AC: 11/07/2022
Item No.: 6.59

University of Mumbai

Manual of
Honours/Minor Degree Programs
In Engineering

(with effect from 2022-2023)

Faculty of Science and Technology

University of Mumbai

Syllabus for Approval

Title of Course	**Honours and Minor Degree Programs in Engineering**
Eligibility	**1. Third year undergraduate engineering student from semester V satisfying following eligibility criteria can opt for Honours and Minor Degree Programs in Engineering.** **A. Students with no backlog in semester I, II, and III** **B. The CGPI (based on semester I, II, and III) of the students must be 6.75 and above** **C. For direct second year (DSE) admitted students - No backlog in semester III and CGPI must be 6.75 and above** **2. It is optional for students to take Honours /Minor degree programs in Engineering.**
Duration of Course	**In TE and BE**
Intake Capacity	**Within Intake as per choice of students**
Scheme of Examination	**Part of Rev 2019 'C'**
Standards of Passing	**40%**
No. of years/Semesters:	**Semesters - 4**
Level:	**U.G.**
Pattern:	**Semester**
Status:	**New**
To be implemented from Academic Year :	**From the academic year 2022-23**

Manuual for Honours and Minor Degree Programs in Engineering

1. Introduction:

As per the AICTE's Approval Process Handbook-2020-21: Chapter VII- clause 7.3.2 (Page 99-101), all branches of Engineering and Technology shall offer Elective Courses in the EMERGING AREAS viz., Artificial Intelligence (AI), Internet of Things (IoT), Blockchain, Robotics, Quantum Computing, Data Sciences, Cyber Security, 3D Printing and Design, Augmented Reality/ Virtual Reality (AR/VR), as specified in Annexure 1 of the Approval Process Handbook.

a) Under Graduate Degree Courses in EMERGING AREAS shall be allowed as specialization from the same Department. The minimum additional Credits for such Courses shall be in the range of 18-20 and the same shall be mentioned in the degree, as specialization in that particular area. For example, doing extra credits for Robotics in Mechanical Engineering shall earn B.E./ B.Tech. (Honours.) Mechanical Engineering with specialization in Robotics

b) Minor specialization in EMERGING AREAS in Under Graduate Degree Courses may be allowed where a student of another Department shall take the minimum additional Credits in the range of 18-20 and get a degree with minor from another Department.

It is also made very clear by AICTE that areas in which Minor Degree/Honours may be offered are numerous. It is up to the Universities with the help of their Academic Board/Council to decide whether Minor Degree/Honours. is to be offered or not in any particular area, which is not mentioned above. AICTE approval is not required for offering Minor Degree/Honours. in any such area, however the criteria that "Minor Degree or Honours. will cumulatively require additional 18 to 20 credits in the specified area in addition to the credits essential for obtaining the Under Graduate Degree in Major Discipline (i.e. 160 credits)"

2. Proposed Honours and Minor Degree:

Honours and Minor degree program is introduced in order to facilitate the students to choose additionally the specialized courses in the emerging areas of their choice and build their competence in such domains. Based on AICTE guidelines, the Faculty of Science and Technology has proposed to offer following Honours/ Minor degree program corresponding to each engineering program:

Table 1: Honours / Minor Degree Programs

Sr. No	Honours/Minor degree programs
1	Infrastructure Engineering
2	Smart Cities
3	Waterways Transport Engineering
4	Professional Practices in Structural Engineering
5	Green Technology and Sustainability Engineering
6	Infrastructure Policies & Regulations
7	Artificial Intelligence and Machine Learning

8	Blockchain
9	Cyber Security
10	Augmented Reality and Virtual Reality
11	Data Science
12	Internet of Things (IoT)
13	Waste Technology
14	Electric Vehicles
15	Microgrid Technologies
16	Robotics
17	3D Printing
18	Industrial Automation

The Honours and Minor degree programs selection for each of the engineering programs offered in University of Mumbai is as given in next section.

3. Mapping with Engineering/Technology Programs in University of Mumbai

Honour's/Minors degree program is being introduced by the Faculty of Science and Technology of University of Mumbai in order to facilitate the students to choose additionally the specialized courses in the emerging areas of their choice and build their competence in such domains. As per AICTE guidelines, Honours/Minors degree program to be chosen by eligible students (based on certain criteria given in manual) studying in third year of various Engineering program's are elaborated in **Table 2** to bring clarity to all stakeholders including students, faculty members and institutions. **Each eligible student can opt for maximum one Honour's or one Minor Programs at any time.**

Table 2: Honours and Minor Degree Program Mapping with Engineering Programs

	Honours / Minor Degree Programs	Programs who can offer this as the Honours Degree Program	Programs who can offer this as the Minor Degree program
Row	**Column A**	**Column B**	**Column C**
1	**Infrastructure Engineering**	**Civil Engineering**	1. Mechanical Engineering 2. Production Engineering 3. Automobile Engineering 4. Mechatronics Engineering 5. Printing and Packaging Technology 6. Electrical Engineering 7. Chemical Engineering 8. Electronics and Telecomm. Engineering 9. Electronics Engineering 10. Computer Engineering 11. Information Technology 12. Instrumentation Engineering 13. Electronics and Computer Science 14. Artificial Intelligence & Data Science 15. Cyber Security 16. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 17. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 18. Computer Science and Engineering (Data Science) 19. Artificial Intelligence & Machine Learning 20. Data Engineering 21. Internet of Things 22. Computer Science and Design

2	**Smart Cities**	**Civil Engineering**	1. Civil and Infrastructure Engineering 2. Mechanical Engineering 3. Production Engineering 4. Automobile Engineering 5. Mechatronics Engineering 6. Printing and Packaging Technology 7. Electrical Engineering 8. Chemical Engineering 9. Electronics and Telecomm. Engineering 10. Electronics Engineering 11. Computer Engineering 12. Information Technology 13. Instrumentation Engineering 14. Electronics and Computer Science 15. Artificial Intelligence & Data Science 16. Cyber Security 17. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 18. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 19. Computer Science and Engineering (Data Science) 20. Artificial Intelligence & Machine Learning 21. Data Engineering 22. Internet of Things 23. Computer Science and Design
3	**Waterways Transport Engineering**	**Civil Engineering**	1. Civil and Infrastructure Engineering 2. Mechanical Engineering 3. Production Engineering 4. Automobile Engineering 5. Mechatronics Engineering 6. Printing and Packaging Technology 7. Electrical Engineering 8. Chemical Engineering 9. Electronics and Telecomm. Engineering 10. Electronics Engineering 11. Computer Engineering 12. Information Technology 13. Instrumentation Engineering 14. Electronics and Computer Science 15. Artificial Intelligence & Data Science 16. Cyber Security 17. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 18. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 19. Computer Science and Engineering (Data Science) 20. Artificial Intelligence & Machine Learning 21. Data Engineering

			22. Internet of Things 23. Computer Science and Design
4	**Professional Practices in Structural Engineering**	**Civil Engineering**	1. Civil and Infrastructure Engineering 2. Mechanical Engineering 3. Production Engineering 4. Automobile Engineering 5. Mechatronics Engineering 6. Printing and Packaging Technology 7. Electrical Engineering 8. Chemical Engineering 9. Electronics and Telecomm. Engineering 10. Electronics Engineering 11. Computer Engineering 12. Information Technology 13. Instrumentation Engineering 14. Electronics and Computer Science 15. Artificial Intelligence & Data Science 16. Cyber Security 17. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 18. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 19. Computer Science and Engineering (Data Science) 20. Artificial Intelligence & Machine Learning 21. Data Engineering 22. Internet of Things 23. Computer Science and Design
5	**Green Technology and Sustainability Engineering**	**1 Civil Engineering** **2 Chemical Engineering** **3 Printing and Packaging Technology**	1. Civil and Infrastructure Engineering 2. Mechanical Engineering 3. Production Engineering 4. Automobile Engineering 5. Mechatronics Engineering 6. Electrical Engineering 7. Electronics and Telecomm. Engineering 8. Electronics Engineering 9. Computer Engineering 10. Information Technology 11. Instrumentation Engineering 12. Electronics and Computer Science 13. Artificial Intelligence & Data Science 14. Cyber Security 15. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 16. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 17. Computer Science and Engineering (Data Science) 18. Artificial Intelligence & Machine Learning 19. Data Engineering

			20. Internet of Things 21. Computer Science and Design
6	**Infrastructure Policies & Regulations**	**Civil and Infrastructure Engineering**	1. Civil Engineering 2. Mechanical Engineering 3. Production Engineering 4. Automobile Engineering 5. Mechatronics Engineering 6. Printing and Packaging Technology 7. Electrical Engineering 8. Chemical Engineering 9. Electronics and Telecomm. Engineering 10. Electronics Engineering 11. Computer Engineering 12. Information Technology 13. Instrumentation Engineering 14. Electronics and Computer Science 15. Artificial Intelligence & Data Science 16. Cyber Security 17. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 18. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 19. Computer Science and Engineering (Data Science) 20. Artificial Intelligence & Machine Learning 21. Data Engineering 22. Internet of Things 23. Computer Science and Design
7	**Artificial Intelligence and Machine Learning**	**1 Computer Engineering** **2 Electronics and Telecomm. Engineering** **3 Electronics Engineering** **4 Information Technology** **5 Electronics and Computer Science** **6 Mechatronics Engineering** **7 Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain)** **8 Cyber Security** **9 Computer Science and Engineering (Data Science)** **10 Internet of Things** **11 Data Engineering** **12 Computer Science and Design**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechanical Engineering 4. Production Engineering 5. Automobile Engineering 6. Printing and Packaging Technology 7. Electrical Engineering 8. Chemical Engineering 9. Instrumentation Engineering 10. Biomedical Engineering

8	**Blockchain**	**1 Computer Engineering** **2 Electronics and Telecomm. Engineering** **3 Electronics Engineering** **4 Information Technology** **5 Electronics and Computer Science** **6 Artificial Intelligence & Data Science** **7 Cyber Security** **8 Computer Science and Engineering (Artificial Intelligence & Machine Learning)** **9 Computer Science and Engineering (Data Science)** **10 Internet of Things** **11 Data Engineering** **12 Computer Science and Design** **13 Artificial Intelligence & Machine Learning**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechanical Engineering 4. Production Engineering 5. Automobile Engineering 6. Mechatronics Engineering 7. Printing and Packaging Technology 8. Electrical Engineering 9. Chemical Engineering 10. Instrumentation Engineering 11. Biomedical Engineering
9	**Cyber Security**	**1 Computer Engineering** **2 Electronics and Telecomm. Engineering** **3 Electronics Engineering** **4 Information Technology** **5 Electronics and Computer Science** **6 Artificial Intelligence & Data Science** **7 Computer Science and Engineering (Artificial Intelligence & Machine Learning)** **8 Computer Science and Engineering (Data Science)** **9 Internet of Things** **10 Artificial Intelligence & Machine Learning** **11 Data Engineering** **12 Computer Science and Design**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechanical Engineering 4. Production Engineering 5. Automobile Engineering 6. Mechatronics Engineering 7. Printing and Packaging Technology 8. Electrical Engineering 9. Chemical Engineering 10. Instrumentation Engineering 11. Biomedical Engineering
10	**Augmented Reality and Virtual Reality**	**1 Computer Engineering** **2 Electronics and Telecomm. Engineering** **3 Electronics Engineering** **4 Information Technology** **5 Electronics and Computer Science** **6 Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain)** **7 Artificial Intelligence & Data Science** **8 Cyber Security** **9 Computer Science and Engineering (Artificial Intelligence & Machine Learning)** **10 Computer Science and Engineering (Data Science)** **11 Internet of Things**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechanical Engineering 4. Production Engineering 5. Automobile Engineering 6. Mechatronics Engineering 7. Printing and Packaging Technology 8. Electrical Engineering 9. Chemical Engineering 10. Instrumentation Engineering 11. Biomedical Engineering

		12 Artificial Intelligence & Machine Learning **13 Data Engineering** **14 Computer Science and Design**	
11	**Data Science**	**1 Computer Engineering** **2 Electronics and Telecomm. Engineering** **3 Electronics Engineering** **4 Information Technology** **5 Electronics and Computer Science** **6 Mechanical Engineering** **7 Production Engineering** **8 Automobile Engineering** **9 Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain)** **10 Cyber Security** **11 Computer Science and Engineering (Artificial Intelligence & Machine Learning)** **12 Internet of Things** **13 Artificial Intelligence & Machine Learning** **14 Electrical Engineering** **15 Computer Science and Design**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechatronics Engineering 4. Printing and Packaging Technology 5. Chemical Engineering 6. Instrumentation Engineering 7. Biomedical Engineering
12	**Internet of Things (IoT)**	**1. Computer Engineering** **2. Electronics and Telecomm. Engineering** **3 Electronics Engineering** **4 Information Technology** **5 Electronics and Computer Science** **6 Electrical Engineering** **7 Mechanical Engineering** **8 Production Engineering** **9 Automobile Engineering** **10 Mechatronics Engineering** **11 Artificial Intelligence & Data Science** **12 Cyber Security** **13 Computer Science and Engineering (Artificial Intelligence & Machine Learning)** **14 Computer Science and Engineering (Data Science)** **15 Artificial Intelligence & Machine Learning** **16 Data Engineering** **17 Computer Science and Design**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Printing and Packaging Technology 4. Chemical Engineering 5. Instrumentation Engineering 6. Biomedical Engineering

13	**Waste Technology**	**Chemical Engineering**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechanical Engineering 4. Production Engineering 5. Automobile Engineering 6. Mechatronics Engineering 7. Printing and Packaging Technology 8. Electrical Engineering 9. Electronics and Telecomm. Engineering 10. Electronics Engineering 11. Computer Engineering 12. Information Technology 13. Instrumentation Engineering 14. Electronics and Computer Science 15. Artificial Intelligence & Data Science 16. Cyber Security 17. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 18. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 19. Computer Science and Engineering (Data Science) 20. Artificial Intelligence & Machine Learning 21. Data Engineering 22. Internet of Things 23. Computer Science and Design
14	**Electric Vehicles**	**1 Electrical Engineering** **2 Mechanical Engineering** **3 Production Engineering** **4 Automobile Engineering**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechatronics Engineering 4. Printing and Packaging Technology 5. Chemical Engineering 6. Electronics and Telecomm. Engineering 7. Electronics Engineering 8. Computer Engineering 9. Information Technology 10. Instrumentation Engineering 11. Electronics and Computer Science 12. Artificial Intelligence & Data Science 13. Cyber Security 14. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 15. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 16. Computer Science and Engineering (Data Science) 17. Artificial Intelligence & Machine Learning 18. Data Engineering 19. Internet of Things 20. Computer Science and Design

15	**Microgrid Technologies**	**Electrical Engineering**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechanical Engineering 4. Production Engineering 5. Automobile Engineering 6. Mechatronics Engineering 7. Printing and Packaging Technology 8. Chemical Engineering 9. Electronics and Telecomm. Engineering 10. Electronics Engineering 11. Computer Engineering 12. Information Technology 13. Instrumentation Engineering 14. Electronics and Computer Science 15. Artificial Intelligence & Data Science 16. Cyber Security 17. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 18. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 19. Computer Science and Engineering (Data Science) 20. Artificial Intelligence & Machine Learning 21. Data Engineering 22. Internet of Things 23. Computer Science and Design
16	**Robotics**	**1. Mechanical Engineering** **2. Production Engineering** **3. Automobile Engineering** **4. Printing and Packaging Technology** **5. Mechatronics Engineering** **6. Electrical Engineering**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Chemical Engineering 4. Electronics and Telecomm. Engineering 5. Electronics Engineering 6. Computer Engineering 7. Information Technology 8. Instrumentation Engineering 9. Electronics and Computer Science 10. Artificial Intelligence & Data Science 11. Cyber Security 12. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 13. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 14. Computer Science and Engineering (Data Science) 15. Artificial Intelligence & Machine Learning 16. Data Engineering 17. Internet of Things 18. Computer Science and Design 19. Biomedical Engineering

17	**3D Printing**	**1. Mechanical Engineering** **2. Production Engineering** **3. Automobile Engineering** **4. Printing and Packaging Technology**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechatronics Engineering 4. Electrical Engineering 5. Chemical Engineering 6. Electronics and Telecomm. Engineering 7. Electronics Engineering 8. Computer Engineering 9. Information Technology 10. Instrumentation Engineering 11. Electronics and Computer Science 12. Artificial Intelligence & Data Science 13. Cyber Security 14. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 15. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 16. Computer Science and Engineering (Data Science) 17. Artificial Intelligence & Machine Learning 18. Data Engineering 19. Internet of Things 20. Computer Science and Design
18	**Industrial Automation**	**Instrumentation Engineering**	1. Civil Engineering 2. Civil and Infrastructure Engineering 3. Mechanical Engineering 4. Production Engineering 5. Automobile Engineering 6. Mechatronics Engineering 7. Printing and Packaging Technology 8. Electrical Engineering 9. Chemical Engineering 10. Electronics and Telecomm. Engineering 11. Electronics Engineering 12. Computer Engineering 13. Information Technology 14. Electronics and Computer Science 15. Artificial Intelligence & Data Science 16. Cyber Security 17. Computer Science and Engineering (Artificial Intelligence & Machine Learning) 18. Computer Science and Engineering (Internet of Things & Cyber Security including Blockchain) 19. Computer Science and Engineering (Data Science) 20. Artificial Intelligence & Machine Learning 21. Data Engineering 22. Internet of Things 23. Computer Science and Design

4. Honours and Minor Degree Eligibility Criteria for Students:

In view of the above-mentioned guidelines issued by AICTE in APH 2020-21 for offering Honours and Minor degree in the various engineering programs, the following recommendations are proposed on the eligibility criteria for students opting for same;

i) **Eligibility criteria for opting the Honours/ Minor Degree program:**

   a. **Students with no backlog in semester I, II, and III**

   b. **The CGPI (based on semester I, II, and III) of the students must be 6.75 and above**

   c. **For direct second year (DSE) admitted students - No backlog in semester III and CGPI must be 6.75 and above**

ii) **Each eligible student can opt for maximum one Honour's or one Minor Programs at any time.**

iii) **However, it is optional for students to take Honours/Minor degree program.**

iv) **The Honours/ Minor degree program can be opted only during regular engineering studies**

v) **The student shall complete the Honours/ Minor degree program in stipulated four semesters only.**

5. Eligibility criteria for Department/Institute to offer Honours/Minor degree:

As the intention of offering the Honours degree program is to facilitate the advanced learners to build their competence in emerging areas with additional in-depth course work, it becomes very essential to ensure availability of such expert faculties and infrastructure with the departments and institutes. **The proposed modality of approval is self-assessment and declaration basis.** Institute can assess on following points before offering Honours/Minor degrees,

1. The Honours Degree program out of 18 programs listed in Table-1 can only be offered by an institute having the regular degree program running as specified in Table 2 column B.

2. Availability of Faculty expertise in domains of Honours/Minor degree programs

   a. Regular faculty on institute role who has completed PhD/Masters in same domain.

   OR

   b. Regular faculty on institute role who is doing research either sponsored by government agencies or industries or trusts.

   OR

   c. Regular faculty on institute role who has successfully completed certificate course in same domain and able to deliver the expectations of specialisation in emerging areas.

3. Availability of laboratory infrastructure/facilities in domains of Honours /Minor degree

   a. Established centre of excellence in same domain.

   OR

   b. Built research facilities to facilitate research in emerging areas

   OR

   c. Minimum facility is already developed to conduct hands on experience in chosen domains of Honours and Minor degrees.

6. Procedure of Starting Honours/Minor Programs:

Departments offering Honours/Minor Programs shall be assessed by Institute as per eligibility criteria mentioned in manual. Once found to be eligible fill the template of self assessment and send to Deputy Registrar Affiliation and Development Section, Fort Campus of University of Mumbai for information and simultaneously copy to Director Board of Examination and Evaluation, Examination House, Mahatma Phule Bhavan, Kalina campus of University of Mumbai. Affiliation section shall handover copy of same to LIC committee to verify correctness of self declaration, as and when appointed to visit for continuation of affiliation. Template to be used for self assessment and decleration form is given in **Table 3.**

Table 3. Self-assessment and Declaration form for starting Honours/Minor Programs under University of Mumbai

Name of Institute:		
Honours / Minor Program:		
Do you have regular program to offer Honours Program?		**Yes/No**
If Yes,		
Availability of **Regular Engineering Programs** (as specified in Table 2 column B of Honours and Minor Degree Program Manual Part-1)	**Following regular programs exists in Institute to offer Honours Program mentioned above,** 1. 2.	
Do you have availability of Faculty expertise as per criteria mentioned in manual to offer Honours Program?		**Yes/No**
If Yes, (Strike through whichever is not applicable)		
1.	**Regular faculty** on institute role who is doing research either sponsored by government agencies or industries or trusts.	**Yes** **No**
2.	**Regular faculty** on institute role who had completed either Phd or Masters in same domain of Honours Program.	**Yes** **No**
3.	**Regular faculty on institute role who has successfully completed certificate course** in same domain of Honours Program	**Yes** **No**
Do you have availability of laboratory facilities as per criteria mentioned in manual to offer Honours Program?		**Yes/No**
If Yes, (Strike through whichever is not applicable)		
1.	**Availability of** Established **Centre of Excellence** (**CoE**) in same domain of Honours Program	**Yes** **No**
2.	**Availability of Research Facilities built to** facilitate research in same domain of Honours Program.	**Yes** **No**
3.	**Availability of Minimum facility** to conduct hands on experience in same domain of Honours Program	**Yes** **No**
This is to certify that Departments offering honours programs is assessed and found that at least one of the eligibility norms in each of the three eligibility criteria has been found fulfilling. Hence forwarded application for starting Honours program in "……..." to University of Mumbai. **Head of Institute sign and seal** (Enclosure: Supporting documents of fulfilling criteria's)		

7. Examination Process and Result Declaration

In current scenario First Year and Final Year of engineering examinations, assessments and result declaration are entirely done by University, while as in Second and Third Year question papers are delivered by University, assessment and results preparation and declaration after approval from university is done by Institute on behalf of University following all ordinances and regulations of university. Honours/Minor degrees courses will be offered in Third and Final Year of engineering as specialisation in emerging areas.

By keeping in mind availability of expertise of faculty with particular Institute only, proposed following modalities of Examination and Evaluation,

Internal Assessment Examination:

1. Two Internal Assessment (IA) tests shall be carried out at institute level for each subject of Honours / Minor programs as per the directives given in the scheme and the syllabus.

End Semester Examination:

1. Question papers of End Semester Examination for each subject shall be prepared by the paper setter panel appointed by University of Mumbai.
2. End Semester Examination answer-books evaluation (for sem. V, sem. VI, sem. VII and sem. VIII) of subjects offered at each Honours / Minor programs shall be carried out by respective institute at institute level by the examiners appointed by Principal from the panel provided by University.
3. Moderation-moderation of the answer books shall be carried out as per the existing rules applicable as per ordinance **O.5046-A** to the regular examination by the moderator appointed by Principal from the panel provided by the university.
4. Revaluation- Revaluation of the answer books shall be carried out as per the existing rules applicable to the regular examination by the examiners appointed by Principal
5. Each institute shall process the result applying ordinance **O.5042-A** and prepare the gazette copy of the results for respective semester for each Honours / Minor programs offered. Institutes shall submit results for moderation and approval to University similar to process of semester II to VI. Institute shall maintain the record of each student for each of the Honours / Minor programs offered till the completion of the Sem VIII end sem. examination.
6. University shall create portal for getting all marks and status of students results of Honours/Minor Programs. University shall issue common grade sheet of Honours/Minors Programs after the successful completion of all semesters including 8^{th} semester (final semester of their regular program).
7. If the students compeletes the Honours / Minor program but fails in Sem VII / VIII, he/ she will not get any degree at that point of time, but both after passing regular degree program and Honours/ Minor program. However, the Honours/ Minor program should be completed in four semesters only.
8. The following **ordinances** are not applicable to Honours/Minors programs as these are applicable for entire examination and overall results of semesters.
    - **i. O.5043-A**
    - **ii. O.5044-A**
    - **iii. O.5045-A**
    - **iv. O.229**

8. Award of Degree Certificates:

University shall make provision of two types of degrees, one without and with honours/ Minors program;

1. Degree certificate without honours/minors programs shall be one, which is currently issued.

2. The students successfully completing the Honours / Minor program Degree shall be awarded with the degree designated as: “B. E. in ……(regular) Engineering with Honours/Minor in …….. (specialization)”

Example 1: Students s successfully completing BE in Mechanical Engineering with specialization (Honours) in 3D Printing shall get a degree as “B.E. in Mechanical Engineering with Honours in 3D Printing”

Example 2: Students successfully completing BE in Electrical Engineering with specialization (Minor) in 3D Printing shall get a degree as “B.E. in Electrical Engineering with Minor in 3D Printing”

9. Honours and Minor Degree Program Scheme and Structure:

Honours and Minor degree program be offered from academic year 2022-23 onwards along with Rev 2019 ‘C’ scheme syllabus.

Honours and Minor credit courses will be offered from Semester V onwards to Semester VIII, scheme structure of syllabus is given in **Table 3**

Table 3. Template for Honours/ Minor degree program syllabus scheme

University of Mumbai Honours in ---------- (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar /Tutorial	Pract.	Internal Assessment	End Sem. Exam	Term Work	Oral	Total	Credits
TE Sem. V	**HXXC501: Subject 1**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
TE Sem. VI	**HXXC601: Subject 2**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
BE Sem. VII	**HXXC701: Subject 3**	04	--	--	20	80	--	--	100	04
	HXXSBL701: Lab-1	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
Total Credits = 06										
BE Sem.VIII	**HXXC801: Subject 4**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										
Reference: https://www.aicte-india.org/sites/default/files/APH%202020_21.pdf (page 99-101)										

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

University of Mumbai

Syllabus

Honours/Minor Degree Programs

(with effect from 2022-2023)

Faculty of Science and Technology

UNIVERSITY OF MUMBAI
Honours/Minor Degree Programs
(with effect from 2022-2023)

Note: Course code format used in the document

1. Course Code: HXXC-Z01: (example- HEVC-501)
   H stands for Honours/ Minor course
   XX : Abbrevation of Program code: eg. For Electric Vehicles- it is 'EV'
   C- Theory Course
   Z for semester. For sem 5 -> 501

2. Skill Based Lab Code: HXXSBL-Z01: (example- HEVSBL-701)
   H stands for Honours/ Minor course
   XX : Abbrevation of Program code: eg. For Electric Vehicles- it is 'EV'
   SBL- Theory Course
   Z for semester. For sem 7 -> 701

University of Mumbai

Syllabus

Honours/Minor Degree Program

in

Infrastructure Engineering

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Infrastructure Engineering (With effect from 2022-23)										
Year &Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HIEC501: Transportation Infrastructure**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HIEC601: Energy and IT Infrastructure**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HIEC701: Geographic Information System**	04	--	--	20	80	--	--	100	04
	HIESBL701:Lab1 Geographic Information System	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**--**	**50**	**200**	**06**
									Total Credits =	**06**
BE Sem. VIII	**HIEC801: Infrastructural Planning and Management**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Infrastructure Engineering: Semester-V		
Subject Code	**Subject Name**	**Credits**
HIEC501	**Transport Infrastructure**	4

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

Urban sprawl worldwide is causing tremendous pressure on transport infrastructure. Transportation infrastructure is one of the most important factors for a country's progress. The complex network of connections between coastal ports, inland ports, rails and air routes is the 'lifeline' of a nation and it forms a foundation of economic development. Transportation is an important sector of the economy in its own right and that has been proven by so many instances how transport infrastructure has added speed and efficiency to a country's progress. India has a large and diverse transport sector with its own share of challenges and students will be conversant with transport infrastructure, diverse Transportation needs and equipments after completion of this course.

