of Meetings, Roles and Responsibilities of Chairperson, Secretary and Members, Meeting Etiquette **Documentation:** Notice, Agenda, Minutes	
4	**TECHNICAL/ BUSINESS PRESENTATIONS**	**02**
	Effective Presentation Strategies: Defining Purpose, Analyzing Audience, Location and Event, Gathering, Selecting &Arranging Material, structuring a Presentation, Making Effective Slides, Types of Presentations Aids, Closing a Presentation, Platform skills **Group Presentations:** Sharing Responsibility in a Team, Building the contents and visuals together, Transition Phases	
5	**INTERPERSONAL SKILLS**	**08**
	Interpersonal Skills: Emotional Intelligence, Leadership & Motivation, Conflict Management & Negotiation, Time Management, Assertiveness, Decision Making **Start-up Skills:** Financial Literacy, Risk Assessment, Data Analysis (e.g. Consumer Behaviour, Market Trends, etc.)	
6	**CORPORATE ETHICS**	**02**
	Intellectual Property Rights: Copyrights, Trademarks, Patents, Industrial Designs, Geographical Indications, Integrated Circuits, Trade Secrets (Undisclosed Information) **Case Studies:** Cases related to Business/ Corporate Ethics	

List of assignments: (In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)

Sr. No.	Title of Experiment
1	Cover Letter and Resume
2	Short Proposal
3	Meeting Documentation
4	Writing a Technical Paper/ Analyzing a Published Technical Paper
5	Writing a SOP
6	IPR
7	Interpersonal Skills
Note:	
1	The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).

2	The group size for the final report presentation should not be less than 5 students or exceed 7 students.
3	There will be an end–semester presentation based on the book report.
Assessment:	
Term Work:	
1	Term work shall consist of minimum 8 experiments.
2	The distribution of marks for term work shall be as follows: Assignment : 10 Marks Attendance : 5 Marks Presentation slides : 5 Marks Book Report (hard copy) : 5 Marks
3	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 Project Presentation : 10 Marks Group Dynamics : 5 Marks
Books Recommended: Textbooks and Reference 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 &PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

Course Code	Course Name	Credits
CSM501	Mini Project 2A	02

Objectives	
1	To understand and identify the problem
2	To apply basic engineering fundamentals and attempt to find solutions to the problems.
3	Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach
4	To develop communication skills and improve teamwork amongst group members and inculcate the process of self-learning and research.
Outcome: Learner will be able to…	
1	Identify societal/research/innovation/entrepreneurship problems through appropriate literature surveys
2	Identify Methodology for solving above problem and apply engineering knowledge and skills to solve it
3	Validate, Verify the results using test cases/benchmark data/theoretical/ inferences/experiments/simulations
4	Analyze and evaluate the impact of solution/product/research/innovation /entrepreneurship towards societal/environmental/sustainable development
5	Use standard norms of engineering practices and project management principles during project work
6	Communicate through technical report writing and oral presentation. ● The work may result in research/white paper/ article/blog writing and publication ● The work may result in business plan for entrepreneurship product created ● The work may result in patent filing.
7	Gain technical competency towards participation in Competitions, Hackathons, etc.
8	Demonstrate capabilities of self-learning, leading to lifelong learning.
9	Develop interpersonal skills to work as a member of a group or as leader
Guidelines for Mini Project	
1	Mini project may be carried out in one or more form of following: Product preparations, prototype development model, fabrication of set-ups, laboratory experiment development, process modification/development, simulation, software development, integration of software (frontend-backend) and hardware, statistical data analysis, creating awareness in society/environment etc.
2	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.
3	Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor or head of department/internal committee of faculties.
4	Students shall submit an implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini projects.
5	A logbook may be prepared by each group, wherein the group can record weekly work progress, guide/supervisor can verify and record notes/comments.
6	Faculty supervisors may give inputs to students during mini project activity; however, focus shall be on self-learning.
7	Students under the guidance of faculty supervisor shall convert the best solution into a 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. Software requirement specification (SRS) documents, research papers, competition certificates may be submitted as part of

	annexure to the report.
9	With the focus on self-learning, innovation, addressing societal/research/innovation problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality be carried out in two semesters by all the groups of the students. i.e. 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 a case by case basis.

Term Work		
The review/ progress monitoring committee shall be constituted by the heads of departments of each institute. The progress of the mini project to be evaluated on a continuous basis, based on the SRS document submitted. 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 25**
1	Marks awarded by guide/supervisor based on logbook	10
2	Marks awarded by review committee	10
3	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:		
1	In one-year project (sem V and VI), first semester the entire theoretical solution shall be made ready, including components/system selection and cost analysis. Two reviews will be conducted based on a presentation given by a student group. □ First shall be for finalization of problem □ Second shall be on finalization of proposed solution of problem.	
2	In the 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 the last month of the said semester.	
Half-year project:		
1	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	
2	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.	

Mini Project shall be assessed based on following points	
1	Clarity of problem and quality of literature Survey for problem identification
2	Requirement Gathering via SRS/ Feasibility Study
3	Completeness of methodology implemented
4	Design, Analysis and Further Plan
5	Novelty, Originality or Innovativeness of project
6	Societal / Research impact
7	Effective use of skill set : Standard engineering practices and Project management standard
8	Contribution of an individual's as member or leader
9	Clarity in written and oral communication
10	Verification and validation of the solution/ Test Cases
11	Full functioning of working model as per stated requirements
12	Technical writing /competition/hackathon outcome being met

In one year project (sem V and VI), first semester evaluation may be based on first 10 criteria and remaining may be used for second semester evaluation of performance of students in mini projects.
In case of half year projects (completing in V sem) all criteria in generic may be considered for evaluation of performance of students in mini projects.

Guidelines for Assessment of Mini Project Practical/Oral Examination:	
1	Report should be prepared as per the guidelines issued by the University of Mumbai.
2	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 approved by the head of Institution.
3	Students shall be motivated to publish a paper/participate in competition based on the work in Conferences/students competitions.

University of Mumbai

No. AAMS_UGS/ICC/2022-23/ 171

CIRCULAR :-

Attention of the Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology is invited to this office circular No. UG/39 of 2018-19 dated 22nd June, 2018 relating to the revised syllabus as per the (CBCS) for the T.E.& B.E. in Computer Engineering (Sem- V to VIII) .

They are hereby informed that the recommendations made by the Ad-hoc Board of Studies in Computer Engineering at its meeting held on 16th June, 2022 and subsequently passed in the Faculty and then by the Board of Deans at its meeting held on 5th July, 2022 vide item No. 6.41 (R) have been accepted by the Academic Council at its meeting held on 11th July, 2022 **vide** item No. 6.41 (R) and that in accordance therewith, the revised syllabus of B.E. (Computer Engineering) (Sem. – VII & VIII) (CBCS) (Rev-2019 'C' Scheme) has been brought into force with effect from the academic year 2022-23. (The circular is available on the University's website www.mu.ac.in).

(Prof. Sunil Bhirud)
I/c Registrar

MUMBAI – 400 032
17th November, 2022

To

The Principals of the Affiliated Colleges and Directors of the Recognized Institutions in Faculty of Science & Technology.

A.C/6.41(R)/11/07/2022

Copy forwarded with Compliments for information to:-

1) The Dean, Faculty of Science & Technology,
2) The Chairman, Ad-hoc Board of Studies in Computer Engineering,
3) The Director, Board of Examinations and Evaluation,
4) The Director, Board of Students Development,
5) The Director, Department of Information & Communication Technology,
6) The Co-ordinator, MKCL.

Copy for information and necessary action :-

1. **The Deputy Registrar, College Affiliations & Development Department (CAD),**
2. **College Teachers Approval Unit (CTA),**
3. **The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Department (AEM),**
4. **The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA)**
5. **The Deputy Registrar, Research Administration & Promotion Cell (RAPC),**
6. **The Deputy Registrar, Executive Authorities Section (EA)**
   He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
7. **The Deputy Registrar, PRO, Fort, (Publication Section),**
8. **The Deputy Registrar, Special Cell,**
9. **The Deputy Registrar, Fort Administration Department (FAD) Record Section,**
10. **The Deputy Registrar, Vidyanagari Administration Department (VAD),**

Copy for information :-

1. **The Director, Dept. of Information and Communication Technology (DICT), Vidyanagari,**
   He is requested to upload the Circular University Website
2. **The Director of Department of Student Development (DSD),**
3. **The Director, Institute of Distance and Open Learning (IDOL Admin), Vidyanagari,**
4. **All Deputy Registrar, Examination House,**
5. **The Deputy Registrars, Finance & Accounts Section,**
6. **The Assistant Registrar, Administrative sub-Campus Thane,**
7. **The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan,**
8. **The Assistant Registrar, Ratnagiri sub-centre, Ratnagiri,**
9. **P.A to Hon'ble Vice-Chancellor,**
10. **P.A to Pro-Vice-Chancellor,**
11. **P.A to Registrar,**
12. **P.A to All Deans of all Faculties,**
13. **P.A to Finance & Account Officers, (F & A.O),**
14. **P.A to Director, Board of Examinations and Evaluation,**
15. **P.A to Director, Innovation, Incubation and Linkages,**
16. **P.A to Director, Department of Lifelong Learning and Extension (DLLE),**
17. **The Receptionist,**
18. **The Telephone Operator,**

Copy with compliments for information to :-

19. **The Secretary, MUASA**
20. **The Secretary, BUCTU.**

AC – 11 July, 2022
Item No. – 6.41 (R)

University of Mumbai

Revised Syllabus for

B.E. (Computer Engineering)

Semester – (VII & VIII)

(Choice Based Credit System)

(With effect from the academic year 2022-23)

University of Mumbai

O: _____ **Title of Course**	B.E. (Computer Engineering)
O: _____ **Eligibility**	After Passing Second Year Engineering as per the Ordinance 0.6243
R: _____ **Passing Marks**	40%
No. of years/Semesters:	4 Years / 8 semesters
Level:	~~P.G.~~ / U.G./ ~~Diploma / Certificate~~
Pattern:	~~Yearly~~ / Semester
Status:	~~New~~ / Revised
To be implemented from Academic Year :	With effect from Academic Year : 2022-23

Signature:

Dr. S. G. Bhirud
Chairman
of Ad-hoc Board of Studies in Computer Engineering

Dr. Suresh K. Ukarande
Associate Dean,
Faculty of Science and Technology

Signature:

Dr Anuradha Majumdar
Dean,
Faculty of Science and Technology

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 2021-22. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2022-23, 2023-24, respectively.

Dr. S.K. Ukarande

Associate Dean

Faculty of Science and Technology

University of Mumbai

Dr Anuradha Muzumdar

Dean

Faculty of Science and Technology

University of Mumbai

Incorporation and Implementation of Online Contents fromNPTEL/ 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

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preface by Board of Studies in Computer Engineering

Dear Students and Teachers, we, the members of Board of Studies Computer Engineering, are very happy to present Third Year Computer Engineering syllabus effective from the Academic Year 2021-22 (REV-2019'C' Scheme). We are sure you will find this syllabus interesting, challenging, fulfill certain needs and expectations.

Computer Engineering is one of the most sought-after courses amongst engineering students. The syllabus needs revision in terms of preparing the student for the professional scenario relevant and suitable to cater the needs of industry in present day context. The syllabus focuses on providing a sound theoretical background as well as good practical exposure to students in the relevant areas. It is intended to provide a modern, industry-oriented education in Computer Engineering. It aims at producing trained professionals who can successfully acquainted with the demands of the industry worldwide. They obtain skills and experience in up-to-date the knowledge to analysis, design, implementation, validation, and documentation of computer software and systems.

The revised syllabus is finalized through a brain storming session attended by Heads of Departments or senior faculty from the Department of Computer Engineering of the affiliated Institutes of the Mumbai University. The syllabus falls in line with the objectives of affiliating University, AICTE, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements.

The salient features of the revised syllabus are:

1. Reduction in credits to 170 is implemented to ensure that students have more time for extracurricular activities, innovations, and research.
2. The department Optional Courses will provide the relevant specialization within the branch to a student.
3. Introduction of Skill Based Lab and Mini Project to showcase their talent by doing innovative projects that strengthen their profile and increases the chance of employability.
4. Students are encouraged to take up part of course through MOOCs platform SWAYAM

We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

Board of Studies in Computer Engineering

Prof. Sunil Bhirud	: Chairman
Prof. SunitaPatil	: Member
Prof. Leena Ragha	: Member
Prof. Subhash Shinde	: Member
Prof .Meera Narvekar	: Member
Prof. Suprtim Biswas	: Member
Prof. Sudhir Sawarkar	: Member
Prof. Dayanand Ingle	: Member
Prof. Satish Ket	: Member

Program Structure for Fourth Year Computer Engineering

UNIVERSITY OF MUMBAI (With Effect from 2022-2023)

Semester VII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract. Tut.	Theory	Pract.	Total
CSC701	Machine Learning	3	--	3	--	3
CSC702	Big Data Analytics	3	--	3		3
CSDC 701X	Department Level Optional Course-3	3	--	3	--	3
CSDC 702X	Department Level Optional Course-4	3	--	3	--	3
ILO 701X	Institute Level Optional Course-1	3	--	3	--	3
CSL701	Machine Learning Lab	--	2	--	1	1
CSL702	Big Data Analytics Lab	--	2	--	1	1
CSDL 701X	Department Level Optional Course-3 Lab	--	2	--	1	1
CSDL 702X	Department Level Optional Course-4 Lab	--	2	--	1	1
CSP701	Major Project 1	--	6#	--	3	3
Total		**15**	**14**	**15**	**7**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. & oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
CSC701	Machine Learning	20	20	20	80	3	--	--	100
CSC702	Big Data Analysis	20	20	20	80	3	--	--	100
CSDC 701X	Department Level Optional Course-3	20	20	20	80	3	--	--	100
CSDC 702X	Department Level Optional Course-4	20	20	20	80	3	--	--	100
ILO 701X	Institute Level Optional Course-1	20	20	20	80	3	--	--	100
CSL701	Machine Learning Lab	--	--	--	--	--	25	25	50
CSL702	Big Data Analytics Lab	--	--	--	--	--	25	25	50
CSDL 701X	Department Level Optional Course-3 Lab						25	-	25
CSDL 702X	Department Level Optional Course-4 Lab	--	--	--	--	--	25	-	25
CSP701	Major Project 1	--	--	--	--	--	50	25	75
Total		**--**	**--**	**100**	**400**	--	**150**	**75**	**725**

Program Structure for Fourth Year Computer Engineering

UNIVERSITY OF MUMBAI (With Effect from 2022-2023)

Semester VIII

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract. Tut.	Theory	Pract.	Total
CSC801	Distributed Computing	3	--	3	--	3
CSDC 801X	Department Level Optional Course -5	3	--	3	--	3
CSDC 802X	Department Level Optional Course -6	3	--	3	--	3
ILO 801X	Institute Level Optional Course -2	3	--	3	--	3
CSL801	Distributed Computing Lab	--	2	--	1	1
CSDL 801X	Department Level Optional Course -5 Lab	--	2	--	1	1
CSDL 802X	Department Level Optional Course -6 Lab	--	2	--	1	1
CSP801	Major Project 2	--	12#	--	6	6
Total		**12**	**18**	**12**	**9**	**21**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract & oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (in Hrs)			
		Test 1	Test 2	Avg					
CSC801	Distributed Computing	20	20	20	80	3	--	--	100
CSDC 801X	Department Level Optional Course -5	20	20	20	80	3	--	--	100
CSDC 802X	Department Level Optional Course -6	20	20	20	80	3	--	--	100
ILO 801X	Institute Level Optional Course -2	20	20	20	80	3	--	--	100
CSL801	Distributed Computing Lab	--	--	--	--	--	25	25	50
CSDL 801X	Department Level Optional Course -5 Lab	--	--	--	--	--	25	25	50
CSDL 802X	Department Level Optional Course -6 Lab						25	25	50
CSP801	Major Project- 2	--	--	--	--	--	100	50	150
Total		**--**	**--**	**80**	**320**	**--**	**175**	**125**	**700**

Major Project 1 and 2 :

- Students can form groups with minimum 2 (Two) and not more than 4 (Four)
- Faculty Load : In Semester VII – ½ hour per week per project group
  In Semester VIII – 1 hour per week per project group

Program Structure for Computer Engineering

UNIVERSITY OF MUMBAI (With Effect from 2022-2023)

Department and Institute Optional Courses and Labs

Semester	**Department/ Institute Optional Courses and Labs**	**Subject**
VII	Department Optional Course -3	CSDC7011: Machine Vision CSDC7012: Quantum Computing CSDC7013: Natural Language Processing
	Department Optional Lab -3	CSDL7011: Machine Vision Lab CSDL7012: Quantum Computing Lab CSDL7013: Natural Language Processing Lab
	Department Optional Course -4	CSDC7021 : Augmented and Virtual Reality CSDC7022 : Block Chain CSDC7023 : Information Retrieval
	Department Optional Lab -4	CSDL7021 : Augmented and Virtual Reality Lab CSDL7022 : Block Chain Lab CSDL7023 : Information Retrieval Lab
	Institute level Optional Courses-I	ILO7011. Product Lifecycle Management ILO7012. Reliability Engineering ILO7013. Management Information System ILO7014. Design of Experiments ILO7015. Operation Research ILO7016. Cyber Security and Laws ILO7017. Disaster Management & Mitigation Measures ILO7018. Energy Audit and Management ILO7019. Development Engineering

Program Structure for Computer Engineering

UNIVERSITY OF MUMBAI (With Effect from 2022-2023)

Department and Institute Optional Courses and Labs

Semester	**Department/ Institute Optional Courses and Labs**	**Subject**
VIII	Department Optional Course -5	CSDC8011 : Deep Learning CSDC8012 : Digital Forensic CSDC8013 : Applied Data Science
	Department Optional Lab -5	CSDL8011 : Deep Learning Lab CSDL8012 : Digital Forensic Lab CSDL8013 : Applied Data Science Lab
	Department Optional Course -6	CSDC8021 : Optimization in Machine Learning CSDC8022: High Performance Computing CSDC8023: Social Media Analytics
	Department Optional Lab -6	CSDL8021 : Optimization in Machine Learning Lab CSDL8022: High Performance Computing Lab CSDL8023: Social Media Analytics Lab
	Institute level Optional Courses-II	ILO8021. Project Management ILO8022. Finance Management ILO8023. Entrepreneurship Development and Management ILO8024. Human Resource Management ILO8025. Professional Ethics and CSR ILO8026. Research Methodology ILO8027. IPR and Patenting ILO8028. Digital Business Management ILO8029. Environmental Management

Course Code:	Course Title	Credit
CSC701	Machine Learning	3

Prerequisite: Engineering Mathematics, Data Structures, Algorithms	
Course Objectives:	
1	To introduce the basic concepts and techniques of Machine Learning.
2	To acquire in depth understanding of various supervised and unsupervised algorithms
3	To be able to apply various ensemble techniques for combining ML models.
4	To demonstrate dimensionality reduction techniques.
Course Outcomes:	
1	To acquire fundamental knowledge of developing machine learning models.
2	To select, apply and evaluate an appropriate machine learning model for the given
3	To demonstrate ensemble techniques to combine predictions from different models.
4	To demonstrate the dimensionality reduction techniques.

Module		Content	Hrs
1		Introduction to Machine Learning	04
	1.1	Machine Learning, Types of Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps in developing a Machine Learning Application.	
	1.2	Training Error, Generalization error, Overfitting, Underfitting, Bias-Variance trade-off.	
2		Learning with Regression and Trees	09
	2.1	Learning with Regression: Linear Regression, Multivariate Linear Regression, Logistic Regression.	
	2.2	Learning with Trees: Decision Trees, Constructing Decision Trees using Gini Index (Regression), Classification and Regression Trees (CART)	
	2.3	Performance Metrics: Confusion Matrix, [Kappa Statistics], Sensitivity, Specificity, Precision, Recall, F-measure, ROC curve	
3		Ensemble Learning	06
	3.1	Understanding Ensembles, K-fold cross validation, Boosting, Stumping, XGBoost	
	3.2	Bagging, Subagging, Random Forest, Comparison with Boosting, Different ways to combine classifiers	
4		Learning with Classification	08
	4.1	Support Vector Machine Constrained Optimization, Optimal decision boundary, Margins and support vectors, SVM as constrained optimization problem, Quadratic Programming, SVM for linear and nonlinear classification, Basics of	

		Kernel trick.	
	4.2	Support Vector Regression, Multiclass Classification	
5		Learning with Clustering	07
	5.1	Introduction to clustering with overview of distance metrics and major clustering approaches.	
	5.2	Graph Based Clustering: Clustering with minimal spanning tree Model based Clustering: Expectation Maximization Algorithm, Density Based Clustering: DBSCAN	
6		Dimensionality Reduction	05
	6.1	Dimensionality Reduction Techniques, Principal Component Analysis, Linear Discriminant Analysis, Singular Valued Decomposition.	
		Total	39

Textbooks:	
1	Peter Harrington, “Machine Learning n Action”, DreamTech Press
2	Ethem Alpaydın, “Introduction to Machine Learning”, MIT Press
3	Tom M. Mitchell, “Machine Learning” McGraw Hill
4	Stephen Marsland, “Machine Learning An Algorithmic Perspective”, CRC Press
References:	
1	Han Kamber, ―Data Mining Concepts and Techniques‖, Morgan Kaufmann Publishers
2	Margaret. H. Dunham, ―Data Mining Introductory and Advanced Topics, Pearson Education
3	Kevin P. Murphy , Machine Learning ― A Probabilistic Perspective‖
4	Samir Roy and Chakraborty, ―Introduction to soft computing‖, Pearson Edition.
5	Richard Duda, Peter Hart, David G. Stork, “Pattern Classification”, Second Edition, Wiley Publications.
Assessment:	
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 the second class test when an additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed 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	In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Useful Digital Links	
1	Data sets for Machine Learning algorithms: https://www.kaggle.com/datasets
2	Machine Learning repository- https://archive.ics.uci.edu/ml/index.php
3	Machine Learning from Coursera
4	https://towardsdatascience.com/machine-learning/home
5	https://onlinecourses.nptel.ac.in/noc21_cs85/preview

Course Code	Course Name	Credit
CSC702	Big Data Analysis	03

Prerequisite: Database, Data mining.	
Course Objectives: The course aims:	
1	To provide an overview of the big data platforms, its use cases and Hadoop ecosystem.
2	To introduce programming skills to build simple solutions using big data technologies such as MapReduce, Scripting for No SQL and R
3	To learn the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability.
4	To enable students to have skills that will help them to solve complex real-world problems for decision support.
Course Outcomes:	
1	Understand the building blocks of Big Data Analytics.
2	Apply fundamental enabling techniques like Hadoop and MapReduce in solving real world problems.
3	Understand different NoSQL systems and how it handles big data.
4	Apply advanced techniques for emerging applications like stream analytics.
5	Achieve adequate perspectives of big data analytics in various applications like recommender systems, social media applications, etc.
6	Apply statistical computing techniques and graphics for analyzing big data.

Module		Detailed Content	Hours
1		**Introduction to Big Data and Hadoop**	2
	1.1	Introduction to Big Data - Big Data characteristics and Types of Big Data	
	1.2	Traditional vs. Big Data business approach	
	1.3	Case Study of Big Data Solutions	
	1.4	Concept of Hadoop, Core Hadoop Components; Hadoop Ecosystem	
2		**Hadoop HDFS and MapReduce**	8
	2.1	Distributed File Systems: Physical Organization of Compute Nodes, Large-Scale File-System Organization.	
	2.2	MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping With Node Failures.	
	2.3	Algorithms Using MapReduce: Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Computing Selections by MapReduce, Computing Projections by MapReduce, Union ,Intersection, and Difference by MapReduce	

	2.4	Hadoop Limitations	
3		**NoSQL**	10
	3.1	Introduction to NoSQL, NoSQL Business Drivers	
	3.2	NoSQL Data Architecture Patterns: Key-value stores, Graph stores, Column family (Bigtable)stores, Document stores, Variations of NoSQL architectural patterns, NoSQL Case Study	
	3.3	NoSQL solution for big data, Understanding the types of big data problems; Analyzing big data with a shared-nothing architecture; Choosing distribution models: master-slave versus peer-to-peer; NoSQL systems to handle big data problems.	
4		**Mining Data Streams**	11
	4.1	The Stream Data Model: A Data-Stream-Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing.	
	4.2	Sampling Data techniques in a Stream	
	4.3	Filtering Streams: Bloom Filter with Analysis.	
	4.4	Counting Distinct Elements in a Stream,Count-Distinct Problem, Flajolet-Martin Algorithm, Combining Estimates, Space Requirements	
	4.5	Counting Ones in a Window: The Cost of Exact Counts,The Datar-Gionis-Indyk-Motwani Algorithm, Query Answering in theDGIM Algorithm, Decaying Windows.	
5		**Real-Time Big Data Models**	4
	5.1	A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering	
	5.2	Case Study: Product Recommendation	
	5.3	Social Networks as Graphs, Clustering of Social-Network Graphs, Direct Discovery of Communities in a social graph	
6		**Data Analytics with R**	4
	6.1	Exploring Basic features of R, Exploring RGUI, Exploring RStudio, Handling Basic Expressions in R, Variables in R, Working with Vectors, Storing and Calculating Values in R, Creating and using Objects, Interacting with users, Handling data in R workspace, Executing Scripts, Creating Plots, Accessing help and documentation in R	
	6.2	Reading datasets and Exporting data from R, Manipulating and Processing Data in R, Using functions instead of script, built-in functions in R	
	6.3	Data Visualization: Types, Applications	

Textbooks:	
1	Cre Anand Rajaraman and Jeff Ullman ―Mining of Massive Datasets‖, Cambridge UniversityPress
2	Alex Holmes ―Hadoop in Practice‖, Manning Press, Dreamtech Press.
3	Dan Mcary and Ann Kelly ―Making Sense of NoSQL‖ – A guide for managers and the rest of us, Manning Press.
4	DT Editorial Services, “Big Data Black Book”, Dreamtech Press
5	EMC Education Services,”Data Science and Big Data Analytics”,Wiley

References:	
1	Bill Franks , —Taming The Big Data Tidal Wave: Finding Opportunities In HugeData StreamsWithAdvancedAnalytics|,Wiley
2	Chuck Lam, —Hadoop inAction|, Dreamtech Press
3	Jared Dean, —Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners|,Wiley India Private Limited, 2014.
4	Jiawei Han and Micheline Kamber, —Data Mining: Concepts and Techniques|, Morgan Kaufmann Publishers, 3rd ed, 2010.
5	Lior Rokach and Oded Maimon, —Data Mining and Knowledge Discovery Handbook|, Springer, 2nd edition,2010.
6	Ronen Feldman and James Sanger, —The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data|, Cambridge University Press, 2006.
7	Vojislav Kecman, —Learning and Soft Computing|, MITPress, 2010.

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links	
1	https://nptel.ac.in/courses/106104189
2	https://www.coursera.org/specializations/big-data#courses
3	https://www.digimat.in/nptel/courses/video/106106169/L01.html
4	https://www.coursera.org/learn/nosql-databases#syllabus
5	https://www.coursera.org/learn/basic-recommender-systems#syllabus

Course Code	Course Name	Credit
CSDC7011	Machine Vision	03

Pre-requisite: Computer Graphics	
Course Objectives: The course aims:	
1	To understand the need and significance Machine Vision
2	To explore basics of image processing
3	To explore the components of Machine Vision System
4	To develop application using machine Vision
5	To study transformation, interpolation, filters.
Course Outcomes: Learners will be able to	
1	Elaborate the components of Machine Vision Application
2	Perform image ,video preprocessing operations
3	Explain various transformations, interpolation.
4	Elaborate motion tracking in video.
5	Analyze and Implement appropriate filtering techniques for a given problem.
6	Develop applications based on machine vision..

Module		Detailed Content	Hours
1		**Introduction to Machine Vision**	4
		Computer and Human Vision Systems., The Human Eye, Computer versus Human Vision Systems, Evolution of Computer Vision, Computer/Machine Vision and Image Processing, Applications of Computer Vision	
2		**Digital Image Fundamentals**	8
		Digital Image, Monochrome and Color Images, Image Brightness and Contrast., 2D, 3D, and 4D Images, Digital Image Representation , Digital Image File Formats, Fundamental Image Operations, Points, Edges, and Vertices , Point Operations , Thresholding ,Brightness, Geometric Transformations , Spatial Transformation , Affine Transformation, Image Interpolation ,Nearest-Neighbor Interpolation ,Bilinear Interpolation , Bi-cubic Interpolation ,Fundamental Steps in Digital Image Processing.	
3		**Machine Vision and System Components**	8
		Machine Vision System, Machine Vision Camera: CCD and CMOS Image Sensors, TDI Sensor, Camera Type - Area Scan Cameras, Line Scan Cameras, Smart Cameras, Camera Lens-Resolution, Contrast and Sharpness, Lenses and their parameters: Types of Lenses, Lens Mounts, Lens Selection Examples-Field of	

		View Much larger than Camera sensor size or Smaller or close to Camera Sensor size, Machine Vision Lighting: Lighting: Light Sources in Machine Vision, Illumination Techniques-Backlighting, Front Lighting, Diffused Lighting, Oblique Lighting, Dark Field Lighting, Infrared and Ultraviolet Light, Filters, Machine Vision Software, Machine Vision Automation, Integration of Machine Vision Components	
4		**Digital Image Processing for Machine Vision Applications**	10
		Preprocessing., Image Filtering, Normalized Box Filter Gaussian Filter Bilateral Filter, Comparison of Filter Techniques, Sub sampling/Scaling Histogram, Image Segmentation, Threshold-Based Segmentation Edge-Based Segmentation First-Order Derivative Edge Detection. Second-Order Derivative Operators, Comparison of Edge Detection Techniques, Region-Based Segmentation Region Growing Methods, Region Split and Merge Method, Morphological Image Processing: Dilation, Erosion, Opening, Closing, Hit-or-Miss transformation, Object Recognition. Template Matching. Blob Analysis	
5		**Motion Analysis**	**4**
		Differential motion Analysis, Optical Flow, Analysis based on correspondence of interest points, Detection of specific motion Patterns, Video Tracking	
6		**Emerging Trends in Machine Vision**	**5**
	6.1	History of Industrial Revolution(s), Machine Vision and Industry 4.0, Emerging Vision Trends in Manufacturing, 3D Imaging, Emerging Vision Trends in Manufacturing,	
	6.2	Applications in Machine/ Computer Vision: Face detection, face recognition, eigen faces, car on roads	

Textbooks:	
1.	Sheila Anand and L.Priya , "A Guide for Machine Vision in Quality Control", Taylor & Francis Inc, Imprint CRC Press Inc, Dec 2019
2.	Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Pearson
3.	Carsten Stegar, Markus Ulrich, and Christian Wiedemann , "Machine Vision Algorithms and Applications",Second completely Revised and Enlarged Edition
4.	Milan Sonka, Vaclav Hlavac, Roger Boyle, "Image Processing Analysis and Machine Vision", Second Edition, Cengage Learning.
References:	

1.	Chiranji Lal Chowdhary, Mamoun Alazab, Ankit Chaudhary, SaqibHakak and Thippa Reddy Gadekallu ,"Computer Vision and Recognition Systems Using Machine and Deep Learning Approaches, Fundamentals, technologies and applications" , IET COMPUTING SERIES 42
2	Joe Minichino Joseph Howse ,"Learning OpenCV 3 Computer Vision with Python", Second Edition, Packt Publishing Ltd.
3.	Alexander Hornberg,, " Handbook of Machine and Computer Vision The Guide for Developers and Users,

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Useful Links

1	https://nptel.ac.in/courses/108103174
2	https://www.coursera.org/learn/introduction-computer-vision-watson-opencv
3	https://www.udacity.com/course/introduction-to-computer-vision--ud810
4	https://onlinecourses.nptel.ac.in/noc21_ee23/preview

Course Code	Course Title	Credit
CSDC7012	Quantum Computing	3

Prerequisite: Engineering Mathematics, Data Structures and Algorithm, Python Programming			
Course Objectives:			
1	To understand basics of quantum computing		
2	To understand mathematics required for quantum computing		
3	To understand building blocks of quantum computing and design algorithms		
4	To understand quantum hardware principles and tools for quantum computing.		
Course Outcomes: After successful completion of the course student will be able to			
1	Understand basic concepts of quantum computing		
2	Illustrate building blocks of quantum computing through architecture and programming models.		
3	Appraise various mathematical models required for quantum computing		
4	Discuss various quantum hardware building principles.		
5	Identify the various quantum algorithms		
6	Describe usage of tools for quantum computing.		
Module		**Content**	**Hrs**
1.0		Introduction to Quantum Computing	**7**
	1.1 1.2	Motivation for studying Quantum Computing Origin of Quantum Computing Quantum Computer vs. Classical Computer Introduction to Quantum mechanics Overview of major concepts in Quantum Computing Qubits and multi-qubits states Bloch Sphere representation Quantum Superposition Quantum Entanglement Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.)	
2.0		Mathematical Foundations for Quantum Computing	**05**
	2.1	Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigen values and Eigen vectors.	
3.0		Building Blocks for Quantum Program	**08**

	3.1 3.2	Architecture of a Quantum Computing platform Details of q-bit system of information representation: Block Sphere Multi-qubits States Quantum superposition of qubits (valid and invalid superposition) Quantum Entanglement Useful states from quantum algorithmic perceptive e.g. Bell State Operation on qubits: Measuring and transforming using gates. Quantum Logic gates and Circuit No Cloning Theorem and Teleportation Programming model for a Quantum Computing Program Steps performed on classical computer Steps performed on Quantum Computer Moving data between bits and qubits.	
4.0		Quantum Algorithms and Error correction	**06**
	4.1 **4.2**	Quantum Algorithms, Shor's Algorithm, Grover's Algorithm. Deutsch's Algorithm, Deutsch -Jozsa Algorithm Quantum error correction using repetition codes 3 qubit codes, Shor's 9 qubit error correction Code	
5.0		Quantum Hardware	**10**
	5.1 **5.2** **5.3** **5.4**	Ion Trap Qubits ,The DiVincenzo Criteria , Lagrangian and Hamiltonian Dynamics in a Nutshell: Dynamics of a Translating Rotor Quantum Mechanics of a Free Rotor: A Poor Person's Atomic Model: Rotor Dynamics and the Hadamard Gate, Two-Qubit Gates The Cirac-Zoller Mechanism: Quantum Theory of Simple Harmonic Motion, A Phonon-Qubit Pair Hamiltonian, Light-Induced Rotor-Phonon Interactions, Trapped Ion Qubits, Mølmer-Sørenson Coupling .. Cavity Quantum Electrodynamics (cQED): Eigenstates of the Jaynes-Cummings Hamiltonian Circuit QED (cirQED): Quantum LC Circuits, Artificial Atoms, Superconducting Qubits Quantum computing with spins: Quantum inverter realized with two exchange coupled spins in quantum dots, A 2-qubit spintronic universal quantum gate.	
6.0		OSS Toolkits for implementing Quantum program	**03**
	6.1	IBM quantum experience Microsoft Q Rigetti PyQuil (QPU/QVM)	