Objectives

1. To understand the fundamentals of infrastructure and different modes of transportation globally and current state of affairs in India
2. To illustrate the types of modern highways, bridges and tunnels required for the transport infrastructure.
3. To identify the Mass Transit systems, for end to end transport and the structural systems required for the same.
4. To design airport infrastructure mechanism
5. To classify water way infrastructure
6. To study all the important tools and equipments required for the efficient functioning of Transportation infrastructure.

Module	Contents	Hours
1	**Introduction to Infrastructure:** Definition of infrastructure, Need of infrastructure, different forms of infrastructure, physical and social infrastructure, role of infrastructure in the development of a nation, Transportation scenario globally and in India; Overview of various transport systems in India-rail, road, air, waterways. Major organizations and players in the field of transport infrastructure	07
2	**Modern Highways**: Roads, Planning concepts, Uninterrupted traffic systems, Signal free intersections, Freeway, Expressway, Service roads, bye pass, Turnpike.	10

	Bridges and Tunnels: Classification based on Structural Materials like Steel, RCC, Pre-stressed concrete or Composite. Bridge types based on structural behaviour such as Beam bridge, Truss Bridge, Arch Bridge, Suspension& Cable stayed cantilever and special purpose bridges. Tunneling Methods: Types and purpose of tunnels; factors affecting choice of excavation technique; Methods – soft ground tunneling, hard rock tunneling, shallow tunneling, deep tunneling; Supports in Tunnels: Different types of supports in tunneling and their applicability.	
3	**Mass Transit system**: trains, ferries, buses, trams, Rapid mass transit systems such as subways and surface light rail systems, Cable cars, Various types of guided transport, tube, U-Bahn, metropolitan or underground, Metro rails, Structural components and their selection criteria.	07
4	**Airport Planning**: Airport Master Plan, Airport Site Feature, Economic and Financial feasibility, Zoning around airports, design considerations for Apron, Runway, Taxiway, Hangar. **Air traffic control**: radar, satellite navigation, One way, Two-way radio communication. ATC assistance during Departure, En-Route, Descent, Approach and Landing.	08
5	**Waterways transportation**: History of water transportation, policies related to water transportation in India. Status of river, canals and ocean transportation in India. Modes of water transport - pontoons, amphibians, hovercrafts, boats, ships, water taxi. Advantages and disadvantages of water transportation. **Ports harbours and docks**: Historical development of Port, Docks and Harbour. Port building facilities, Classification of harbours, Requirement of Harbour, Jetty, Harbour components, characteristics of good harbour and principles of harbour planning	09
6	**Modern surveying tools** - Drones, satellite survey, GIS software, GPS system, Total station, Electronic Distance Measurement (EDM) Instruments **Modern Equipment**- Dumper trucks, dozers, vibratory rollers, graders, tunneling equipments, lifting equipments (Cranes), sand washing equipments, earth movers, different excavators, wheel tractor scraper, trenchers, loaders, pile boring and pile driving machine, concrete mixers. concrete batching/mixing plant, concrete pumps, slip forms, concrete vibrator, hot mix plant	11

Contribution to Outcomes

After completion of the course work, students will be able to,

1. Understand the fundamentals of infrastructure and different modes of transportation
2. Illustrate the types of modern highways, bridges and tunnels along with tunnelling methods required for the transport infrastructure.
3. Identify the mass transit system in transport infrastructure
4. Design different components of airport infrastructure along with it's economical and financial feasibility
5. Classify different modes of water transportation and evaluate the principles of harbour planning
6. Study different modern surveying tools and modern equipment required for transport infrastructure

Theory Examination:-

1. The question paper will comprise **six** questions; each carrying 20 marks.
2. The **first** question will be **compulsory** that will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The remaining **five** questions will be based on all the modules. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. There can be an **internal** choice in various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
5. The students will have to attempt any **three** questions out of remaining five questions.
6. A total of **four** questions need to be attempted.

Text Books:-

1. A Sustainable Vision for Urban India, Jain A K, Publisher: Kalpaz Publications
2. Highway Engineering, C. E. G. Justo and S. K. Khanna, Nem Chand & Bros; 10th Edition 2015 (1 January 2001)
3. Railway Engineering, M. M. Agarwal and Satish Chandra, Oxford University Press.
4. Design of Bridges, N. Krishna raju, Oxford and IBH Publishing
5. Airport Engineering: Planning And Design by Saxena S C , CBS Publication
6. Airport planning and design, S.K. Khanna, S. S Jain, M.G Arora , Nem Chand Brothers; 6th edition (January 1, 1999)
7. Inland Water Transport in India by R.P. Misra published by Prasaranga, University of Mysore in 1972.
8. Docks and Harbour Engineering: Dr. S.P Bindra, Dhanpatrai Publications, India
9. Harbour, Dock and Tunnel Engineering: R. Srinivasan, Charotar Publication, India
10. Remote sensing and Geographical Information System, By A. M. Chandra and S. K. Ghosh, Narosa Publishing House.
11. Advanced Surveying -Total Station, GIS and Remote Sensing by Satheesh Gopi, R. Sathikumar and N. Madhu, Pearson publication
12. Surveying Vol. 2 by S. K. Duggal, McGraw Hill Publication

Recommended Books:-

1. Introduction to Infrastructure: An Introduction to Civil and Environmental Engineering, Michael R Penn
2. Remote Sensing & GIS,2/E—Bhatta– Oxford University Press
3. Modern Construction Equipment and Methods by Frank Harris
4. Construction Planning, Equipment, and Methods (McGraw-Hill Series In Civil Engineering) by Robert L Peurifoy), Clifford J. Schexnayder, AviadShapira
5. Driving Horizontal Workings and Tunnel, by Pokorovski, Mir Publishers, 1980.
6. Harbour, Dock and Tunneling Engineering by R. Srinivasan Published by Charotar Publication

Infrastructure Engineering: Semester-VI		
Subject Code	**Subject Name**	**Credits**
HIEC601	**Energy and IT Infrastructure**	**4**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

The power infrastructure consists of generation, transmission, and distribution systems that are essential to all other infrastructures and every aspect of the economy. In India, various sources of energy are used to generate power. These include coal, natural gas, hydro, nuclear, and renewable (includes solar, wind, small hydro and biomass). Telecommunications infrastructure is a physical medium through which all Internet traffic flows. This includes telephone wires, cables and mobile technology such as fifth-generation (5G) mobile networks. The IT infrastructure consists of all elements that support the management and usability of data and information. These include the physical hardware and facilities (including data centers), data storage and retrieval, network systems, legacy interfaces, and software to support the business goals of an enterprise.

Objectives

1. Evaluate energy infrastructure and hydroelectric power plant.
2. Classify the tidal, wind and solar energy and its operation
3. Explain nuclear energy infrastructure, policies and regulations for establishing nuclear power plant and issues related to radioactive waste
4. Design criterions for telecommunication tower
5. Describe the fundamental elements of IT infrastructure
6. Design criterions for development of smart grid networks

Module	Contents	Hours
1	**Introduction to energy infrastructure**: Types of electrical generation; generation system architecture; power plant planning and design. **Hydroelectric infrastructure**: Site selection; classification; hydrographs; storage and pondage; essential elements; selection of turbines, environmental impact assessment.	04
2	**Tidal energy infrastructure**: Fundamentals of tide; wave theory, loading and energy; operating principle - oscillating device; turbine characteristics; devices; moorings and anchors; foundations. **Wind energy infrastructure**: Offshore and onshore wind; properties of wind; wind resource assessment; wind turbine blades; wind turbines in grid; wind projects.	06

	Solar energy infrastructure: Basics of solar PV, fundamentals of the design of solar energy fields; concentrated solar power plant; solar water heating systems	
3	**Nuclear energy infrastructure**: Policy and regulations; economics and financing of nuclear power plants; nuclear technology selection and project implementation; fuel supply, radioactive waste and management; issues; environmental impact	10
4	**Telecommunication** – Definition, use, functions, and components, site surveys- raw land tower site survey and boundary survey, classification of telecommunication towers, Telecommunication signals, Design of towers – configuration, tower erection, transmission lines construction, operation and maintenance of distribution systems.	13
5	**IT infrastructure** – components of IT infrastructure, Internet and world wide web, design, planning, and implementation of networks and servers, storage management , Backup / Restore Methodology, Remote Access, Control, Administration.	12
6	**Smart grid, transmission and distribution**: Grid resilience; environmental performance; operational efficiencies; network architecture; transmission systems; wide area monitoring, protection and control, transmission and distribution architecture; micro grids; vulnerability; peak load shifting and grid storage.	07

Contribution to Outcomes

After completion of the course work, students will have ability to

1. Explain generation of hydroelectric power and its impact on environment
2. Classify and design infrastructure for non conventional energy sources
3. Describe the policies and regulations for nuclear power plant, infrastructural requirement and its environmental impact assessment
4. Evaluate the components and functions of telecommunication
5. Summarize the fundamental elements of IT infrastructure such as networks and servers, storage and remote access
6. Design and develop smart grid networks for transmission and distribution of the energy

Theory Examination:-

1. The question paper will comprise **six** questions; each carrying 20 marks.
2. The **first** question will be **compulsory** that will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The remaining **five** questions will be based on all the modules. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. There can be an **internal** choice in various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
5. The students will have to attempt any **three** questions out of remaining five questions.
6. A total of **four** questions need to be attempted.

Text Books:-

1. Textbook of Renewable Energy (Wood head Publishing India in Energy) ,by S.C. Bhatia , R.K. Gupta
2. P. Jain, Wind Energy Engineering, McGraw-Hill.
3. Nuclear Power in India by N. Sharma, B. Banerjee, Rupa Publication 2008
4. Environmental Issues for 21st Century by S. P. Dasgupta, Mittal Publication.
5. Steve Morris, Up the Tower: The complete Guide to Tower Construction, Champion Radio Products Brian W. Smith, Communication Structures, Thomas Telford publications
6. ICT in Urban services, Compendium of global good practices, National Institute of Urban affairs, http://pearl.niua.org/sites/default/files/books/GPGL1_ICT.pdf
7. Fundamentals of telecommunication- https://www.net.t-labs.tuberlin.de/teaching/computer_networking/documents/telecomm_fundamentals.pdf

Recommended Books:-

1. Hydroelectric Energy, Renewable Energy and the Environment By Bikash Pandey, Ajoy Karki, ISBN 9781439811672 CRC Press
2. Tidal Energy Systems, 1st Edition, Design, Optimization and Control, Vikas Khare Cheshta Khare Savita Nema Prashant Bareda, Elsevier
3. E book on Energy Law in India by Mohammad Naseem, Saman Naseem, 2017, publisher Wolters Kluwer
4. Graham, S. and Marvin, S. Planning Cybercities Integrating Telecommunications into Urban Planning, The town planning review, 70(1), Liverpool University Press
5. S. Borlase (2013) Smart Grid Infrastructure, Technology, and Solutions, CRC Press. ISBN 9781439829103.
6. L.F. Drbal, P.G. Boston, K.L. Westra, R.B. Erickson (1996) Power Plant Engineering, Kluwer Academic Publishers. ISBN 9781461380474.
7. D. Greaves, G. Iglesias (2018) Wave and Tidal Energy, John Wiley & Sons Ltd. ISBN 9781119014454.
8. S. A. Kalogirou (2009) Solar Energy Engineering Processes and Systems, Elsevier. ISBN 9780123745019.
9. Basic Infrastructure for a Nuclear Power Project (2006) Technical Report, CI#128 IAEA. ISBN 9201085060.
10. Kiessling, F., Nefzger,P., Nolasco,J.F., Kaintzyk,U., (2003), Overhead Power Lines Planning Design Construction, 4th Edition, Springer
11. Ganguli, S.K., Kohli,V., (2016), Power Cable Technology, CRC Press

Infrastructure Engineering: Semester-VII		
Subject Code	**Subject Name**	**Credits**
HIEC701	**Geographic Information Systems**	**4**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

Geographic information system (**GIS**) is a computer system for capturing, storing, checking, and displaying data related to positions on Earth's surface. By relating seemingly unrelated data, GIS can help individuals and organizations better understand spatial patterns and relationships. IS technology is a crucial part of spatial data infra-structure. Many different types of information can be compared and contrasted using GIS. The system can include data about people, such as population, income, or education level. It can include information about the landscape, such as the location of streams, different kinds of vegetation, and different kinds of soil. It can include information about the sites of factories, farms, and schools, or storm drains, roads, and electric power lines. Use of Geographic's Information system in all infrastructures will enhance the social, economic, development of India in all aspects.

Objectives

1. To understand the fundamentals of GIS, basics tools, and its applications in all branches of Civil and infrastructure Engineering.
2. To Illustrate the variousComponent of GIS, co-ordinate systems for creations of vector data and raster dataset by using various GIS tools.
3. To understand Basic geodata base system for Creation of various types of maps.
4. To create various thematic maps by using the vector Data set as well as raster data set.
5. To analyze spatial Data for solving real word problems.
6. To apply GIS output data for solving real life problems.

Module	Contents	Hours
1	**Introduction to Geographic Information System** GIS: History, Development of GIS, Objective of GIS, Advantages of GIS.	03
2	**Introduction to Maps:** Definition, Scale, Types of Maps, elements of Map, Projection Coordinate Systems: Geographic, rectangular and Polar – Transformation, types and application. **GIS:** What is GIS, components of GIS, its applications, open source softwares.	09

3	**DBMS: -**Database Management system – function – types – advantages, Introduction to Toposheet. Various open data sources. **GIS Data Model**: Spatial Data Types- , Vector data, Raster data, TIN (Triangulated reregulated network) data model, comparison of Vector &raster data, Non spatial data (attributes) & its types. Preprocessing of spatial data set.	10
4	**GIS input data:** **Vector Data: -**Sources for GIS Data Shape files, Vector Data Input – Georeferencing, Map digitization and editing, and Topology – Topological Relationship. **Raster Data Input** – Digital Elevation Mode (DEM)- Introduction to DEM, types of Dem, Uses of Dem & different types of resolution, Introduction to satellite images, image classification, Quality assessment of freely available Digital Elevation Model, Raster File Formats, Vector File Formats – Raster to Vector and Vector to Raster Conversion.	12
5	**GIS Data Analysis**: Introduction to GIS data Analysis – Data selection, reclassification, overlaying analysis, Buffer Analysis, Spatial Analysis (Dem Analysis,) Surface Analysis, Network Analysis, proximity Analysis, Vector & Raster Analysis Methods. Error in GIS and key elements of maps.	12
6	**GIS Output Design and Presentation** Introduction - Spatial and non-spatial data presentation - Map layout – Charts, graphs and multimedia output, elements of spatial data quality, Meta data and introduction to web GIS.	06

Contribution to Outcomes

After completion of the course work, students will be able to,

1. Explain GIS applications in various fields
2. Illustrate the types of maps, their characteristics and different co-ordinate system, Components of GIS& Familiar with new GIS software.
3. Compare the basics of Data Base Management system for GIS - vector data set, raster data set & Produce an error free GIS database for civil engineering applications.
4. Create & design basic database like creation of shape files, vector data set, raster data set & Produce an error free GIS database for civil engineering applications
5. Analyze GIS Data which includes creating buffers, Clipping Features, raster data analysis, vector Data Analysis and Dissolve Features.
6. Application of spatial data output along with quality assessment for applications in Civil & Infrastructure Engg.

Internal Assessment (20 Marks):

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

End Semester Examination (80 Marks):

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

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

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

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

4) The students will have to attempt any **three** questions out of remaining five questions

5) Total Four questions need to be attempted.

Text Books:-

1. Remote Sensing and Geographic Information System, By A.M. Chandra and S.K. Ghosh, Narosa Publication House.
2. Remote Sensing: Principles and Applications by B C Panda.
3. Geographic Information System by Jatin Pandey .
4. Remote Sensing and GIs by Basudeb Bhatta, Oxford University.

Recommended Books:-

1. Jonathan Campbell and Michael Shin, Essentials of Geographic Information Systems, 2011, Saylor Foundation, ISBN: 9781453321966.
2. Michael N. DeMeres, Fundamentals of Geographic Information Systems, 4th Edition, 2009, Wiley, ISBN: 9780470129067
3. NPTEL GIS web course.

Infrastructure Engineering: Semester-VII		
Subject Code	**Subject Name**	**Credits**
HIESBL701	**Geographic Information System – Lab**	**2**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**4**	**-**	**-**	**2**	**-**	**2**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
-	-	-	-	-	50	-	50	100

Objectives

1. To acquire basic knowledge of Geographic Information System Lab practices and applying it for solving real life problem in Civil & Infrastructure Engineering.
2. To illustrate basic GIS-terms which are connected to data processing by means of exercises
3. To prepare basic geo data for Spatial and non spatial Analysis.
4. To apply Google earth in Geographic information system for preparation of various shapes files, preparation of vector data set.
5. To analyze basic geodata base by using various tools.
6. To convert GIS output into various thematic maps for solving various real life problems in Civil – infrastructure Engineering.

List of Experiments

Module	Contents	Hours
1	Getting started with GIS software (QGIS, ArcGIS) & data collection from various free available sources.	**4**
2	Georeferenceing and projection of toposheet, Digitization of map/ Toposheet.	**4**
3	Creation of thematic maps, Base Map preparation, Data Conversion – Vector to Raster, Raster to Vector.	**4**
4	Google earth integrations in GIS.	**4**
5	Vector analysis and Raster analysis, adding attribute data – quarries on attribute data, Map composition.	**4**
6	Developing Digital Elevation Model, its application & analysis.	**4**
7	A case study of GIS applications.	**4**

Contribution to Outcomes

Learner will be able to…

1. Apply the installation of GIS software's and various tools.
2. Explain various Database structure like vector data, raster data set.
3. Prepare and convert vector data set into raster data set.

4. Interpret Google earth with GIS.
5. Perform various types of Analysis on raster data, vector data.
6. Transform GIS output by preparation of various thematic maps.

GIS Software's: Arc GIS 10.3, QGis.

Assessment

Term Work Including

Laboratory work : 25 Marks

Case Study/Report/Tutorial: 20 Marks

Attendance: 05 Marks

End Semester Oral Examination

Oral examination will be based on the entire syllabus.

Text Books:-

1. Remote Sensing and Geographic Information System, By A.M. Chandra and S.K. Ghosh, Narosa Publication House.
2. Remote Sensing: Principles and Applications by B C Panda.
3. Geographic Information System,by JatinPandey .
4. Remote Sensing and GIs by Basudeb Bhatta, Oxford University.

Recommended Books:-

1. Jonathan Campbell and Michael Shin, Essentials of Geographic Information Systems, 2011, Saylor Foundation, ISBN: 9781453321966.
2. Michael N. DeMeres, Fundamentals of Geographic Information Systems, 4th Edition, 2009, Wiley, ISBN: 9780470129067
3. NPTEL GIS web course.

Infrastructure Engineering: Semester-VIII		
Subject Code	**Subject Name**	**Credits**
HIEC801	**Infrastructural planning and management**	**4**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

Infrastructure is the resources required for a society and its economy to function. Infrastructure Planning primarily relates to new infrastructure creation but also phasing out of deficient and outdated infrastructure when it is cost-effective.

Economic infrastructure is an internal facility of a country that make business activity possible, Such as communication, transportation and distribution networks, financial institutions and markets, and energy supply systems. Economic infrastructure definitely ensures the mobility of labour and capital within/from the economy. It results in the overall growth of towns and cities. Infrastructures provide for a lot of employment generation and employment opportunities. They also play a crucial role in national defense activities.

Objectives

1. To understand the infrastructural scenario in India and opportunities and challenges to be faced in road development.
2. To understand the Infrastructure economics, finance and social environmental risk in infrastructure
3. To Realizing the real-world risks and challenges in managing infrastructure.
4. To identify the needs in urban infrastructure development and recycling technologies
5. To Understand the impact of infrastructural projects on environment
6. To analyse success and failure of measure infrastructural projects in India

Module	Contents	Hours
1	**Introduction-** Infrastructure scenario in India, transportation, power and telecom sectors, urban and rural infrastructure in India, road infrastructure development in India, rural roads development in India-opportunities and challenges	06
2	Infrastructure economics and finance, project structuring and risk allocation in project finance, Public-Private Partnership (PPP) for infrastructure- case studies, risk management in infrastructure projects, term sheet development economic and social e4nvironmental risk in infrastructure,	08
3	Project Governance, public sector governance, strategies for governing against infr6astructure project turbulence, the governance model, data–base management,	10

	actor mapping and social network analysis, fair process and negotiations, design thinking, life cycle and benefit cost analysis	
4	Innovative infrastructure financing, urban infrastructure needs in India and funding options, new and innovative materials for long lasting road infrastructure, green highways –recycling technology, durable road infrastructure –options and recent developments, polycentric governance and incomplete design, successful project delivery strategies.	10
5	Environmental impact assessment: Tools, impact on air ,water, soil & Noise, Role of Biodiversity impact Assessment, Identification ,Prediction &Evaluation of Impacts on Biodiversity, Techniques of Biodiversity impact assessment, E I A Report Preparation	10
6	Case Studies: Case studies for 1)BOT 2)Dams 3)Mass Transit System 4)Government Funded Projects	08

Contribution to Outcomes

Students will have the ability to

1. Explain Indian Infrastructural framework and future challenges.
2. Analyze the infrastructure projects based on various risks.
3. Develop critical thinking on a variety of novel solutions or fixes which aids in execution infrastructure projects better.
4. Design innovative methods for long lasting infrastructure and understand the successful project delivery strategies.
5. Analyze the effect of infrastructural projects on environment.
6. Apply the design methodologies to the real world case studies

Theory Examination:-

1. The question paper will comprise **six** questions; each carrying 20 marks.
2. The **first** question will be **compulsory** that will have short questions having weightage of 4-5 marks covering the entire syllabus.
3. The remaining **five** questions will be based on all the modules. For this, the module shall be divided proportionately further, and the weightage of the marks shall be judiciously awarded in proportion to the importance of the sub-module and contents thereof.
4. There can be an **internal** choice in various sub-questions/ questions in order to accommodate the questions on all the topics/ sub-topics.
5. The students will have to attempt any **three** questions out of remaining five questions.
6. A total of **four** questions need to be attempted.

Text Books:-

1. Infrastructure Planning and Management (2018) by Prof. Ashwin Mahalingam NPTEL. https://nptel.ac.in/courses/105/106/105106188/
2. Projects planning, Analysis Selection, Implementation and Review, Prasanna Chandra Tata McGraw Hill, New Delhi, 2005
3. Vasant Desai, “Project Management”, Himalaya Publishing, 1st Edition, 2010
4. Arbitration”, Jubilee Publications, 2nd Edition., 1996 Engineering Contracts and B. J. Vasavada, “

5. Construction Management & PWD Accounts --- D Lal, S. K. Kataria & Sons, 2012
6. Fundamentals of Engineering Economics—Pravin Kumar, Wiley, India

Recommended Books:-

1. Goodman AS, Hastak M (2006). Infrastructure planning handbook: planning, engineering, and economics. New York: ASCE Press.
2. Miller R, Lessard DR (2001). The strategic management of large engineering projects: Shaping institutions, risks, and governance. MIT press.
3. J. Parkin and D. Sharma, Infrastructure planning, Thomas Telford, London, 1999.
4. Construction project scheduling and control ----Mubarak, Wiley India
5. Construction Management: Planning and finance-- Cormican D. Construction press, London, Feb 2002.

University of Mumbai

Syllabus

Honours/Minor Degree Program

in

Smart Cities

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Smart Cities (With effect from 2022-23)										
Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/ Tutorial	Pract	Internal Assess-ment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HSCC501: Smart City Planning and Development**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
TE Sem VI	**HSCC601: Smart City-Project Management**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
BE Sem VII	**HSCC701: Smart Urban Infrastructures**	04	--	--	20	80	--	--	100	04
	HSCSBL701: Lab-1: Smart City-Project Management	--	--	02	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
Total Credits = 06										
BE Sem VIII	**HSCC801: Smart Management of Smart Urban Infrastructures**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
Total Credits = 04										
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Smart Cities: Semester V		
Course Code	**Course Name**	**Credits**
HSCC501	**Smart City Planning and Development**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

Today, more than 54% of the world's total population lives in urban areas. It is projected that urbanization will continue in the coming years, raising the urban population to 6.0 billion people by 2045. The significant increase in urban population will put awesome load on urban infrastructure which results in increasing the demand for energy, mobility, water, and other urban services in cities. So, cities have to become smarter in provision of urban services. Also due to the global awareness about negative environmental impacts of pollution, cities are feeling more pressure to improve their environmental performance, while improving their level of services. Increasing demand for sustainable, inclusive, reliable and efficient urban service puts our urban infrastructures under a huge pressure. But digitalization provides a powerful tool to address these issues and create a paradigm shift in our concept of cities. Due to this novel nature of smart cities, it is important that policymakers, urban managers and other relevant actors be prepared to understand and address the challenges that the transition will bring about. This course will provide the basic principles that to consider for a successful transition into a smart city.

Objectives

1. Enable students in understanding the concepts, discourses and practices of "Smart Cities" across the Globe.
2. To develop competence in planning projects at the city level to ensure sustainability of environment and human beings.
3. Apply smart technologies across the spectrum of infrastructure and governance.
4. Develop overall city strategy to become contemporary and competitive.
5. Enable students to understand city centric capital formation and finance, risk and feasibility to ensure the economic health of the city.
6. Develop overall smart cities and villages.

Detailed Syllabus		
Module	**Course Module / Contents**	**Hours**
1	**Introduction to Smart Cities-**	09

	1.1	Definition and concept of smart city, Introduction to City planning, Introduction to Development Control Rules, Building Bye Laws	
	1.2	Conventional Vs. Smart city, Understanding Smart City	
	1.3	Various approaches to smart city, Pan city concept	
	1.4	Challenges of Urbanization, Smart City Characteristics	
2	**Smart City Standards-**		09
	2.1	Smart City Planning and Development, Dimensions of Smart Cities	
	2.2	Government of India initiatives "100 Smart Cities" Policy and Mission	
	2.3	Global experience of smart cities	
	2.4	Smart cities –Global standards	
	2.5	Smart cities-Performance benchmarks	
	2.6	Smart cities-Practice codes	
3	**Important sectors of smart city**		09
	3.1	Various sectors in smart city, Smart building and home device	
	3.2	Smart water, Smart Transportation, Smart Health, Smart Energy, smart public service	
	3.3	Cyber security, Safety and privacy, Concept of smart community	
	3.4	Concept of Digitalization, brief information about the various tools used for digitalization such as- ICT, IoT, Sensors, Artificial Intelligence	
4	**Governance of Smart Cities-E-Governance**		09
	4.1	Introduction to smart E-Governance, Smart E-Governance for Citizen services	
	4.2	Smart E-Governance for Industries and Commerce	
	4.3	Smart E-Governance within Government	
	4.4	Envisaging Future Smart E-Governance	
	4.5	Models for smart Governance	
	4.6	Regulatory Guidelines and Standards for E-Governance	
5	**Smart Citizen Services**		08
	5.1	Smart leadership and strategy; Stakeholder's engagement	
	5.2	Smart healthcare	
	5.3	Smart education, skill development centers, incubation/ Trade facilitation centers	
	5.4	Safety and security of citizens particularly women, children and the elderly people	
6	**Green Building in Smart Cities and Smart Villages-**		08
	6.1	Sustainability, smart housing, Green buildings, Rating system of Green Building	
	6.2	Energy efficient buildings, Energy Saving System in buildings	
	6.3	Introduction to Rural Planning and Development, Understanding Concept of Smart Village, Issues of Smart Village	
	6.4	Smart Village Performance Benchmark, Smart Village Policy and Mission, Planning and Management of Smart Village, Financing Smart Village	

Contribution to Outcome

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

1. Conceptualize cities as socio-technical systems
2. Evaluate the main impacts of information and communication technologies on urban infrastructures and services.
3. Describe the main steps and considerations of the smart city transition.
4. Compare the main managerial and governance challenges of developing and managing a smart city.
5. Apply such concepts and tools in the case of smart water and smart housing systems.