Textbooks:	
1	Michael A. Nielsen, "Quantum Computation and Quantum Information", Cambridge University Press.
2	David McMahon, "Quantum Computing Explained", Wiley ,2008
3	Qiskit textbook https://qiskit.org/textbook-beta/
4	Vladimir Silva, Practical Quantum Computing for Developers,2018

References:

1	Bernard Zygelman, A First Introduction to Quantum Computing and Information,2018
2	Supriyo Bandopadhyay and Marc Cahy, “Introduction to Spintronics”, CRC Press, 2008
3	The Second Quantum Revolution: From Entanglement to Quantum Computing and Other Super-Technologies, Lars Jaeger
4	La Guardia, Giuliano Gladioli “Quantum Error correction codes”Springer,2021

Digital References:

https://onlinecourses.nptel.ac.in/noc21_cs103/preview
https://www.coursera.org/courses?query=quantum%20computing
https://www.cl.cam.ac.uk/teaching/1617/QuantComp/

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved.
5	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Course Code	Course Name	Credit
CSDC7013	Natural Language Processing	03

Pre-requisite: Theory of Computer Science, System Programming &Compiler Construction	
Course Objectives: The course aims	
1	To define natural language processing and to learn various stages of natural language processing.
2	To describe basic concepts and algorithmic description of the main language levels: Morphology, Syntax, Semantics, and Pragmatics &Discourse analysis.
3	To design and implement various language models and POS tagging techniques.
4	To design and learn NLP applications such as Information Extraction, Question answering.
5	To design and implement applications based on natural language processing.
Course Outcomes: Students will be able	
1	To describe the field of natural language processing.
2	To design language model for word level analysis for text processing.
3	To design various POS tagging techniques and parsers.
4	To design, implement and test algorithms for semantic and pragmatic analysis.
5	To formulate the discourse segmentation and anaphora resolution.
6	To apply NLP techniques to design real world NLP applications.

Module		Detailed Content	Hours
1	1.1	**Introduction to NLP**	3
		Origin & History of NLP; Language, Knowledge and Grammar in language processing; Stages in NLP;Ambiguities and its types in English and Indian Regional Llanguages; Challenges of NLP;Applications of NLP	
	1.2	**Self-Learning topics:** Variety types of tools for regional languages pre-processing and other functionalities	
2	2.1	**Word Level Analysis**	9
		Basic Terms: Tokenization, Stemming, Lemmatization; Survey of English Morphology, Inflectional Morphology, Derivational Morphology; Regular expression with types; Morphological Models: Dictionary lookup, finite state morphology; Morphological parsing with FST (Finite State Transducer);Lexicon free FST Porter Stemmer algorithm; Grams and its variation: Bigram, Trigram; Simple (Unsmoothed) N-grams; N-gram Sensitivity to the Training Corpus; Unknown Words: Open versus closed vocabulary tasks; Evaluating N-grams: Perplexity;	

		Smoothing: Laplace Smoothing, Good-Turing Discounting;	
	2.2	**Self-Learning topics:** Noisy channel models, various edit distance, Advance Issues in Language Modelling	
3	3.1	**Syntax analysis**	10
		Part-Of-Speech tagging(POS); Tag set for English (Upenn Treebank); Difficulties /Challenges in POS tagging; Rule-based, Stochastic and Transformation-based tagging; Generative Model: Hidden Markov Model (HMM Viterbi) for POS tagging; Issues in HMM POS tagging; Discriminative Model: Maximum Entropy model, Conditional random Field (CRF);Parsers: Top down and Bottom up; Modelling constituency; Bottom Up Parser: CYK, PCFG (Probabilistic Context Free Grammar), Shift Reduce Parser; Top Down Parser: Early Parser, Predictive Parser	
	3.2	**Self-Learning topics:** Evaluating parsers, Parsers based language modelling, Regional languages POS tree banks	
4	4.1	**Semantic Analysis**	7
		Introduction, meaning representation; Lexical Semantics; Corpus study; Study of Various language dictionaries like WorldNet, Babelnet; Relations among lexemes & their senses –Homonymy, Polysemy, Synonymy, Hyponymy; Semantic Ambiguity; Word Sense Disambiguation (WSD); Knowledge based approach(Lesk's Algorithm), Supervised (Naïve Bayes, Decision List),Introduction to Semi-supervised method (Yarowsky) Unsupervised (Hyperlex)	
	4.2	**Self-Learning topics:** Dictionaries for regional languages, Distributional Semantics, Topic Models	
5	5.1	**Pragmatic & Discourse Processing**	5
		Discourse: Reference Resolution, Reference Phenomena, Syntactic & Semantic constraint on coherence; Anaphora Resolution using Hobbs and Cantering Algorithm	
	5.2	**Self-Learning topics:** Discourse segmentation, Conference resolution	
6	6.1	**Applications of NLP**	5
		Case studies on (preferable in regional language):Machine translation; Text Summarization; Sentiment analysis; Information retrieval; Question Answering system	
	6.2	**Self-Learning topics:** Applications based on Deep Neural Network with NLP such as LSTM network, Recurrent Neural network etc.	

Textbooks:	
1	Daniel Jurafsky, James H. and Martin, Speech and Language Processing, Second Edition, Prentice Hall, 2008.
2	Christopher D.Manning and HinrichSchutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.

References:

1	Siddiqui and Tiwary U.S., Natural Language Processing and Information Retrieval, Oxford University Press, 2008.
2	Daniel M Bikel and ImedZitouni — Multilingual natural language processing applications:

	from theory to practice, IBM Press, 2013.
3	Alexander Clark, Chris Fox, Shalom Lappin — The Handbook of Computational Linguistics and Natural Language Processing, John Wiley and Sons, 2012.
4	Nitin Indurkhya and Fred J. Damerau, —Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.
5	Niel J le Roux and SugnetLubbe, A step by step tutorial: An introduction into R application and programming.
6	Steven Bird, Ewan Klein and Edward Loper, Natural language processing with Python: analyzing text with the natural language toolkit, O'Reilly Media, 2009.

Digital References :	
1	http://www.cse.iitb.ac.in/~cs626-449
2	http://cse24-iiith.virtual-labs.ac.in/#
3.	https://nptel.ac.in/courses/106105158

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

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Course Code	Course Name	Credit
CSDC7021	Augmented and Virtual Reality	03

Prerequisite: Computer Graphics	
Course Objectives: The course aims:	
1	To understand the need and significance of Virtual Reality.
2	To explore the concepts of Virtual reality and develop 3D virtual environments.
3	To understand the technical and engineering aspects of virtual reality systems.
4	To analyze various techniques for applying virtual reality.
5	To provide a foundation to the fast growing field of AR and make the students aware of the various AR devices.
Course Outcomes: Learners will be able to	
1:	Describe how VR systems work and list the applications of VR
2:	Elaborate geometric presentationof the virtual world and its operations.
3:	Explain the concepts of motion and tracking in VR systems.
4:	Design and implementation of the hardware that enables VR systems tobe built.
5:	Describe how AR systems work and analyze the hardware requirement of AR
6:	Analyze and understand the working of various state of the art AR devices.

Module		Detailed Content	Hours
1		**Introduction to Virtual Reality**	5
		What is virtual reality? ,The beginnings of VR , VR paradigms , Collaboration, Virtual reality systems, Representation ,User interaction	
2		**The Geometry of Virtual Worlds**	6
		Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations	
3		**Motion in Real and Virtual Worlds**	6
		Velocities and Accelerations , The Vestibular System , Physics in the Virtual World , Mismatched Motion and Vection	
4		**Applying Virtual Reality**	7
		Virtual reality: the medium, Form and genre, What makes an application a good candidate for VR, Promising application fields, Demonstrated benefits of virtual reality , More recent trends in virtual reality application development, A framework for VR application development	
5		**Augmented Reality**	8
		Terminology, Simple augmented reality, Augmented reality as an emerging technology, Augmented reality applications, Marker detection, Marker pose, Marker types and identification: Template markers, 2D bar-code markers, Imperceptible markers: Image markers, Infrared markers, Miniature markers, Discussion on marker use, General marker detection application	
6		**AR Development & Applications**	

		User interfaces, Avoiding physical contacts , Practical experiences with head-mounted displays , Authoring and dynamic content ,AR applications and future visions, How to design an AR application ,Technology adoption and acceptance , Where to use augmented reality	

Textbooks:	
1	Virtual Reality, Steven M. LaValle, Cambridge University Press, 2016
2	Understanding Virtual Reality: Interface, Application and Design, William R Sherman and Alan B Craig, (The Morgan Kaufmann Series in Computer Graphics)". Morgan Kaufmann Publishers, San Francisco, CA, 2002
3	Developing Virtual Reality Applications: Foundations of Effective Design, Alan B Craig,William R Sherman and Jeffrey D Will, Morgan Kaufmann, 2009.
4	Theory and applications of marker-based augmented reality SanniSiltanen
References:	
1	AR Game Development‖, 1st Edition,Allan Fowler, A press Publications, 2018, ISBN 978-1484236178
2	Augmented Reality: Principles & Practice by Schmalstieg / Hollerer, Pearson Education India; First edition (12 October 2016),ISBN-10: 9332578494
3	Learning Virtual Reality, Tony Parisi,O'Reilly Media, Inc., 2015, ISBN- 9781491922835

Digital Useful Links	
1	https://freevideolectures.com/course/3693/virtual-reality
2	https://www.vrlabacademy.com/
3	https://arvr.google.com/ar/
4	https://konterball.com/

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Course Code:	Course Title	Credit
CSDC7022	Blockchain	3

Prerequisite: Cryptography and System Security	
Course Objectives:	
1	Understand blockchain platforms and its terminologies.
2	Understand the use of cryptography required for blockchain.
3	Understand smart contracts, wallets, and consensus protocols.
4	Design and develop blockchain applications
Course Outcomes:	
1	Explain blockchain concepts.
2	Apply cryptographic hash required for blockchain.
3	Apply the concepts of smart contracts for an application.
4	Design a public blockchain using Ethereum.
5	Design a private blockchain using Hyperledger.
6	Use different types of tools for blockchain applications.

Module		Content	Hrs
1		**Introduction to Blockchain**	**6**
	1.1	What is a blockchain, Origin of blockchain (cryptographically secure hash functions), Foundation of blockchain: Merkle trees	
	1.2	Components of blockchain, Block in blockchain, Types: Public, Private, and Consortium, Consensus Protocol, Limitations and Challenges of blockchain	
2		**Cryptocurrency**	**6**
	2.1	Cryptocurrency: Bitcoin, Altcoin, and Tokens (Utility and Security), Cryptocurrency wallets: Hot and cold wallets, Cryptocurrency usage, Transactions in Blockchain, UTXO and double spending problem	
	2.2	Bitcoin blockchain: Consensus in Bitcoin, Proof-of-Work (PoW), Proof-of-Burn (PoB), Proof-of-Stake (PoS), and Proof-of-Elapsed Time (PoET), Life of a miner, Mining difficulty, Mining pool and its methods	
3		**Programming for Blockchain**	**8**
	3.1	Introduction to Smart Contracts, Types of Smart Contracts, Structure of a Smart Contract, Smart Contract Approaches, Limitations of Smart Contracts	
	3.2	Introduction to Programming: Solidity Programming – Basics, functions, Visibility and Activity Qualifiers, Address and Address Payable, Bytes and Enums, Arrays-Fixed and Dynamic Arrays, Special Arrays-Bytes and strings, Struct, Mapping, Inheritance, Error handling	
	3.3	Case Study – Voting Contract App, Preparing for smart contract development	

4		**Public Blockchain**	**8**
		Introduction to Public Blockchain, Ethereum and its Components, Mining in Ethereum, Ethereum Virtual Machine (EVM), Transaction, Accounts, Architecture and Workflow, Comparison between Bitcoin and Ethereum	
		Types of test-networks used in Ethereum, Transferring Ethers using Metamask, Mist Wallet, Ethereum frameworks, Case study of Ganache for Ethereum blockchain. Exploring etherscan.io and ether block structure	
5		**Private Blockchain**	**8**
	5.1	Introduction, Key characteristics, Need of Private Blockchain, Smart Contract in a Private Environment, State Machine Replication, Consensus Algorithms for Private Blockchain - PAXOS and RAFT, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT	
	5.2	Introduction to Hyperledger, Tools and Frameworks, Hyperledger Fabric, Comparison between Hyperledger Fabric & Other Technologies	
	5.3	Hyperledger Fabric Architecture, Components of Hyperledger Fabric: MSP, Chain Codes, Transaction Flow, Working of Hyperledger Fabric, Creating Hyperledger Network, Case Study of Supply Chain Management using Hyperledger	
6		**Tools and Applications of Blockchain**	**3**
		Corda, Ripple, Quorum and other Emerging Blockchain Platforms, Blockchain in DeFi: Case Study on any of the Blockchain Platforms.	

Textbooks:

1	Blockchain Technology, Chandramouli Subramanian, Asha A. George, Abhillash K. A and Meena Karthikeyen, Universities Press.
2	Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
3	Imran Bashir, Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more, 3rd Edition, Packt Publishing

References:

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,Luc Desrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4	Only Four question need to be solved.
5	In question paper weightage of each module will be proportional to the number of respective lecture hours as mention in the syllabus.

Digital Useful Links	
1	Blockchain By Example, Bellaj Badr, 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.
3	https://www.hyperledger.org/use/fabric
4	NPTEL: https://onlinecourses.nptel.ac.in/noc19_cs63/preview

Course Code	Course Name	Credit
CSDC7023	Information Retrieval	03

Prerequisite: Data structures and algorithms	
Course Objectives: The course aims students :	
1	To learn the fundamentals of Information Retrieval
2	To analyze various Information retrieval modeling techniques
3	To understand query processing and its applications
4	To explore the various indexing and scoring techniques
5	To assess the various evaluation methods
6	To analyze various information retrieval for real world application
Course Outcomes: Learner will be able to: -	
1	Define and describe the basic concepts of the Information retrieval system.
2	Design the various modeling techniques for information retrieval systems.
3	Understand the query structure and various query operations
4	Analyzing the indexing and scoring operation in information retrieval systems
5	Perform the evaluation of information retrieval systems
6	Analyze various information retrieval for real world application

Module		Detailed Content	Hours
1		**Introduction to Information Retrieval**	4
	1.1	Introduction to Information Retrieval, Basic Concepts, Information Versus Data, Trends and research issues in information retrieval.	
	1.2	The retrieval process, Information retrieval in the library, web and digital libraries.	
2		**Modeling in Information Retrieval**	8
	2.1	Taxonomy of Information Retrieval models, Classic Information Retrieval, Alternate set: Theoretical model, Alternative Algebraic models, Alternative Probabilistic models	
	2.2	Structured text Retrieval models, Models for browsing	
3		**Query and Operations in Information Retrieval**	8
	3.1	Query structures, Keyboard based querying, Pattern matching, Structured queries	
	3.2	User relevance feedback, Automatic local analysis, Automatic global analysis	
4		**Indexing and Scoring in Information Systems**	8
	4.1	Introduction, Inverted Files, Other Indices for Text, Boolean queries and Introduction to Sequential searching	

	4.2	Scoring, term weighting and the vector space model, Parametric and zone indexes, Weighted zone scoring, Learning weights, The optimal weight, Term frequency and weighting, Inverse document frequency, Tf-idf weighting. The vector space model for scoring, Queries as vectors, Computing vector scores, Efficient scoring and ranking, Inexact top K document retrieval	
5		**Evaluation of Information Retrieval Systems**	6
	5.1	Information retrieval system evaluation, Standard test collections, Evaluation of unranked retrieval sets, Evaluation of ranked retrieval results, Assessing and justifying the concept of relevance	
	5.2	System quality and user utility, System issues, Refining a deployed system	
6.		**Applications of Information Retrieval Systems**	5
	6.1.	Introduction to Multimedia Information Retrieval	
	6.2	Introduction to Distributed Information Retrieval	

Textbooks:	
1	Modern information retrieval, Baeza-Yates, R. and Ribeiro-Neto, B., 1999. ACM press.
2	Introduction to Information Retrieval By Christopher D. Manning and PrabhakarRaghavan, Cambridge University Press
3	Information Storage & Retrieval By Robert Korfhage – John Wiley & Sons
References:	
1	Storage Network Management and Retrieval, VaishaliKhairnar
2	Introduction to Modern Information Retrieval. G.G. Chowdhury. NealSchuman
3	Natural Language Processing and Information Retrieval by Tanveer Siddiqui, U.S Tiwarey

Useful Digital Links	
1	https://web.stanford.edu/class/cs276/
2	https://www.coursera.org/learn/text-retrieval

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Course Code	Course Name	Credits
ILO 7011	**Product Life Cycle Management**	**03**

Objectives:

1. To familiarize the students with the need, benefits and components of PLM
2. To acquaint students with Product Data Management & PLM strategies
3. To give insights into new product development program and guidelines for designing and developing a product
4. To familiarize the students with Virtual Product Development

Outcomes: Learner will be able to…

1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products.
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Acquire knowledge in applying virtual product development tools for components, machining and manufacturing plant

Sr. No.	Detailed Contents	Hrs
01	**Introduction to Product Lifecycle Management (PLM):**Product Lifecycle 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
02	**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 Design for X System, Objective Properties and Design for X Tools, Choice of Design for X Tools and Their Use in the Design Process	09
03	**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
04	**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

05	**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
06	**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

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**.