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

Reference Books:

1. “Smart Cities Unbundled” by, Sameer Sharma, Bloomsbury Publishing India Pvt. Ltd.
2. **“**Introduction to Smart Cities” by P.P. Anil Kumar, Pearson Publications
3. “Smart Cities & Urban Development in India “by N. Mani, New Century Publications
4. “Smart City” by Arun Firodia, Vishwakarma Publications.
5. “The Smart City Transformations: The Revolution of the 21st Century” by Amitabh Satyam & Igor Calzada, Bloomsbury Publishing India Pvt. Ltd.
6. “Financing Cities in India: Municipal Reforms, Fiscal Accountability and Urban Infrastructure” by, Prasanna K. Mohanty, SAGE publications India pvt. Ltd.
7. “Transforming Our Cities: Facing Up To India's Growing Challenge: Postcards of Change”, by Isher Judge Ahluwalia, Harper Collins publications
8. "Urban Systems Design Creating Sustainable Smart Cities in the Internet of Things Era”, by Yoshiki Yamagata, Perry P. J. Yang, Elsevier publications
9. “Internet of Things in Smart Technologies for Sustainable Urban Development” by G. R. Kanaga chidambaresan, R. Maheswar V. Manikandan, K. Ramakrishnan by Springer Publications
10. “Smart Cities: Introducing Digital Innovation to Cities” by Oliver Gassmann, Jonas Böhm, Maximilian Palmié, Emerald Publications.

Honours in Smart Cities: Semester VI		
Course Code	**Course Name**	**Credits**
HSCC601	**Smart City-Project Management**	**4**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

Smart City projects involve great technical complexity, and require a wide diversity of skills to control and monitor them. Project Management would be an integral part for smart infrastructure and cities. Like other complex infrastructure projects; smart city projects are subjected to risk and uncertainties leading to huge time and cost overrun. Managers are faced with the problem of putting together and directing large temporary organizations subjected to constrained resources, limited time, and environmental uncertainty. Project management plays an important role in developing the Smart Cities. It has grown in response to the need for a managerial approach that deals with the problems and opportunities of modern society. It provides the technical and managerial competency, communication and decision making necessary to meet the challenges of complex activities. Application of modern project management tools would ensure more collaboration, communication flow and much flawless implementation of Smart City projects. Modern project management concepts of application of Integrated Project Delivery (IPD) and Building Information Modeling (BIM) would reduce the co-ordination problems and ensure much higher probability of successful completion of the projects within stipulated time and cost frame

Objectives

1. This course is designed to give exposure to project management tools and techniques applicable for planning, controlling and monitoring of Smart Infrastructure and Cities.
2. This course would also enable to develop insight for managing project risks, uncertainties and complexities of smart city projects.
3. To provide overview on sound disaster risk management practices for preparing towards “Safe Cities”. To educate and sensitize students, government officers, planners, policy makers, academician, researchers and others on process of disaster management in smart cities.
4. To educate participants on various tools and methods that can be adopted for hazard identification, vulnerability analysis and disaster risk reduction measures.
5. To stimulate thought process to address hazard risks and vulnerabilities of distinct groups within the city to make more resilient communities.
6. To stimulate process of critically analyzing risks to various urban sectors like Health, Transport, Communication, Housing, Services, Infrastructure etc to come up with strategy to reduce risks Researchers and Academicians.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	Name of Module 1: **Philosophy and Concepts of Project Management in smart cities-**		08
	1.1	Philosophy and Concepts of Project Management-Phases	
	1.2	Philosophy and Concepts of Project Management- Stages of Project-	
	1.3	Philosophy and Concepts of Project Management-Approval Status	
	1.4	Philosophy and Concepts of Project Management-Work Break down Structure	
2	Name of Module 2: **Project Organization Structure-**		08
	2.1	Project Organization Structure- Planning	
	2.2	Project Organization Structure- Scheduling	
	2.3	Project Organization Structure-Controlling	
	2.4	Project Organization Structure-CPM	
	2.5	Project Organization Structure-The PERT Model	
	2.6	Project Management using BIM	
3	Name of Module 3: **Project Cost Analysis**		09
	3.1	Project Cost Analysis	
	3.2	Updating a Project	
	3.3	Resource Allocation and Leveling	
	3.4	Line of Balance Technique	
4	Name of Module 4: **Smart City Project Management with Case Studies -**		09
	4.1	Smart Project Planning	
	4.2	Smart Project Scheduling	
	4.3	Smart Project Monitoring	
	4.4	Smart Project Controlling	
	4.5	Project Risk Management	
	4.6	Case Studies on Smart Cities	
5	Name of Module 5: **Safety, Security and Disaster Management for Smart Citizen-**		09
	5.1	Safety, Security and Disaster Management for Smart Citizen	
	5.2	Disaster Risk Reduction (DRR) Overview	
	5.3	Smart Cities and Disaster Management	
	5.4	DRR Framework for Smart Cities	
6	Name of Module 6: **Thematic Analysis and Resilience Strategy for Smart Cities-**		09
	6.1	Thematic Analysis, Infrastructure Data/Digital Services	

	6.2	Data Management and Analytics	
	6.3	Resilience Strategy for Smart Cities	
	6.4	Stakeholder Capacity Building, Self-Assessment at project and city level	

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

1. Explain role of project management in developing the Smart Cities.
2. Evaluate the risk and uncertainties throughout all the phases of Smart City projects.
3. Compare application of modern project management tools for flawless implementation of smart city projects.
4. Evaluate the managerial approach that deals with the problems and opportunities challenges of modern society of developing and managing a smart city.
5. Apply such concepts and tools for smart infrastructure and cities.

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

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

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

4 Only four questions need to be solved.

Reference Books:

1. Principles of Sustainable Project Management" by Mohamed Salama, Goodfellow Publishers
2. "Smart Cities Unbundled" by Sameer Sharma, Bloomsbury Publishing India Pvt. Ltd.
3. "Introduction to Smart Cities" by P.P. Anilkumar, Pearson Publications
4. "Smart Cities & Urban Development in India" by N. Mani, New Century Publications
5. "Smart City" by Arun Firodia, Vishwakarma Publications
6. "The Smart City Transformations: The Revolution of the 21st Century" by Amitabh Satyam & Igor Calzada, Bloomsbury Publishing India Pvt. Ltd.
7. "Financing Cities in India: Municipal Reforms, Fiscal Accountability and Urban Infrastructure" by, Prasanna K. Mohanty, SAGE publications India pvt. Ltd.
8. "Transforming Our Cities: Facing Up To India's Growing Challenge: Postcards of Change", by Isher Judge Ahluwalia, Harper Collins publications
9. Smart City Tech Planning Handbook by Wade Sarver
10. https://www.projectsmart.co.uk/project-management-ebooks.php

Smart Cities: Semester VII		
Course Code	**Course Name**	**Credits**
HSCC701	**Smart Urban Infrastructures**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4		**-**	**4**		**-**	**4**

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

Rationale

The smart city infrastructure is the introductory step for establishing the overall smart city framework and architecture. The scope of these cities is mainly limited to construct a technology park converting the industrial real estate to state-of-the-art information technology using the evolution in the telecom and IP networks including insignificant asset management automation system. Urbanization is not only associated with economic development but over the time it started aspiring people to better quality of life. Cities are seen as solutions for boosting economy, generating employment, creating skills, providing better health services and many more things. However, the state of urban service delivery in India's cities and towns is far poorer than is desirable for India's current income levels. Considering that the Indian economy has been one of the fastest growing economies in the world for some time, and aspirations and standards are raising, the current state of service delivery is simply unacceptable. Moreover, a successful city cannot operate efficiently in isolation from its environment. It must balance social, economic and environmental needs. Smart Cities focus on their most pressing needs and on the greatest opportunities to improve lives. They tap a range of approaches – digital and information technologies, urban planning best practices, public private partnerships, and policy change to make a difference.

Objectives

1. To study application of Solar Energy for Smart Cities-Conventional vs. Smart City
2. To prepare the qualified resource persons for the upcoming specialization in solid waste management practices after the mission period of SBM i.e., after 2020.
3. To learn from the challenges and limitations faced in e-governance projects in Citizen Services delivery, industries and commerce and intra-government systems for efficiency and transparency.
4. To develop ability to conceptualize, design, implement and manage the new era smart e-governance projects.
5. An understanding of the urban water supply and sanitation systems and linkages with urban forms.
6. Understanding the fundamentals of large project financing-Financial markets for smart city project finance such as syndicated bank loans, capital markets, private equity fund, multilateral institutions, joint ventures, public-private-partnership (PPP)
7. Understanding the projects and their business risks.
8. Understanding the documentation used to structure individual large project financings.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Conceptualization of Smart Energy System for Smart city:**		08
	1.1	Application of Solar Energy for Smart Cities, Conventional vs. Smart City, Green approach to meet Energy demand, Energy scenarios of conventional cities, Energy Efficient Building	
	1.2	Meeting energy demand through direct and indirect solar resources, Efficiency of indirect solar resources and its utility, Structure of Smart Grid, Indian Perspective, Advantage and limitation	
	1.3	Renewable in Smart grid Structural concept, Specific applications, Perspective in Smart Cities	
	1.4	Application of Solar in mobility, Matching demand and supply of energy in typical Smart city through Green mobility	
2	**Smart Water Management in Smart Cities-**		10
	2.1	Introduction to water Bye-Laws	
	2.2	Details of Water Supply system, various stages in implementing the system	
	2.3	Planning Stage: Conversion of existing maps to GIS	
	2.4	Assessing earlier population forecast, Demand estimation	
	2.5	Validation of ground elevations	
	2.6	Design Stage: Hydraulic model of distribution system	
3	**Solid Waste Management in Smart Cities**		09
	3.1	Introduction to an effective urban Solid Waste Management (SWM) with 5Rs, MSW Characteristics and Quantities, MSW Rules 2016, Swachh Bharat Mission and Smart Cities Program	
	3.2	Disposal of Municipal Solid Waste: Landfill, Biochemical Processes and Composting, Energy Recovery from Municipal Solid Waste, case study of any Smart Cities in the Country	
	3.3	Construction and Demolition (C&D) Waste Management - Overview, Regulation, Beneficial Reuse of C&D Waste Materials, E-Waste Management Issues & Challenges and Status in India, E-Waste Management Rules 2016 and Management	
	3.4	Critical examinations of SBM endeavor with special emphasis on clean city rankings along with case study on solid waste management	
4	**Smart Transportation in Smart Cities-**		08
	4.1	Introduction of “Smart Transport”	
	4.2	Application of traffic engineering to smart cities: Level of service, Traffic system management, reduction of conflicts, signal design	
	4.3	Smart pavement materials: plastic pavement, porous pavement, electric generating roads (Piezo electric roads) etc.	
	4.4	Introduction to Urban Transportation system planning: Trip Generation, distribution	
	4.5	Modal split and traffic assignment	

	4.6	Highway economics	
5	**Smart sanitation and storm water drainage system for Smart city-**		09
	5.1	Crisis of Sanitation- India, Key Sanitation policy issues and goals, Benchmarks for Smart Sewerage and Sanitation, steps required to achieve these benchmarks	
	5.2	Need of sewer model, Assessment of sewerage system at Planning and Design stage for transforming into smart sanitation	
	5.3	Sludge Management, Wastewater Reuse and Recycling. Need of Storm water drainage system, Storm water Planning, Challenges in Sustainable Storm water Planning	
	5.4	Trends and issues in storm water system Storm water management to for sustainable water management in Indian smart cities	
6	**Smart Funding for Smart Cities-**		08
	6.1	Financing Smart Cities Development-Types of sources for sustainable smart city funding: GOI seed capital grant of Rs 500 crore to each smart city, Leveraging this grant for funding from open sources, Business Risk Assessment, Public Private Partnership PPP concept and Modes of Smart City funding-BOOT, BOT, BOO, DBFOT etc.	
	6.2	PPP Request for Qualification (RFQ) and Criteria as per Planning Commission guidelines (Case Study), PPP request for Proposal (RFP) along with Concession agreement terms and conditions as per Planning Commission Guidelines	
	6.3	Debt funding, Consortium of financiers, Guarantees and mortgage, Joint venture, Municipal Bonds, Documentation of debt funding, Equity Funding through Initial Public Offer	
	6.4	Private equity funding and risk factors in IPO, Procedure of IPO funding, Other funding sources like Viability gap funding, Special subsidy for the project, Merger and Acquisition, Long term Lease, Financing etc.	

Contribution to Outcome

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

1. Smart Energy System required for Smart city.
2. Explain the effective urban Solid Waste Management practices, MSW rules.
3. Evaluate the importance of best sanitation practices, storm water management and its linkage for the smart city transition.
4. Describe the evolution of e-governance and smart public services to be provided for developing and managing a smart city.
5. Evaluate application of traffic engineering to smart cities

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

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

Recommended Books:

1. "Water, Wastewater, and Stormwater Infrastructure Management", by Neil S. Grigg, CRC Press Taylor and Francis Group
2. "Smart Cities Unbundled" by Sameer Sharma, Bloomsbury Publishing India Pvt. Ltd.
3. "Introduction to Smart Cities" by P.P. Anilkumar, Pearson Publications
4. "Smart Cities & Urban Development in India" by N. Mani, New Century Publications
5. "Smart City" by Arun Firodia, Vishwakarma Publications
6. "Municipal Stormwater Management" by Debo, Thomas, Reese, Andrew, Lewis Publishers
7. "State of the Capital: Creating a Truly Smart City", by K.S. Mehra, Rupa Publications India
8. Security in Smart Cities: Models, Applications, and Challenges", by Aboul Ella Hassanien Mohamed Elhoseny, Syed Hassan Ahmed, Amit Kumar Singh Published by Springer
9. "Transportation and Power Grid in Smart Cities: Communication Networks and Services" by Melike Erol-Kantarci, Hussein T. Mouftah, Mubashir Husain Rehmani , Wiley Publications
10. Cities and Mobility & Transportation: Towards the next generation of Urban Mobility by Pascual Berrone, Joan EnricRicart Costa, Ana Duch T-Figueras, IESE CITIES IN MOTION: International.

Smart Cities: Semester VII							
Course Code	**Course Name**					**Credits**	
Lab 1: HSCSBL701	**Smart City-Project Management**					**02**	
Contact Hours			**Credits Assigned**				
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**	
-	**04**	**-**	**-**	**02**		**02**	

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	**50**	**-**	**50**	**100**

Rationale

Smart City projects involve great technical complexity. It requires a widespread diversity of skills to control and monitor them. For any smart infrastructure project management would be an integral part. Like other complex infrastructure projects; smart city projects are subjected to risk and uncertainties leading to huge time and cost overrun. Project managers are faced with many problems that are putting together subjected to constrained resources, finance, time, and environmental uncertainty. Therefore, project management plays an important role in the development of the Smart Cities. It provides the technical and managerial competency, communication and decision making necessary to meet the challenges of complex activities. It has grown in response to the need for a managerial approach that deals with the problems and opportunities of modern society. A successful city operates efficiently only when it balances social, economic and environmental needs. Smart Cities focus on their most demanding needs to improve lives. They tap various approaches like digital and information technologies, urban planning best practices, public private partnerships, capacity building, policy change to achieve the success.

Course Objective:

1. To acquire knowledge on various components of Smart Cities.
2. To study ongoing projects and their business risks
3. To understand documentation, financings, capacity building used to structure individual large project
4. To study urban water supply, sanitation, solid waste management, transportation & application of Solar Energy for Smart Cities

List of Experiments (Conduct three practical out of six practical's mentioned below)		
Module	**Detailed Content**	**Lab Session / Hours.**

1	Preparing a report on Project Management-**Phases-Stages of project** -**Work Break down Structure of Smart city in India** (Ongoing Smart City Project-Case study).	08
2	Preparing a report of **Project Cost Analysis-Resource Allocation and Leveling, Line of Balance Technique** (Ongoing Smart City Case Study).	08
3	Preparing a report on **Smart Energy System for Smart city** (Ongoing Smart City-Case Study).	08
4	Preparing a report on **Smart Water Management in Smart Cities** (Ongoing Smart City-Case Study).	08
5	Preparing a report on **Solid Waste Management in Smart Cities** (Ongoing Smart City-Case Study).	08
6	Preparing a report on **Smart Transportation in Smart Cities** (Ongoing Smart City-Case Study).	08

Course Outcomes:

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

1. Compare various stages of project of smart city.
2. Evaluate the effective urban Solid Waste Management practices, MSW rules.
3. Compare the importance smart water management, best sanitation practices, storm water management and its linkage for the smart city transition.
4. Prepare application of traffic engineering to smart cities

Assessment:

- Term Work Including Laboratory Work and neatly written project report of the work done. Laboratory Work: 50 Marks
- End Semester Oral Examination: 50 Marks

Recommended Books:

1. Manual on Water Supply and Treatment, (latest Ed.): Ministry of Urban Development, New Delhi
2. Manual on Wastewater Treatment 3rd Ed. Pub: CPHEEO, Ministry of Urban Development, Govt. of India, New Delhi,
3. Municipal Solid Waste Management Manual, (Part1,2,3) Ministry of Urban Development, CPHEEO, 2016
4. Refer various websites of municipal corporations of the cities selected under the smart city mission to study success story,
5. Refer following official government websites
    - http://cpheeo.gov.in
    - https://moef.gov.in/en/

Smart Cities: Semester VIII		
Course Code	**Course Name**	**Credits**
HSCC801	**Smart Management of Smart Urban Infrastructures**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hours**	**-**	**-**	**-**	**100**

Rationale

The introduction of Smart urban technologies into legacy infrastructures has resulted in numerous challenges and opportunities for contemporary cities and will continue to do so. Over the past few years, advances in the Information and Communication Technologies (ICTs) have significantly challenged the traditionally stable landscape of urban infrastructure service provision. This has resulted in increasing interest from both technology vendors and public authorities in the transition of cities towards so-called “Smart Cities”. Although such “Smart technologies” can provide immense opportunities for citizens and service providers alike, the ICTs often act as disruptive innovators of urban infrastructure service provision.

Objectives

1. Enable students to develop competence in planning of projects at the city level to ensure sustainability of environment and humans
2. Enable students to apply smart technologies across the spectrum of infrastructure and governance
3. Enable students to develop overall city strategy to become contemporary and competitive
4. Enable students to understand city centric capital formation and finance, risk and feasibility to ensure the economic health of the city

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Management of Smart Urban Infrastructures**		08
	1.1	Issues and Challenges in Construction and Maintenance of Infrastructure, Information Technology and Systems for Successful Infrastructure Management	

	1.2	Innovative Design and Maintenance of Infrastructure Facilities, Infrastructure Modeling and Life Cycle Analysis Techniques	
	1.3	Capacity Building and Improving the Governments Role in Infrastructure Implementation	
	1.4	An Integrated Framework for Successful Infrastructure Planning and Management, Infrastructure Management Systems and Future Directions	
2	**Management of Smart water, Wastewater System-**		10
	2.1	Overview of Urban Water Supply, Rainwater Harvesting, Dual water supply system, water recycling	
	2.2	Building blocks of 24x7 water supply system,	
	2.3	Performance indicator and Benchmark for water supply services	
	2.4	Smart metering, Leakage management & NRW reduction for achieving 24x7 water supply	
	2.5	Smart monitoring through SCADA system for various components of water and sewerage system	
	2.6	Redressal of complaints on real time basis, Current Practices in Wastewater Recycling	
3	**Management of Smart Urban Energy Systems**		08
	3.1	Meaning of 'Smart Energy Management	
	3.2	Smart Energy Management – Water, Transport	
	3.3	Smart Energy Management-Waste Management and Public Services etc	
	3.4	Challenges and Implementation Barriers for Smart Energy Management, Way forward for achieving integrated Smart Energy Management	
4	**Management of Smart Solid Waste System-**		10
	4.1	The environmental impact of waste management and its relationship on the sustainable development and smart city development	
	4.2	Management of Solid Waste using IoT	
	4.3	management issues in source reduction, recycling, material recovery and transformation of waste through composting	
	4.4	Implementation of solid waste management options -collection system, energy recovery and landfill disposal.	
	4.5	Biomedical waste management, Economy and financial aspects of solid waste management.	
	4.6	Case Studies of Smart cities having successful solid waste Management program	
5	Name of Module 5: **Management of Smart Urban Transportation Systems**		08
	5.1	Introduction of "Smart Transport", Smart Automobile and Sustainable fuels	
	5.2	Smart infrastructure-Intelligent Transport systems (ITS), GIS, RS, GPS, Navigation and Identification Systems	
	5.3	Electronic fee payment technology (E-ticketing), Traffic Safety Management	

	5.4	Human and Environmental Impacts, Safety and Sustainability, Case Study: BRTS or Smart Parking with economics and costing, Mobility Services, Smart Mobility	
6	**Case Study Towards Smart Cities: Part I & II**		08
	6.1	**Towards Smart Cities: Part I: (0 4 hours)** The transition of legacy cities to Smart Cities is not a spontaneous process. To get the transition process right, and to the benefit of citizens, cities have to adopt effective management and governance approaches to successfully deal with numerous complexities of this process. This Module will help to understand the most important factors in the transition phase of legacy cities to smart cities and their managerial implications	
	6.2	**Towards Smart Cities: Part II: (04 hours)** Management of Smart Cities calls for different approaches from conventional urban management approaches, Role of city government in the network of actors who play an important role in management of clean, safe, healthy living conditions. Modern, efficient infrastructure that enables and promotes high-quality work opportunities and high-quality living, Efficient and sustainable use of resources, The city challenges such as city master plans, long term urban plans, city mobility plans, city strategic plans for renewable energy, water sources, waste management, pricing on water, power, tax assessment and frequent revisions, appropriation of resources, water harvesting and recycling, public participatory approach, citizen participation, citizen audit, capacity building in key disciplines, effective urban governance, adoption of ICT facilities, in due respect to local and regional culture, social aspects, safety and security based on economical vibrancy-Smart Cities-Internet of Things (IoT) and Artificial Intelligence (AI).	

Contribution to Outcome

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

1. Explain how to make the best of these smart technologies in your cities' legacy infrastructures.
2. Learn about state-of-the-art strategies for effectively managing the transition from legacy infrastructures to smart urban systems.
3. Evaluate Life Cycle Analysis Techniques and sustainable development of Infrastructure.
4. Describe principles for the management of Smart urban infrastructures as well as the applications of these principles in the various sectors.

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

Recommended Books:

1. Integrated Solid Waste management, George Tchobanoglous, Hilary Theisen and Samuel A Vigil Tata McGraw Hill
2. “Smart Cities Unbundled” by Sameer Sharma, Bloomsbury Publishing India Pvt. Ltd.
3. “Introduction to Smart Cities” by P.P. Anilkumar, Pearson Publications
4. “Smart Cities & Urban Development in India”by N. Mani, New Century Publications
5. “Smart City” by Arun Firodia, Vishwakarma Publications
6. “The Smart City Transformations: The Revolution of the 21st Century” by Amitabh Satyam & Igor Calzada, Bloomsbury Publishing India Pvt. Ltd.
7. “Financing Cities in India: Municipal Reforms, Fiscal Accountability and Urban Infrastructure” by, Prasanna K. Mohanty, SAGE publications India pvt. Ltd.
8. “Transforming Our Cities: Facing Up To India's Growing Challenge: Postcards of Change”, by Isher Judge Ahluwalia, Harper Collins publications
9. “Urban Systems Design Creating Sustainable Smart Cities in the Internet of Things Era”, by Yoshiki Yamagata, Perry P. J. Yang, Elsevier publications
10. “Internet of Things in Smart Technologies for Sustainable Urban Development” by G. R. Kanaga chidambaresan, R. Maheswar V. Manikandan, K. Ramakrishnan by Springer Publications
11. “Smart Cities: Introducing Digital Innovation to Cities” by Oliver Gassmann, Jonas Bohm, Maximilian Palmie, emerald Publications

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Waterways Transportation Engineering

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Waterways Transportation Engineering (With effect from 2022-23)										
Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HWTC501: Waterways and Ports**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HWTC601: Design of Ports and Harbour structures**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HWTC701: Port and Harbour Operations and Services**	04	--	--	20	80	--	--	100	04
	HWTSBL701: Lab-1	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits =	**06**
BE Sem. VIII	**HWTC801: Construction and Management of Port and Harbour**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**

Waterways Transportation Engineering : Semester V		
Course Code	**Course Name**	**Credits**
HWTC501	**Waterways and Ports**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

Waterways are critically important to the transportation of people and goods throughout the world. The complex network of connections between coastal ports, inland ports, rail, air, and truck routes forms a foundation of material economic wealth worldwide. This subject introduces the basic elements related to waterway engineering.

Objectives

- To understand the historical development of waterways at a national and global level and also the significance of ports and harbours as a mode of transport.
- To understand the present status and different surveys required for the planning of Ports and Harbours.
- To understand the policies related to water transportation in India.
- To understand the natural phenomenon affecting waterways and its elements.
- To understand the coastal protection works and coastal Regulations to be adopted
- To study and understand all the important facilities required at the port for the efficient planning of port.

Detailed Syllabus		
Module	**Contents**	**Hours**
1	**General:** Comparison of different modes of transportation. Types, Characteristics, advantages and disadvantages of water transportation. History of water transportation at world level and at national level. Case studies of countries with excellent water transportation facilities.	04
2	**Historical development and Harbour planning:** Development and policies related to water transportation in India. Status of river, canal and ocean transportation in India. Classification of harbours, Requirement of Harbour. Harbour components, ship characteristics,	12

	characteristics of good harbour and principles of harbour planning, size of harbour, site selection criteria and layout of harbours. Surveys to be carried out for harbour planning Marine surveys, Topographic survey of marine area. Hydro graphic surveys, Tide Surveys.	
3	**Port development and planning**: Port building facilities. Differences between Port, Docks and Harbour. Requirement of a good port, Port development in India, Major ports in India. Maritime policies, Port authorities, bodies and associations. Port modernization and new port development (Sagarmala project). Connectivity enhancement Port-linked industrialization and Coastal community development and development of river information services. Environment Impact Statement (EIS). Approvals and mitigation .Case studies of various available Ports in India and abroad.	10
4	**Natural Phenomena:** Wind, waves, tide formation and currents phenomena, their generation characteristics and effects on marine structures. Wind strength, water waves, origin of water waves, effect of wind duration, and bottom friction and water depth on water waves. Wave form and generation. Velocity, height and length of waves. Diffraction, breaking and reflection of waves, wave action on vertical walls, piles. Beach protection, literal drift, silting, erosion and littoral drift.	12
5	**Coastal Structures**: Piers, Break waters, Wharves, Jetties, Quays, Spring Fenders, Dolphins and Floating Landing Stage Types, Objective, principal function and suitability.	06
6	**Harbour Terminal facilities and Navigational Aids:** Port building facilities, Transit sheds, Warehouses, Cargo handling facility, Services for shipping terminals, Inland port facilities planning, purpose and general description. Necessity of navigation aids and their types, Requirement of signals, Fixed and floating navigation aid.	08

Contribution to Outcomes

After completion of the course work, the students are expected to

1. Develop a strong fundamentals related to waterways transportation Engineering.
2. Understand the present status and different surveys required for the planning of Ports and Harbours.
3. The students shall be in a commanding position to plan and execute hydrographic surveys required at various stages of planning, construction and execution of Port and harbours. Also understand the policies related to water transportation in India.
4. The student will also be able to understand the role and effect of natural phenomenon such as wind and waves on the waterways.
5. Understand the coastal protection works and coastal Regulations to be adopted.
6. The student is expected to get full knowledge related to all the modern techniques and various important methods for effective management of port facilities.