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 Lifecycle Management: Driving the next generation of lean thinking", Tata McGraw Hill, 2006, ISBN: 0070636265

Course Code	Course Name	Credits
ILO 7012	Reliability Engineering	03

Objectives:

1. To familiarize the students with various aspects of probability theory
2. To acquaint the students with reliability and its concepts
3. To introduce the students to methods of estimating the system reliability of simple and complex systems
4. To understand the various aspects of Maintainability, Availability and FMEA procedure

Outcomes: Learner will be able to…

1. Understand and apply the concept of Probability to engineering problems
2. Apply various reliability concepts to calculate different reliability parameters
3. Estimate the system reliability of simple and complex systems
4. Carry out a Failure Mode Effect and Criticality Analysis

Sr. No	Detailed Contents	Hrs
01	**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
02	**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
03	**System Reliability:** System Configurations: Series, parallel, mixed configuration, k out of n structure, Complex systems.	05
04	**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
05	**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
06	**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

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**.

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.

Course Code	Course Name	Credits
ILO 7013	Management Information System	03

Objectives:

1. The course is blend of Management and Technical field.
2. Discuss the roles played by information technology in today's business and define various technology architectures on which information systems are built
3. Define and analyze typical functional information systems and identify how they meet the needs of the firm to deliver efficiency and competitive advantage
4. Identify the basic steps in systems development

Outcomes: Learner will be able to…

1. Explain how information systems Transform Business
2. Identify the impact information systems have on an organization
3. Describe IT infrastructure and its components and its current trends
4. Understand the principal tools and technologies for accessing information from databases to improve business performance and decision making
5. Identify the types of systems used for enterprise-wide knowledge management and how they provide value for businesses

Sr. No.	Detailed Contents	Hrs
01	Introduction To Information Systems (IS): Computer Based Information Systems, Impact of IT on organizations, Importance of IS to Society. Organizational Strategy, Competitive Advantages and IS	4
02	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
03	Ethical issues and Privacy: Information Security. Threat to IS, and Security Controls	7
04	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
05	Computer Networks Wired and Wireless technology, Pervasive computing, Cloud computing model.	6
06	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

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**.

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

Course Code	Course Name	Credits
ILO 7014	Design of Experiments	03

Objectives:

1. To understand the issues and principles of Design of Experiments (DOE)
2. To list the guidelines for designing experiments
3. To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Outcomes: Learner will be able to…

1. Plan data collection, to turn data into information and to make decisions that lead to appropriate action
2. Apply the methods taught to real life situations
3. Plan, analyze, and interpret the results of experiments

Sr. No	Detailed Contents	Hrs
01	**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
02	**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
03	**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
04	**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
05	**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	07

	5.4 Experimental Designs for Fitting Response Surfaces	
06	**Taguchi Approach** 6.1 Crossed Array Designs and Signal-to-Noise Ratios 6.2 Analysis Methods 6.3 Robust design examples	04

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**.

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 D. T.Voss

Course Code	Course Name	Credits
ILO 7015	Operations Research	03

Objectives:

1. Formulate a real-world problem as a mathematical programming model.
2. Understand the mathematical tools that are needed to solve optimization problems.
3. Use mathematical software to solve the proposed models.

Outcomes: Learner will be able to…

1. Understand the theoretical workings of the simplex method, the relationship between a linear program and its dual, including strong duality and complementary slackness.
2. Perform sensitivity analysis to determine the direction and magnitude of change of a model's optimal solution as the data change.
3. 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.
4. Understand the applications of integer programming and a queuing model and compute important performance measures

Sr. No.	Detailed Contents	Hrs
01	**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 **Integer Programming Problem**: Introduction, Types of Integer Programming Problems, Gomory's cutting plane Algorithm, Branch and Bound Technique. Introduction to Decomposition algorithms.	14
02	**Queuing models**: queuing systems and structures, single server and multi-server models, Poisson input, exponential service, constant rate service, finite and infinite population	05
03	**Simulation**: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method: Introduction, Monte-Carlo Simulation, Applications of Simulation, Advantages	05

	of Simulation, Limitations of Simulation	
04	**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
05	**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
06	**Inventory Models**: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model,	05

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**.

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

Course Code	Course Name	Credits
ILO 7016	Cyber Security and Laws	03

Objectives:

1. To understand and identify different types cybercrime and cyber law
2. To recognized Indian IT Act 2008 and its latest amendments
3. To learn various types of security standards compliances

Outcomes: Learner will be able to…

1. Understand the concept of cybercrime and its effect on outside world
2. Interpret and apply IT law in various legal issues
3. Distinguish different aspects of cyber law
4. Apply Information Security Standards compliance during software design and development

Sr. No.	Detailed Contents	Hrs
01	**Introduction to Cybercrime:** Cybercrime definition and origins of the world, Cybercrime and information security, Classifications of cybercrime, Cybercrime and the Indian ITA 2000, A global Perspective on cybercrimes.	4
02	**Cyber offenses & Cybercrime:** How criminal plan the attacks, Social Engg, Cyber stalking, Cyber café and Cybercrimes, 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
03	**Tools and Methods Used in Cyberline** Phishing, Password Cracking, Key loggers and Spywares, Virus and Worms, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Over Flow, Attacks on Wireless Networks, Phishing, Identity Theft (ID Theft)	6
04	**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
05	**Indian IT Act.** Cyber Crime and Criminal Justice: Penalties, Adjudication and Appeals Under the IT Act, 2000, IT Act. 2008 and its Amendments	6
06	**Information Security Standard compliances** SOX, GLBA, HIPAA, ISO, FISMA, NERC, PCI.	6

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**.

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

Course Code	Course Name	Credits
ILO 7017	Disaster Management and Mitigation Measures	03

Objectives:

1. To understand physics and various types of disaster occurring around the world
2. To identify extent and damaging capacity of a disaster
3. To study and understand the means of losses and methods to overcome /minimize it.
4. To understand role of individual and various organization during and after disaster
5. To understand application of GIS in the field of disaster management
6. To understand the emergency government response structures before, during and after disaster

Outcomes: Learner will be able to…

1. Get to know natural as well as manmade disaster and their extent and possible effects on the economy.
2. Plan of national importance structures based upon the previous history.
3. Get acquainted with government policies, acts and various organizational structure associated with an emergency.
4. Get to know the simple do's and don'ts in such extreme events and act accordingly.

Sr. No.	Detailed Contents	Hrs
01	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
02	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
03	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
04	Institutional Framework for Disaster Management in India: 4.1 Importance of public awareness, Preparation and execution of emergency management program. 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.	06

	4.2 Use of Internet and softwares for effective disaster management. Applications of GIS, Remote sensing and GPS in this regard.	
05	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
06	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

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**.

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 Elsevier 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)

Course Code	Course Name	Credits
ILO 7018	Energy Audit and Management	03

Objectives:

1. To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
2. To introduce performance evaluation criteria of various electrical and thermal installations to facilitate the energy management
3. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Outcomes: Learner will be able to…

1. To identify and describe present state of energy security and its importance.
2. To identify and describe the basic principles and methodologies adopted in energy audit of an utility.
3. To describe the energy performance evaluation of some common electrical installations and identify the energy saving opportunities.
4. To describe the energy performance evaluation of some common thermal installations and identify the energy saving opportunities
5. To analyze the data collected during performance evaluation and recommend energy saving measures

Sr. No	Detailed Contents	Hrs
01	**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
02	**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
03	**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. **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.	10
04	**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,	10

	use of insulation- types and application. HVAC system: Coefficient of performance, Capacity, factors affecting Refrigeration and Air Conditioning system performance and savings opportunities.	
05	**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
06	**Energy conservation in Buildings:** Energy Conservation Building Codes (ECBC): Green Building, LEED rating, Application of Non-Conventional and Renewable Energy Sources	03

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.

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

Course Code	Course Name	Credits
ILO7019	**Development Engineering**	**03**

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

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

Sr. No.	**Module Contents**	**Hrs**
01	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**
02	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**
03	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**
04	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	**04**

	social mobilization; Information Technology and rural planning; Need for further amendments.	
05	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**
06	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**

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

References:

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 andPractice, Vol. 4, No.4, pp.395 – 407

Lab Code	Lab Name	Credit
CSL70011	Machine Learning Lab	1

Prerequisite: Data Structures, Analysis of Algorithms	
Lab Objectives:	
1	To introduce the basic concepts and techniques of Machine Learning.
2	To acquire in depth understanding of various supervised and unsupervised algorithms
3	To be able to apply various ensemble techniques for combining ML models.
4	To demonstrate dimensionality reduction techniques.
Lab Outcomes: At the end of the course, the students will be able to	
1	To implement an appropriate machine learning model for the given application.
2	To implement ensemble techniques to combine predictions from different models.
3	To implement the dimensionality reduction techniques.

Suggested List of Experiments	
Sr. No.	**Title of Experiment**
1	To implement Linear Regression.
2	To implement Logistic Regression.
3	To implement Ensemble learning (bagging/boosting)
4	To implement multivariate Linear Regression.
5	To implement SVM
6	To implement PCA/SVD/LDA
7	To implement Graph Based Clustering
8	To implement DB Scan
9	To implement CART
10	To implement LDA

Term Work:	
1	Term work should consist of 6 experiments.
2	Journal must include one mini project/case study on any machine learning application.
3	The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments & Assignments: 15-marks, Attendance: 05-marks, mini project: 05-marks)
Oral & Practical exam.	
Based on the entire syllabus **CSC7011** Machine Learning **and CSL7011**: Machine Learning Lab	

Lab Code	Lab Name	Credit
CSL7012	Big Data Analytics Lab	1

Prerequisite: C Programming Language.	
Lab Objectives: Students will be able to	
1	Solve Big Data problems using Map Reduce Technique and apply to various algorithms.
2	Identify various types of NoSQL databases and execute NOSQL commands
3	Understand implementation of various analytic techniques using Hive/PIG/R/Tableau, etc.
4	Apply streaming analytics to real time applications.
Lab Outcomes:	
1	To interpret business models and scientific computing paradigms, and apply software tools for big data analytics.
2	To implement algorithms that uses Map Reduce to apply on structured and unstructured data
3	To perform hands-on NoSql databases such as Cassandra, HadoopHbase, MongoDB, etc.
4	To implement various data streams algorithms.
5	To develop and analyze the social network graphs with data visualization techniques.

Suggested List of Experiments **(Select a case study and perform the experiments 1 to 8.)**.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
1*	Hadoop HDFS Practical: -HDFS Basics, Hadoop Ecosystem Tools Overview. -Installing Hadoop. -Copying File to Hadoop. -Copy from Hadoop File system and deleting file. -Moving and displaying files in HDFS. -Programming exercises on Hadoop
2	Use of Sqoop tool to transfer data between Hadoop and relational database servers. a. Sqoop - Installation. b. To execute basic commands of Hadoop eco system componentSqoop.
3*	To install and configure MongoDB/ Cassandra/ HBase/ Hypertable to execute NoSQL commands
4	Experiment on Hadoop Map-Reduce: -Write a program to implement a word count program using MapReduce.
5	Experiment on Hadoop Map-Reduce: -Implementing simple algorithms in Map-Reduce: Matrix multiplication, Aggregates, Joins, Sorting, Searching, etc
6	Create HIVE Database and Descriptive analytics-basic statistics.
7*	Data Stream Algorithms (any one): - Implementing DGIM algorithm using any Programming Language - Implement Bloom Filter using any programming language Implement Flajolet Martin algorithm using any programming language
8	Social Network Analysis using R (for example: Community Detection Algorithm)
9	Data Visualization using Hive/PIG/R/Tableau/.
10	Exploratory Data Analysis using Spark/ Pyspark.

11*	Mini Project: One real life large data application to be implemented (Use standard Datasets available on the web). - Streaming data analysis – use flume for data capture, HIVE/PYSpark for analysis of twitter data, chat data, weblog analysis etc. - Recommendation System (for example: Health Care System, Stock Market Prediction, Movie Recommendation, etc.) SpatioTemporal DataAnalytics

Useful Links:	
1	https://www.coursera.org/learn/hadoop#syllabus
2	https://www.coursera.org/learn/introduction-mongodb#syllabus
3	https://www.coursera.org/learn/data-visualization-tableau?specialization=data-visualization#syllabus
4	https://www.coursera.org/learn/introduction-to-big-data-with-spark-hadoop#syllabus

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignment: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of and CSC702 : Big Data Analytics and CSL702 Big Data Analytics Lab

Lab Code	Lab Name	Credit
CSDL7011	**Machine Vision Lab**	**1**

Prerequisite: Computer Graphics, Image Processing, Python	
Lab Objectives:	
1	To perform basic image processing operations
2	To explore different preprocessing technique
3	To develop application related to Machine vision
4	To detect and recognize objects
Lab Outcomes:	
1	Students will be able to read image and video file, perform different processing
2	Students will be able to do edge detection ,depth estimation
3	Students will be able to choose appropriate algo for segmentation
4	Students will be able to implement object detection technique

Suggested Experiments: Students are required to complete at least 8 experiments.	
Sr.No.	**Name of the Experiment**
1	**Handling Files, Cameras, and GUIs** Basic I/O scripts ,Reading/writing an image file ,Converting between an image and raw bytes ,Accessing image data with numpy.array ,Reading/writing a video file ,Capturing camera frames, Displaying images in a window, Displaying camera frames in a window
2	**Processing Images** with OpenCV 3 Converting between different color spaces, The Fourier Transform, High pass filter, Low pass filter,
3	**Edge detection** with Canny, Contour detection, Contours – bounding box, minimum area rectangle, and minimum enclosing circle ,Contours – convex contours and the Douglas-Peucker algorithm ,Line and circle detection
4	**Depth Estimation** Capturing frames from a depth camera Creating a mask from a disparity map Masking a copy operation Depth estimation with a normal camera
5	**Object segmentation** using the Watershed and GrabCut algorithms Example of foreground detection with GrabCut Image segmentation with the Watershed algorithm
6	**Detecting and Recognizing Faces** Conceptualizing Haar cascades Getting Haar cascade data Using OpenCV to perform face detection Performing face detection on a still image
7	**Performing face detection on video** Performing face recognition Generating the data for face recognition Recognizing faces Preparing the training data Loading the data and recognizing faces

	Performing an Eigenfaces recognition
8	**Retrieving Images and Searching** Using Image Descriptors , Feature detection algorithms, Defining features Detecting features – corners Feature extraction and description using DoG and SIFT Anatomy of a keypoint
9	**Detecting and Recognizing Objects** Object detection and recognition techniques HOG descriptors The scale issue The location issue Non-maximum (or non-maxima) suppression Support vector machines People detection
10	**Creating and training an object detector** Bag-of-words BOW in computer vision Detecting cars in a scene

Reference &Useful Links:	
1	Learning OpenCV 3 Computer Vision with Python Second Edition, by Joe Minichino Joseph Howse Published by Packt Publishing Ltd.
2	http://iitk.ac.in/ee/computer-vision-lab
3	https://nptel.ac.in/courses/108103174
4	https://docs.opencv.org/3.4/d9/df8/tutorial_root.html

Term Work:	
1	Term work should consist of 8 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Lab Code	Lab Name	Credit
CSDL7012	**Quantum Computing Lab**	**1**

Prerequisite: Python Programming Language.	
Lab Objectives:	
1	To implement fundamental quantum computing concepts
2	To learn quantum computation and quantum information
3	To understand quantum entanglement, quantum algorithms
4	To understand quantum information theory and channels
Lab Outcomes: Students will be able to	
1	Implement basic quantum computing logic by building dice and random numbers using open source simulation tools.
2	Understand quantum logic gates using open source simulation tools.
3	Implement quantum circuits using open source simulation tools.
4	I implement quantum algorithms using open source simulation tools.

Suggested Experiments: Students are required to complete at least 10 experiments.Faculty may develop their own set of experiments for students. List below is only suggestive.

Sr. No.	Name of the Experiment
1	Building Quantum dice
2	Building Quantum Random No. Generation
3	Composing simple quantum circuits with q-gates and measuring the output into classical bits.
4	Implementation of Shor's Algorithms
5	Implementation of Grover's Algorithm
6	Implementation of Deutsch's Algorithm
7	Implementation of Deutsch-Jozsa's Algorithm
8	Quantum Circuits
9	Qubit Gates
10	Bell Circuit & GHZ Circuit
11	Accuracy of Quantum Phase Estimation
12	Mini Project such as implementing an API for efficient search using Grover's Algorithms or Integer factorization using Shor's Algorithm.

Useful Links:	
1	IBM Experience: https://quantum-computing.ibm.com/
2	Microsoft Quantum Development Kit https://azure.microsoft.com/en-us/resources/development-kit/quantum-computing/#overview
3	Forest SDK PyQuil: https://pyquil-docs.rigetti.com/en/stable/
4	Google Quantum CIRQ https://quantumai.google/cirq
5	Qiskit Labs IBM https://learn.qiskit.org/course/ch-labs/lab-1-quantum-circuits

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Lab Code	Lab Name	Credit
CSDL7013	**Natural Language processing Lab**	**1**

Prerequisite: Java/Python	
Lab Objectives: The course aims	
1	To understand the key concepts of NLP.
2	To learn various phases of NLP.
3	To design and implement various language models and POS tagging techniques.
4	To understand various NLP Algorithms
5	To learn NLP applications such as Information Extraction, Sentiment Analysis, Question answering, Machine translation etc.
6	To design and implement applications based on natural language processing
Lab Outcomes: Learners will be able	
1	Apply various text processing techniques.
2	Design language model for word level analysis.
3	Model linguistic phenomena with formal grammar.
4	Design, implement and analyze NLP algorithms.
5	To apply NLP techniques to design real world NLP applications such as machine translation, sentiment analysis, text summarization, information extraction, Question Answering system etc.
6	Implement proper experimental methodology for training and evaluating empirical NLP systems.

Suggested List of Experiments **(Select a case study and perform the experiments 1 to 8.)**.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
1	Study various applications of NLP and Formulate the Problem Statement for Mini Project based on chosen real world NLP applications: [Machine Translation, Text Categorization, Text summarization, chat Bot, Plagarism, Spelling & Grammar checkers, Sentiment / opinion analysis, Question answering, Personal Assistant, Tutoring Systems, etc.]
2	Apply various text preprocessing techniques for any given text : Tokenization and Filtration & Script Validation.
3	Apply various other text preprocessing techniques for any given text : Stop Word Removal, Lemmatization / Stemming.
4	Perform morphological analysis and word generation for any given text.
5	Implement N-Gram model for the given text input.
6	Study the different POS taggers and Perform POS tagging on the given text.
7	Perform Chunking for the given text input.
8	Implement Named Entity Recognizer for the given text input.
9	Implement Text Similarity Recognizer for the chosen text documents.

10	Exploratory data analysis of a given text (Word Cloud)
11	Mini Project Report: For any one chosen real world NLP application.
13	Implementation and Presentation of Mini Project

Term Work:	
1	Study various applications of NLP and Formulate the Problem Statement for Mini Project based on chosen real world NLP applications: [Machine Translation, Text Categorization, Text summarization, chat Bot, Plagarism, Spelling & Grammar checkers, Sentiment / opinion analysis, Question answering, Personal Assistant, Tutoring Systems, etc.]
2	Apply various text preprocessing techniques for any given text: Tokenization and Filtration & Script Validation.
3	Apply various other text preprocessing techniques for any given text: Stop Word Removal, Lemmatization / Stemming.

Lab Code	Lab Name	Credit
CSDL7021	**Augmented and Virtual Reality Lab**	**1**

Prerequisite: Computer Graphics, Image Processing, Python	
Lab Objectives:	
1	To perform installation of Unity
2	To explore working of VR Gadget
3	To develop scene VR application
4	To track objects in virtual environment
Lab Outcomes: Learners will be able to	
1	Setup VR development environment
2	Use HTC Vive/ Google Cardboard/ Google Daydream and Samsung gear VR.
3	Develop VR scene and place object
4	Work with Augmented Faces features.

Suggested Experiments: Students are required to complete at least 6 experiments.	
Sr. No.	**Name of the Experiment**
1	Installation of Unity and Visual Studio, setting up Unity for VR development, understanding documentation of the same.
2	Demonstration of the working of HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR.
3	Develop a scene in Unity that includes: i. a cube, plane and sphere, apply transformations on the 3 game objects. ii. add a video and audio source
4	Develop a scene in Unity that includes a cube, plane and sphere. Create a new material and texture separately for three Game objects. Change the colour, material and texture of each Game object separately in the scene. Write a C# program in visual studio to change the colour and material/texture of the game objects dynamically on button click.
5	Develop a scene in Unity that includes a sphere and plane . Apply Rigid body component, material and Box collider to the game Objects. Write a C# program to grab and throw the sphere using vr controller.
6	Develop a simple UI(User interface) menu with images, canvas, sprites and button. Write a C# program to interact with UI menu through VR trigger button such that on each successful trigger interaction display a score on scene .
7	Place a three-dimensional ARCore pawn on detected AR plane surfaces
8	Using the Augmented Faces feature in your own apps**.**

Term Work:	
1	Term work should consist of 6 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Lab Code	Lab Name	Credit
CSDL7022	Blockchain Lab	1

Prerequisite: Cryptography and Network Security	
Lab Objectives:	
1	To explore Blockchain concepts.
2	To implement public and private Blockchain.
3	To create applications using Blockchain.
Lab Outcomes: At the end of the course, the students will be able to	
1	Creating Cryptographic hash using merkle tree.
2	Design Smart Contract using Solidity.
3	Implementing ethereum blockchain using Geth.
4	Demonstrate the concept of blockchain in real world application.

Suggested List of Experiments	
Sr. No.	**Title of Experiment**
1	Cryptography in Blockchain, Merkle root tree hash
2	Creating Smart Contract using Solidity and Remix IDE.
3	Creating Transactions using Solidity and Remix IDE
4	Embedding wallet and transaction using Solidity
5	Blockchain platform ethereum using Geth.
6	Blockchain platform Ganache.
7	Case Study on Hyperledger
8	Case Study on Other Blockchain platforms.
9	Creating a blockchain Application

Term Work:	
1	Term work should consist of 8 experiments and one mini project.
2	Journal must include at least 2 assignments on content of theory and practical of "Blockchain Lab"
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)

Lab Code	Lab Name	Credit
CSDL7023	Information Retrieval Lab	1

Prerequisite: Java, Python	
Lab Objectives:	
1	To understand the formation of queries.
2	To implement the various modeling techniques for IR.
3	To execute query expansion techniques.
4	To evaluate Information retrieval systems.
Lab Outcomes: Students will be able :-	
1	To frame queries for information retrieval
2	To implement modeling techniques
3	To perform query expansion techniques
4	To demonstrate evaluation techniques for IR

Suggested Experiments: Students are required to perform any **5 experiments** from the suggested list along with **a case study** (* indicates compulsory experiment)

Sr. No.	Name of the Experiment
1	To understand the query structure and execute various structured queries
2	To implement any IR modeling technique
3	To implement Pattern matching method used for IR
4	To execute query expansion technique (Local/Global)
5	To design inverted indices for any information retrieval model
6	To implement tf-id weighting
7	To evaluate the system/application under study
8*	To understand the Case Study and generate a report for the same

Term Work:	
1	Term work should consist of **5 experiments and 1 case study**
2	Journal must include **at least 2 assignments**.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total: **25 Marks (Experiments: 10-marks, Case study - 5 marks Attendance Theory & Practical: 05-marks, Assignments: 05-marks)**

Course Code	Course Name	Credit
CSP701	**Major Project 1**	**03**

Course Objectives:	
The project work facilitates the students to develop and prove Technical, Professional and Ethical skills and knowledge gained during graduation program by applying them from problem identification, analyzing the problem and designing solutions.	
Course Outcomes: Learner will able	
1	To develop the understanding of the problem domain through extensive review of literature.
2	To Identify and analyze the problem in detail to define its scope with problem specific data.
3	To know various techniques to be implemented for the selected problem and related technical skills through feasibility analysis.
4	To design solutions for real-time problems that will positively impact society and environment..
5	To develop clarity of presentation based on communication, teamwork and leadership skills.
6	To inculcate professional and ethical behavior.

Guidelines:

1. **Project Topic Selection and Allocation:**

- Project topic selection Process to be defined and followed:
  - Project orientation can be given at the end of sixth semester.
  - Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
  - Student's should be recommended to refer papers from reputed conferences/ journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
  - Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer Digital India portal, SIH portal or any other hackathon portal for problem selection.

- Topics can be finalized with respect to following criterion:
  - **Topic Selection**: The topics selected should be novel in nature (Product based, Application based or Research based) or should work towards removing the lacuna in currently existing systems.
  - **Technology Used:** Use of latest technology or modern tools can be encouraged**.**
  - Students should not repeat work done previously (work done in the last three years).

- Project work must be carried out by the group of at least 2 students and maximum 4.
- The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)
- The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.
- Head of department and senior staff along with project coordinators will take decision regarding final selection of projects.
- Guide allocation should be done and students have to submit weekly progress report to the internal guide.
- Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.
- In case of industry/ out-house projects, visit by internal guide will be preferred and external members can be called during the presentation at various levels

2. **Project Report Format:**

At the end of semester, each group needs to prepare a project report as per the guidelines issued by the University of Mumbai.

A project report should preferably contain at least following details:

- Abstract
- Introduction
- Literature Survey/ Existing system
- Limitation Existing system or research gap
- Problem Statement and Objective
- Proposed System
    - Analysis/Framework/ Algorithm
    - Design details
    - Methodology (your approach to solve the problem) Proposed System
- Experimental Set up
    - Details of Database or details about input to systems or selected data
    - Performance Evaluation Parameters (for Validation)
    - Software and Hardware Set up
- Implementation Plan for Next Semester
    - Timeline Chart for Term1 and Term-II (Project Management tools can be used.)
- References

Desirable

Students can be asked to undergo some Certification course (for the technical skill set that will be useful and applicable for projects.)

3. Term Work:

Distribution of marks for term work shall be done based on following:

- Weekly Log Report
- Project Work Contribution
- Project Report (Spiral Bound) (both side print)
- Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

4. Oral and Practical:

Oral and Practical examination (Final Project Evaluation) of Project 1 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

Suggested quality evaluation parameters are as follows:

- Quality of problem selected
- Clarity of problem definition and feasibility of problem solution
- Relevance to the specialization / industrial trends
- Originality
- Clarity of objective and scope
- Quality of analysis and design
- Quality of written and oral presentation
- Individual as well as team work

Course Code:	Course Title	Credit
CSC801	Distributed Computing	3

Prerequisite: Computer Networks and Operating Systems.	
Course Objectives:	
1	To provide students with contemporary knowledge in distributed systems.
2	To explore the various methods used for communication in distributed systems.
3	To provide skills to measure the performance of distributed synchronization algorithms.
4	To provide knowledge of resource management, and process management including process migration.
5	To learn issues involved in replication, consistency, and file management.
6	To equip students with skills to analyze and design distributed applications.
Course Outcomes: At the end of the course students will be able to	
1	Demonstrate the knowledge of basic elements and concepts related to distributed system technologies.
2	Illustrate the middleware technologies that support distributed applications such as RPC, RMI and Object-based middleware.
3	Analyze the various techniques used for clock synchronization, mutual exclusion and deadlock.
4	Demonstrate the concepts of Resource and Process management.
5	Demonstrate the concepts of Consistency, Replication Management and fault Tolerance.
6	Apply the knowledge of Distributed File systems in building large-scale distributed applications.

Module	Content	Hrs
1	**Introduction to Distributed Systems**	**4**
1.1	Characterization of Distributed Systems: Issues, Goals, Types of distributed systems, Grid and Cluster computing Models, Hardware and Software Concepts: NOS, DOS.	
1.2	Middleware: Models of middleware, Services offered by middleware.	
2	**Communication**	**4**
2.1	Interprocess communication (IPC): Remote Procedure Call (RPC), Remote Method Invocation (RMI).	
2.2	Message-Oriented Communication, Stream Oriented Communication, Group Communication.	
3	**Synchronization**	**10**
3.1	Clock Synchronization: Physical clock, Logical Clocks, Election Algorithms	
3.2	Distributed Mutual Exclusion, Requirements of Mutual Exclusion Algorithms and Performance measures. Non- token Based Algorithms: Lamport, Ricart–Agrawala‘s and Maekawa‘s Algorithms; Token-based Algorithms: Suzuki-Kasami‘s Broadcast Algorithms and Raymond‘s Tree-based Algorithm; and Comparative Performance Analysis.	

3.3	Deadlock: Introduction, Deadlock Detection: Centralized approach, Chandy - Misra_Hass Algorithm.	
4	**Resource and Process Management**	**7**
4.1	Desirable Features of Global Scheduling algorithm, Task assignment approach, Load balancing approach and load sharing approach.	
4.2	Introduction to Process Management, Process Migration, Code Migration.	
5	**Replication, Consistency and Fault Tolerance**	
5.1	Distributed Shared Memory: Architecture, design issues.	8
5.2	Introduction to replication and consistency, Data-Centric and Client-Centric Consistency Models, Replica Management.	
5.3	Fault Tolerance: Introduction, Process resilience, Recovery.	
6	**Distributed File Systems**	**6**
6.1	Introduction and features of DFS, File models, File Accessing models, File-Caching Schemes, File Replication, Case Study: Network File System (NFS).	
6.2	Designing Distributed Systems: Google Case Study.	

Textbooks:	
1	Andrew S. Tanenbaum and Maarten Van Steen, Distributed Systems: Principles and Paradigms, 2nd edition, Pearson Education.
2	Mukesh Singhal, Niranjan G. Shivaratri, "Advanced concepts in operating systems: Distributed, Database and multiprocessor operating systems", MC Graw Hill education.
3	Pradeep K.Sinha, "Distributed Operating System-Concepts and design", PHI.
References:	
1	M. L. Liu, ―Distributed Computing Principles and Applications‖, Pearson Addison Wesley, 2004
2	George Coulouris, Jean Dollimore, Tim Kindberg, "Distributed Systems: Concepts and Design", 4th Edition, Pearson Education, 2005.

Useful Links	
1	https://nptel.ac.in/courses/106106107
2	https://nptel.ac.in/courses/106106168
3	http://csis.pace.edu/~marchese/CS865/Lectures/Chap7/Chapter7fin.htm
4	https://nptel.ac.in/courses/106104182

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and the second-class test when an additional 40% syllabus is completed. The duration of each test shall be one hour.	
End Semester Theory Examination:	
1	The question paper will comprise a total of six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed 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	In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Course Code:	Course Title	Credit
CSDC8011	Deep Learning	3

Prerequisite: Basic mathematics and Statistical concepts, Linear algebra, Machine Learning	
Course Objectives:	
1	To learn the fundamentals of Neural Network.
2	To gain an in-depth understanding of training Deep Neural Networks.
3	To acquire knowledge of advanced concepts of Convolution Neural Networks, Autoencoders and Recurrent Neural Networks.
4	Students should be familiar with the recent trends in Deep Learning.
Course Outcomes:	
1	Gain basic knowledge of Neural Networks.
2	Acquire in depth understanding of training Deep Neural Networks.
3	Design appropriate DNN model for supervised, unsupervised and sequence learning applications.
4	Gain familiarity with recent trends and applications of Deep Learning.

Module		Content	39Hrs
1		**Fundamentals of Neural Network**	**4**
	1.1	Biological neuron, Mc-Culloch Pitts Neuron, Perceptron, Perceptron Learning, Delta learning, Multilayer Perceptron: Linearly separable, linearly non-separable classes	
	1.2	Deep Networks: Fundamentals, Brief History, Three Classes of Deep Learning Basic Terminologies of Deep Learning	
2		**Training, Optimization and Regularization of Deep Neural Network**	**10**
	2.1	**Training Feedforward DNN** Multi Layered Feed Forward Neural Network, Learning Factors, Activation functions: Tanh, Logistic, Linear, Softmax, ReLU, Leaky ReLU, Loss functions: Squared Error loss, Cross Entropy, Choosing output function and loss function	
	2.2	**Optimization** Learning with backpropagation, Learning Parameters: Gradient Descent (GD), Stochastic and Mini Batch GD, Momentum Based GD, Nesterov Accelerated GD, AdaGrad, Adam, RMSProp	
	2.3	**Regularization** Overview of Overfitting, Types of biases, Bias Variance Tradeoff Regularization Methods: L1, L2 regularization, Parameter sharing, Dropout, Weight Decay, Batch normalization, Early stopping, Data Augmentation, Adding noise to input and output	
3		**Autoencoders: Unsupervised Learning**	**6**
	3.1	Introduction, Linear Autoencoder, Undercomplete Autoencoder, Overcomplete Autoencoders, Regularization in Autoencoders	

	3.2	Denoising Autoencoders, Sparse Autoencoders, Contractive Autoencoders	
	3.3	Application of Autoencoders: Image Compression	
4		**Convolutional Neural Networks (CNN): Supervised Learning**	**7**
	4.1	Convolution operation, Padding, Stride, Relation between input, output and filter size, CNN architecture: Convolution layer, Pooling Layer, Weight Sharing in CNN, Fully Connected NN vs CNN, Variants of basic Convolution function	
	4.2	Modern Deep Learning Architectures: LeNET: Architecture, AlexNET: Architecture	
5		**Recurrent Neural Networks (RNN)**	**8**
	5.1	Sequence Learning Problem, Unfolding Computational graphs, Recurrent Neural Network, Bidirectional RNN, Backpropagation Through Time (BTT), Vanishing and Exploding Gradients, Truncated BTT	
	5.2	Long Short Term Memory: Selective Read, Selective write, Selective Forget, Gated Recurrent Unit	
6		**Recent Trends and Applications**	**4**
	6.1	Generative Adversarial Network (GAN): Architecture	
	6.2	Applications: Image Generation, DeepFake	

Textbooks:	
1	Ian Goodfellow, Yoshua Bengio, Aaron Courville. “Deep Learning”, MIT Press Ltd, 2016
2	Li Deng and Dong Yu, “Deep Learning Methods and Applications”, Publishers Inc.
3	Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill.
4	JM Zurada “Introduction to Artificial Neural Systems”, Jaico Publishing House
5	M. J. Kochenderfer, Tim A. Wheeler. “Algorithms for Optimization”, MIt Press.
References:	
1	Buduma, N. and Locascio, N., “Fundamentals of deep learning: Designing next-generation machine intelligence algorithms" 2017. O'Reilly Media, Inc.".
2	François Chollet. “Deep learning with Python “(Vol. 361). 2018 New York: Manning.
3	Douwe Osinga. “Deep Learning Cookbook”, O’REILLY, SPD Publishers, Delhi.
4	Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc
5	S.N.Sivanandam and S.N.Deepa, Principles of soft computing-Wiley India

Assessment:	
Internal Assessment:	
The assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All questions carry equal marks.
3	Question 1 and question 6 will have questions from all modules. Remaining 4 questions will be based on the remaining 4 modules.
4	Only four questions need to be solved.