Internal Assessment (20 Marks)

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

End Semester Examination (80 Marks)

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

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

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

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

4 **Only Four questions need to be solved.**

Recommended Books:-

1. Docks and Harbour Engineering: *Dr. S.P Bindra*, Dhanpatrai Publications, India
2. Docks and Harbour Engineering: *Hasmukh P. Oza, Gautam H. Oza,* Charotar Publication, India
3. Harbour, Dock and Tunnel Engineering: *R. Srinivasan*, Charotar Publication, India
4. Alonzo Def. Quinn, Design and Construction of Ports and Marine Structure, McGraw – Hill Book Company, New York.
5. PeraBrunn, "Port Engineering", 1 st Edition, Gulf Publishing Company, 2000.
6. Leslie A.Bryan, "Principles of Water Transportation", University of Chicago Press

Waterways Transportation Engineering : Semester VI		
Course Code	**Course Name**	**Credits**
HWTC601	**Design of Ports and Harbour structures**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

In the subject of Transportation Engineering, study of Harbour, Dock and Port Engineering is essential. This course is designed to give the basic understanding of ports and harbour structures. The course will also cover wide areas such as vessel types, types of harbours, design of entrance channel, turning circle, breakwaters, berthing structures etc. A key feature of this course is to introduce the international practice and technologies in fields of coastal, ports and harbour including the codal requirements for designing the various components of port and harbour structures.

Objectives

1. To make the students understand the basic principles of design of port and harbour structures.
2. To cover the design aspects of areas such as vessel types, types of harbours, design of entrance channel, turning circle, breakwaters, berthing structures etc.
3. To understand the importance of load consideration and will enable the students to calculate the different loads in designing the various components.
4. To introduce the international practices and construction technologies in order to design the foundation and fenders of ports and harbour.
5. To appreciate the design principles and codal requirements for designing a breakwater with the help of model studies.
6. To enable the students in understanding the concept, types and differences of docks and locks in order to navigate safely.

Detailed Syllabus		
Module	**Content**	**Hours**
1	**Introduction:** Ports and harbours – an infrastructure layer between two transport media. Introduction to navigation channel, entrance channel and turning circle.	08

	Design issues: Sea port layout with regards to - wave action- siltation - navigability, berthing facilities.-Vessel type and size	
2	**Wind rose and wave rose** as per IS 4651, Operational and design wave as per return period, seismic, sidescan and bathymetry charts	08
3	**Load consideration and calculations:** Environmental Loads: Wind, Currents, Waves. Mooring Loads: Mooring Lines Arrangement, Mooring Line Materials, Mooring Forces. Loads From Cargo Handling and Hauling Equipment and Uniform Distributed Loads. Design Load Assumptions, Uniform Distributed Cargo Loads and Miscellaneous Live Loads, Rubber Tire and Crawler Track Mounted Equipment, Rail-Mounted Cargo, Fixed-Base Equipment, Ship Impact.	12
4	**Foundation Design:** Vertical Loads on Piles or Piers Due to Changes in Water Level Ice Load of Thermal Origin, Other Ice-Induced Loads design methodology for pier , girder, slab, foundations and fenders - codes and standards	10
5	**Design of breakwater** and physical model studies on stability. Introduction to effect of breakwater on shoreline, dredging and disposal	06
6	**Docks and Locks:** Tidal basin, wet docks-purpose, design consideration, operation of lock gates and passage, repair docks - graving docks, floating docks	08
	Total	**52**

Contribution to Outcomes

After successful completion of the course the students shall be able to

1. Understand the different terminologies and components of port and harbour and will enable the students to understand the design issues.
2. Embrace the concept and principle behind load consideration and will eable the students to determine the different loads as well.
3. Design the foundation of different structures of ports and harbour and explore the codal requirements while designing.
4. Understand the concept of breakwater and will enable the students to design a breakwater.
5. Discuss the various international practices and modern construction technologies introduced in ports and harbour in order to design the foundation and fenders.
6. Understand the purpose of docks and locks with the major differences between them.

Internal Assessment (20 Marks)

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

End Semester Examination (80 Marks)

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

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

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

References:

1. Port Design - Guidelines and recommendations by C. A. Thoresen, Tapir Publications.
2. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by J. W. Gaythwaite, Van Nostrand.
3. Handbook of Offshore Engineering by S.K. Chakrabarti, Elseviers, 2005.
4. Agerschou, H., Lundgren, H., Sorensen, T., Ernst, T., Korsgaard, J., Schmidt, L.R. and Chi, W.K., (1983). "Planning and Design of Ports and Marine Terminals", A Wiley-Interscience Publication.
5. Per brun (1983). "Port Engineering" Gulf Publishing Co.
6. Docks and Harbour Engineering: Bindra, S. P.; Dhanpat Rai and Sons, New Delhi.
7. Harbour, Dock and Tunnel Engineering: Shrinivas, R.; Charotar Publishing House, Anand
8. Design and Construction of Ports and Marine Structures: Quinn, A. D., Tata Mc-Graw Hill India Publishing House

Additional Reading

IS-4651 Indian standard Code of practice for planning and design of ports and harbour, Bureau of Indian Standards, New Delhi.

Waterways Transportation Engineering : Semester VII		
Course Code	**Course Name**	**Credits**
HWTC701	**Port and Harbour Operations and Services**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

Today 80% of the world's cargo is being transported by waterways. The boom in e-commerce has led to the thinning of borders between countries and goods being exchanged seamlessly. Thus, ports have become the bedrock of todays' global economy and India is no exception. Thus it's imperative for students to understand how seaport operates and apply the best practices along with the latest industrial developments. This course is designed in line with the contemporary developments. The syllabus covers global port management practices at the regulatory, commercial, technological, operational and financial levels. The shipping industry has myriad complexities and the syllabus provides students wide-ranging and up-to-date understanding required to thrive in today's highly competitive and evolving environment.

Objectives

1. To study History of Ports, its evolution, Governance and Ownership structure.
2. To Understand different types of logistic integration, Port operations and services.
3. To study planning of vessel movements and improvement of Port capacity.
4. To study the different types of International agreements which are the tools for growth in Indian ports.
5. To study and analyze traffic forecasting in order to plan the port operations effectively.
6. To study port authorities and regulatory framework

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Introduction**		08
	1.1	The History of Ports: Ports history, Planning, and Development.	
	1.2	Port Ownership, Structure, and Organization. Port Governance and Structural Type.	
	1.3	Port Workforce: Productivity, Growth, and Empowerment Strategies. Measuring Productivity, Throughput, and Growth.	
	Connecting Hub port Gateways to the Inland Infrastructure		

2	2.1	Logistics Integration of Port Activities: The Five Stages of Integration for the Maritime Industry.	08
	2.2	Strategic Location and Market Accessibility for Existing and Emerging Seaports.	
	2.3	Ports' Success Factors. Supply Chain Opportunities, Competition, and Conflict Prevention	
3	Port Operations		14
	3.1	Terminal Operators; Property Leasing Opportunities. Port Management Services and Operations. The Harbourmaster's Department and Functions, Terminal Manager, Vessels' Planning.	
	3.2	The Four Stages of Port Management and Operations: Leasing Opportunities, Marine Terminal Operator (MTO) Agreements and Leasing Opportunities and MTO case studies	
	3.3	Charter Party Types, Charter Party Clauses and Areas of Dispute, The Port and Charter Party Terms	
	3.4	The Components of Shipbuilding, Intellectual Property Rights, The History of Shipbuilding , Reasons for Shipyards Losing Market Share, Contemporary Shipbuilding Trends, Shipbuilding and Oil Market Analysis, Global Market Analysis.	
	3.5	Liner Services, Tramp Trade, and Offshore Support Agents. Agency Selection and Practices, Port Agency Responsibilities. General Agency Duties, for Tramp, Liner, and Logistics Services.	
4	International Trade and Port capacity		06
	4.1	The General Agreement on Tariffs and Trade. The World Trade Organization. Ports' Growth and the Global Trade Agreements Matrix.	
	4.2	Traffic Forecasting, Ports and the Principles of Derived Demand, Shipping, Ports, and the Ripple Effect. Optimum Size and Economies of Scale	
	4.3	Port Capacity Utilization, Capacity Management, Capacity Planning and Ports' Technology and Innovation.	
5	Strategic Planning		08
	5.1	Strategic Planning, Development, and Management: Corporate Objectives and factors considered in planning, developing and management	
	5.2	Port Pricing Strategies: Tariff Changing and Competitiveness. Port Pricing. Pricing Systems and Price-Setting Considerations.	
	5.3	KPIs: Measuring Financial and Operational Performance.	
	5.4	Port Equipment and Berth Facilities: Operations and Maintenance, Port Cargo Handling Equipment (CHE). Performance Management and the Human Factor	
6	Port Regulations and Future of Ports		08
	6.1	ISM: International Safety Management ISPS: International Ship and Port Facility Security Code OHSAS and OSHA: Occupational Safety and Health Administration VGP: Vessel General Permit by the US Environmental Protection Agency	
	6.2	ISO 14001: Environmental Management System HAZMAT: Hazardous Materials; HAZWOPER: Hazardous Waste Operations and Emergency Response BWM: Ballast Water Management	
	6.3	Incident Investigation and Root Cause Analysis; Inspections, Surveys, and Audits; Global and National Regulatory Compliance for Ships	

	6.4	Port Development Strategy: Elements of Long-Term Strategic Planning, Strategic Port Planning and Tactical Port Planning, Port Planning and the Factors of Production	
	6.5	Forecasting the Market: Port Management and Forecasting Areas. The Risk Element in Forecasting, Forecasting Methods and Tools	

Contribution to Outcome

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

1. Port operations and planning
2. Port capacity Planning and Forecasting
3. Understand the Key Performance Indicators (KPIs) for strategic planning and management in port operations
4. Understand the different types of International agreements which are the tools for growth in Indian ports
5. Understand the regulatory framework involved in running a port.
6. Understand the traffic forecasting in order to plan the port operations effectively

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

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

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

4 Only Four questions need to be solved.

Recommended Books:

1 Maria G. Burns , “Port Management and Operations ”1st Edition,2015

2 Muir Wood, A.M., and Fleming. C.A., “Coastal Hydraulics Sea and Inland Port Structures”, 1st Edition, Hallstead Press, 2002.

3 Ozha&Ozha, “Dock and Harbour Engineering”, 1 st Edition, Charotar Books, Anand., 1990

Reference Books:

1 S. Seetharaman, “Construction Engineering and Management”, 4 thEdition ,Umesh publications, New Delhi, 1999.

2 Richand L. Silister, “Coastal Engineering Volume I & II, Elsevier Publishers, 2000.

3 PeraBrunn, “Port Engineering”, 1 st Edition, Gulf Publishing Company

Waterways Transportation Engineering : Semester VII		
Course Code	**Course Name**	**Credits**
Lab 1: HWTSBL701	**Port and Harbour Operations and Services**	**02**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**04 Per Week**	**-**	**-**	**02**		**02**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	50	-	50	100

Rationale

This subject is designed to give the basic understanding of ports and harbour structures. The course will also cover wide areas such as design of entrance channel, turning circle, breakwaters, berthing structures etc. Thus it's imperative for students to understand how seaport planned, designed, operates and apply the best practices along with the latest industrial developments. The course equips students with necessary field exposure and makes them aware of complex administration and structural reforms and acquaints them with necessary precautions and precision of this profession.

Course Objectives

- To study and understand all the important facilities required at the port for the efficient planning.
- To make the students to understand design and analysis of port and harbour structures using conventional approach as well as software.
- To understand the importance of load consideration and will enable the students to calculate the different loads in designing the various components.
- To study and analyse traffic forecasting in order to plan the port operations effectively
- To understand organizational behavior and management techniques for management of port.
- To study human resource management skills required at port.

List of Experiments(Any Six)		
Exp.No.	**Detailed Content**	**Lab Session / Hr.**
1	The visit of any harbour and port to understand the various structures, its construction and operations-Report	02
2	Effect of earth quake and Tsunami on port structures - Case studies	02
3	IT System and Port Planning	02

4	Design of Jetties using STAAD Pro and Midas	02
5	Design of Jetties using Sacs	02
6	Design of breakwater using STAAD Pro and Midas	02
7	Design of breakwater using Sacs	02
8	Planning and Designing of Storage, warehouse using STAAD Pro or any other designing software's.	02
9	Planning of placing the components of Port and estimating its capacity.	02
10	Current Issues in Port Management: Report on Case Study	02
11	Marine Structure, Navigation Aids	02
12	Docks and Repair Facilities, Port Facilities	02
13	Dredging, Coastal Protection	02

Contribution to Outcomes

- Develop a strong fundamental related to waterways transportation Engineering. Understand the different terminologies and components of port and harbour and will enable the students to understand the design issues.
- Understand the concept and principle behind load consideration and will enable the students to determine the different loads as well.
- Understand the concept of design the foundation and breakwater of different structures of ports and harbour and explore the codal and software requirements while designing.
- Understand the Port operations, planning and process of Dredging
- Understand skill required for effective organizational behavior, project management and port management skills.

Term work

Shall consist of Assignment, design report, case study and Site visit report related to this course. Distribution of marks for Term Work shall be as follows:
Assignment : 15 marks
Case study and design report: 15 marks
Site visit : 15 marks
Attendance: 05 Marks
Further, while giving weightage of marks on the attendance, following guidelines shall be resorted to: 75%-80%: 03 Marks; 81%- 90%: 04 Marks; 91% onwards: 05 Marks.

End Semester Oral Examination

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

Reference Books:

1. Docks and Harbour Engineering: Dr. S.P Bindra, Dhanpatrai Publications, India
2. Docks and Harbour Engineering: Hasmukh P. Oza, Gautam H. Oza, Charotar Publication, India.

3. Port Design - Guidelines and recommendations by C. A. Thoresen, Tapir Publications.
4. Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels by J. W. Gaythwaite, Van Nostrand.
5. Handbook of Offshore Engineering by S.K. Chakrabarti, Elseviers, 2005.
6. Maria G. Burns, “Port Management and Operations ”1st Edition,2015
7. Detnorskeveritas, Rules for the Design, Construction and Inspection of Fixed Offshore Structures
8. R. Srinivasan and S. C. Rangwala, Harbour, Dock and Tunnel Engineering, 1995, Charotar Pub.House, Anand
9. SCI/SCOPUS Indexed Refereed International Journals (For Case Studies) 2 Relevant Indian Standard Specifications Codes, BIS Publications, New Delhi. 3 Departmental Laboratory Manual
10. Standard Geotechnical Engineering Handbook
11. NPTEL Video lectures on Practical.

Waterways Transportation Engineering : Semester VIII		
Course Code	**Course Name**	**Credits**
HWTC801	**Construction and Management of Port and Harbour**	**04**

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

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

Rationale

This is a course which deals with various construction equipment and processes of various structures involved in the port and shipping business as well as teaching capable administration strategies for the same. The course equips students with necessary field exposure and makes them aware of complex administration and structural reforms and acquaints them with necessary precautions and precision of this profession.

Objectives

1. To study the various construction equipment and process of Port and harbor structures.
2. To study the construction and maintenances of Fishing Harbor.
3. To understand the process of Dredging
4. To understand organizational behavior and management techniques for management of port.
5. To study human resource management skills required at port.
6. To understand health, safety, security and environment concerns related to port activities.

Detailed Syllabus		
Module	**Course Module / Contents**	**Hours**
1	Marine and offshore construction equipment: Basic motions of Barges, crane barges, Offshore derrick barges, semisubmersible barges, Jack-up construction barges, launch barges, pipe laying barges, floating concrete plant. Pile driving equipment.	10
2.	**Fishing Harbour Construction**	12

	Fishing Harbour and Fish landing centres – Types, Various components of fishing Harbour and landing centre. Land side and water side facilities and structures of fishing Harbour. Small and medium fishing Harbour, Deep sea fishing Harbour, Environmental auditing for fishing Harbour. Dredging and breakwater construction. Layout and construction of Jetties, quays and slipways. Use of different construction materials for shore based and seaside structures. Fishing Harbour maintenance and waste disposal, Water treatment plant in fishing Harbour. Status of fishing Harbours in India.	
3	**Dredging** General ,Classification of dredging works, Types of dredgers, Uses of dredged material ,Execution of dredging work	06
4	**Introduction to Port management:** Organizational behavior: Definition, diversity in workplace, Ethics and ethical behavior in organizations. Project Management: Principles of management, Project definition, Project manager skills, Stages of project, Scheduling, Contract Strategy, selection and appointment of contractors, project implementation and execution, closure of project. Port and terminal operations, types of ports and terminals, terminal ownership, port and cargo movements, competition and other challenges facing the industry	08
5	**Port Labour, People Management and Port master planning:** Historic and current port labour environment, effective management of staff on ports, Labour reforms and social issues, employment framework and employee relations. Introduction to post master planning, land parcelisation, development phasing strategy, developing 30 year masterplan. Terminal Ownership: Impact of port ownership, Privatization benefits and concerns, BOT, BOOT and BOO, Concession agreement, Tariff setting, role of port regulators.	08
6	**Health, Safety, Security and the Environment (HSSE) in Ports:** Importance of HSSE culture, HSSE concepts, HSS on Ports, safety and security indicators, regulations related to HSSE. Risk awareness and risk management, system approach to port safety and security. Environment management: Introduction, Environment impact, Environment regulations and governance.	08

Contribution to Outcome

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

1 Understand the various methods and equipment for the construction of Port and harbor structures

2 Understand the construction and maintenances of Fishing Harbor.

3 Understand the process of Dredging.

4 Understand skill required for effective organizational behavior, project management and port management skills.
5 Carry out human resource management in accordance to labour laws and to develop master plan for port.
6 Understand the importance of health, safety, security and environment concerns at port and to suggest measure.

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

Recommended Books:

1 S. Seetharaman, "Construction Engineering and Management", 4th Edition , Umesh publications, New Delhi, 1999.
2 Detnorskeveritas, Rules for the Design, Construction and Inspection of Fixed Offshore Structures.
3 R. Srinivasan and S. C. Rangwala, Harbour, Dock and Tunnel Engineering, 1995, Charotar Pub.House, Anand
4 Alonzo Def. Quinn, Design and Construction of Ports and Marine Structure, McGraw – Hill **Book Company, New York**
5 Construction project management by KK Chitkara, Tata McGraw Hill (2010)

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Professional Practices in Structural Engineering

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Professional Practices in Structural Engineering (With effect from 2022-23)										
Year &Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	HPSC501: Concrete Consultant Practices	04	--	--	20	80	--	--	100	04
	Total	04	-	--	100		-	-	100	04
									Total Credits = 04	
TE Sem VI	HPSC601: Formwork Design Practices	04	--	--	20	80	--	--	100	04
	Total	04	-	-	100		-	-	100	04
									Total Credits = 04	
BE Sem VII	HPSC701: Structural Consultant practices – I	04	--	--	20	80	--	--	100	04
	HPSSBL701: Structural Consultant Practices (SBL)			04	--		50	50	100	02
	Total	04		04	100		50	50	200	06
									Total Credits = 04+02=06	
BE Sem VIII	HPSC801: Structural Consultant practices – II	04	-	--	20	80	--	--	100	04
		04	--		100		--	--	100	04
									Total Credits = 04	
Total Credits for Semesters V,VI, VII & VIII = 04+04+06+04=18										

Professional Practices in Structural Engineering: Semester V		
Course Code	**Course Name**	**Credits**
HPSC501	**Concrete Consultant Practices**	**04**

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

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

Rationale

Basic concept of concrete technology is essential for civil engineering students to execute the civil engineering projects as per the standard laid down time to time. The concrete technology is the backbone of infrastructure of civil engineering field. The students must know various concreting operations and testing operations during and after construction. It is expected to know the properties of materials, especially concrete and to maintain quality in construction projects. The civil engineering students ought to know the selection of materials, its mix proportioning, mixing, placing, compacting, curing and finishing.

Objectives

1 To study the properties of fresh and hardened concrete.

2 To study the properties such as workability and durability.

3 To acquaint the practical knowledge by experimental processes of various materials required for concrete.

4 To understand the Mix design by different methods.

5 To understand ordering and handling of RMC.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Introduction to concrete making materials**		09
	1.1	**Cement** Physical properties of cement as per IS Codes, types of cements and their uses.	
	1.2	**Aggregates** Properties of coarse and fine aggregates and their influence on properties of concrete, properties of crushed aggregates.	
2	**Special cementitious materials**		07

	2.1	GGBS: properties, advantages and disadvantages, uses	
	2.2	Silica fume: properties, advantages and disadvantages, uses	
	2.3	**Admixture** Plasticizers, Super-plasticizers, Retarders, Accelerators, Mineral admixtures and other admixtures, test on admixtures, chemistry and compatibility with concrete.	
3	**Concrete and its properties**		13
	3.1	Grades of concrete, Manufacturing of concrete, importance of w/c ratio.	
	3.2	**Properties of fresh concrete-** workability and factors affecting it, consistency, cohesiveness, bleeding, segregation.	
	3.3	**Properties of hardened concrete-** Compressive, Tensile and Flexural strength, Modulus of Elasticity, Shrinkage and Creep.	
	3.4	**Durability-** Factors affecting durability, Relation between durability and permeability	
4	**Concrete Mix Design**		10
	4.1	Design of concrete mixes by IS code method	
	4.2	Design of concrete mixes by ACI method	
	4.3	Design of concrete mixes by Road Note 4 method	
	4.4	Design of high strength concrete mixes, design of light weight aggregate concrete mixes, design of fly-ash cement concrete mixes, design of high-density concrete mixes.	
5	**Testing of Concrete**		07
	5.1	**Non-Destructive testing of concrete** Rebound Hammer test, ultrasonic pulse velocity test, load test, carbonation test, 1⁄2 cell potentiometer test, core test and relevant provisions of I.S. codes.	
	5.2	**Durability** Permeability test, Rapid chloride penetration test.	
6	**Ready mix concrete**		06
	6.1	Advantages of RMC, components of RMC plant, distribution and transport, handling and placing, mix design of RMC.	
	6.2	Distribution and transport, handling and placing, mix design of RMC.	
	6.3	Handling Quality Complaints	

Contribution to Outcome

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

1 Identify the properties of ingredients of concrete.

2 Know the properties of wet concrete, hardened concrete.

3 Understand the Mix design by different methods for different grades of concrete.

4 Perform various test on concrete.

5 Understand the concept of durability and cracking in concrete.

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

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

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

4 Only Four questions need to be solved.

Recommended Books:

1 Concrete Technology: A. R. Shanthakumar, Oxford University Press.

2 Concrete mix proportioning-guidelines (IS 10262:2009).

3 Method making, curing and determining compressive strength of accelerated-cured concrete test specimens as per IS: 9013-2004.

4 Tentative Guidelines for cement concrete mix design for pavements (IRC: 44-1976): Indian Road Congress, New Delhi.

5 Properties of concrete: Neville, Isaac Pitman, London.

Reference Books:

1 Concrete Technology Theory and Practice: Shetty M.S., S. Chand.

2 Relevant I.S. codes: Bureau of Indian standard.

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

4 Chemistry of Cement and Concrete: F.M. Lue, Edward Arnold, 3rd Edition, 1970.

5 Concrete Technology: Neville A.M. & Brooks. J. J., ELBS-Longman.

6 Concrete Technology: Gambhir M.L., Tata McGraw Hill, New Delhi.

Professional Practices in Structural Engineering: Semester VI		
Course Code	**Course Name**	**Credits**
HPSC601	**Formwork Design Practices**	**04**

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

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

Rationale

Course focuses on importance of Formwork design in RCC construction apart from concreting and bar bending work. It deals with the changing scenario towards formwork designing as a career option in Construction Industry. The course helps the students to know the market outlook as well as the requirements of formwork design by knowing all the technical as well as field considerations while designing formwork for various components of building. It gives the exposer to students regarding cost benefits and time saving along with advanced technologies and new formwork material in construction industry.

Objectives

1 To know the different types of formwork and importance of formwork in RCC Construction

2 To study the market outlook and requirements of system formwork in construction industry.

3 To design a formwork for walls, columns, beams and slabs considering all the live loads, concrete pressures, wind loads, concreting methods and do the necessary checks.

4 To understand the formwork selection criteria for various tunnel construction methods, bridge construction methods and high-rise construction.

5 To plan and estimate the material and man power required for Formwork.

6 To know the various advancements in formwork design in construction market.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Introduction to Formwork**		08
	1.1	Various Activities and Equipment involved in concrete construction- Concrete, Reinforcement, Batching Plant, Boom Placer, Concrete Pumps, Buckets, Crane, Formwork (Shuttering/Centering), Scaffolding, etc.	

	1.2	Introduction of Formwork, Types of Formwork, Importance of Formwork in RCC Structure	
	1.3	Conventional Formwork and Scaffolding- Advantages and Disadvantages in view of ongoing approach and site requirements	
	1.4	System Formwork and Scaffolding, Time-Cost Distribution in RCC Construction with respect to Formwork, Reinforcement and Concreting.	
2	**System Formwork**		09
	2.1	Importance of System Formwork- Construction Market Outlook, Market Growth Drivers (Increasing Urbanization, Housing Shortage, Economic Development),	
	2.2	Factors driving demand for System Formwork and Scaffolding, Key Challenges at construction sites, Requirements and Solutions against Challenges- Design and Planning, Equipment usage time, etc.	
	2.3	Design and Planning- Project Planning Sequence- Current and Correct Practice, Any TWO Case Studies.	
	2.4	Equipment usage time- Crane Availability, Boom Placer, labour, etc.	
	2.5	Parameters considered in High Rise Buildings- Comparison between System Formwork and Conventional Formwork	
3	**Formwork Design- Walls, Columns & Slabs**		14
	3.1	Introduction to Formwork Design- Factors related to Concreting, Concrete Placing method influence pressure of Concrete - Crane Bucket Concreting, Boom Placer Concreting	
	3.2	Loads on formwork and lateral pressure of concrete, Calculation of design pressure based on type of concrete, method of concreting, grade of concrete, type of structure and rate of concreting	
	3.3	Concrete Pressure Calculation- Column and Wall Formwork	
	3.4	Design of formwork for slab (less than 4 m height)- Design Loads for slabs and beams formwork	
	3.5	Design of formwork Material for walls & Columns (Vertical application) - Sheathing Member (Plywood), Secondary Member, Primary Member, Tie System; Check against various forces and bending.	
	3.6	Design of Slab Formwork Material- Primary, Secondary and Prop Members; Checks against failures.	
	3.7	Planning & Estimation of Formwork for Residential & Commercial Buildings, Column Formwork Sets, Cycle time- Slabs and Beams	
4	**Formwork for High Rise Constructions, Tunnels and Bridges**		12
	4.1	Design Concept for Climbing system- Define, Types, CB 240 and SCS 250 system, Anchoring System	
	4.2	Study of IS: 875(Part3): Wind Loads on Buildings and Structures, Wind Force for Formwork design- High Rise Construction and Slab height more than 4 m	
	4.3	Design of Formwork system for any typical floor plan with self-climbing system for walls, columns, beams and slabs	
	4.4	Overview of Tunnel Construction Methods & Formwork selection	
	4.5	Overview Bridge Construction Methods & Formwork Selection	
	4.6	Overview of High-Rise Construction & Formwork Selection	

5	**Economics and Maintenance of Formwork**		05
	5.1	Factors affecting supply and demand of Formwork	
	5.2	Manpower Management required for formwork	
	5.3	Maintenance of Formwork & its Stacking.	
6	**Advancement & Scope of Formwork Design**		04
	6.1	Advance formwork technology Available in the market	
	6.2	Advanced Material used as a Formwork	
	6.3	Formwork field as career option	

Contribution to Outcome

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

1 Understand the different types of formwork and its importance in various RCC construction activities.

2 Understand various aspects of system formwork over conventional formwork. Also, understand the market outlook and various parameters need to be considered in design of formwork

3 Design a formwork for walls, columns, beams and slabs considering all the live loads, concrete pressures, wind loads in a view of different concreting methods and do the necessary checks

4 Understand the formwork selection criteria for various tunnel construction methods, bridge construction methods and high-rise construction.