5	In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Useful Links	
1	https://nptel.ac. https://deeplearning.cs.cmu.edu/S21/index.html
2	http://www.cse.iitm.ac.in/~miteshk/CS6910.html
3	https://nptel.ac.in/courses/106/106/106106184/
4	https://www.deeplearningbook.org/

Course Code:	Course Title	Credit
CSDC8012	Digital Forensics	3

Prerequisite: Computer Network, Cryptography and System Security	
Course Objectives:	
1	To discuss the need and process of digital forensics and Incident Response Methodology.
2	To explore the procedures for identification, preservation, and acquisition of digital evidence.
3	To explore techniques and tools used in digital forensics for Operating system and malware investigation .
4	To explore techniques and tools used for Mobile forensics and browser, email forensics
Course Outcomes:	
1	Discuss the phases of Digital Forensics and methodology to handle the computer security incident.
2	Describe the process of collection, analysis and recovery of the digital evidence.
3	Explore various tools to analyze malwares and acquired images of RAM/hard drive.
4	Acquire adequate perspectives of digital forensic investigation in mobile devices
5	Analyze the source and content authentication of emails and browsers.
6	Produce unambiguous investigation reports which offer valid conclusions.

Module		Content	Hrs
1		**Introduction to Digital Forensics**	**6**
	1.1	Digital ForensicsDefination, Digital Forensics Goals, Digital Forensics Categories - Computer Forensics, Mobile Forensics, Network Forensics, Database Forensics	
	1.2	Introduction to Incident - Computer Security Incident, Goals of Incident Response, CSIRT, Incident Response Methodology, Phase after detection of an incident	
2		**Digital Evidence, Forensics Duplication and Digital Evidence Acquisition**	**9**
	2.1	Digital evidence, Types of Digital Evidence, Challenges in acquiring Digital evidence, Admissibility of evidence, Challenges in evidence handling, Chain of Custody	
	2.2	Digital Forensics Examination Process - Seizure, Acquisition, Analysis, Reporting. Necessity of forensic duplication, Forensic image formats, Forensic duplication techniques,.	
	2.3	Acquiring Digital Evidence - Forensic Image File Format, Acquiring Volatile Memory (Live Acquisition), Acquiring Nonvolatile Memory (Static Acquisition), Hard Drive Imaging Risks and Challenges, Network Acquisition	
3		**Forensics Investigation**	**4**
	3.1	Analyzing Hard Drive Forensic Images, Analyzing RAM Forensic Image, Investigating Routers	
	3.2	Malware Analysis - Malware, Viruses, Worms, Essential skills and tools for Malware Analysis, List of Malware Analysis Tools and	

		Techniques	
4		**Windows and Unix Forensics Investigation**	**8**
	4.1	Investigating Windows Systems - File Recovery, Windows Recycle Bin Forensics, Data Carving, Windows Registry Analysis, USB Device Forensics, File Format Identification, Windows Features Forensics Analysis, Windows 10 Forensics, Cortana Forensics	
	4.2	Investigating Unix Systems - Reviewing Pertinent Logs, Performing Keyword Searches, Reviewing Relevant Files, Identifying Unauthorized User Accounts or Groups, Identifying Rogue Processes, Checking for Unauthorized Access Points, Analyzing Trust Relationships	
5		**Mobile Forensics**	**8**
	5.1	Android Forensics, Mobile Device Forensic Investigation - Storage location, Acquisition methods, Data Analysis	
	5.2	GPS forensics - GPS Evidentiary data, GPS Exchange Format (GPX), GPX Files, Extraction of Waypoints and TrackPoints, Display the Tracks on a Map.	
	5.3	SIM Cards Forensics - The Subscriber Identification Module (SIM), SIM Architecture, Security, Evidence Extraction.	
6		**Browser, Email Forensic & Forensic Investigation Reporting**	**4**
	6.1	Web Browser Forensics, Google chrome, Other web browser investigation Email forensics - Sender Policy Framework (SPF), Domain Key Identified Mail (DKIM), Domain based Message Authentication Reporting and Confirmation (DMARC)	
	6.2	Investigative Report Template, Layout of an Investigative Report, Guidelines for Writing a Report	

Textbooks:	
1	Kevin Mandia, Chris Prosise, “Incident Response and computer forensics”, Tata McGrawHill, 2006
2	Digital Forensics Basics A Practical Guide Using Windows OS — Nihad A. Hassan, APress Publication, 2019
3	Xiaodong Lin, “Introductory Computer Forensics: A Hands-on Practical Approach”, Springer Nature, 2018

Suggested MOOC Course Links	
1	Course on “Ethical Hacking” https://nptel.ac.in/courses/106/105/106105217/
2	Course on “Digital Forensics” https://onlinecourses.swayam2.ac.in/cec20_lb06/preview
3	Course on Cyber Incident Response https://www.coursera.org/learn/incident-response
4	Course on “Penetration Testing, Incident Responses and Forensics” https://www.coursera.org/learn/ibm-penetration-testing-incident-response-forensics

Assessment:

Internal Assessment:

Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.

End Semester Theory Examination:

1	Question paper will comprise a total of six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed 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	In question paper weightage of each module will be proportional to the number of respective lecture hours as mention in the syllabus.

Course Code	Course Name	Credit
CSDC8013	Applied Data Science	03

Prerequisite: Machine Learning, Data Structures & Algorithms	
Course Objectives:	
1	To introduce students to the basic concepts of data science.
2	To acquire an in-depth understanding of data exploration and data visualization.
3	To be familiar with various anomaly detection techniques.
4	To understand the data science techniques for different applications.
Course Outcomes:	
1	To gain fundamental knowledge of the data science process.
2	To apply data exploration and visualization techniques.
3	To apply anomaly detection techniques.
4	To gain an in-depth understanding of time-series forecasting.
5	Apply different methodologies and evaluation strategies.
6	To apply data science techniques to real world applications.

Module		Detailed Content	Hours
1		**Introduction to Data Science**	2
	1.1	Introduction to Data Science, Data Science Process	
	1.2	Motivation to use Data Science Techniques: Volume, Dimensions and Complexity, Data Science Tasks and Examples	
	1.3	Overview of Data Preparation, Modeling, Difference between data science and data analytics	
2		**Data Exploration**	8
	2.1	Types of data, Properties of data **Descriptive Statistics:** Univariate Exploration: Measure of Central Tendency, Measure of Spread, Symmetry, Skewness: Karl Pearson Coefficient of skewness, Bowley's Coefficient, Kurtosis Multivariate Exploration: Central Data Point, Correlation, Different forms of correlation, Karl Pearson Correlation Coefficient for bivariate distribution	

	2.2	**Inferential Statistics:** Overview of Various forms of distributions: Normal, Poisson, Test Hypothesis, Central limit theorem, Confidence Interval, Z-test, t-test, Type-I, Type-II Errors, ANOVA	
3		**Methodology and Data Visualization**	**06**
	3.1	**Methodology:** Overview of model building, Cross Validation, K-fold cross validation, leave-1 out, Bootstrapping	
	3.2	**Data Visualization** Univariate Visualization: Histogram, Quartile, Distribution Chart Multivariate Visualization: Scatter Plot, Scatter Matrix, Bubble chart, Density Chart Roadmap for Data Exploration	
	3.3	**Self-Learning Topics:** Visualizing high dimensional data: Parallel chart, Deviation chart, Andrews Curves.	
4		**Anomaly Detection**	**06**
	4.1	Outliers, Causes of Outliers, Anomaly detection techniques, Outlier Detection using Statistics	
	4.2	Outlier Detection using Distance based method, Outlier detection using density-based methods, SMOTE	
5		**Time Series Forecasting**	4
	5.1	Taxonomy of Time Series Forecasting methods, Time Series Decomposition	
	5.2	Smoothening Methods: Average method, Moving Average smoothing, Time series analysis using linear regression, ARIMA Model, Performance Evaluation: Mean Absolute Error, Root Mean Square Error, Mean Absolute Percentage Error, Mean Absolute Scaled Error	
	5.3	**Self-Learning Topics:** Evaluation parameters for Classification, regression and clustering.	
6		**Applications of Data Science**	4
		Predictive Modeling: House price prediction, Fraud Detection Clustering: Customer Segmentation Time series forecasting: Weather Forecasting Recommendation engines: Product recommendation	

Textbooks:	
1	Vijay Kotu, Bala Deshpande. “Data Science Concepts and Practice”, Elsevier, M.K. Publishers.
2	Steven Skiena, “Data Science Design Manual”, Springer International Publishing AG
3	Samir Madhavan. “Mastering Python for Data Science”, PACKT Publishing
4	Dr. P. N. Arora, Sumeet Arora, S. Arora, Ameet Arora, “Comprehensive Statistical Methods”, S.Chand Publications, New Delhi.

References:	
1	Jake VanderPlas. “Python Data Science Handbook”, O’reilly Publications.
2	Francesco Ricci, LiorRokach, BrachaShapira, Paul B. Kantor, “Recommender Systems Handbook”, Springer.
3	S.C. Gupta, V. K. Kapoor “Fundamentals of Mathematical Statistics”, S. Chand and Sons, New Delhi.
4	B. L. Agrawal. “Basic Statistics”, New Age Publications, Delhi.

Useful Links	
1	https://onlinecourses.nptel.ac.in/noc22_cs32/preview
2	https://onlinecourses.nptel.ac.in/noc21_cs69/preview

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All questions carry equal marks.
3	Questions will be mixed in nature (for example supposed 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.

Course Code:	Course Title	Credit
CSDC8021	Optimization in Machine Learning	3

Prerequisite: Engineering Mathematics, Algorithms and data structures
Course Objectives:
1. Understand, analyze and apply existing derivative based optimization algorithms
2. Analyze and apply stochastic methods in optimization
3. Analyze convex optimization for machine learning problems
4. Understand real life problems and apply evolutionary methods to optimize them
Course Outcomes:
1. To understand foundational optimization ideas including gradient descent, stochastic gradient methods
2. To apply convex optimization algorithm
3. To analyze and demonstrate several population methods in Evolutionary Computation
4.Toapply advanced evolutionary algorithms such as particle swarm and ant colony optimization

Module		Content	Hrs
1		**Introduction and Background to Optimization Theory**	**4**
	1.1	Basic Ingredients of Optimization Problems, Optimization Problem Classifications, Optima Types, Optimization Method Classes, Overview of Unconstrained and Constrained Optimization, Basics of convex optimization	
2		**Derivative based Optimization**	**10**
	2.1 2.2 2.3	The Basics of Optimization (univariate, bivariate and multivariate optimization), Convex Objective Functions First-Order optimization Methods : Gradient Descent, Conjugate Gradient, Momentum, Nesterov Momentum, Adagrad, RMSProp, learning rate optimization Second order optimization: Newton method	
3		**Stochastic Methods**	**6**
		Noisy Descent, Mesh Adaptive Direct Search, Cross-Entropy Method, Natural Evolution Strategies, Covariance Matrix Adaptation	
4		**Convex Optimization**	**6**
		Optimization problems, Convex optimization, Linear optimization problems, Quadratic optimization problems,	

		Geometric programming, Overview of Generalized inequality constraints and Vector optimization	
5		**Evolutionary Methods**	**8**
	5.1 5.2	Introduction to Evolutionary Computation: Generic Evolutionary Algorithm, Representation: The Chromosome, Initial Population, Fitness Function, Selection: Selective Pressure, Random Selection, Proportional Selection,Tournament Selection, Rank-Based Selection, Elitism and Evolutionary Computation versus Classical Optimization, Stopping conditions Canonical Genetic Algorithm, Binary Representations of Crossover and Mutation: Binary Representations, Control Parameters	
6		**Advance Evolutionary Methods**	**5**
	6.1	Basic Particle Swarm Optimization, Global Best PSO, Local Best PSO, g-best versus l-best PSO, Velocity Components, Geometric Illustration, Algorithm Aspects, Social Network Structures	
	6.2	Ant Colony Optimization Meta-Heuristic, Foraging Behavior of Ants, Stigmergy and Artificial Pheromone, Simple Ant Colony Optimization, Ant System, Ant Colony System	

Textbooks:	
1	Mykel J. Kochenderfer, Tim A.Wheeler, Algorithms for Optimization, MIT Press (2019)
2	Andries P Engelbrecht, Computational Intelligence-An Introduction, Second-Edition, Wiley publication
3	Charu C. Aggarwal, Linear Algebra and Optimization for Machine Learning, , Springer ,2020.
References:	
1	SuvritSra, Sebastian Nowozin, Stephen J. Wright, Optimization for Machine Learning, The MIT Press
2	Xin-She Yang Middlesex ,Optimization techniques and applications with examples, Wiley
3	A.E. Eiben, J. E. Smith, Introduction to Evolutionary Computing, Springer

Useful Links	
1	**Convex optimization (NPTEL)**
2	**Constrained and Unconstrained optimization (NPTEL)**
3	**Machine-learning-model-performance (Coursera)**
4	**Deep-neural-network optimization (Coursera)**

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first class test is to be conducted when approx. 40% syllabus is completed and second class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise a total of six questions.
2	All questions carry equal marks
3	Questions will be mixed in nature (for example supposed 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	In question paper weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Course Code:	Course Title	Credit
CSDC8022	High Performance Computing	3

Prerequisite: Computer Architecture, Operating System, Cloud Computing	
Course Objectives: The objective of the course is to	
1	Introduce the fundamental concepts of high-performance computing (HPC) architecture and parallel computing.
2	Provide foundations for developing, analyzing, and implementing parallel algorithms using parallelization paradigms like MPI, OpenMP, OpenCL, and CUDA.
3	Introduce range of activities associated with HPC in Cloud
Course Outcomes: After learning the course, the students will be able to:	
1	Understand parallel and pipeline processing approaches
2	Design a parallel algorithm to solve computational problems and identify issues in parallel programming.
3	Analyze the performance of parallel computing systems for clusters in terms of execution time, total parallel overhead, speedup.
4	Develop efficient and high-performance parallel algorithms using OpenMP and message passing paradigm
5	Develop high-performance parallel programming using OpenCL and CUDA framework
6	Perform the range of activities associated with High Performance Computing in Cloud Computing

Module		Content	Hrs
1		**Introduction to Parallel Computing**	**5**
	1.1	Parallelism (What, Why, Applications), Levels of parallelism(instruction, transaction, task, thread, memory, function)	
	1.2	**Classification Models:** Architectural Schemes(Flynn's, Shore's, Feng's, Handler's)	
	1.3	**Memory Access:** Distributed Memory, Shared Memory, Hybrid Distributed Shared Memory	
	1.4	**Parallel Architecture:** Pipeline Architecture: Arithmetic pipelines, Floating Point, Array Processor	
2		**Parallel Programming Platform and Algorithm Design**	**11**
	2.1	**Parallel Programming Platform:** Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines	
	2.2	**Algorithm Design:** Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing, Methods for Containing Interaction Overheads, Parallel Algorithm Models.	
3		**Performance Measures**	**3**
		Performance Measures: Speedup, execution time, efficiency, cost, scalability, Effect of granularity on performance, Scalability of Parallel Systems, Amdahl's Law, Gustavson's Law, Performance Bottlenecks, The Karp Flatt Metric.	
4		**HPC Programming: OpenMP and MPI**	**10**

		HPC Programming: OpenMP	
	4.1	Introduction: Threads, Share memory Architecture, Multi-core processors and Hyperthreading, Fork and join model.	
	4.2	OpenMP directives: #pragma omp parallel, Hello world with openMP, #pragma omp for, #pragma omp for schedule.Serial vs Parallel PI program.	
	4.3	Synchronisation: Introduction, Private vs Shared variables. Critical section, #pragma omp critical, #pragma omp atomic, #pragma omp barrier, #pragma omp reduction	
		HPC Programming: MPI	
	4.4	Introduction: Processes, Multiprocessor programming model, Distributed system programming model, Inter-process communication using message passing: Asynchronous and Synchronous	
	4.5	MPI Programming: Hello world problem, mpi_initMPI_sendMPI_Recv, Synchronisation: MPI_Barrier	
	4.6	Hybrid (MPI + OpenMP) programming, Hardware requirement, Threads inside Processes, Hybrid Matrix multiplication	
	4.7	Message passing vs Share memory communication: Advantages and disadvantage	
5		**Parallel programming using accelerators**	**4**
		An Overview of GPGPUs, Introduction to CUDA, Introduction to Heterogeneous Computing using OpenCL, An Overview of OpenCL API, Heterogeneous Programming in OpenCL.	
6		**High Performance Computing in the Cloud**	**4**
		Virtualization and Containerization, Parallel Computing Frameworks, Scaling, HPC in the Cloud Use Cases.	