5 Plan and estimate the material and man power required for Formwork.

6 Know the advance formwork technologies and advanced material available in the market.

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

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

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

4 Only Four questions need to be solved.

Recommended Books:

1 Formwork for concrete structures: Robert L. Peurifoy and Garold D. Oberlender, The McGraw hill publishing company.

2 Concrete Formwork Systems: Awad S. Hanna, Marcel Dekker.

3 Design and Construction of Formwork for Concrete Structures: Albert Edward Wynn, Cement and Concrete Assn.

4 Concrete Formwork: Leonard Koel, Amer Technical Pub.

Reference Books:

1 IS: 875(Part3): Wind Loads on Buildings and Structures

2 Formwork for concrete structures: Dr. Kumar Neeraj Jha, The McGraw Hill Education India

3 Modern Practices in Formwork for Civil Engineering Construction Work: Dr. Janardan Jha, Prof. S. K. Sinha.

Professional Practices in Structural Engineering: Semester VII		
Course Code	**Course Name**	**Credits**
HPSC701	**Structural Consultant Practice-1**	**04**

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

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

Rationale

Course is equipped with the basic knowledge about structural designs and various other consultants and venders related with the structural consultant which combines together to carry out the design of any structural project. This will make students to understand the hierarchy of the work which has to carry out the structural consultant and structural engineer with other agencies and consultants and also it will highlight the brief information regarding structural quantity estimation and tenders.

Objectives

1 To understand types of various structures, importance of structural consultant and role of structural engineer

2 To understand the scope, responsivities and activities of structural engineer

3 To study the schematic designs, documentation and certification in structural design.

4 To understand the roles of client, architect, another consultant with structural consultant.

5 To understand relation of structural consultant with different agencies and vendors.

6 To study structural quantity estimation and tender preparation and also documentation.

Detailed Syllabus

Module	Course Module / Contents		Hours
1	Introduction		09
	1.1	Types of Structures, functionality, various forms of structures, usage driven requirements, notable structures in the world, country, state, city.	
	1.2	Information on team of consultants required for the comprehensive design of structures. Responsibilities of various consultants' team members – legal, professional, ethical and moral	

	1.3	Place of a structural engineer in the matrix of the overall project, Set up of a structural designer's office, Various personnel working in a structural designer's office	
2	Role of Structural Consultant		07
	2.1	Scope of a structural consultant, Tasks and deliverables for a structural consultant	
	2.2	Activities that a structural engineer has to carry out	
	2.3	Legal responsibilities of a structural engineer	
3			09
	3.1	Introduction to: Concept, Schematic, Tender, Design Development, Detail Design of various structural designs	
	3.2	Construction Stage Documentation, Construction Administration, Completion Stage Documentation, Certification	
	3.3	Bye laws pertaining to structural engineers in MCGM rule book, HRC, liaison, NBC, DCR etc.	
	3.4	Licensing requirements for a structural engineer	
4	Teaming up with other consultants, contractors and vendors – Nature of communication transactions – Part 1		11
	4.1	Client – Brief and scope defined by Client's representative Architects – Design and Liaison, Surveyor, Geotechnical Engineer, Wind Engineer	
	4.2	Façade Engineer, Interior Architect, Landscape architect, Steel Fabrication contractor's detailers	
	4.3	Water proofing Consultant/vendor, Fire proofing Consultant/Vendor, Concrete technologists, concrete manufacturers	
5	Teaming up with other consultants, contractors and vendors – Nature of communication transactions – Part 2		08
	5.1	Agencies: Material Testing Agency, Rebaring Agency, Anchoring Agency, Post Tensioning Agency, Ground Anchoring Agency, Piling Agency.	
	5.2	Vendors: Steel suppliers/manufacturers, Alternate material suppliers/ manufacturers/ vendors, Bearings/isolators suppliers/manufacturers / vendors, Electrical Engineers, Mechanical Engineers	
	5.3	Other vendor and agencies: Plumbing/Drainage Engineers, Traffic Consultants / Parking system vendor / parking requirements, Vertical Transportation Consultants, Pre-Engineered Building Agencies Contractors in general	
6	Structural Quantity Estimation and Tender		08
	6.1	Structural Quantity Estimation: Structural Specifications, Structural Bill of Quantities, General material consumption ratios, Actual sample workout problem.	
	6.2	Tender Stage: Preparation of Tender Drawings, Bill of Quantities, Specifications, Special Notes, Consultant's estimate, Disclaimers	
	6.3	Construction Documentation and Construction Administration Delivery of drawings and other documents to site for execution.	
Contribution to Outcome			

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

1	Understand types of various structures, importance of structural consultant and role of structural engineer.
2	Understand the various scope, responsivities and activities of structural engineer has in structural consultant.
3	Study and understand the schematic designs, documentation and certification in structural design
4	Understand the roles and nature of client, architect, other consultant with structural consultant and also safety measures at site.
5	Understand the nature of communication transactions of structural consultant with different agencies and vendors.
6	Study the structural quantity estimation and tender preparation and also documentation works required to the structural consultant.

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

Recommended Books:

1. Fundamentals of Reinforced Concrete: Sinha& Roy, S. Chand and Co. Ltd.
2. Estimating, Costing, Specifications and Valuation: Chakraborty, M., Kolkata.
3. Relevant Indian Standard Specifications, BIS Publications
4. Professional Construction Management: Barrie D.S. & Paulson B C, McGraw Hill
5. The cost management toolbox; A Managers guide to controlling costs and boosting profits- Oliver, Lianabel (Tata McGraw Hill).

Professional Practices in Structural Engineering: Semester VII		
Course Code	**Course Name**	**Credits**
HPSSBL701	**Structural Consultant Practice-Lab**	**02**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
--	**04**	**-**	**--**	**02**	**--**	**02**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
--	--	--	--	--	**50**	--	**50**	**100**

Course Objectives	
1	To understand types of various structures, importance of structural consultant and role of structural engineer
2	To understand the scope, responsibilities and activities of structural engineer
3	To study the schematic designs, documentation and certification in structural design.
4	To understand the roles of client, architect, another consultant with structural consultant.
5	To understand relation of structural consultant with different agencies and vendors.
6	To study structural quantity estimation and tender preparation and also documentation.

Contribution to Outcome

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

1. Understand types of various structures, importance of structural consultant and role of structural engineer.
2. Understand the various scope, responsibilities and activities of structural engineer has in structural consultant.
3. Study and understand the schematic designs, documentation and certification in structural design
4. Understand the roles and nature of client, architect, and other consultant with structural consultant and also safety measures at site.
5. Understand the nature of communication transactions of structural consultant with different agencies and vendors.
6. Study the structural quantity estimation and tender preparation and also documentation works required to the structural consultant.

List of Tutorials and Assignments		
Week (Activity)	**Detailed Content**	**Lab Session / Hr.**
1	Study of different types of structures based on its utility, roles and responsibilities of various consultants.	02/04
2	Study of Legal responsibilities, scope and activities for structural consultant	02/04
3	Preparation of tender, documentations and detailed design of various structural components of any one structure	02/04
4	Design of single bay double storey building structure using softwares like ETAB/STAAD and SAFE	03/06
5	Application of different IS codes for the selection of parameters (like loading, design, materials, etc) for different types of structural systems	02/04
6	Structural quantity estimation which includes bill of quantities, general material consumption ratios, consultant's estimate	02/04

Assessment:

- **End Semester Oral Examination**
  Oral examination will be based on entire syllabus

Reference Books:

1. Design of Reinforced Concrete Structures: Dayaratnam, P; Oxford and IBH.
2. Illustrated Reinforced Concrete Design: Dr. V. L. Shah and Dr. S. R. Karve, Structure Publications, Pune
3. Relevant IS codes, BIS Publication, New Delhi
4. Project Preparation, Appraisal, Budgeting, and Implementation: Prasanna Chandra (Tata McGraw Hill).
5. Construction Engineering and Management: S. Seetharaman, Umesh Publications, Delhi.

Professional Practices in Structural Engineering: Semester VIII		
Course Code	**Course Name**	**Credits**
HPSC801	**Structural Consultant Practice-II**	**04**

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

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

Rationale

This course is capable of different parameters with the designs and drawing of various structures and the roles of different structural consultant. The course will give ideas regarding the software applications in the structural engineering works which ease the design and drawing stage difficulties. It also provides students the brief knowledge about different tests required from various agencies, consultants and venders.

Objectives

1 To understand different structures, material required for construction and various interpretations

2 To study the various IS codes, loadings and framing structure systems.

3 To understand and prepare the cost comparison report and hand calculation techniques.

4 To study and run different software used in structural consultant.

5 To understand reinforcement details, drawings and various design audit

6 To conduct different tests and to form stagewise and final certifications for the designs.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	Introduction		09
	1.1	Concept and Schematic Stages Definition of a given structure – identifying the structural system	
	1.2	Material of construction – Appropriate selection based on functional requirement, space constraints, aesthetics, special demands from client/architect/function	
	1.3	Data and drawing reading and its interpretation as received from all collaborating agencies	
2	Introduction to IS codes		07

	2.1	Introduction to IS 456, IS 800, IS 1786, Loading parameters – as per architectural drawings and usage requirements	
	2.2	Introduction to IS 875, IS 875-Part 3, IS 1893	
	2.3	Various types of framing, structural systems – gravity and lateral, codal interpretations, parameter selection – comparative studies	
3	Cost Comparison and Report		12
	3.1	Comparative costing of components: Flooring, Column grids, Types of columns, Lateral Systems, Foundation systems and Soil retention structures – retaining walls, shoring systems etc	
	3.2	Formation of Design Basis Report, Preliminary Analysis Tools – Introduction	
	3.3	Preparation of Concept and Schematic Drawings. Contents of these drawings.	
	3.4	Hand Calculation techniques, Sofwares available, tips for usage of software Introduction to Etabs/ Staad	
4	Softwares to carry out structural designs		10
	4.1	Hands on ETABS / STAAD / SAFE modelling for sample simple structures for understanding of the working of the software only, its various facilities, capacity and limitations. Meaning of various parameter definitions	
	4.2	Design Development / Working Stage, Incorporation of other consultants' requirements, Preparation of DD stage drawings	
	4.3	Running final ETABS model, Running final SAFE mode	
5	Reinforcement details		06
	5.1	Reinforcement calculations, Feeding data to structural draughtsman Preparation of GFC / working reinforcement drawings – contents	
	5.2	Notes on reinforcement drawings, Typical details, Standard formats of reinforcement drawings	
	5.3	Special requirements of detailing – Introduction to SP34 and IS 13920 Drawing and design audit	
6	Tests and Certifications		08
	6.1	List of submittals expected from contractors/vendors/agencies for structural engineer's approval	
	6.2	Site visit records / reports / approvals / comments / suggestions, Changes in design / drawings / details as per site situations, Monitoring safety / stability on the site during construction, Retrofitting / repairs / modifications etc. if necessary	
	6.3	Stage wise Certification, Monitoring quantities as construction progresses as in built drawings, Final certification	

Contribution to Outcome

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

1 Explain different concepts and schematic stages of structures, material required for construction and various interpretations.

2 Demonstrate use of the various IS codes, loadings parameters and different framing structure systems.

3	Prepare the cost comparison report and hand calculation techniques.
4	Prepare and run sample models in different software such as ETABS, STAAD, SAFE used in structural consultant.
5	Explain reinforcement details from samples, preparation of drawings and various design audit.
6	Conduct different tests according to list wise submittals and to form stage wise and final certifications for the designs.

Internal Assessment 20 Marks

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

End Semester Examination 80 Marks

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

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

Recommended Books:

1. Design of Reinforced Concrete Structures*: Dayaratnam, P;* Oxford and IBH.
2. Illustrated Reinforced Concrete Design: *Dr. V. L. Shah and Dr. S. R. Karve*, Structure Publications, Pune
3. Relevant IS codes, BIS Publication, New Delhi
4. Project Preparation, Appraisal, Budgeting, and Implementation: Prasanna Chandra (Tata McGraw Hill).
5. Construction Engineering and Management: S. Seetharaman, Umesh Publications, Delhi.

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Green Technology and Sustainable Engineering

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai
Green Technology and Sustainable Engineering
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HGSC501: Green Technologies and Practices**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HGSC601: Green Building and Infrastructure Engineering**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HGSC701: Fundamentals of Sustainable Engineering**	04	--	--	20	80	--	--	100	04
	HGSSBL701: Lab-1 Green Building and Infrastructure Engineering	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HGSC801: Sustainable Built Environment Engineering**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
									Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18	

Green Technology and Sustainable Engineering: Semester V		
Course Code	**Course Name**	**Credits**
HGSC501	**Green Technologies and Practices**	04

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	-	-	4	-	-	4

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

Rationale

Technology is application of knowledge to practical requirements. Green technologies encompass various aspects of technology which help us reduce the human impact on the environment and create ways of sustainable development. Social equitability, economic feasibility and sustainability are the key parameters for green technology. Today, the environment is racing towards the tipping point at which we would have done permanent irreversible damages to the planet earth. Our current actions are pulling the world towards an ecological landslide which if happens would make destruction simply inevitable. Green technologies are an approach towards savings earth and are necessary. Green technologies are our way out of destruction.

Objectives

1. To acquire knowledge on the concept of green technologies
2. To understand the principles of Green Chemistry in the Energy efficient technologies.
3. To analyze the methods of reducing CO2 levels in atmosphere for Cleaner Production Project Development and Implementation
4. To evaluate the methods of Pollution Prevention and Cleaner Production Awareness Plan.
5. To analyze the application of Energy Efficacy.
6. To apply the knowledge of Green Fuels during implementation.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Introduction to Green Technology**		07
	1.1	Definition- Importance – Historical evolution – advantages and disadvantages of green technologies.	
	1.2	Factors affecting green technologies.	
	1.3	Role of Industry, Government and Institutions-Industrial Ecology.	
	1.4	Role of industrial ecology in green technology.	
2	**Green Chemistry**		08

	2.1	Principles of Green Chemistry, Green chemistry metrics-atom economy.	
	2.2	E factor, reaction mass efficiency.	
	2.3	Waste: Sources of waste, different types of waste.	
	2.4	Chemical, physical and biochemical methods of waste minimization.	
	2.5	Clean development mechanism: reuse, recovery & recycle.	
	2.6	Raw material substitution: Wealth from waste, case studies.	
3	**Cleaner Production Project Development and Implementation**		09
	3.1	Overview of CP Assessment Steps and Skills, Process Flow Diagram.	
	3.2	Material Balance, CP Option Generation: Technical and Environmental Feasibility analysis.	
	3.3	Economic valuation of alternatives: Total Cost Analysis – CP Financing.	
	3.4	Preparing a Program Plan: Measuring Progress-ISO 14000.	
4	**Pollution Prevention and Cleaner Production Awareness Plan**		10
	4.1	Waste audit: Environmental Statement.	
	4.2	Carbon credit, Carbon trading, Carbon footprint.	
	4.3	Carbon sequestration.	
	4.4	Life Cycle Assessment- Elements of LCA.	
	4.5	Life Cycle Costing.	
	4.6	Eco Labeling.	
5	**Energy Efficacy**		08
	5.1	Availability and need of conventional energy resources: major environmental problems related to the conventional energy resources.	
	5.2	Future possibilities of energy need and availability.	
	5.3	Non-conventional energy sources: Solar Energy-solar energy conversion technologies and devices.	
	5.4	Solar Energy: principles, working and application.	
6	**Green Fuels**		10
	6.1	Definition-benefits and challenges: comparison of green fuels with conventional fossil fuels with reference to environmental, economical and social impacts- public policies and market driven initiatives.	
	6.2	Biomass energy: Concept of biomass energy utilization, types of biomass energy, conversion processes.	
	6.3	Wind Energy, energy conversion technologies, their principles, equipment and suitability in Indian context.	
	6.4	Tidal and geothermal energy.	

Contribution to Outcome

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

1. Enlist different concepts of green technologies in a project.
2. Describe the principles of Green Chemistry in the Energy efficient technologies.
3. Select the best method for the carbon credits of various activities for Cleaner Production Project Development and Implementation.
4. Evaluate the importance of life cycle assessment for Pollution Prevention and Cleaner Production Awareness Plan.
5. To apply the problems related to Pollution Prevention and Cleaner Production Awareness Plan.
6. To choose the green fuels based on their benefits for sustainable development.

Internal Assessment **20 Marks**

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

End Semester Examination **80 Marks**

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

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

Recommended Books:

1. Pollution Prevention: Fundamentals and Practice' by Paul L Bishop (2000), McGraw Hill International.
2. 'Pollution Prevention and Abatement Handbook –Towards Cleaner Production' by World Bank Group (1998), World Bank and UNEP, Washington D.C.
3. 'Cleaner Production Audit' by Prasad Modak, C. Visvanathan and Mandar Parasnis (1995), Environmental System Reviews, No.38, Asian Institute of Technology, Bangkok
4. 'Handbook of Organic Waste Conversion' by Bewik M.W.M.
5. 'Solar Energy' by Sukhatme S.P.

Reference Books:

1. 'Energy, The Solar Hydrogen Alternative' by Bokris J.O.
2. 'Non-conventional Energy Sources' by Rai G.D.
3. 'Waste Energy Utilization Technology' by Kiang Y. H.
4. Wind, Tidal, Geothermal, Biomass and Non–conventional energy Green fuel by G.D.Rai.

Green Technology and Sustainable Engineering : Semester VI		
Course Code	**Course Name**	**Credits**
HGSC601	**Green Building and Infrastructure Engineering**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hours**	**-**	**-**	**-**	**100**

Rationale

This course incorporating sustainable design/thinking as a new civil engineering course and experiences from the pilot offering. Important areas are outlined to aid all engineers in understanding sustainability in context with traditional engineering principles. Green-building rating systems are used to introduce the concepts of sustainability in buildings and infrastructure, highlighted by presentations from green-building professionals. By providing a better understanding of sustainability through education, civil engineers can provide proactive solutions to a growing global infrastructure.

Objectives

1. To acquire knowledge on various aspects of green building concepts.
2. To acquire knowledge on Indian Green Building Council.
3. To understand to green building design.
4. To apply knowledge on material conservation handling of non-process waste.
5. To analyze green building assessment systems national as well international.
6. To evaluate various terminologies Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Green Building Concepts**		07
	1.1	What is Green Building, Why to go for Green Building, Benefits of Green Buildings-	
	1.2	Green Building Materials and Equipment in India, What are key Requisites for Constructing a Green Building?	

	1.3	Principles of green building – Selection of site and Orientation of the building – usage of low energy materials – effective cooling and heating systems-	
	1.4	Effective electrical systems – effective water conservation systems-	
2	**Green Building Practices in India**		09
	2.1	Practices Indian Green Building Council, Green Building Moment in India, Benefits Experienced in Green Buildings-	
	2.2	Launch of Green Building Rating Systems, Residential Sector, Market Transformation-	
	2.3	Green Building Opportunities And Benefits: Opportunities of Green Building-	
	2.4	Green Building Features, Material and Resources, Water Efficiency	
	2.5	Optimum Energy Efficiency-	
	2.6	Typical Energy Saving Approach in Buildings-	
3	**Introduction to Green Building Design**		09
	3.1	Green Building Design Introduction, Reduction in Energy Demand-	
	3.2	Onsite Sources and Sinks, Maximize System Efficiency-	
	3.3	Steps to Reduce Energy Demand and Use Onsite Sources and Sinks, Use of Renewable Energy Sources.	
	3.4	Eco-friendly captive power generation for factory, Building requirement-	
4	**Material Conservation and Occupational Health**		09
	4.1	Material Conservation Handling of non -process waste, waste reduction during construction-	
	4.2	Materials with recycled content, local materials, material reuse, certified wood, Rapidly renewable building materials and furniture-	
	4.3	Indoor Environment Quality And Occupational Health: Air conditioning, Indoor air quality, Sick building syndrome, Tobacco smoke control-	
	4.4	Minimum fresh air requirements avoid use of asbestos in the building-	
	4.5	Improved fresh air ventilation, Measure of IAQ-	
	4.6	Reasons for poor IAQ, Measures to achieve Acceptable IAQ levels-	
5	**Green building Rating Systems**		09
	5.1	Green building assessments system studying e.g. LEED US (Leadership in Energy and Environmental Design)-	
	5.2	Living Building Challenge, Green Globes (Green Building Initiative) (US), Green Globes (ECD-Canada; LEED-Canada, Built Green CANADA	
	5.3	BREEAM (Building Research Establishment Environmental Assessment Method) (UK)-	
	5.4	LEED India (Indian GBC); IGBC Green modules; TERI-GRIHA (Green Rating for Integrated Habitat Assessment) (India) Rating modules-	
6	**Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management**		09
	6.1	Introduction to the Concept: “Life Cycle assessment of materials”-	

	6.2	EIA: Introduction to EIA. Process of EIA and its application through a case study, EIA as a strategic tool for sustainable development-Social Impact Assessment of Infrastructure projects-	
	6.3	Embodied energy of various construction materials-Energy Management with respect to buildings-	
	6.4	Clean Development Mechanism, Kyoto Protocol, Energy Conservation Building Code-	

Contribution to Outcome

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

1. Explain the concepts of green building.
2. Learn practices Indian Green Building Council and GRIHA.
3. Use the green building design in the projects.
4. Learn material conservation handling of non -process waste.
5. Learn green building assessment systems national as well international.
6. Study various terminologies Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management.

Internal Assessment **20 Marks**

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

End Semester Examination **80 Marks**

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

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

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

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

4 Only Four questions need to be solved.

Recommended Books:

1. Manual of Tropical housing and climate by Koenisberger
2. Climate responsive architecture by Arvind Krishnan
3. Manual of solar passive architecture - by Nayak J.K. R. Hazra J. Prajapati.
4. Energy Efficient Buildings in India by Milli Mujumdar
5. Solar Energy in Architecture and Urban Planning by Herzog Thomas
6. Sustainable Building Design Manual-Volume I and II –TERI Publication
7. Green building codes and standards
8. International Green Construction Code
9. Complete Guide to Green Buildings by Trish riley
10. Standard for the design for High Performance Green Buildings by Kent Peterson, 2009

Reference Books:

1. Green Building Hand Book by Tom woolley and Sam kimings, 2009.
2. Green Building Materials by Ross Spiegel and Dru Meadows
3. Publications from - CBRI, SERC, BMTPC
4. Shahane, V. S, “Planning and Designing Building”, Poona, Allies Book Stall, 2004.
5. Michael Bauer, Peter Mösle and Michael Schwarz “Green Building – Guidebook for Sustainable Architecture” Springer, 2010.
6. Tom Woolley, Sam Kimmins, Paul Harrison and Rob Harrison “Green Building Handbook” Volume I, Spon Press, 2001.

Green Technology and Sustainable Engineering : Semester VII		
Course Code	**Course Name**	**Credits**
HGSC701	**Fundamentals of Sustainable Engineering**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

This course contains content that address sustainability issues and innovations of relevance to the discipline area. Sustainability content (principles and theory) is well integrated into the course. The course outline specifically addresses the sustainability content.

Objectives

1. To acquire knowledge and awareness among students on issues in areas of sustainability.
2. To understand the role of engineering Environmental Pollution and Environmental legislations in India.
3. To understand the International Environmental Management Standards.
4. To apply a clear understanding of the role and impact of various aspects of engineering and engineering decisions on environmental, societal, and economic problems.
5. To analyze the Sustainable Engineering.
6. To evaluate the Sustainable Assessment Systems.

Detailed Syllabus			
Module	**Course Module / Contents**		**Hours**
1	**Introduction to Sustainability**		08
	1.1	Sustainability-Introduction, Historical Evolution-Goals of Sustainable Development-Principles of Sustainability-Sustainability-need and concept, challenges.	
	1.2	Social, Environmental and Economic sustainability concepts	
	1.3	Sustainable development, Nexus between Technology and Sustainable development, Challenges for Sustainable Development.	
	1.4	Multilateral environmental agreements and Protocols-Clean Development Mechanism (CDM)	
2	**Environmental Pollution and Environmental legislations in India**		09

	2.1	Regional and Local Environmental Issues-Air Pollution, Sources- Effects-Preventative Measures of Air Pollution; Water pollution- Land Pollution	
	2.2	Sustainable wastewater treatment, Solid waste - sources, impacts of solid waste, Zero waste concepts, 3 R concept-	
	2.3	Environmental legislations in India-Water Act, Air (Pollution & Prevention) Act	
	2.4	Environmental Protection Act and Climate Change Act	
	2.5	Forest Act, Animal Protection Act, Factory Act, Labour Act	
	2.6	SEZ Notifications, CRZ Notifications etc	
3	**International Environmental Management Standards**		09
	3.1	International Environment Acts and Protocols, Global, Regional and Local environmental issues, Natural resources and their pollution, Carbon credits, Carbon Trading, Carbon Foot Print	
	3.2	ISO 14000, ISO 14001, Life Cycle Analysis, Environmental Impact Assessment studies, Sustainable habitat	
	3.3	Global environmental issues-Resource degradation, Climate change, Global warming, Ozone layer depletion	
	3.4	Sustainable materials-Conventional and renewable material sources, sustainable development, Sustainable urbanization, Industrial Ecology	
4	**Basic concepts of sustainable habitat and Energy sources**		09
	4.1	Basic concepts of sustainable habitat, Sustainable materials for building construction	
	4.2	Material selection for sustainable design	
	4.3	Conventional and non-conventional energy sources-Solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans, Geothermal energy-Methods for increasing energy efficiency of buildings	
	4.4	Embodied energy of various construction materials-Energy Management with respect to buildings	
	4.5	Clean Development Mechanism	
	4.6	Kyoto Protocol, and Energy Conservation Building Code	
5	**Sustainable Engineering**-		08
	5.1	Sustainable Urbanization- Sustainable cities-	
	5.2	Sustainable transport-Industrialization and poverty reduction-Social and technological change-	
	5.3	Industrial Processes: Material selection, Pollution Prevention, Industrial Ecology, Industrial symbiosis	
	5.4	Bio-mimicking	
6	**Sustainable Assessment Systems**		09
	6.1	Studying few Green/Sustainable building assessments systems e.g. Living Building Challenge, Green Globes (Green Building Initiative) (US)	
	6.2	LEED India and GRIHA Sustainability Assessment Techniques-	
	6.3	Green Globes (ECD–Canada, International Initiative for a Sustainable Built Environment: iiSBTool	

	6.4	SBModel 15	
Contribution to Outcome			

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

1. To explain issues in areas of sustainability.
2. To summarize the role of engineering Environmental Pollution and Environmental legislations in India.
3. To interpret the International Environmental Management Standards.
4. To relate a clear understanding of the role and impact of various aspects of engineering and engineering decisions on environmental, societal, and economic problems.
5. To connect the Sustainable Engineering
6. To develop the Sustainable Assessment Systems.

Internal Assessment **20 Mark**s

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

End Semester Examination **80 Marks**

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

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

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

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

4 Only Four questions need to be solved.

Recommended Books:

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
2. Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
3. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
4. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Lang.
5. Prohit, S. S., Green Technology - An approach for sustainable environment, Agrobios publication uage Book Society (ELBS).

Reference Books:

1. Environment Impact Assessment Guidelines, Notification of Government of India, 2006
2. ECBC Code 2016, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System
3. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.

Green Technology and Sustainable Engineering : Semester-VII		
Course Code	**Course Name**	**Credits**
Lab 1: HGSSBL601	**Green Building and Infrastructure Engineering**	**02**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**04 Per Week**	-	-	**02**		**02**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
-	-	-	-	-	**50**	-	**50**	**100**

Course Objective:

1. To acquire knowledge on various aspects of green building concepts.
2. To acquire knowledge on Indian Green Building Council.
3. To understand green building design.
4. To analyze green building assessment systems national as well international.
5. To apply knowledge on material conservation handling of non-process waste.
6. To evaluate various terminologies of Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management

List of Experiments (Conduct six practicals out of nine mentioned below)		
Module	**Detailed Content**	**Lab Session / Hr.**
1	To study sustainable planning aspects for urban housing (Literature based).	04
2	To study the benefits given by Municipal Corporations to Green Buildings (Literature based).	04
3	To prepare detailed plan for a hypothetical site indicating utility of solar path, wind direction, rainfall intensity etc., to make it sustainable (Literature based)	04
4	To prepare a report on energy efficient buildings in India (Case Study based).	04
5	To compare the benefits under different green building rating systems (Literature based)	04
6	To study: Innovative Materials Developed by CBRI, SERC (Literature based).	04
7	To study, analyze present scenario of organic waste collection and management of any of the premise; preferably hotels (Case Study based)	04
8	To prepare a report on carbon credit, carbon Trading and Carbon footprint (Literature based).	04
9	To study: Environmental Audit of any existing building and prepare a report (Case Study based).	04

Course Outcomes

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

1. Understand the concepts of green building.
2. Learn practices of Indian Green Building Council and GRIHA
3. Design a sustainable green building
4. Assessed green building systems nationally as well internationally.
5. Learn material conservation handling of non-process waste.
6. Study various terminologies of Embodied Energy, Life Cycle Assessment, Environmental Impact Assessment, Energy Audit and Energy Management.

Assessment:

Term work:

Shall consist of Assignment, design report, case study and Site visit report related to this course. Distribution of marks for Term Work shall be as follows:

Assignment: 15 marks

Case study/Literature report: 15 marks

Site visit: 15 marks

Attendance: 05 marks

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

End Semester Oral Examination:

Oral examination shall be based upon the entire theory, site visit and laboratory syllabus.

Recommended Books:

1. 'Handbook of Organic Waste Conversion' by Bewik M.W.M.
2. Green Building Hand Book by Tom woolley and Sam kimings, 2009.
3. Energy Efficient Buildings in India by Milli Mujumdar
4. Allen, D. T. and Shonnard, D. R., 'Sustainability Engineering: Concepts, Design and Case Studies', Prentice Hall.
5. 'Solar Energy' by Sukhatme S.P.
6. 'Waste Energy Utilization Technology' by Kiang Y. H.

Reference Books:

1. Handbook on Green Practices published by Indian Society of Heating Refrigerating and Air-conditioning Engineers, 2009.
2. Manual of Tropical housing and climate by Koenisberger
3. Climate responsive architecture by Arvind Krishnan
4. Manual of solar passive architecture - by Nayak J.K. R. Hazra J. Prajapati.
5. Green Building Materials by Ross Spiegel and Dru Meadows Publications from - CBRI, SERC, BMTPC
6. Solar Energy in Architecture and Urban Planning by Herzog Thomas
7. Sustainable Building Design Manual-Volume I and II –TERI Publication
8. Green building codes and standards
9. International Green Construction Code
10. Complete Guide to Green Buildings by Trish riley
11. Standard for the design for High Performance Green Buildings by Kent Peterson, 2009
12. Shahane, V. S, "Planning and Designing Building", Poona, Allies Book Stall, 2004.
13. Michael Bauer, Peter Mösle and Michael Schwarz "Green Building – Guidebook for Sustainable Architecture" Springer, 2010.
14. Tom Woolley, Sam Kimmins, P. Harrison and R. Harrison "Green Building Handbook" Volume-I, Spon Press, 2001.

Green Technology and Sustainable Engineering : Semester VIII		
Course Code	**Course Name**	**Credits**
HGSC801	**Sustainable Built Environment Engineering**	**04**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

Theory					Term Work/Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	Term Work	Pract.	Oral	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hours**	**-**	**-**	**-**	**100**

Rationale

Education for sustainability is an important part of the journey to live and work in a sustainable manner. Curricula changes to incorporate sustainability education in the built environment disciplines is not a new phenomenon. Often, curricula changes are made from the perspective of the discipline and the individual learning the course.

Objectives

1. To Understand Sustainable Development
2. To apply knowledge for Understanding Ecosystems
3. To evaluate Environmental Sustainability.
4. To create Socio-economic Sustainability.
5. To create Urban Planning and Environment.
6. To analyze the Built in Environment.

Detailed Syllabus

Module	Course Module / Contents		Hours
1	**Sustainable Development**		08
	1.1	Definitions and principles of Sustainable Development - History and emergence of the concept of Sustainable Development.	
	1.2	Environment and Development linkages- Globalization and environment.	
	1.3	Millennium Development Goals- Status (global and Indian)-	
	1.4	Impacts on approach to development policy and practice in India, future directions.	
2	**Understanding Ecosystems**		09
	2.1	Understanding Ecosystems-biodiversity hotspots, Understanding Critical Perspectives on Environment and Development-Environmental Policy and Law, Landscape Ecology and human development.	
	2.2	Introduction to Policy, Institutions and Governance-Urbanization-Conservation of natural resources and livelihood security.	

	2.3	Environment- Evaluation and Impact Assessment Frameworks-Knowledge of ecosystem dynamics, ecosystem-livelihood linkages, Environmental vulnerabilities and adaptations.	
	2.4	Resilience towards climate change and disasters-Environment-development-poverty linkages, issues of access and justice.	
	2.5	Understanding of field techniques and skills to assess ecological processes-Skills to engage with local communities, undertake impact assessments.	
	2.6	Experiential learning of conservation and development issues.	
3	**Environmental Sustainability**		09
	3.1	Land, Water and Food production	
	3.2	Moving towards sustainability: Energy powering	
	3.3	Sustainable Development - Financing the environment	
	3.4	Sustainable Development- Development of Environmental Protection Mechanism	
4	**Socio-economic Sustainability**		09
	4.1	Empowerment of Women, Children, Youth, Indigenous People	
	4.2	Non-Governmental Organizations, Local Authorities, Business and Industry	
	4.3	Sustainability Performance indicators and Assessment mechanism	
	4.4	Hurdles to sustainability- Constraints and barriers for sustainable development	
	4.5	Operational guidelines-Interconnected prerequisites for sustainable development	
	4.6	Science and Technology for sustainable development	
5	**Urban Planning and Environment**		08
	5.1	Environment and Resources	
	5.2	Sustainability Assessment- Future Scenarios	
	5.3	Form of Urban Region- Managing the change	
	5.4	Integrated Planning-Sustainable Development	
6	**The Built in Environment**		09
	6.1	Urban Form	
	6.2	Land Use-Compact Development	
	6.3	Principles of street design-complete streets	
	6.4	Transport Integrated Urban land use Planning- Guidelines for Environmentally sound Transportation	

Contribution to Outcome

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

1. Describe the concept and socio-economic policies of Sustainable Development.
2. Identify the strategies for implementing eco development programs.
3. Identify different approaches for resource conservation and management.

4. Suggest action plans for implementation of sustainable development.
5. Explain Urban Planning and Environment.
6. Explain the built in environment.

Internal Assessment **20 Marks**

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

End Semester Examination **80 Marks**

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

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

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

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

4 Only Four questions need to be solved.

Recommended Books:

1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
2. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
3. ECBC Code 2016, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System
4. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.
5. Prohit, S. S., Green Technology - An approach for sustainable environment, Agrobios publication uage Book Society (ELBS).
6. Ganesha Somayaji and Sakarama Somayaji, "Environmental Concerns and Sustainable development: Some perspectives from India", Editors: publisher TERI Press, ISBN 8179932249.
7. Kirkby. J, O'Keefe P. and Timberlake, "Sustainable development" Earth Scan Publication, London, 1996.

Reference Books:

1. Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
2. Environment Impact Assessment Guidelines, Notification of Government of India, 2006
3. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Lang
4. Gilg A W and Yarwood R, "Rural Change and Sustainability - Agriculture, the Environment and Communities", CABI Edited by S J Essex, September2005.
5. James H. Weaver, Michael T. Rock, Kenneth Kustere, "Achieving Broad-Based Sustainable Development: Governance, Environment, and Growth with Equity", Kumarian Press, West Hartford, CT. Publication Year, 1997.
6. Kerry Turner. R, "Sustainable Environmental Management", Principles and Practice Publisher: Belhaven Press, ISBN: 1852930039.
7. Munier N, "Introduction to Sustainability", Springer2005.

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Infrastructure Policies & Regulations

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Infrastructure Policies & Regulations (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract.	Internal Assess-ment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HIPC501: Environmental Policies & Regulations**	04	--	--	20	80	-	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HIPC601: Land Policies & Regulations**	04	--	--	20	80	-	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HIPC701: Infrastructure Finance & Business Policies**	04	--	--	20	80	--	--	100	04
	HIPSBL 701: Lab-1 Infrastructure Finance & Business Policies	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HIPC801: Arbitration & Conciliation**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
Total Credits for Semesters V, VI, VII & VIII = 04+04+06+04 = 18										

Infrastructure Policies & Regulations : Semester-V		
Course Code	**Course Name**	**Credits**
HIPC 501	**Environmental Policies & Regulations**	04

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

Environmental law describes a network of regulations and customary laws that address the effects of human activity on the natural environment. These laws are also referred to as environmental and natural resource laws and centre on the idea of environmental pollution. Environmental law is necessary to combat issues related to the environment and conservation of natural resources. Environmental law addresses a wide variety of different areas like reducing air pollution and maintaining air quality, Water Quality, Waste management, Sustainability of resources. This course covers the laws related to sustainable development and protections of environment under general laws. It also emphasizes the laws regarding hazardous and solid waste management, water, air and noise pollution and its prevention. It explores the compliance and enforcement of international environmental law.

Objectives

1. To understand and explain the significance of sustainable development and laws regarding protection of environment.
2. To study the laws related to environment (protection) act, 1986.
3. To emphasize the salient features of water act and describe the laws related to water pollution.
4. To study the salient features of air pollution act and understand the laws related to air and noise pollution.
5. To study the laws regarding hazardous and solid waste management.
6. To understand the International Environment Laws and policies.

Detailed Syllabus

Module	Course Modules / Contents	Hours
1	**Sustainable Development and Protection of environment under General Laws** Introduction, Sustainable development, Precautionary principle, the polluter pays principle, the public trust doctrine, eco-development, sustainable development and the Indian judiciary, Environment protection under the law of Torts, Environment protection under the Indian Penal Code:1860, Environment protection under the criminal procedure code:1973, Constitutional provisions and environment protection in India.	**10**
2	**The Environment (Protection) Act, 1986**	**8**

	Introduction, Aims and objectives, Scope and commencement of the act, Salient features of the act, definitions, general powers of the central government, prevention, control and abatement of environmental pollution, offences and penalties, miscellaneous provisions.	
3	**Water Pollution**	**9**
	Introduction, aims and objectives, Salient features of the water pollution act, constitution of central and state boards and their powers and functions, appeals and revisions, offences and penalties, prevention and control of water pollution, miscellaneous provisions.	
4	**Air pollution and Noise Pollution**	**10**
	Introduction, Aims and objectives, Salient features of the air pollution act, constitution of central and state boards and their powers and functions, appeals and revisions, offences and penalties, miscellaneous provisions, Noise Pollution regulation and control rule 2000, legislative and non-legislative measures, control of noise pollution.	
5	**Hazardous and Solid Waste Management**	**8**
	Introduction, ozone depleting substances (Regulation and control rule 2000), Hazardous and other waste (Management and transboundary movement) Rules 2016, Construction and demolition waste management Rule 2016, Solid waste management Rule 2016, Wetland (Conservation and management) Rule 2017.	
6	**International Environment Law**	**7**
	An introduction to international law, Sources and basic principles of international law, development of international laws, nature and scope, establishment of environment institutions like UNEP, World charter for nature 1982, Relationship between international laws and domestic laws: Compliance and enforcement.	
	Total	**52**

Contribution to Outcome

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

1. Illustrate the significance of sustainable development and protection of environment under general laws.
2. Explain and implement the laws related to environment (protection) act, 1986.
3. Summarize the salient features of water act and identify the laws related to water pollution.
4. Understand the salient features of air pollution act and classify the laws related to air and noise pollution.
5. Analyze and appraise the laws regarding hazardous and solid waste management.
6. Explore and justify the importance of International Environment Laws and policies.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

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

End Semester Examination (80 Marks):

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

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

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

Recommended Books:

1. Divan S. and Rosencranz A. (2005) Environmental Law and Policy, 2nd ed., New Delhi.
2. Leelakrishnan P. (2008) Environmental Law in India, 3rd ed., Lexis Nexis, India.
3. Shastri S. C. (2012) Environmental Law, Eastern Book Company, 4th ed., Lucknow.
4. Gurdip Singh (2016) Environmental Law in India, 2nd ed.
5. Dr. Paramjit Jaswal, Dr. Nishtha Jaswal and Vibhuti Jaswal (2021) Environmental Law, Allahabad Law Agency, 5th ed., Allahabad.

Reference Books:

1. Alaxander kiss and Diana Shelton (2007) Guide to International Environmental Laws, Martinus Nijhoff Publisher, USA.
2. Philippe Sands and Jacqueline Peel, Principles of International EnvironmentalLaw (4th ed., 2018).
3. Shibani Ghosh ed., Indian Environmental Law: Key Concepts and Principles (2019).
4. Geetanjoy Sahu, Environmental Jurisprudence and the Supreme Court: Litigation, Interpretation, Implementation (2014).
5. Stuart Bell & Donald Mc Gillivray, Environmental Law (7th ed., 2008).

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Infrastructure Policies & Regulations : Semester-VI		
Course Code	**Course Name**	**Credits**
HIPC 601	**Land Policies & Regulations**	**04**

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

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

Rationale

Land law is important in relation with the Infrastructure Engineering students. This will familiarize the students with the acts and codes that are applicable as per actual conditions in the field. The course deals with the overall knowledge of the central and state acts and rules. Land law is the form of law that deals with the rights to use, alienate, or exclude others from land. In many jurisdictions, these kinds of property are referred to as real estate or real property, as distinct from personal property. Land use agreements, including renting, are an important intersection of property and contract law. Civil and Infrastructural Engineers need to have a working knowledge of the land laws that affect their work and that will enable them to comply with local, state & national regulations; understand the boundaries of their personal and professional liability; negotiate contracts; protect their intellectual property; develop a relationship with a law firm that understands the engineering business.

Objectives

1. To understand and explain the registration act and coastal regulations zones.
2. To provide knowledge of the urban land act & the land acquisition act.
3. To understand Maharashtra stamp act & the development control regulations.
4. To understand the MHADA and MahaRERA act.
5. To study Maharashtra Regional Town Planning Act.
6. To study the Maharashtra Land Revenue Code.

Detailed Syllabus

Module		Course Module / Contents	Periods
A		**CENTRAL LEGISLATION**	
1		**The Registration Act, 1908 & The Environment (Protection) Act, 1986 – Coastal Regulation Zones (CRZ)**	**08**
	1.1	The Registration Act, 1908: Introduction, definitions, documents, time limit for registration and effects of non-registrations of documents.	
	1.2	The Environment (Protection) Act, 1986 – Coastal Regulation Zones (CRZ): Areas covered, prohibited and regulated activities and classification of CRZ.	
2		**The Urban Land (Celling and Regulation) Act, 1976 & The Land Acquisition Act, 1894**	**09**
	2.1	The Urban Land (Celling and Regulation) Act, 1976: Introduction and repeal, definitions, celling limits on vacant lands and power to exempt and retention of excess vacant land	

	2.2	The Land Acquisition Act, 1894: General, introduction and definitions, acquisition of land, reference to the court, miscellaneous provisions and case law. Land Records documents i.e. 7x12 abstract, 8A, Ferfar, property card, Gut book. CTS Plan	
B	**STATE LEGISLATION**		
3	**Maharashtra Stamp Act, 1958 & The Development Control Regulations (DCR), 1991**		**07**
	3.1	Maharashtra Stamp Act, 1958: Constitutional provisions, objects & summary of the act, payment of stamp duty, adjudication of stamp duty, impounding of instruments, admissibility of instrument and prosecution for stamp law offences.	
	3.2	The Development Control Regulations (DCR), 1991: Floor Space Index (FSI), transfer of development rights (TDR), heritage buildings and precincts.	
4	**The Maharashtra Housing & Area Development Act (MHADA), 1976 & Maharashtra's Real Estate (Regulation and Development) Act, 2016 (MahaRERA)**		**14**
	4.1	The Maharashtra Housing & Area Development Act (MHADA), 1976: Definitions, powers & duties of the Mumbai repairs and reconstruction board, levy and collection of cess, structural repairs, acquisition of cessed properties for cooperative societies.	
	4.2	Maharashtra's Real Estate (Regulation and Development) Act, 2016 (MahaRERA): Introduction, regulatory framework, registration of real estate project and registration of real estate agents, functions and duties of promoter, rights and duties of allottees, the real estate regulatory authority, central advisory council, offences, penalties and adjudication, FAQ's.	
5	**Maharashtra Regional Town Planning (MRTP) Act, 1966**		
	5.1	Introductory & definitions, control of development, unauthorized development and acquisition of land.	**04**
6	**Maharashtra Land Revenue Code, 1966**		
	6.1	Introduction, use of land, removal & regularisation of encroachments, grant of sanad, record of rights, rights in unoccupied land, appeals, revision and review	**10**
	6.2	Special provisions for land revenue in Bombay city: general, assessment and collection of land revenue, Bombay city survey & boundary marks, government lands and foreshore, transfer of lands.	
		Total	**52**

Contribution to Outcome

After the completion of the course the student should be able to:

1. Understand the functionality of the registration act and coastal regulations zones as per central regulations of India.
2. Analyse and integrate functionality of the urban land act & the land acquisition act in India.
3. Explain Maharashtra Stamp Act & the development control regulations.
4. Understand the MHADA and MahaRERA act.
5. Understand Maharashtra Regional Town Planning Act.
6. Familiarise with the Maharashtra Land Revenue Code.

Internal Assessment (20 Marks):
Consisting **Two Compulsory Class Tests**

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

End Semester Examination (80 Marks):

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

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

Recommended & Reference Books:

1. MahaRERA Act, The Real Estate (Regulation and Development) Act, 2016 and Rule 2017 - Y. M. Agarwala, Adv. A. B. Shah; Aarti & Company's Publications
2. Land Law – Prof. H.D. Pithawalla; C. Jamndas & Co.
3. Maharashtra Land Laws by D N Mathur, Central Law Publications
4. Land Laws in Maharashtra by Sunil Dighe, Snow White Pub. P Ltd
5. Land Laws by Abhay Shah; Aarti & Company's Publications
6. Land Law (Law and Real Estate Laws) by Krishan Keshav; Singhal's Publications
7. Land Laws (Including Land Acquisition and Rent Laws) by Kanwal D.P. Singh; Satyam Law International

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Infrastructure Policies & Regulations : Semester-VII		
Course Code	**Course Name**	**Credits**
HIPC 701	**Infrastructure Finance & Business Policies**	**04**

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

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

Rationale

Looking at India's exponential growth with the infrastructure space teeming with activity and the government as well as the private sector heavily investing in the creation of better infrastructure both in terms of its business and with an eye on its longevity, this course will prove to be a holy grail for students considering the aspects of business law. The course will provide an overview of the underlying legal framework for doing business in India including Constitutional Acts, Companies Act and other relevant statutes. The course will familiarize students with the sector specific legislation, the constitutional, general legal context, regulatory law, where it exists. The course intends to enable each student to have knowledge of fundamental tools of legal research and application of the same in development of the infrastructure sector.

Objectives

1. To highlight the business environment, forms of business, scale of business and emerging trends in business.
2. To describe about the general legal environment and framework in India.
3. To provide an overview of Indian Constitutional Acts, Companies Act and other relevant statutes.
4. To define & interpret the financing of infrastructure and growth of PPP (Public Private Partnership) in various sectors of Infrastructural development.
5. To understand preconstruction and post construction processes involved in infrastructural projects/contracts.
6. To examine the details of Project Financing in Infrastructure Contracts.

Detailed Syllabus

Module	Course Modules / Contents	Hours
1	**Business Environment**	**8**
	Types of Business Environment, Forms of Business Organization, Concept and Features in relation to following business models- Sole Proprietorship; Partnership, Company; Statutory Bodies and Corporations; HUF and Family Business. Scales of Business, Micro, Small and Medium Enterprises; Large Scale Enterprises and Public Enterprises; MNC's Emerging Trends in Business, Concepts, Advantages and Limitations-Franchising, Aggregators, Business Process Outsourcing (BPO)& Knowledge Process Outsourcing (KPO); E-Commerce, Digital Economy.	
2	**Legal Environment of Business in India**	**10**
	Introduction to Bills, Laws/Acts, Rules, Regulations, and associated legal reasoning and procedures, Introduction to Constitution and Constitutional Law. Stakeholders including legal	

	system covering judicial, quasi-judicial authorities & Constitutional Authorities etc. and other Advisory Boards/entities. Outline the intent of Business Allocation of Rules of Government (e.g. Departments in States and Ministries at the Centre)	
3	**Acts, Statutes and Regulation**	**10**
	Introduction to various Acts and their key provisions, such as Indian Companies Act- 2013, Negotiable Instruments Act, Industrial Dispute Act, Minimum Wages Act, Special Relief Act, Transfer of property act, Right to fair compensation & transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013, Income Tax Act.	
4	**Infrastructure Contracts**	**8**
	Introduction and Features of Infrastructure contracts, Introduction to PPP in India, PPP Models in India, Contracts in PPP model Principles of contract-essential conditions, Void & voidable contract, capacity & consideration, types & terms of contracts (in accordance with Indian Contract Act 1872); Performance and discharge of contract; breaches of contracts and remedies; introduction to special contracts such as contract of indemnity, guarantee, leasing agreement.	
5	**Infrastructure Project Contracts**	**8**
	Parties in Infrastructure Contracts, Bidding Process, Negotiation of Infrastructure Project Management Contracts, Allotment of Contracts, Drafting EPC & Concession Agreements, Project Appraisal, Compliances and Due Diligence.	
6	**Project Financing in Infrastructure Contracts**	**8**
	Introduction to project financing, Equity and corporate debt financing, Stages in Project Financing, Regulatory Framework and Authorities, Borrowing from International financial institutions, FDI in Infrastructure developments, Documentation in Project Financing, Restructuring in project finance transactions, Case Studies on Infrastructure Project Management	
	Total	**52**
Contribution to Outcome		

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

1. Explain the concepts related to Business environment
2. Elaborate the general legal environment and framework in India
3. Understand the acts, statutes and their regulation involved in infrastructure projects
4. Apply models of infrastructure development on respective projects in PPP
5. Understand preconstruction and post construction processes involved in infrastructural projects/contracts.
6. Define and interpret the financing of Infrastructure Contracts.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

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

End Semester Examination (80 Marks):

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

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

Recommended Books:

1. Satyanarayana, G. (2017). Infrastructure Development & the Role of Public-PrivatePartnership. 1st ed. New Delhi, India: New Century Publications.
2. Piyush Joshi(2003), Law Relating to Infrastructure Projects, New Delhi: Butterworths.
3. N.D. Kapoor &DinkarPagare Business Laws and Management; Sultan Chand & Sons.
4. P. P. S. Gogna A Textbook of Business Law; Sultan Chand & Company, New Delhi.
5. Poonam Gandhi Business Studies; Dhanpat Rai & Company Private Limited, Delhi.
6. Willie Tan, (2007). Principles of Project and Infrastructure Finance, 1 edition. Routledge;
7. Hoffman, Scott L., (2007). The Law and Business of International Project Finance, 3rd Edition, London: Cambridge University Press.
8. Vinter, Graham (2013) Project Finance, 4th Edition, London: Sweet and Maxwell.
9. Gajendra Haldea, (2011). Infrastructure at Crossroads: The Challenges of Governance, Oxford University Press; 1st ed edition
10. Dewar, John (2015) International Project Finance: Law and Practice, 2nd Edition, Oxford University Press
11. Mulla, D.F., The Indian Contract Act, 13th Ed., LexisNexis/Butterworths
12. Tripathi, S.C., Modern Company Law, 5th Ed., Central Law Publications
13. I.P Massey (2008), Administrative Law, Lucknow: Eastern Book Company.
14. D D Basu (2009), The Constitutional Law of India, New Delhi: Lexis Nexis Butterworths.

Reference Books:

1. Sen & Mitra Commercial Law; The World Press Pvt. Ltd., Calcutta.
2. Ian Wirthington & Chris Britton The Business Environment; Pearson Education Ltd., England.
3. Raymond W.Y. Kao Entrepreneurship and Enterprises Development

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Infrastructure Policies & Regulations : Semester-VII		
Course Code	**Course Name**	**Credits**
HIPSBL 701	**Infrastructure Finance & Business Policies (Lab)**	**02**

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**04**	-	-	**02**	-	**02**

Theory					Term Work/Practical/Oral			
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	Total
Test-I	Test-II	Average						
-	-	-	-	-	**50**	-	**50**	**100**

Objectives

1. To study the business environment and emerging trends in business.
2. To learn the general legal environment followed for infrastructure projects in India.
3. To provide detail overview of land acquisition, rehabilitation and redevelopment of infrastructure.
4. To explain emerging sectoral growth of PPP (Public Private Partnership) in various sectors of infrastructural development.
5. To develop contracts and agreements with various stakeholders related to infrastructure projects.
6. Examine the intricacies of Project Financing in Infrastructure Contracts.

Module	Detailed Contents (Any Six)	Lab Sessions/Hr
1	To prepare a case study report of Knowledge Process Outsourcing (KPO) related to infrastructure-based company.	4
2	To prepare a case study report of Business Process Outsourcing (BPO) related to infrastructure-based company.	4
3	To prepare a case study report based on legal environment of business in India.	4
4	To prepare a case study report based on land acquisition and rehabilitation (eg. Sardar Sarovar).	4
5	To prepare a case study report of PPP in one of the sectors of Infrastructural development.	4
6	Prepare a sample draft of EPC contracts enlisting all the necessary elements for infrastructure project.	4
7	To prepare a case study report of business model applying key parameters in project financing.	4
8	To prepare a case study report highlighting the important features of slum rehabilitation (eg. SRA project).	4
9	To prepare a case study report based on mega redevelopment projects in India (eg. BDD chawl).	4

Lab Outcomes

Learner will be able to…

1. Explain the business environment and emerging trends in business.
2. Elaborate the general legal environment followed for infrastructure projects in India.
3. Apply intricacies of land acquisition, rehabilitation and redevelopment of infrastructure.
4. Apply emerging techniques related to PPP (Public Private Partnership) in various sectors of infrastructural development.
5. Build contracts and agreements with various stakeholders related to Infrastructure projects.
6. Define the intricacies of project financing in infrastructure contracts.

End Semester Oral Examinations:

Oral exam will be based on laboratory work performed (case study report).

Recommended Books:

1. Satyanarayana, G. (2017). Infrastructure Development & the Role of Public-Private Partnership. 1st ed. New Delhi, India: New Century Publications.
2. Piyush Joshi(2003), Law Relating to Infrastructure Projects, New Delhi: Butterworths.
3. N. D. Kapoor & Dinkar Pagare Business Laws and Management; Sultan Chand & Sons.
4. P. P. S. Gogna A Textbook of Business Law; Sultan Chand & Company, New Delhi.
5. Poonam Gandhi Business Studies; Dhanpat Rai & Company Private Limited, Delhi.
6. Willie Tan, (2007). Principles of Project and Infrastructure Finance, 1 edition. Routledge;
7. Hoffman, Scott L., (2007). The Law and Business of International Project Finance, 3rd Edition, London: Cambridge University Press.
8. Vinter, Graham (2013) Project Finance, 4th Edition, London: Sweet and Maxwell.
9. Gajendra Haldea, (2011). Infrastructure at Crossroads: The Challenges of Governance, Oxford University Press; 1st ed edition
10. Dewar, John (2015) International Project Finance: Law and Practice, 2nd Edition, Oxford University Press
11. Mulla, D. F., The Indian Contract Act, 13th Ed., LexisNexis/Butterworths
12. Tripathi, S.C., Modern Company Law, 5th Ed., Central Law Publications
13. I. P. Massey (2008), Administrative Law, Lucknow: Eastern Book Company.
14. D. D. Basu (2009), The Constitutional Law of India, New Delhi: Lexis Nexis Butterworths

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Infrastructure Policies & Regulations : Semester-VIII		
Course Code	**Course Name**	**Credits**
HIPC801	**Arbitration & Conciliation**	

Contact Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
4	**-**	**-**	**4**	**-**	**-**	**4**

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

Rationale

The Arbitration and Conciliation concept has been modelled on lines of the UNCITRAL (United Nations Commission on International Trade Law) framework of laws with the idea to modernize Indian arbitration law and bring it in line with the best global practices and also make India a global hub for arbitration. Arbitration and conciliation play significant role in construction industry due to disputes arising on large scale construction projects. Alternative Dispute Resolution (ADR) mechanism provides scientifically developed techniques to Indian judiciary. ADR provides various modes of settlement including arbitration, conciliation, mediation, negotiation, etc. This course deals with introduction to arbitration and conciliation, there requisites, rules, proceedings, roles of individuals, etc.