Textbooks:	
1	AnanthGrama, Anshul Gupta, George Karypis, Vipin Kumar “Introduction to Parallel Computing”, 2nd edition, Addison Wesley, 2003.
2	Shane Cook, Morgan Kaufmann “CUDA Programming: A Developer's Guide to Parallel Computing with GPUs”, 2012.
3	M. R. Bhujade “Parallel Computing”,2nd edition, New Age International Publishers, 2009.
4	Kai Hwang, Naresh Jotwani, “Advanced Computer Architecture: Parallelism, Scalability, Programmability” McGraw Hill, Second Edition, 2010.
5	Georg Hager, Gerhard Wellein, Chapman “Introduction to High Performance Computing for Scientists and Engineers” Hall/CRC Computational Science Series, 2011.
References:	
1	Michael J. Quinn “Parallel Programming in C with MPI and OpenMPI” by, McGraw Hill Education, 2008.
2	Kai Hwang ,Zhiwei, “Scalable Parallel Computing: Technology, Architecture, Programming”, McGraw-Hill Education, 1998.
3	Laurence T. Yang, Minyi Guo, “High-Performance Computing: Paradigm and Infrastructure”, by, Wiley, 2006.

Useful Links	
1	https://nptel.ac.in/courses/112105293
2	https://archive.nptel.ac.in/courses/128/106/128106014/

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will comprise of total six questions.
2	All question carries equal marks
3	Questions will be mixed in nature (for example supposed 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	In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

Course Code	Course Name	Credit
CSDC8023	Social Media Analytics	03

Prerequisite: Graph Theory, Data Mining, Python/R programming	
Course Objectives: The course aims:	
1	Familiarize the learners with the concept of social media.
2	Familiarize the learners with the concept of social media analytics and understand its significance.
3	Enable the learners to develop skills required for analyzing the effectiveness of social media.
4	Familiarize the learners with different tools of social media analytics.
5	Familiarize the learner with different visualization techniques for Social media analytics.
6	Examine the ethical and legal implications of leveraging social media data.
Course Outcomes:	
1	Understand the concept of Social media
2	Understand the concept of social media Analytics and its significance.
3	Learners will be able to analyze the effectiveness of social media
4	Learners will be able to use different Social media analytics tools effectively and efficiently.
5	Learners will be able to use different effective Visualization techniques to represent social media analytics.
6	Acquire the fundamental perspectives and hands-on skills needed to work with social media data.

Module	Detailed Content	Hours
1.	**Social Media Analytics: An Overview**	
	Core Characteristics of Social Media, Types of Social Media, Social media landscape, Need for Social Media Analytics (SMA), SMA in small & large organizations. Purpose of Social Media Analytics, Social Media vs. Traditional Business Analytics, Seven Layers of Social Media Analytics, Types of Social Media Analytics, Social Media Analytics Cycle, Challenges to Social Media Analytics, Social Media Analytics Tools	6
2.	**Social Network Structure, Measures & Visualization**	
	Basics of Social Network Structure - Nodes, Edges & Tie Describing the Networks Measures - Degree Distribution, Density, Connectivity, Centralization, Tie Strength & Trust Network Visualization - Graph Layout, Visualizing Network features, Scale Issues. Social Media Network Analytics - Common Network Terms, Common Social Media Network Types, Types of Networks, Common Network Terminologies, Network Analytics Tools.	6
3.	**Social Media Text, Action & Hyperlink Analytics**	
	Social Media Text Analytics - Types of Social Media Text, Purpose of Text Analytics, Steps in Text Analytics, Social Media Text	8

	Analysis Tools Social Media Action Analytics - What Is Actions Analytics? Common Social Media Actions, Actions Analytics Tools Social Media Hyperlink Analytics - Types of Hyperlinks, Types of Hyperlink Analytics, Hyperlink Analytics Tools	
4.	**Social Media Location & Search Engine Analytics**	
	Location Analytics - Sources of Location Data, Categories of Location Analytics, Location Analytics and Privacy Concerns, Location Analytics Tools Search Engine Analytics - Types of Search Engines, Search Engine Analytics, Search Engine Analytics Tools	6
5.	**Social Information Filtering**	
	Social Information Filtering - Social Sharing and filtering , Automated Recommendation systems, Traditional Vs social Recommendation Systems Understanding Social Media and Business Alignment, Social Media KPI, Formulating a Social Media Strategy, Managing Social Media Risks	6
6.	**Social Media Analytics Applications and Privacy**	
	Social media in public sector - Analyzing public sector social media, analyzing individual users, case study. Business use of Social Media - Measuring success, Interaction and monitoring, case study. Privacy - Privacy policies, data ownership and maintaining privacy online.	7

Textbooks:	
1.	Seven Layers of Social Media Analytics_ Mining Business Insights from Social Media Text, Actions, Networks, Hyperlinks, Apps, Search Engine, and Location Data, Gohar F. Khan,(ISBN-10: 1507823207).
2.	Analyzing the Social Web 1st Edition by Jennifer Golbeck
3.	Mining the Social Web_ Analyzing Data from Facebook, Twitter, LinkedIn, and Other Social Media Sites, Matthew A Russell, O'Reilly
4	Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011
References:	
1.	Social Media Analytics [2015], Techniques and Insights for Extracting Business Value Out of Social Media, Matthew Ganis, AvinashKohirkar, IBM Press
2.	Social Media Analytics Strategy_ Using Data to Optimize Business Performance, Alex Gonçalves, APress Business Team
3.	Social Media Data Mining and Analytics, Szabo, G., G. Polatkan, O. Boykin & A. Chalkiopoulus (2019), Wiley, ISBN 978-1-118-82485-6

Useful Links	
1	https://cse.iitkgp.ac.in/~pawang/courses/SC16.html
2	https://onlinecourses.nptel.ac.in/noc20_cs78/preview
3	https://nptel.ac.in/courses/106106146
4	https://7layersanalytics.com/

Assessment:	
Internal Assessment:	
Assessment consists of two class tests of 20 marks each. The first-class test is to be conducted when approx. 40% syllabus is completed and second class test when additional40% syllabus is completed. Duration of each test shall be one hour.	
End Semester Theory Examination:	
1	Question paper will consist of 6 questions, each carrying 20 marks.
2	The students need to solve a total of 4 questions.
3	Question No.1 will be compulsory and based on the entire syllabus.
4	Remaining question (Q.2 to Q.6) will be selected from all the modules.

Course Code	Course Name	Credits
ILO 8021	Project Management	03

Objectives:

1. 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.
2. To appraise the students with the project management life cycle and make them knowledgeable about the various phases from project initiation through closure.

Outcomes: Learner will be able to…

1. Apply selection criteria and select an appropriate project from different options.
2. Write work break down structure for a project and develop a schedule based on it.
3. Identify opportunities and threats to the project and decide an approach to deal with them strategically.
4. Use Earned value technique and determine & predict status of the project.
5. Capture lessons learned during project phases and document them for future reference

Module	Detailed Contents	Hrs
01	**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
02	**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
03	**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
04	**Planning Projects:** Crashing project time, Resource loading and levelling, Goldratt's critical chain, Project Stakeholders and Communication plan 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	6
05	**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:**	8

	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,	
06	**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

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**

REFERENCES:

1. Project Management: A managerial approach, Jack Meredith & Samuel Mantel, 7th Edition, Wiley India
2. A Guide to the Project Management Body of Knowledge (PMBOK® Guide), 5th Ed, Project Management Institute PA, USA
3. Project Management,Gido Clements, Cengage Learning
4. Project Management,Gopalan, Wiley India
5. Project Management,Dennis Lock, 9th Edition, Gower Publishing England

Course Code	Course Name	Credits
ILO 8022	Finance Management	03

Objectives:

1. Overview of Indian financial system, instruments and market
2. Basic concepts of value of money, returns and risks, corporate finance, working capital and its management
3. Knowledge about sources of finance, capital structure, dividend policy

Outcomes: Learner will be able to…

1. Understand Indian finance system and corporate finance
2. Take investment, finance as well as dividend decisions

Module	Detailed Contents	Hrs
01	**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
02	**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
03	**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; Profitability Ratios; Capital Structure Ratios; Stock Market Ratios; Limitations of Ratio Analysis.	09
04	**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	10

	Working Capital Needs; Estimation of Working Capital Requirements; Management of Inventories; Management of Receivables; and Management of Cash and Marketable Securities.	
05	**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
06	**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

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**.

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.
4. Financial Management, 11th Edition (2015) by I. M. Pandey; Publisher: S. Chand (G/L) & Company Limited, New Delhi.

Course Code	Course Name	Credits
ILO8023	Entrepreneurship Development and Management	03

Objectives:

1. To acquaint with entrepreneurship and management of business
2. Understand Indian environment for entrepreneurship
3. Idea of EDP, MSME

Outcomes: Learner will be able to…

1. Understand the concept of business plan and ownerships
2. Interpret key regulations and legal aspects of entrepreneurship in India
3. Understand government policies for entrepreneurs

Module	Detailed Contents	Hrs
01	**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
02	**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
03	Women's Entrepreneurship Development, Social entrepreneurship-role and need, EDP cell, role of sustainability and sustainable development for SMEs, case studies, exercises	05
04	**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, National Skill development Mission, Credit Guarantee Fund, PMEGP, discussions, group exercises etc	08
05	**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
06	**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

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**.

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. Maddhurima Lall, Shikah Sahai, 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

Course Code	Course Name	Credits
ILO8024	Human Resource Management	03

Objectives:

1. To introduce the students with basic concepts, techniques and practices of the human resource management
2. To provide opportunity of learning Human resource management (HRM) processes, related with the functions, and challenges in the emerging perspective of today's organizations
3. To familiarize the students about the latest developments, trends & different aspects of HRM
4. To acquaint the student with the importance of inter-personal & inter-group behavioural skills in an organizational setting required for future stable engineers, leaders and managers

Outcomes: Learner will be able to…

1. Understand the concepts, aspects, techniques and practices of the human resource management.
2. Understand the Human resource management (HRM) processes, functions, changes and challenges in today's emerging organizational perspective.
3. Gain knowledge about the latest developments and trends in HRM.
4. Apply the knowledge of behavioural skills learnt and integrate it with in inter personal and intergroup environment emerging as future stable engineers and managers.

Module	Detailed Contents	Hrs
01	**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
02	**Organizational Behaviour (OB)** • Introduction to OB Origin, Nature and Scope of Organizational Behaviour, 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 Behaviour • Motivation: Theories of Motivation and their Applications for Behavioural Change (Maslow, Herzberg, McGregor); • Group Behaviour 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
03	**Organizational Structure &Design** • Structure, size, technology, Environment of organization; Organizational Roles & conflicts: Concept of roles; role dynamics; role conflicts and stress. • Leadership: Concepts and skills of leadership, Leadership and managerial roles, Leadership styles and contemporary issues in leadership.	6

	• Power and Politics: Sources and uses of power; Politics at workplace, Tactics and strategies.	
04	**Human resource Planning** • Recruitment and Selection process, Job-enrichment, Empowerment - Job-Satisfaction, employee morale • Performance Appraisal Systems: Traditional & modern methods, Performance Counselling, Career Planning • Training & Development: Identification of Training Needs, Training Methods	5
05	**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
06	**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 **Labor 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

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**.

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

Course Code	Course Name	Credits
ILO8025	Professional Ethics and Corporate Social Responsibility (CSR)	03

Objectives:

1. To understand professional ethics in business
2. To recognized corporate social responsibility

Outcomes: Learner will be able to…

1. Understand rights and duties of business
2. Distinguish different aspects of corporate social responsibility
3. Demonstrate professional ethics
4. Understand legal aspects of corporate social responsibility

Module	Detailed Contents	Hrs
01	**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
02	**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
03	**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
04	**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
05	**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) in India	08
06	**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

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**.

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 Bidyut Chakrabarty, Routledge, New Delhi.

Course Code	Course Name	Credits
ILO8026	Research Methodology	03

Objectives:

1. To understand Research and Research Process
2. To acquaint students with identifying problems for research and develop research strategies
3. To familiarize students with the techniques of data collection, analysis of data and interpretation

Outcomes: Learner will be able to…

1. Prepare a preliminary research design for projects in their subject matter areas
2. Accurately collect, analyze and report data
3. Present complex data or situations clearly
4. Review and analyze research findings

Module	Detailed Contents	Hrs
01	**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**
02	**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**
03	**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**
04	**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 **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	**08**
05	**Formulating Research Problem** **5.1** Considerations: Relevance, Interest, Data Availability, Choice of data, Analysis of data, Generalization and Interpretation of analysis	**04**

06	**Outcome of Research** **6.1** Preparation of the report on conclusion reached **6.2** Validity Testing & Ethical Issues **6.3** Suggestions and Recommendation	**04**

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**.

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, (2nded), Singapore, Pearson Education

Course Code	Course Name	Credits
ILO8027	IPR and Patenting	03

Objectives:

1. To understand intellectual property rights protection system
2. To promote the knowledge of Intellectual Property Laws of India as well as International treaty procedures
3. To get acquaintance with Patent search and patent filing procedure and applications

Outcomes: Learner will be able to…

1. understand Intellectual Property assets
2. assist individuals and organizations in capacity building
3. work for development, promotion, protection, compliance, and enforcement of Intellectual Property and Patenting

Module	Detailed Contents	Hr
01	**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
02	**Enforcement of Intellectual Property Rights:** Introduction, Magnitude of problem, Factors that create and sustain counterfeiting/piracy, International agreements, International organizations (e.g. WIPO, WTO) active in 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
03	**Emerging Issues in IPR:**Challenges for IP in digital economy, e-commerce, human genome, biodiversity and traditional knowledge etc.	05
04	**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
05	**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
06	**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, Time frame and cost, Patent Licensing, Patent Infringement **Patent databases:** Important websites, Searching international databases	07

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 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. Lous Harns, 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.

Course Code	Course Name	Credits
ILO 8028	**Digital Business Management**	**03**

Objectives:

1. To familiarize with digital business concept
2. To acquaint with E-commerce
3. To give insights into E-business and its strategies

Outcomes: The learner will be able to …..

1. Identify drivers of digital business
2. Illustrate various approaches and techniques for E-business and management
3. Prepare E-business plan

Module	Detailed content	Hours
1	**Introduction to Digital Business-** Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts Difference 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
2	**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
3	**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
4	**Managing E-Business**-Managing Knowledge, Management skills for e-business, Managing Risks in e –business Security Threats to e-business -Security Overview, Electronic Commerce 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	06
5	**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
6	**Materializing e-business: From Idea to Realization**-Business plan preparation **Case Studies and presentations**	08

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**.

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, VinocenzoMorabito, 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

Course Code	Course Name	Credits
ILO8029	Environmental Management	03

Objectives:

1. Understand and identify environmental issues relevant to India and global concerns
2. Learn concepts of ecology
3. Familiarise environment related legislations

Outcomes: Learner will be able to…

1. Understand the concept of environmental management
2. Understand ecosystem and interdependence, food chain etc.
3. Understand and interpret environment related legislations

Module	Detailed Contents	Hrs
01	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
02	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
03	Concepts of Ecology: Ecosystems and interdependence between living organisms, habitats, limiting factors, carrying capacity, food chain, etc.	05
04	Scope of Environment Management, Role and functions of Government as a planning and regulating agency Environment Quality Management and Corporate Environmental Responsibility	10
05	Total Quality Environmental Management, ISO-14000, EMS certification.	05
06	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

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**.

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 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

   Environment and Ecology, Majid Hussain, 3rd Ed. Access Publishing.2015

Lab Code	Lab Name	Credit
CSL801	**Distributed Computing Lab**	**1**

Prerequisite: Computer Networks and Operating Systems.	
Lab Objectives:	
1	To understand basic underlying concepts of forming distributed systems.
2	To learn the concept of clock Synchronization
3	To learn Election Algorithm.
4	To explore mutual exclusion algorithms and deadlock handling in the distributed system
5	To study resource allocation and management.
6	To understand the Distributed File System
Lab Outcomes: At the end of the course, the students will be able to	
1	Develop test and debug usingMessage-Oriented Communication or RPC/RMI based client-server programs.
2	Implement techniques for clock synchronization.
3	Implement techniques for Election Algorithms.
4	Demonstrate mutual exclusion algorithms and deadlock handling.
5	Implement techniques of resource and process management.
6	Describe the concepts of distributed File Systems with some case studies.