Objectives

1. To understand the importance of arbitration in resolving disputes in construction infrastructure industry.
2. To study the constitution of arbitral tribunal in the process of arbitration.
3. To study the procedures and conduct of arbitral proceedings.
4. To understand the making of arbitral award & termination of proceedings.
5. To study the significance and concepts of conciliation.
6. To study of the alternative means of settlement of disputes with negotiations.

Detailed Syllabus

Module	Course Modules / Contents	Hours
1	**Arbitration** Arbitration and its significance in construction industry, Role of arbitrator, The Construction Industry Arbitration Commission (CIAC), Arbitration agreement- Form, constitution, Guarantor to agreement, Interim measures by court, Arbitral award, Arbitral tribunal, International commercial arbitration, legal representative, Scope of arbitration, Arbitral disputes, the arbitration & conciliation act 1996- Consolidating & amendment act, provisions, preamble & its purpose.	**09**
2	**Composition of Arbitral Tribunal**	**09**

	Arbitrator, No. of arbitrator, Agreement providing two arbitrators, Appointment of arbitrator, Appointment of international commercial arbitrator, appointment of sole arbitrator, objection to nationality of arbitrator, Selection of arbitrator, appointment of arbitrator by court, Removal of arbitrator, Grounds for challenge, challenge procedure, Termination and substitution of mandate of arbitrator, insolvency notice.	
3	**Conduct of Arbitral Proceedings**	**06**
	Equal treatment of parties, Determination of rules of procedure- English law, Indian law, Place of arbitration, Commencement of arbitral proceedings, Statement of claim and defense, Expert appointment by arbitral tribunal,	
4	**Making of Arbitral Award & Termination of Proceedings**	**06**
	Rules applicable to substance of disputes, decision making by panel of arbitrators, Settlement, Form and contents of arbitral award, Termination of proceedings, Correction and interpretation of award, Additional award	
5	**Conciliation**	
	Application and scope, commencement of proceedings, Appointment of conciliation, Role of conciliator, sole conciliator, Communication between conciliator and parties, Settlement agreement- Concept, status and effect, Confidentiality, Termination of proceedings, costs, Deposits, Role of conciliator in other proceedings, Difference between conciliation and mediation. ICC Rules of Conciliation and arbitration, Rules of arbitration of the Indian council of arbitration.	**13**
6	**Alternative Means of Settlement of Disputes (ADR)**	
	Introduction, Methods, merits, demerits, Indian statutes, Difference between mediation and arbitration, Mediator and its necessity, Rules and Limitation of mediation, mediator's settlement. Negotiation- Necessity, state of negotiation, power sources, , styles, kinds of approaches, qualities of negotiation power, Obstructions to negotiation, Trade unions and negotiation.	**09**
	Total	**52**

Contribution to Outcome

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

1. Appraise the significance and concepts of arbitration in resolving disputes in construction infrastructure industry.
2. Explain the intricacies of constitution of arbitral tribunal in the process of arbitration.
3. Value the importance of the procedures and conduct of arbitral proceedings.
4. Comply the making of arbitral award & termination of proceedings.
5. Compare and study the significance and concepts of conciliation and mediation.
6. Apply the process of alternative means of settlement of disputes with negotiations.

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests**

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

End Semester Examination (80 Marks):

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

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

Recommended Books:

1. Dr. S C Tripathi (2012), The Arbitration and Conciliation Act, 1996, 6th Edn. Central Law Publication.
2. Dr. Rega Surya Rao. (2021), Lextures on Arbitration, Conciliation and ADR Systems, Andhra Law House.
3. Dr. Harman Shergil Sullar (2021), Alternative Dispute Resolution - Including Arbitration Conciliation Act, 1996 Amended Amendment Act, 4th Edn., Shreeram Law House Publication.
4. H C Johari Edition, A Guide to Arbitration and Conciliation Act, 1996 (2022), Kamal Law House.
5. Rahul Ranjan (2020), Alternative Dispute Resolution Arbitration, Conciliation, Negotiation and Mediation, 2022 Edn., Proflic Publication.
6. Madhusudan Saharay, Textbook on Arbitration & Conciliation with Alternative Dispute Resolution, 4th Edn., Universal Law Publishing.
7. Dr. Anupam Kurlwal (2017), An Introduction to Alternative Dispute Resolution, 3rd Edn., Central Law Publications.

Reference Books:

1. P. C. Markanda, Naresh Markanda & Rajesh Markanda (2020), Law Relating to Arbitration and Conciliation, 10th Edn., LexisNexis.
2. Abraham P. Ordover & Andrea Doneff (2002), Alternatives to Litigation: Mediation, Arbitration, and the Art of Dispute Resolution, 2nd Edn., LexisNexis / National Institute for Trial Advocacy Publication.
3. Elkouri & Elkouri (2003), How Arbitration Works, Bna Books Publications, Edison, New Jersey, USA.

University of Mumbai

Syllabus for

Honours/Minor Degree Program

In

Blockchain

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai
Blockchain
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HBCC501: Bit coin and Crypto currency**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HBCC601: Blockchain Platform**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HBCC701: Block chain Development**	04	--	--	20	80	--	--	100	04
	HBCSBL701: Private Blockchain Setup Lab(SBL)	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HBCC801: DeFi (Decentralized Finance)**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
									Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18	

Blockchain: Sem V								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HBCC501	**Bit coin and Crypto currency**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HBCC501	**Bit coin and Crypto currency**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To get acquainted with the concept of Block and Blockchain.
2	To learn the concepts of consensus and mining in Blockchain.
3	To get familiar with the bitcoin currency and its history.
4	To understand and apply the concepts of keys, wallets and transactions in the Bitcoin Network.
5	To acquire the knowledge of Bitcoin network, nodes and their roles.
6	To analyze the applications& case studies of Blockchain.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Describe the basic concept of Block chain.	L1,L2
2	Associate knowledge of consensus and mining in Block chain.	L1,L2
3	Summarize the bit coin crypto currency at an abstract level.	L1,L2
4	Apply the concepts of keys, wallets and transactions in the Bit coin network.	L3
5	Interpret the knowledge of Bit coin network, nodes and their roles.	L1,L2
6	Illustrate the applications of Block chain and analyze case studies.	L3

Detailed Syllabus:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	**Introduction to Cryptography:** Hash functions, Public key cryptography, Digital Signature (ECDSA).	**2**	--
I	**Introduction to Block chain**	Structure of a Block, Block Header, Block Identifiers: Block Header Hash and Block Height, The Genesis Block, Linking Blocks in the Block chain, Merkle Trees and Simplified Payment Verification (SPV). **Self-learning Topics:** Block chain Demo.	**6**	CO1

II	**Consensus and Mining**	Decentralized Consensus, Byzantine General's Problem, Independent Verification of Transactions, Mining Nodes, Aggregating Transactions into Blocks, Constructing the Block header, Mining the Block, Successfully Mining the Block, Validating a New Block, Assembling and Selecting Chains of Blocks, Block chain Forks **Self-learning Topics:** Study different consensus algorithms	**12**	CO2
III	**Introduction to Bit coin**	What is Bit coin and the history of Bit coin, Getting the first bit coin, finding the current price of bit coin and sending and receiving bit coin, Bit coin Transactions. **Self-learning Topics:** Study the website coinmarketcap.com/	**4**	CO3
IV	**Concepts of Bit coin**	**Keys and addresses, Wallets and Transactions:** Public Key Cryptography and Crypto currency, Private and Public Keys, Bit coin Addresses, Base58 and Base58Check Encoding, Nondeterministic (Random) Wallets, Deterministic (Seeded) Wallets, HD Wallets (BIP-32/BIP-44), Wallet Best Practices, Using a Bit coin Wallets, Transaction Outputs and Inputs, Transaction Fees, Transaction Scripts and Script Language, Turing Incompleteness, Stateless Verification, Script Construction (Lock + Unlock), Pay-to-Public-Key-Hash (P2PKH), Bitcoin Addresses, Balances, and Other Abstractions **Self-learning Topics:** Visit and use https://bitcoin.org/en/	**13**	CO4
V	**Bit coin Networks**	Peer-to-Peer Network Architecture, Node Types and Roles, Incentive based Engineering The Extended Bitcoin Network, Bitcoin Relay Networks, Network Discovery, Full Nodes, Exchanging "Inventory", Simplified Payment Verification (SPV) Nodes, Bloom Filters, SPV Nodes and Privacy, Encrypted and Authenticated Connections, Transaction Pools **Self-learning Topics:** Study technical papers based on bitcoin security	**7**	CO5
VI	**Blockchain Applications & case studies**	Domain-Specific Applications: FinTech, Internet of Things, Industrial and Manufacturing, Energy, Supply chain & Logistics, Records & Identities, Healthcare Case studies related to cryptocurrencies Concept of Altcoin **Self-learning Topics:** Read Technical papers on blockchain applications	**8**	CO6

Text Books:

1. "Mastering Bitcoin, PROGRAMMING THE OPEN BLOCKCHAIN", 2nd Edition by Andreas M. Antonopoulos, June 2017, O'Reilly Media, Inc. ISBN: 9781491954386.
2. "Blockchain Applications: A Hands-On Approach", by ArshdeepBahga, Vijay Madisetti, Paperback – 31 January 2017.
3. "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction", July 19, 2016, by Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, Steven Goldfeder, Princeton University Press.

Reference Books:

1. **"**Mastering Blockchain", by Imran Bashir, Third Edition, Packt Publishing
2. **"**Mastering Ethereum: Building Smart Contracts and Dapps Paperback" byAndreas Antonopoulos, Gavin Wood, Publisher(s): O'Reilly Media

3. “Blockchain revolution: how the technology behind bitcoin is changing money, business and the world $ don tapscott and alex tapscot, portfolio penguin, 856157449

Online References:

Sr. No.	Website Name
1	https://andersbrownworth.com/blockchain/
2	https://andersbrownworth.com/blockchain/public-private-keys/
3	https://www.coursera.org/learn/cryptocurrency
4	https://coinmarketcap.com/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Blockchain: Sem VI								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HBCC601	**Block chain Platform**	**04**	--	--	**04**	--	--	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg**					
HBCC601	**Block chain Platform**	**20**	**20**	**20**	**80**	--	--	--	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	Understand the blockchain platform and its terminologies.
2	Understand smart contracts, wallets, and consensus protocols.
3	Design and develop decentralized applications using Ethereum, and Hyperledger.
4	Creating blockchain networks using Hyperledger Fabric deployment.
5	Understand the considerations for creating blockchain applications.
6	Analyze various Blockchain Platforms.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Explain the Blockchain platform and its types.	L1,L2
2	Create Public Blockchain using Ethereum.	L3,L4,L5, L6
3	Develop Smart Contracts using REMIX IDE.	L3,L4,L5
4	Apply the concept of private blockchain using Hyperledger.	L3
5	Analyze different types of blockchain platforms.	L3,L4
6	Deploy Enterprise Applications on Blockchain.	L3,L4,L5

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Introduction to Block chain and Bit coin,	**2**	--
I	**Introduction to Block chain Platforms**	Why Blockchain Platform: Platform types, Public, Private, technology requirements for implementation. Introduction to Ethereum, Hyperledger and Smart Contracts. Case study of blockchain Application. **Self-learning Topics:** Study different applications of block chain.	**6**	CO1

II	**Public Block chain**	Introduction, Characteristics of Public Blockchain, Advantages. Examples of Public Blockchain-Bitcoin: Terminologies and Transaction, Ethereum: Smart contract, Comparison of Bitcoin and Ethereum, Other public Blockchain platforms. **Self-learning Topics:** Study any one case study on public block chain.	**8**	CO2, CO3
III	**Ethereum Blockchain**	Introduction, Ethereum and Its Components: Mining, Gas, Ethereum, Ether, Ethereum Virtual Machine, Transaction, Accounts. Architecture of ethereum, Smart Contract: Remix IDE, Developing smart contract for ethereum blockchain, e-voting applications using smart contract, Dapp Architecture. Types of test-networks used in ethereum, Transferring Ethers Using MetaMask, Mist Wallet, Ethereum Frameworks, Case study of Ganache for ethereum blockchain. Deploying e-voting applications on Ganache framework. Ethereum 2., Concept of Beacon chain, POS (Proof of Stake), Shading of Chain. **Self-learning Topics:** Study case study on any ethereum blockchain.	**12**	CO2, CO3, CO6
IV	**Private Blockchain**	Introduction, Key Characteristics, Need of Private Blockchain. Consensus Algorithm for private Blockchain (Ex. RAFT and PAXOS), Smart Contract in Private Blockchain, Case Study of E-commerce Website, Design Limitations. **Self-learning Topics:** Case study on private block chain.	**8**	CO4
V	**Hyperledger Blockchain**	Introduction to Hyperledger, tools and frameworks, Hyperledger Fabric, Comparison between Hyperledger Fabric & Other Technologies, Distributed Ledgers. Hyperledger Fabric Architecture, Components of Hyperledger Fabric: MSP, Chain Codes etc., Transaction Flow, Advantages of Hyperledger Fabric Blockchain, working of Hyperledger Fabric, Creating Hyperlegder network, Case Study of Supply chain management using Hyperledger **Self-learning Topics:** Case study on Hyperledger blockchain.	**12**	CO5, CO6
VI	**Other Blockchain platforms**	Corda, Ripple, Quorum and other emerging blockchain platforms, Case Study on any of the blockchain platforms. Developing Blockchain application on Cloud(AWS/Azure) **Self-learning Topics:** Compare different blockchain platforms.	**4**	CO5

Text Book:

1) Blockchain Technology, Chandramouli Subramanian, Asha A George, Abhillash K. A and MeenaKarthikeyen, Universities press.
2) Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.

Reference Books:

1) Blockchain for Beginners, Yathish R and Tejaswini N, SPD
2) Blockchain Basics, A non Technical Introduction in 25 Steps, Daniel Drescher, Apress.

3) Blockchain with Hyperledger Fabric, LucDesrosiers, Nitin Gaur, Salman A. Baset, Venkatraman Ramakrishna, Packt Publishing

E Books:

1) Blockchain By Example, BellajBadr, Richard Horrocks, Xun (Brian) Wu, November 2018, Implement decentralized blockchain applications to build scalable Dapps.
2) Blockchain for Business, https://www.ibm.com/downloads/cas/3EGWKGX7.

Online References:

Sr. No.	Website Name
1.	https://www.hyperledger.org/use/fabric

Assessment:
Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Blockchain: Sem VII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HBCC701	**Blockchain Development**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg**					
HBCC701	**Block chain Development**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To understand Ethereum Ecosystem.
2	To understand aspects of different programming languages.
3	To explain how to use the solidity programming language to develop a smart contract for blockchain.
4	To demonstrate deployment of smart contracts using frameworks.
5	To understand principles of Hyperledger fabric.
6	To understand challenges to apply blockchain in emerging areas.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	To use Ethereum Components.	L1,L2
2	To analyse different blockchain programming languages.	L3
3	To implement smart contract in Ethereum using solidity.	L4,L5
4	To analyse different development frameworks.	L4
5	To implement private blockchain network with Hyperledger fabric.	L4,L5
6	To illustrate blockchain integration with emerging technologies and security issues.	L1,L2

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Blockchain cryptocurrency, Blockchain platform	**2**	--
I	**Ethereum Ecosystem**	Ethereum components: miner and mining node, Ethereum virtual machine, Ether, Gas, Transactions, accounts, swarm and whisper, Ethash, end to end transaction in Ethereum, architecture of Ethereum **Self-learning Topics**: Emerging blockchain platforms	**4**	CO1
II	**Blockchain Programming**	Types of Blockchain Programming, Solidity, GoLang, Vyper, Java, Simplicity, Rholang, Game Theory and Cryptonomics,	**8**	CO2

		Comparative study of different blockchain programming languages Decentralized file system-IPFS. **Self-learning Topics:** Emerging blockchain programming languages		
III	**Smart Contract**	Solidity programming, Smart Contract programming using solidity, mapper function, ERC20 and ERC721 Tokens, comparison between ERC20 & ERC721, ICO, STOMetamask (Ethereum Wallet), setting up development environment, use cases of smart contract, smart Contracts: Opportunities, Risks **Self-learning Topics:** Cryptocurrencies and their security issues, Consensus mechanisms, Digital Signatures	**10**	CO3
IV	**Blockchain Deployment**	Ethereum client, Ethereum Network, Introduction to Go Ethereum (Geth), Geth Installation and Geth CLI, Setting up a Private Ethereum Blockchain. Introduction to Truffle, Smart Contract deployment on a Private Blockchain. Introduction to Ganache Introduction to Dapp, Dapp architecture, Daaps Scalability, testing Connecting to the Blockchain and Smart Contract, Web3js, Deployment **Self-learning Topics:** Smart Contract deployment using Ganache.	**10**	CO4
V	**Hyperledger Application Development**	Installing Hyperledger Fabric, Hyperledger Fabric Network, Building Your First Network, Hyperledger Fabric Demo, Hyperledger Fabric Network Configuration, Certificate Authorities, Chaincode Development and Invocation, Deployment and testing of chaincode on development network, Hyperledger Fabric Transactions **Self-learning Topics:** Hyperledger sawtooth,Hyperledger caliper	**12**	CO5
VI	**Blockchain integration and Research challenges**	Integrating Blockchain with cloud, IoT, AI, ERP, End to end blockchain integration, Risks and Limitations of Blockchain: Privacy & Security. Criminal Use of Payment Blockchains, The "Dark" Side of Blockchain Research challenges in blockchain, **Self-learning Topics**: Use Cases: Blockchain for Health Insurance, Blockchain in Supply chain management, Blockchain & PropTech, Blockchain in Banking	**6**	CO6

Text Books:

1. Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly.
2. Blockchain Technology, Chandramouli Subramanian, Asha A George, Abhillash K. A and Meena Karthikeyen, Universities press

References:

1. Blockchin enabled Applications, Vikram Dhillon, DevidMetcalf, Max Hooper, Apress
2. Building Blockchain Projects, Narayan Prusty, Packt

Online References:

Sr. No.	Website Name
1.	https://ethereum.org/en/
2.	https://hyperledger-fabric.readthedocs.io/en/release-2.2/whatis.html
3.	https://www.blockchain.com/
4.	https://docs.soliditylang.org/en/v0.7.4/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Blockchain: Sem VII								
		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HBCSBL701	Private Blockchain Setup Lab(SBL)	--	4	--	--	02	--	02

Course Code	Course Title	Examination Scheme						
		Theory Marks				Term Work	Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg.				
HBCSBL601	Private Blockchain Setup Lab(SBL)	--	--	--	--	50	50	100

Lab Objectives:

Sr. No.	Lab Objectives
The Lab aims:	
1	To build and test Private Ethereum Blockchain.
2	To learn the concept of the genesis block and Account in the Blockchain.
3	To get familiar with the mining blocks to create a ether.
4	To understand and apply the concepts of keys, wallets.
5	To acquire the knowledge of gateway and desktop application.
6	To analyze the applications & case studies of Blockchain.

Lab Outcomes:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of lab, learner/student will be able to:		
1	To understand how blockchain systems (mainly Etherum) work.	L1,L2
2	To create the genesis block using Puppeth, a CLI tool and account using Smart Contract.	L6
3	To create mining blocks, check the account and PoW.	L6
4	To use cryptocurrency exchanges and wallets safely.	L1,L2,L3
5	To create Gateway to Blockchain Apps.	L6
6	To use Blockchain on Mobile App and on Cloud.	L1,L2,L3

Prerequisite: Expertise in Programming, Basic knowledge of Computer Security, Networking.

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. PC i3/i5/i7 Processor or above. 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card	1. NodeJs 2. Ethereum 3. Geth 4. Solidity	1. Internet Connection.

DETAILED SYLLABUS:

Note: All practical are to be conducted on Linux platform its Compulsory for this entire practical

Sr. No	Module .	Description	Hours	LO Mapping
1	**Build and Test**	**Install Ethereum network to create a private Ethereum Blockchain** **Self- learning topic : Hyperledger**	**4**	LO1
2	**Build and Test**	**Installation of geth**	**5**	LO1
3	**Create the Genesis block**	**Create the genesis block using Puppeth, a CLI tool**	**5**	LO2
4	**Create Account in the blockchain**	**Smart contract**	**6**	LO2
5	**Mining Blocks to create Ether**	**Mine blocks, check account balance, PoWvsPoA**	**6**	LO3
6	**Gateway to Blockchain Apps**	**Metamask**	**5**	LO4
7	**Web and Desktop Application**	**Solidity programming on remix**	**6**	LO4
8	**Application Development**	Crypto Exchange and Wallet	**4**	LO5
9	**Application Development**	Blockchain Mobile App or Web Application using Dapp	**6**	LO6
10	**Application Development**	Hosting of a private blockchain on cloud(AWS/Azure)	**5**	LO6

Text Books:

1. Mastering Ethereum: Building Smart Contracts and Dapps, Andreas Antonopoulos, Gavin Wood, O'Reilly Publication
2. Mastering Blockchain, Second Edition: Distributed ledger technology, decentralization, and smart contracts explained, 2nd Edition, Imran Bashir
3. Solidity Programming Essentials: A beginner's Guide to Build Smart Contracts for Ethereum and Blockchain, RiteshModi, Packt publication
4. Mastering Blockchain, Imran Bashir, Second Edition, Packt Publication.

References Books:

1. Mastering Bitcoin, PROGRAMMING THE OPEN BLOCKCHAIN, 2nd Edition by Andreas M. Antonopoulos, June 2017, Publisher(s): O'Reilly Media, Inc. ISBN: 9781491954386.
2. Blockchain Applications: A Hands-On Approach, by ArshdeepBahga, Vijay Madisetti, Paperback – 31 January 2017.
3. Mastering Blockchain, Imran Bashir, Packt Publication.

Online References:

Sr. No.	Website Name
1.	https://geth.ethereum.org/downloads/

2.	https://medium.com/@agrawalmanas09/how-to-setup-private-ethereum-blockchain-on-windows-10-machine-ab497e03d6b8
3.	https://geth.ethereum.org/docs/dapp/
4.	https://www.edureka.co/blog/ethereum-private-network-tutorial
5.	https://docs.soliditylang.org/en/develop/index.html
6.	https://metamask.io
7.	https://medium.com/publicaio/a-complete-guide-to-using-metamask-updated-version-cd0d6f8c338f
8.	https://docs.aws.amazon.com/blockchain-templates/latest/developerguide/blockchain-templates-create-stack.html

Term Work:
The Term work shall consist of at least 10 to 12 practical based on the above syllabus. The term work Journal must include at least 2 assignments. The assignments should be based on real world applications which cover concepts from all above syllabus**.**

Term Work Marks: 50 Marks (Total marks) = 40 Marks (Experiment) + 5 Marks (Assignments/tutorial/write up) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above syllabus.

Blockchain: Sem VIII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HBCC801	**DeFi (Decentralized Finance)**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg**					
HBCC801	**DeFi (Decentralized Finance)**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	The basic concepts of Centralized and Decentralized Finance and compare them.
2	The DeFi System and its key categories.
3	The DeFi components, primitives, incentives, metrics and major business models where they are used.
4	The DeFi Architecture and EcoSystem.
5	The DeFi protocols.
6	The real time use cases of DeFi.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Explain the basic concepts of Centralized and Decentralized Finance and compare them.	L1, L2
2	Describe the the DeFi System and its key categories.	L1
3	Discuss the DeFi components, primitives, incentives, metrics and major business models where they are used.	L1, L2
4	Explain the DeFi Architecture and EcoSystem.	L1, L2
5	Illustrate the DeFi protocols.	L1
6	Discuss the real time use cases of DeFi.	L1,L2

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Blockchain & Cryptocurrency, Blockchain Platform, Blockchain Development	**02**	-
I	**Introduction:**	Difference between Centralized and Decentralized Finance, Traditional Financial Institution- Banks: 1. Payment and	**06**	CO1

	Centralized and decentralized finance	Clearance systems, 2. Accessibility, 3. Centralization and Transparency, Decentralized Finance Vs Traditional Finance **Self-learning Topics:** The Potential Impact of Decentralized Finance		
II	**What is decentralized finance (defi)?**	The DeFi Ecosystem, Problems that DeFi Solves How Decentralized is DeFi? Defi key Categories:-Stablecoins, Stable coin and pegging, Lending and Borrowing, Exchanges, Derivations, Fund Management, Lottery, Payments, Insurance **Self-learning Topics:** How Decentralized Finance Could Make Investing More Accessible.	**06**	CO2
III	**DeFi Primitives and Business Models**	3.1 DeFi Components: Blockchain Cryptocurrency The Smart Contract Platform Oracles Stablecoins Decentralized Applications 3.2 DeFi Primitives: Transactions Fungible Token: Equity Tokens, Utility Tokens and Governance TokensNFT: NFT Standard, Multi-token standard Custody Supply Adjustment: Burn-Reduce Supply, Mint-Increase Supply, Bonding Curve-Pricing Supply Incentives: Staking Rewards, Slashing, Direct Rewards and Keepers, Fees Swap: Order Book Matching, Automated Market Makers Collaterlized Loans Flash Loans (Uncollaterlized Loans) 3.3 DeFi Key Metrics: Total Value Locked, Daily Active Users,Market Cap 3.4 DeFi Major Business Models: Decentralized Currencies, Decentralized Payment Services, Decentralized fundraising, Decentralized Contracting **Self-learning Topics:** Study any real time Business model.	**10**	CO3
IV	**DeFi Architecture and EcoSystem**	4.1DeFi Architecture: Consumer Layer: Blockchains, Cross-Blockchain networks, Oracles, Digital Asset Layer: Cryptocurrencies, Infrastructure Layer: Wallets and Asset Management, DEXes and Liquidity, Lending and Borrowing, Prediction Markets, Synthetic Assets, Insurance 4.2 DeFi EcoSystem and Protocols: On-chain Asset Exchange, Loanable Fund Markets on-chain assets, Stablecoins, Portfolio Management, Derivatives, Privacy-preserving mixers 4.3 DeFi Risk and Challenges: Technical Risks, Usability Risks, Centralization Risks, Liquidity Risks, Regulation Risk	**10**	CO4

		Self-learning Topics: Study of the Problems which are holding DeFi adoption back		
V	**DeFi Deep Dive**	5.1.Maker DAO:Maker Protocol: Dai Stablecoins, Maker Vaults, Maker Protocol Auctions Maker Actors: Keepers, Price Oracles, Emergency Oracles, DAO Teams, Dai Savings Rate Dai Use case Benefits and Examples 5.2.UniSwap:UniSwap Protocol Overview: How UniSwap Works, EcoSystem Participants, Smart Contracts UniSwap Core Concepts: Swaps, Pools, Flash Swaps, Oracles 5.3. Compound: Compound Protocol: Supplying Assets, Borrowing Assets, Interest Rate Model Compound Implementation and Architecture: cToken Contracts, Interest Rate Mechanics, Borrowing, Liquidation, Price Feeds, Comptroller, Governance 5.4. wBTC:Need for wBTC: Tokenization and common Issues wBTC Implementation and Technology: Users, Custodian Wallet Setup, Minting, Burning wBTC Governance, wBTC vs Atomic Swaps, Fees, Legal Binding, Trust Model and Transparency **Self-learning Topics:** MakerDAO Governance, UniSwap Governance Protocol Math, Compound Protocol Math	**10**	CO5
VI	**Use Cases**	6.1Decentralized Exchanges 6.2Decentralized Stablecoins 6.3Decentralized Money Markets 6.4Decentralized Synthetix 6.5Decentralized Insurance 6.6Decentralized Autonomous Organization (DAO), **Self-learning Topics:** Stock Exchange Operations, Derivatives, Tether, Ampleforth, How to get stablecoins, Synthetix Network, Token, The Ongoing Impact of The DAO's Rise and Fall, DAO Projects	**08**	CO6

Text Books:

1. How to DeFi,Darren Lau, Daryl Lau, Teh Sze Jin,Kristian Kho, Erina Azmi, TM Lee,Bobby Ong-1st Edition, March 2020
2. DeFi and the Future of Finance-Campbell R. Harvey
3. DeFi Adoption 2020 A Definitive Guide to Entering the Industry

Reference Books/White Papers:

1. Blockchain disruption and decentralized finance: The rise of decentralized business models-Yan Chen, Cristiano Bellavitis
2. SoK: Decentralized Finance (DeFi)-Sam M. Werner, Daniel Perez, Lewis Gudgeon,Ariah Klages-Mundt,Dominik Harz∗‡, William J. Knottenbelt,Imperial College London, † Cornell University, Interlay
4. Decentralized Finance (DeFi) –A new Fintech Revolution?
5. https://makerdao.com/da/whitepaper/
6. https://uniswap.org/
7. https://compound.finance/documents/Compound.Whitepaper.pdf
8. https://wbtc.network/assets/wrapped-tokens-whitepaper.pdf

9. https://defiprime.com/exchanges
10. https://defirate.com/stablecoins/
11. https://academy.ivanontech.com/blog/decentralized-money-markets-and-makerdao
12. https://www.gemini.com/cryptopedia/nexus-mutual-blockchain-insurance-nxm-crypto
13. https://consensys.net/blockchain-use-cases/decentralized-finance/
14. https://tokenlon.zendesk.com/hc/en-us/articles/360041114431-DeFi-Explained-Synthetic-Assets, https://www.blockchain-council.org/synthetix/synthetix-snx-the-biggest-ecosystem-in-decentralized-finance/

Online References:

Sr. No.	Website Name
1.	https://www.udemy.com/
2.	https://www.coursera.org/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

University of Mumbai

Syllabus

Honours/ Minor Degree Program

in

Cyber Security

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Cyber Security (With effect from 2022-23)										
Year &Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HCSC501: Ethical Hacking**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HCSC601: Digital Forensic**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HCSC701: Security Information Management**	04	--	--	20	80	--	--	100	04
	HCSSBL601: Vulnerability Assessment Penetration Testing (VAPT) Lab (SBL)	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits =	**06**
BE Sem. VIII	**HCSC801: Application Security**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
HCSC501	Ethical Hacking	04	--	--	04	--	--	04

Course Code	Course Title	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test 1	Test 2	Avg. of 2 Tests					
HCSC501	Ethical Hacking	20	20	20	80	--	--	--	100

Course Objectives:

Sr. No.	Course Objectives
The course aims:	
1	To describe Ethical hacking and fundamentals of computer Network.
2	To understand about Network security threats, vulnerabilities assessment and social engineering.
3	To discuss cryptography and its applications.
4	To implement the methodologies and techniques of Sniffing techniques, tools, and ethical issues.
5	To implement the methodologies and techniques of hardware security.
6	To demonstrate systems using various case studies.