Suggested List of Experiments	
Sr. No.	**Title of Experiment**
1	Inter-process communication
2	Client/Server using RPC/RMI
3	Group Communication
4	Clock Synchronization algorithms
5	Election Algorithm.
6	Mutual Exclusion Algorithm
7	Deadlock Management in Distributed System
8	Load Balancing
9	Distributed shared Memory
10	Distributed File System (AFS/CODA)
11	Case Study: CORBA
12	Case Study: Android Stack

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments on content of theory and practical of CSC801 and CSL801(Distributed Computing)
3	The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral and Practical exam	
Based on the entire syllabus of CSC801: Distributed Computing and CSL801: Distributed Computing Lab	

Lab Code	Lab Name	Credit
CSDL8021	Deep Learning Lab	1

Prerequisite: Python Programming, Engineering Mathematics	
Lab Objectives:	
1	To implement basic neural network models for simulating logic gates.
2	To implement various training algorithms for feedforward neural networks.
3	To design deep learning models for supervised, unsupervised and sequence learning.
Lab Outcomes: At the end of the course, the students will be able to	
1	Implement basic neural network models to learn logic functions.
2	Design and train feedforward neural networks using various learning algorithms.
3	Build and train deep learning models such as Autoencoders, CNNs, RNN, LSTM etc.

Suggested List of Experiments	
1.	**Based on Module 1 (Any two) using Virtual Lab**
	1. Implement Mc-Culloch Pitts model for binary logic functions. 2. Implement Perceptron algorithm to simulate any logic gate. 3. Implement Multilayer Perceptron algorithm to simulate XOR gate. 4. To explore python libraries for deep learning e.g. Theano, TensorFlow etc.
2	**Module 2 (Any Two)**
	5. Apply any of the following learning algorithms to learn the parameters of the supervised single layer feed forward neural network. a. Stochastic Gradient Descent b. Mini Batch Gradient Descent c. Momentum GD d. Nestorev GD e. Adagrad GD f. Adam Learning GD 6. Implement a backpropagation algorithm to train a DNN with at least 2 hidden layers. 7. Design and implement a fully connected deep neural network with at least 2 hidden layers for a classification application. Use appropriate Learning Algorithm, output function and loss function.
4.	**Module 3 (Any One)**
	8. Design the architecture and implement the autoencoder model for Image Compression. 9. Design the architecture and implement the autoencoder model for Image denoising.
5	**Module 4 (Any One)**
	10. Design and implement a CNN model for digit recognition application. 11. Design and implement a CNN model for image classification.
6	**Module 5 (Any One)**

	12. Design and implement LSTM for Sentiment Analysis. 13. Design and implement GRU for classification on text data. 14. Design and implement RNN for classification of temporal data.

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignment: 05-marks)
Practical and Oral exam	
	Based on the entire syllabus of CSDC8011: Deep Learning and CSDL8011: Deep Learning Lab

Lab Code	Lab Name	Credit
CSDL8022	**Digital Forensics Lab**	**1**

Prerequisite: Computer Network, Cryptography and System Security	
Lab Objectives:	
1	To demonstrate the procedures for identification, preservation, and acquisition of digital evidence.
2	To demonstrate techniques and tools used in digital forensics for operating systems and malware investigation.
3	To demonstrate tools formobile forensics and browser, email forensics
4	To explore scenario based crime forensics investigations.
Lab Outcomes: At the end of the course, the students will be able to	
1	Explore various forensics tools and use them to acquire, duplicate and analyze data and recover deleted data.
2	Implement penetration testing using forensics tools.
3	Explore various forensics tools and use them to acquire and analyze live and static data.
4	Verification of source and content authentication of emails and browsers.
5	Demonstrate Timeline Report Analysis using forensics tools.
6	Discuss real time crime forensics investigations scenarios.

Suggested List of Experiments	
Sr. No.	**Title of Experiment**
1	Analysis of forensic images using open source tools. ● FTK Imager ● Autopsy
2	Explore forensics tools in kali linux for acquiring, analyzing and duplicating data. ● dd ● dcfldd
3	Performing penetration testing using Metasploit - kali Linux.
4	Performing RAM Forensic to analyze memory images to find traces of an attack. ● Capturing RAM Using the DumpIt Tool ● Volatility tool
5	Network forensics using Network Miner.
6	Windows Recycle Bin Forensics
7	Data Carving using open source tools ● Foremost ● Scalpel ● Jpegcarver
8	USB Device Forensics using ● USBDeview ● USB Detective
9	Web Browser Forensics using DB Browser for SQLite
10	Generate a Timeline Report Using Autopsy
11	Email Analysis
12	Case Study

Term Work:	
1	Term work should consist of 7 experiments covering all the modules and one case study.
2	Journal must include at least 2 assignments on content of theory and practical
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments & Case Study : 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Oral & Practical exam	
	Based on the entire syllabus of CSDC8012- Digital Forensics and CSDL8012- Digital Forensics Lab

Lab Code	Lab Name	Credit
CSL8023	Applied Data Science Lab	1

Prerequisite: Engineering Mathematics, Machine Learning, Programming fundamentals	
Lab Objectives:	
1	To explore various stages in the data science lifecycle.
2	To understand data preparation, exploration and visualization techniques.
3	To model and evaluate different supervised/unsupervised learning techniques.
Lab Outcomes: At the end of the course, the students will be able to	
1	Apply various stages of the data science lifecycle for the selected case study.
2	Demonstrate data preparation, exploration and visualization techniques.
3	Implement and evaluate different supervised and unsupervised techniques.

Suggested List of Experiments
(Select a case study and perform the experiments 1 to 8.).

Star (*) marked experiments are compulsory.

Name of the Experiment

1. Explore the descriptive and inferential statistics on the given dataset.
2. Apply data cleaning techniques (e.g. Data Imputation).
3. Explore data visualization techniques.
4. Implement and explore performance evaluation metrics for Data Models (Supervised/Unsupervised Learning)
5. Use SMOTE technique to generate synthetic data.(to solve the problem of class imbalance)
6. Outlier detection using distance based/density based method.
7. Implement time series forecasting.

Illustrate data science lifecycle for selected case study. (Prepare case study document for the selected case study)

Suggested Case Studies:

1. Customer Segmentation
2. Fraud Detection
3. House Price prediction
4. Product Recommendation
5. Stock price prediction
6. Weather prediction

Suggested Assignment List

Assignments can be given on self learning topics or data deployment tools.

Term Work:	
1	Term work should consist of 8 experiments.
2	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignment: 05-marks)
Practical and Oral exam	
	Based on the entire syllabus of CSDC 8013: Applied Data Science and CSDL 8013: Applied Data Science Lab

Lab Code	Lab Name	Credit
CSDL8021	Optimization in Machine Learning Lab	1

Prerequisite: Algorithms and data structures	
Lab Objectives:	
1	To apply derivative based optimization techniques
2	To understand evolutionary optimization to a given machine learning problem.
3	To apply advanced evolutionary optimization
4	To design and analyze optimization problems for real world applications
Lab Outcomes: At the end of the course, the students will be able to	
1	To implement derivative based optimization techniques
2	To implement evolutionary optimization
3	To implement advanced evolutionary optimization
4	To apply efficient optimization algorithm for real world applications

Suggested List of Experiments	
Sr. No.	**Title of Experiment**
1	To implement Gradient Descent algorithm
2	To implement the Stochastic Gradient Descent algorithm
3	To implement Newton method
4	To apply Genetic Algorithm for real world problem
5	To compare and implement different selection mechanism using genetic algorithm
6	To implement various mutation and crossover mechanisms
7	To implement Particles Swarm optimization
8	To implement Ant colony optimization

Term Work:	
1	Term work should consist of 6 experiments.
2	Journal must include at least 2 assignments on content of theory and practical of "**Optimization in Machine Learning**"
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments and assignments: 15-marks, Attendance Theory & Practical: 05-marks, Case study /Mini project: 05-marks)
Practical and Oral exam	
	Based on the entire syllabus of CSDC8021: Optimization in Machine Learning and CSDL8021: Optimization in Machine Learning

Lab Code	Lab Name	Credit
CSDL8022	**High Performance Computing Lab**	**1**

Prerequisite: C Programming	
Lab Objectives: The objective of the course is to:	
1	Enable students to build the logic to parallelize the programming task.
2	Give insight about performance of parallel computing systems.
3	Provide hands-on experience on parallel programming platforms/frameworks
Lab Outcomes: After learning the course, the students will be able to:	
1	Perform Linux based commands on remote machine
2	Compare the performance of sequential algorithms with parallel algorithm in terms of execution time, speedup and throughput.
3	Implement parallel program using OpenMP libraryand analyze its performance
4	Implement parallel program using MPIplatform and analyze its performance
5	Implement parallel program using OpenCL framework and analyze its performance
6	Implement parallel program using CUDA framework and analyze its performance

Suggested Experiments: Students are required to complete at least 8 experiments.	
Star (*) marked experiments are compulsory.	
Sr. No.	**Name of the Experiment**
1*	To analyse the Linux based computer systems using following commands: **a.** top , **b.**ps , **c.** kill, **d.** cat /proc/cpuinfo**e.**vmstat **Hardware/Software Requirement:** Linux Operating System
2*	To setup SSH passwordless logins for two or more Linux based machines and execute commands on a remote machine. **Hardware/Software Requirement:** Linux Operating System, Multi-core computer systems
3*	Write a program in C to multiply two matrices of size 10000 x 10000 each and find it's execution-time using "time" command. Try to run this program on two or more machines having different configurations and compare execution-times obtained in each run. Comment on which factors affect the performance of the program. **Hardware/Software Requirement:** Linux Operating System, gcc compiler,Multi-core computer systems
4*	Write a "Hello World" program using OpenMP library also display number of threads created during execution. **Hardware/Software Requirement:** Linux Operating System, gcc compiler,Dual core with HT or Quad-core or higher computer system.
5*	Write a parallel program to calculate the value of PI/Area of Circle using OpenMP library. **Hardware/Software Requirement:** Linux Operating System, gcc compiler,Dual core

	with HT or Quad-core or higher computer system.
6*	Write a parallel program to multiply two matrices using openMP library and compare the execution time with its serial version. Also change the number of threads using omp_set_num_threads() function and analyse how thread count affects the execution time. **Hardware/Software Requirement:** Linux Operating System, gcc compiler,Dual core with HT or Quad-core or higher computer system.
7*	Install MPICH library and write a "Hello World" program for the same. **Hardware/Software Requirement:** Linux Operating System, MPICH, Multi-processor systems or MPI Cluster.
8*	Write a parallel program to multiply two matrices using MPI library and compare the execution-time with it's OpenMP and serial version. **Hardware/Software Requirement:** Linux Operating System, MPICH, gcc, Multi-processor systems, or MPI Cluster.
9*	Install MPICH on two and more machines and create a MPI cluster. Execute MPI programs on this cluster and check the performance. **Hardware/Software Requirement:** Linux Operating System, MPICH, Multi-processor systems or MPI Cluster.
10*	Implement a program to demonstrate balancing workload on MPI platform. **Hardware/Software Requirement:** Linux Operating System, MPICH, Multi-processor systems or MPI Cluster.
11	Implement a parallel program to demonstrate the cube of N number within a set range using MPI/OpenMP/OpenCL/CUDA. **Hardware/Software Requirement:** Linux Operating System, MPICH, Multi-processor systems or MPI Cluster. A CUDA-capable GPU,A supported version of Microsoft Windows,A supported version of Microsoft Visual Studio, The NVIDIA CUDA Toolkit
12	Implement DFT computation of vector using OpenCL/CUDA/ Parallel Matlab **Hardware/Software Requirement:** A CUDA-capable GPU,A supported version of Microsoft Windows,A supported version of Microsoft Visual Studio, The NVIDIA CUDA Toolkit
13	Implement Two Vector addition using OpenCL/CUDA/ Parallel Matlab **Hardware/Software Requirement:** A CUDA-capable GPU, A supported version of Microsoft Windows,A supported version of Microsoft Visual Studio, The NVIDIA CUDA Toolkit
14	Implement even-odd/Bucket /Radix /Shell sort using OpenCL/CUDA/ Parallel Matlab **Hardware/Software Requirement:** A CUDA-capable GPU, A supported version of Microsoft Windows,A supported version of Microsoft Visual Studio, The NVIDIA CUDA Toolkit

Term Work:	
1	Term work should consist of 8 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures that satisfactory performance of laboratory work and minimum passing marks in term work.
4	Total 25 Marks (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Practical and Oral Exam	
	Based on the entire syllabus of CSDC8022 : High Performance Computing and CSDL8022 High Performance Computing Lab

Lab Code	Lab Name	Credit
CSDL8023	**Social Media Analytics Lab**	**1**

Prerequisite: Types of Graphs, Data Mining, Data Analytics	
Lab Objectives:	
1	To understand the fundamental concepts of social media networks.
2	To learn various social media analytics tools and evaluation matrices.
3	To collect and store social media data.
4	To analyze and visualize social media data
5	To design and develop social media analytics models.
6	To design and build a social media analytics application.
Lab Outcomes: The students will be able to	
1	Understand characteristics and types of social media networks.
2	Use social media analytics tools for business
3	Collect, monitor , store and track social media data
4	Analyze and visualize social media data from multiple platforms
5	Design and develop content and structure based social media analytics models.
6.	Design and implement social media analytics applications for business.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Study various - i) Social Media platforms (Facebook, twitter, YouTubeetc) ii) Social Media analytics tools (Facebook insights, google analytics net lyticetc) iii) Social Media Analytics techniques and engagement metrics (page level, post level, member level) iv) Applications of Social media analytics for business. e.g. Google Analytics https://marketingplatform.google.com/about/analytics/ https://netlytic.org/
2	Data Collection-Select the social media platforms of your choice (Twitter, Facebook, LinkedIn, YouTube, Web blogs etc) ,connect to and capture social media data for business (scraping, crawling, parsing).
3	Data Cleaning and Storage- Preprocess, filter and store social media data for business (Using Python, MongoDB, R, etc).
4	Exploratory Data Analysis and visualizationof Social Media Data for business.
5	Develop Content (text, emoticons, image, audio, video) based social media analytics model for business. (e.g. Content Based Analysis :Topic , Issue ,Trend, sentiment/opinion analysis, audio, video, image analytics)
6	Develop Structure based social media analytics model for any business. (e.g. Structure Based Models -community detection, influence analysis)
7	Develop a dashboard and reporting tool based on real time social media data.
8	Design the creative content for promotion of your business on social media

	platform.
9	Analyze competitor activities using social media data.
10	Develop social media text analytics models for improving existing product/ service by analyzing customer's reviews/comments.

Reference Books:	
1	Python Social Media Analytics: Analyze and visualize data from Twitter, YouTube, GitHub, and more Kindle Edition by Siddhartha Chatterjee , Michal Krystyanczuk
2	Learning Social Media Analytics with R,byRaghav Bali, Dipanjan Sarkar, Tushar Sharma.
3	Jennifer Golbeck, Analyzing the social web, Morgan Kaufmann, 2013
4	Matthew A. Russell. Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More, 2nd Edition, O'Reilly Media, 2013
5	Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011

Term Work:	
1	Term work should consist of 10 experiments.
2	Journal must include at least 2 assignments.
3	The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
4	**Total 25 Marks** (Experiments: 15-marks, Attendance Theory & Practical: 05-marks, Assignments: 05-marks)
Practical and Oral Exam	
Based on the entire syllabus of CSDC8023: **Social Media Analytics** and CSDL80223: **Social Media Analytics Lab**	

Course Code	Course Name	Credit
CSP801	Major Project 2	06

Course Objectives::	
The Project work facilitates the students to develop and prove Technical, Professional and Ethical skills and knowledge gained during graduation program by applying them from problem identification to successful completion of the project by implementing the solution.	
Course Outcomes: Student will able to	
1	Implement solutions for the selected problem by applying technical and professional skills.
2	Analyze impact of solutions in societal and environmental context for sustainable development.
3	Collaborate best practices along with effective use of modern tools.
4	Develop proficiency in oral and written communication with effective leadership and teamwork.
5	Nurture professional and ethical behavior.
6	Gain expertise that helps in building lifelong learning experience.

Guidelines:

1. Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.

2. **Project Report Format:**
   At the end of semester, each group needs to prepare a project report as per the guidelines issued by the University of Mumbai. Report should be submitted in hardcopy. Also, each group should submit softcopy of the report along with project documentation, implementation code, required utilities, software and user Manuals.

   A project report should preferably contain at least following details:
   - Abstract
   - Introduction
   - Literature Survey/ Existing system
   - Limitation Existing system or research gap
   - Problem Statement and Objective
   - Proposed System
     - Analysis/Framework/ Algorithm
     - Design details
     - Methodology (your approach to solve the problem) Proposed System
   - Experimental Set up

- Details of Database or details about input to systems or selected data
- Performance Evaluation Parameters (for Validation)
- Software and Hardware Set up

- Results and Discussion
- Conclusion and Future Work
- References
- Appendix – List of Publications or certificates

Desirable:

Students should be encouraged -

- to participate in various project competition.
- to write minimum one technical paper & publish in good journal.
- to participate in national / international conference.

3. Term Work:

Distribution of marks for term work shall be done based on following:

a. Weekly Log Report
b. Completeness of the project and Project Work Contribution
c. Project Report (Black Book) (both side print)
d. Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

4. Oral & Practical:

Oral &Practical examination (Final Project Evaluation) of Project 2 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

Suggested quality evaluation parameters are as following:

a. Relevance to the specialization / industrial trends
b. Modern tools used
c. Innovation
d. Quality of work and completeness of the project
e. Validation of results
f. Impact and business value
g. Quality of written and oral presentation
h. Individual as well as team work