Course Outcomes:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Articulate the fundamentals of Computer Networks, IP Routing and core concepts of ethical hacking in real world scenarios.	L1,L2
2	Apply the knowledge of information gathering to prevent penetration testing and social engineering attacks.	L3
3	Demonstrate the core concepts of Cryptography, Cryptographic checksums and evaluate the various biometric authentication mechanisms.	L1,L2
4	Apply the knowledge of network reconnaissance to prevent Network and web application-based attacks.	L3
5	Apply the concepts of hardware elements and endpoint security to provide security to physical devices.	L3
6	Simulate various attack scenarios and evaluate the results.	L4,L5

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Computer Networks, Databases, system security	**2**	-
I	**Introduction to Ethical Hacking**	Fundamentals of Computer Networks/IP protocol stack, IP addressing and routing, Routing protocol, Protocol vulnerabilities, Steps of ethical hacking, Demonstration of Routing Protocols using Cisco Packet Tracer **Self-learning Topics**:TCP/IP model, OSI model	**10**	CO1
II	**Introduction to Cryptography**	Private-key encryption, public key-encryption, key Exchange Protocols, Cryptographic Hash Functions & applications, steganography, biometric authentication, lightweight cryptographic algorithms. Demonstration of various cryptographic tools and hashing algorithms **Self-learning Topics**: Quantum cryptography, Elliptic curve cryptography	**08**	CO3
III	**Introduction to network security**	Information gathering, reconnaissance, scanning, vulnerability assessment, Open VAS, Nessus, System hacking: Password cracking, penetration testing, Social engineering attacks, Malware threats, hacking wireless networks (WEP, WPA, WPA-2), Proxy network, VPN security, Study of various tools for Network Security such as Wireshark, John the Ripper, Metasploit, etc. **Self-learning Topics**: Ransomware(Wannacry), Botnets, Rootkits, Mobile device security	**12**	CO2
IV	**Introduction to web security and Attacks**	OWASP, Web Security Considerations, User Authentication, Cookies, SSL, HTTPS, Privacy on Web, Account Harvesting, Web Bugs, Sniffing, ARP poisoning, Denial of service attacks, Hacking Web Applications, Clickjacking, Cross-Site scripting and Request Forgery, Session Hijacking and Management, Phishing and Pharming Techniques, SSO, Vulnerability assessments, SQL injection, Web Service Security, OAuth 2.0, Demonstration of hacking tools on Kali Linux such as SQLMap, HTTrack, hping, burp suite,Wireshark etc. **Self-learning Topics**: Format string attacks	**10**	CO4
V	**Elements of Hardware Security**	Side channel attacks, physical unclonable functions, Firewalls,Backdoors and trapdoors,	**6**	CO5

		Demonstration of Side Channel Attacks on RSA, IDS and Honeypots. **Self-learning Topics**: IoT security		
VI	**Case Studies**	Various attacks scenarios and their remedies. Demonstration of attacks using DVWA. **Self-learning Topics**: Session hijacking and man-in-middle attacks	**4**	CO6

Text Books:

1. Computer Security Principles and Practice --William Stallings, Seventh Edition, Pearson Education, 2017
2. Security in Computing -- Charles P. Pfleeger, Fifth Edition, Pearson Education, 2015
3. Network Security and Cryptography -- Bernard Menezes, Cengage Learning, 2014
4. Network Security Bible -- Eric Cole, Second Edition, Wiley, 2011
5. Mark Stamp's Information Security: Principles and Practice --Deven Shah, Wiley, 2009

References:

1.UNIX Network Programming –Richard Steven,Addison Wesley, 2003
2. Cryptography and Network Security -- Atul Kahate, 3rd edition, Tata Mc Graw Hill, 2013
3.TCP/IP Protocol Suite -- B. A. Forouzan, 4th Edition, Tata Mc Graw Hill, 2017
4. Applied Cryptography, Protocols Algorithms and Source Code in C -- Bruce Schneier, 2nd Edition / 20th Anniversary Edition, Wiley, 2015

Online Resources:

Sr. No.	Website Name
1.	https://www.owasp.org/index.php/Category:OWASP_Top_Ten_Project
2.	https://dvwa.co.uk/
3.	http://testphp.vulnweb.com/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
HCSC601	Digital Forensic	04	--	--	04	--	--	04

Course Code	Course Title	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
HCSC601	Digital Forensic	20	20	20	80	--	--	--	100

Course Objectives:

Sr. No.	Course Objectives
The course aims:	
1	To understand the various computer and cyber-crimes in the digital world.
2	To understand a significance of digital forensics life cycle, underlying forensics principles and investigation process.
3	To understand the importance of File system management with respect to computer forensics.
4	To be able to identify the live data in case of any incident handling and application of appropriate tools and practices for the same.
5	To Develop the skills in application of various tools and investigation report writing with suitable evidences.
6	To be able to identify the network and mobile related threats and recommendation of suitable forensics procedures for the same.

Course Outcomes:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Identify and define the class for various computer and cyber-crimes in the digital world.	L1,L2
2	Understand the need of digital forensic and the role of digital evidence.	L1,L2
3	Understand and analyze the role of File systems in computer forensics.	L1,L2,L3
4	Demonstrate the incident response methodology with the best practices for incidence response with the application of forensics tools.	L3
5	Generate/Write the report on application of appropriate computer forensic tools for investigation of any computer security incident .	L5
6	Identify and investigate threats in network and mobile.	L4

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	**Computer Hardware**: Motherboard, CPU, Memory: RAM, Hard Disk Drive (HDD), Solid State Drive (SSD), Optical drive **Computer Networks:** Introduction CN Terminology: Router, Gateway, OSI and TCP/IP Layers **Operating Systems:** Role of OS in file management, Memory management utilities, Fundamentals of file systems used in Windows and Linux.	**2**	--
I	**Introduction to Cybercrime and Computer-crime**	**1.1 Definition and classification of cybercrimes:** Definition, Hacking, DoS Attacks, Trojan Attacks, Credit Card Frauds, Cyber Terrorism, Cyber Stalking. **1.2 Definition and classification of computer crimes:** Computer Viruses, Computer Worms. **1.3 Prevention of Cybercrime**: Steps that can be followed to prevent cybercrime, Hackers, Crackers, Phreakers. **Self-learning Topics:** Steps performed by Hacker	**4**	CO1
II	**Introduction to Digital Forensics and Digital Evidences**	**2.1 Introduction to Digital Forensics:** Introduction to Digital Forensics and lifecycle, Principles of Digital Forensic. **2.2 Introduction to Digital Evidences:** Challenging Aspects of Digital Evidence, Scientific Evidence, Presenting Digital Evidence. **2.3 Digital Investigation Process Models:** Physical Model, Staircase Model, Evidence Flow Model. **Self-learning Topics:** Digital Investigation Process Models comparison and its application, Rules of Digital Evidence.	**5**	CO2
III	**Computer Forensics**	**3.1 OS File Systems Review:** Windows Systems- FAT32 and NTFS, UNIX File Systems, MAC File Systems **3.2 Windows OS Artifacts:** Registry, Event Logs	**7**	CO3

		3.3 Memory Forensics : RAM Forensic Analysis, Creating a RAM Memory Image, Volatility framework, Extracting Information **3.4 Computer Forensic Tools:** Need of Computer Forensic Tools, Types of Computer Forensic Tools, Tasks performed by Computer Forensic Tools **Self-learning Topics:** Study of 'The Sleuth Kit' Autopsy tool for Digital Forensics		
IV	**Incident Response Management, Live Data Collection and Forensic Duplication**	**4.1 Incidence Response Methodology:** Goals of Incident Response, Finding and Hiring IR Talent **4.2 IR Process:** Initial Response, Investigation, Remediation, Tracking of Significant Investigative Information. **4.3 Live Data Collection:** Live Data Collection on Microsoft Windows, **4.4 Forensic Duplication:** Forensic Duplicates as Admissible Evidence, Forensic Duplication Tools: Creating a Forensic evidence, Duplicate/Qualified Forensic Duplicate of a Hard Drive. **Self-learning Topics:** Live Data Collection on Unix-Based Systems	**10**	CO4
V	**Forensic Tools and Report Writing**	**5.1 Forensic Image Acquisition in Linux :** Acquire an Image with dd Tools, Acquire an Image with Forensic Formats, Preserve Digital Evidence with Cryptography, Image Acquisition over a Network, Acquire Removable Media **5.2 Forensic Investigation Report Writing:** Reporting Standards, Report Style and Formatting, Report Content and Organization. **Self-learning Topics:** Case study on Report Writing	**10**	CO5
VI	**Network Forensics and Mobile Forensics**	**6.1 Network Forensics:** Sources of Network-Based Evidence, Principles of Internetworking, Internet Protocol Suite, Evidence Acquisition, Analyzing Network Traffic: Packet Flow and Statistical Flow, Network Intrusion Detection and Analysis, Investigation of Routers, Investigation of Firewalls **6.2 Mobile Forensics:** Mobile Phone Challenges, Mobile phone evidence extraction	**14**	CO6

		process, Android OS Architecture, Android File Systems basics, Types of Investigation, Procedure for Handling an Android Device, Imaging Android USB Mass Storage Devices. **Self-learning Topic:** Elcomsoft iOS Forensic Toolkit, Remo Recover tool for Android Data recovery		

Text Books:

1. Digital Forensics by Dr. Dhananjay R. Kalbande Dr. Nilakshi Jain, Wiley Publications, First Edition, 2019.
2. Digital Evidence and Computer Crime by Eoghan Casey, Elsevier Academic Press, Third Edition, 2011.
3. Incident Response & Computer Forensics by Jason T. Luttgens, Matthew Pepe and Kevin Mandia, McGraw-Hill Education, Third Edition (2014).
4. Network Forensics : Tracking Hackers through Cyberspace by Sherri Davidoff and Jonathan Ham, Pearson Edu,2012
5. Practical Mobile Forensic by Satish Bommisetty, Rohit Tamma, Heather Mahalik, PACKT publication, Open source publication, 2014 ISBN 978-1-78328-831-1
6. The Art of Memory Forensics: Detecting Malware and Threats in Windows, Linux, and Mac Memory by Michael Hale Ligh (Author), Andrew Case (Author), Jamie Levy (Author), AAron Walters (Author), Publisher : Wiley; 1st edition (3 October 2014),

References:

1. Scene of the Cybercrime: Computer Forensics by Debra Littlejohn Shinder, Syngress Publication, First Edition, 2002.
2. Digital Forensics with Open Source Tools by Cory Altheide and Harlan Carvey, Syngress Publication, First Edition, 2011.
3. Practical Forensic Imaging Securing Digital Evidence with Linux Tools by Bruce Nikkel,NoStarch Press, San Francisco,(2016)
4. Android Forensics : Investigation, Analysis, and Mobile Security for Google Android by Andrew Hogg, Elsevier Publication,2011

Online References:

Sr. No.	Website Name
1.	https://www.pearsonitcertification.com/articles/article.aspx?p=462199&seqNum=2
2.	https://flylib.com/books/en/3.394.1.51/1/
3.	https://www.sleuthkit.org/autopsy/
4.	http://md5deep.sourceforge.net/md5deep.html
5.	https://tools.kali.org/
6.	https://kalilinuxtutorials.com/
7.	https://accessdata.com/product-download/ftk-imager-version-4-3-0
8.	https://www.amazon.in/Art-Memory-Forensics-Detecting-Malware/dp/1118825098

Research Papers: Mobile Forensics/Guidelines on Cell Phone Forensics

1. Computer Forensics Resource Center: NIST Draft Special Publication 800-101 : https://csrc.nist.gov/publications/detail/sp/800-101/rev-1/final
2. https://cyberforensicator.com/category/white-papers
3. https://www.magnetforensics.com/resources/ios-11-parsing-whitepaper/
4. Samarjeet Yadav , Satya Prakash , Neelam Dayal and Vrijendra Singh, "Forensics Analysis WhatsApp in Android Mobile Phone", Electronic copy available at: https://ssrn.com/abstract=3576379

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

- **Question paper format**

  - Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

  - A total of **four questions** need to be answered

Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
HCSC701	Security Information Management	04	--	--	04	--	--	04

Course Code	Course Title	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
HCSC701	Security Information Management	20	20	20	80	--	--	--	100

Course Objectives:

Sr. No.	Course Objectives
The course aims:	
1	The course is aimed to focus on cybercrime and need to protect information.
2	Understand the types of attacks and how to tackle the amount of risk involved.
3	Discuss the role of industry standards and legal requirements with respect to compliance.
4	Distinguish between different types of access control models, techniques and policy.
5	Awareness about Business Continuity and Disaster Recovery.
6	Awareness about Incident Management and its life cycle.

Course Outcomes:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Understand the scope of policies and measures of information security to people.	L1,L2
2	Interpret various standards available for Information security.	L1,L2
3	Apply risk assessment methodology.	L3
4	Apply the role of access control to Identity management.	L3
5	Understand the concept of incident management**,** disaster recovery and business continuity.	L1,L2
6	Identify common issues in web application and server security.	L3

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Vulnerability Assessment for Operating Systems, Network (Wired and Wireless). Tools for conducting Reconnaissance.	**2**	--

I	**Basics of Information Security**	**1.1** What is Information Security & Why do you need it? – **1.2** Basics Principles of Confidentiality, Integrity **1.3** Availability Concepts, Policies, procedures, Guidelines, Standards **1.4** Administrative Measures and Technical Measures, People, Process, Technology, IT ACT 2000, IT ACT 2008 **Self-learning Topics:** Impact of IT on organizations, Importance of IS to Society	**6**	CO1, CO2
II	**Current Trends in Information Security**	**2.1** Cloud Computing: benefits and Issues related to information Security. **2.2** Standards available for InfoSec: Cobit, Cadbury, ISO 27001, OWASP, OSSTMM. **2.3** An Overview, Certifiable Standards: How, What, When, Who. **Self-learning Topics:** Cloud Threats, Impact of cloud computing on users, examples of cloud service providers: Amazon, Google, Microsoft, Salesforce etc.	**8**	CO2
III	**Threat & Risk Management**	**3.1** Threat Modelling**:** Threat, Threat-Source, Vulnerability, Attacks. **3.2** Risk Assessment Frameworks**:** ISO 31010, NIST-SP-800-30, OCTAVE **3.3** Risk Assessment and Analysis: Risk Team Formation, Information and Asset Value, Identifying Threat and Vulnerability, Risk Assessment Methodologies **3.4** Quantification of Risk, Identification of Monitoring mechanism, Calculating Total Risk and Residual Risk. **Self-learning Topics:** Risk management trends today and tomorrow.	**8**	CO3
IV	**Identity and Access Management**	**4.1** Concept**s** of Identification, Authentication, Authorization and Accountability. **4.2** Access Control Models: Discretionary, Mandatory, Role based and Rule-based. **4.3** Access Control Techniques: Constrained User, Access control Matrix, Content-dependent, Context – dependent **4.4** Access Control Methods: Administrative, Physical, Technical, Layering of Access control **4.5** Access Control Monitoring: IDS and IPS and anomaly detection. **4.6** Accountability: Event-Monitoring and log reviews. Log Protection **4.7** Threats to Access Control: Various Attacks on the Authentication systems. **Self-learning Topics:** challenges and solutions in identity and access management	**10**	CO4

V	**Operational Security**	**5.1** Concept of Availability, High Availability, Redundancy and Backup. **5.2** Calculating Availability, Mean Time Between Failure (MTBF), Mean Time to Repair (MTTR) **5.3** Incident Management**:** Detection, Response, Mitigation, Reporting, Recovery and Remediation **5.4** Disaster Recovery: Metric for Disaster Recovery, Recovery Time Objective (RTO), Recovery Point Objective (RPO), Work Recovery Time (WRT), Maximum Tolerable Downtime (MTD), Business Process Recovery, Facility Recovery (Hot site, Warm site, Cold site, Redundant site), Backup & Restoration **Self-learning Topics:** Challenges and Opportunities of Having an IT Disaster Recovery Plan	**10**	CO5
VI	**Web Application, Windows, and Linux security**	**6.1** Types of Audits in Windows Environment **6.2** Server Security, Active Directory (Group Policy), Anti-Virus, Mails, Malware **6.3** Endpoint protection, Shadow Passwords, SUDO users, etc. **6.4** Web Application Security: OWASP, Common Issues in Web Apps, what is XSS, SQL injection, CSRF, Password Vulnerabilities, SSL, CAPTCHA, Session Hijacking, Local and Remote File Inclusion, Audit Trails, Web Server Issues, etc. **Self-learning Topics:**, Network firewall protection,Choosing the Right Web Vulnerability Scanner	**8**	CO6

Textbooks:

1. Shon Harris, Fernando Maymi, CISSP All-in-One Exam Guide, McGraw Hill Education, 7th Edition, 2016.
2. Andrei Miroshnikov, Introduction to Information Security - I, Wiley, 2018
3. Ron Lepofsky, The Manager's Guide to Web Application Security, Apress; 1st ed. edition, 2014

References:

1. Rich-Schiesser, IT Systems Management: Designing, Implementing and Managing World - Class Infrastructures, Prentice Hall; 2 edition, January 2010.
2. NPTEL Course: - Introduction to Information Security – I (URL: https://nptel.ac.in/noc/courses/noc15/SEM1/noc15-cs03/)
3. Dr. David Lanter – ISACA COBIT – 2019 Framework - Introduction and Methodology
4. Pete Herzog, OSSTMM 3, ISECOM
5. NIST Special Publication 800-30, Guide for Conducting Risk Assessments, September 2012

Online References:

Sr. No.	Website Name
1.	**https://www.ultimatewindowssecurity.com/securitylog/book/Default.aspx**
2.	**http://www.ala.org/acrl/resources/policies/chapter14**
3.	**https://advisera.com/27001academy/what-is-iso-27001/**

4.	https://nvlpubs.nist.gov/nistpubs/legacy/sp/nistspecialpublication800-30r1.pdf
5.	http://www.diva-portal.org/smash/get/diva2:1117263/FULLTEXT01.pdf

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HCSSBL601	Vulnerability Assessment Penetration Testing (VAPT) Lab (SBL)	--	4	--	--	2	--	02

Course Code	**Course Title**	**Examination Scheme**						
		Theory Marks				**Term Work**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**			
		Test 1	**Test 2**	**Avg. of 2 Tests**				
HCSSBL601	Vulnerability Assessment Penetration Testing (VAPT) Lab (SBL)	--	--	--	--	50	50	100

Lab Objectives:

Sr. No.	**Lab Objectives**
The Lab aims:	
1	To identify security vulnerabilities and weaknesses in the target applications.
2	To discover potential vulnerabilities which are present in the system in network using vulnerability assessment tools.
3	To identify threats by exploiting them using penetration test attempt by utilizing the vulnerabilities in a system
4	To recognize how security controls can be improved to prevent hackers gaining access controls to database.
5	To test and exploit systems using various tools and understands the impact in system logs.
6	To write a report with a full understanding of current security posture and what work is necessary to both fix the potential threat and to mitigate the same source of vulnerabilities in the future

Lab Outcomes:

Sr. No.	**Lab Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of lab, learner/student will be able to:		
1	Understand the structure where vulnerability assessment is to be performed.	L1,L2
2	Apply assessment tools to identify vulnerabilities present in the system in network.	L3

3	Evaluate attacks by executing penetration tests on the system or network.	L4
4	Analyse a secure environment by improving security controls and applying prevention mechanisms for unauthorised access to database.	L5
5	Create security by testing and exploit systems using various tools and remove the impact of hacking in system.	L6
6	Formation of documents as per applying the steps of vulnerabilities of assessment and penetration testing.	L3, L4, L5

Prerequisite: Computer Networks, Basic of Network Security.

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. Intel PIV Processor 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card	1. Windows or Linux Desktop OS 2. Security Software and tools	1. Internet Connection.

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Computer Network, Basics of Network Security, Ethical Hacking, Digital Forensics	**2**	
I	**Human Security (Social Engineering) Assessment**	**Visibility Audit: C**ollecting information through social media and internet. Collecting contact details (like phone number, email ID, What's App ID, etc) **Active Detection Verification:** Test if the phone number, email id etc are real by test message. Test whether the information is filtered at point of reception. Test if operator / another person assistance can be obtained. **Device Information:** IP Address, Port details, Accessibility, Permissions, Role in business **Trust Verification:** Test whether the information can be planted in form of note / email / Message (Phishing) **Test Subjects:** College Staff, Reception, PA to Director / Principal. To conduct information gathering to conduct social engineering audit on various sections in your college. **Self-Learning Topics:** Networking Commands	**8**	LO1
II	**Network & Wireless Security Assessment**	**Network Discovery:** Using various tools to discover the various connected devices, to get device name, IP Address, relation of the device in network, Detection of	**8**	LO2

		Active port, OS Fingerprinting, Network port and active service discovery **Tools:** IP Scanner, Nmap etc **Network Packet Sniffing:** Packet Sniffing to detect the traffic pattern, Packet capturing to detect protocol specific traffic pattern, Packet capturing to reassemble packet to reveal unencrypted password **Tools:** Wireshark **Self-Learning Topics:** Learning the CVE database for vulnerabilities detected.		
III	**Setting up Pentester lab**	Including an attacker machine preferably Kali and in the same subnet victim machines either DVWA/ SEEDlabs/ multiple VULNHUB machines as and when required. Understanding Categories of pentest and legalities/ ethics. Installed Kali machine on VM environment with some VULNHUB machines and we can find out vulnerability of Level 1-VULNHUB machine like deleted system files, permissions of files. **Self learning Topics:** Vulnerability exploitation for acquire root access of the Kioptrx machine	**9**	LO3
IV	Database and Access Control Security Assessment	**Database Password Audit:** Tool based audit has to be performed for strength of password and hashes. **Tools:** DBPw Audit **Blind SQL Injection:** Test the security of the Database for SQL Injection **Tools:** BSQL Hacker **Password Audit:** Perform the password audit on the Linux / Windows based system **Tools:** Cain & Able, John the ripper, LCP Password Auditing tools for Windows. **Active Directory and Privileges Audit:** Conduct a review of the Active Directory and the Group Policy to assess the level of access privileges allocated. **Tools:** SolarWinds **Self-Learning Topics:** Federated Database security challenges and solutions.	**9**	LO4
V	Log Analysis	Conduct a log analysis on Server Event Log / Firewall Logs / Server Security Log to review and obtain insights Tools: graylog, Open Audit Module. **Self-Learning Topics:** Python and R-Programming scripts	**6**	LO5
VI	Compliance and Observation Reporting	**License Inventory Compliance:** Identify the number of licenses and its deployment in your organization. Tools: Belarc Advisor, Open Audit Report Writing: NESSUS tool Report should contain:	**10**	LO6

		a. Vulnerability discovered b. The date of discovery c. Common Vulnerabilities and Exposure (CVE) database reference and score; those vulnerabilities found with a medium or high CVE score should be addressed immediately d. A list of systems and devices found vulnerable e. Detailed steps to correct the vulnerability, which can include patching and/or reconfiguration of operating systems or applications f. Mitigation steps (like putting automatic OS updates in place) to keep the same type of issue from happening again **Purpose of Reporting:** Reporting provides an organization with a full understanding of their current security posture and what work is necessary to both fix the potential threat and to mitigate the same source of vulnerabilities in the future. **Self-Learning Topics:** Study of OpenVAS, Nikto, etc.		

Text & Reference Books and Links:

1. The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws Paperback – Illustrated, 7 October 2011 by Dafydd Stuttard
2. Hacking: The Art of Exploitation, 2nd Edition 2nd Edition by Jon Erickson
3. Important links of Vulnhub: Vulnhub Kioptrix
   Download Link: https://www.vulnhub.com/entry/basic-pentesting-1,216/
   https://www.vulnhub.com/entry/kioptrix-level-1-1,22/
   Installation Video: https://youtu.be/JupQRHtfZmw
   Walkthrough/solutions Video: https://youtu.be/Qn2cKYZ6kBI
4. OWASP Broken Web Application Projects
   https://sourceforge.net/projects/owaspbwa/
5. Mastering Modern Web Penetration Testing By Prakhar Prasad, October 2016, Packt Publishing.
6. Kali Linux Revealed: Mastering the Penetration Testing Distribution – June 5, 2017 by Raphael Hertzog (Author), Jim O'Gorman (Author), Offsec Press Publisher

Term Work:

The Term work shall consist of at least 10 to 12 practical based on the above syllabus. The term work Journal must include at least 2 assignments. The assignments should be based on real world applications which cover concepts from all above syllabus**.**

Term Work Marks: 50 Marks (Total marks) = 40 Marks (Experiment) + 5 Marks Assignments/tutorial/write up) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above syllabus.

Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical/ Oral	Tutorial	Total
HCSC801	Application Security	04	--	--	04	--	--	04

Course Code	Course Title	Examination Scheme							
		Theory Marks				Term Work	Practical	Oral	Total
		Internal assessment			End Sem. Exam				
		Test1	Test 2	Avg. of 2 Tests					
HCSC801	Application Security	20	20	20	80	--	--	--	100

Course Objectives:

Sr. No.	Course Objectives
The course aims:	
1	The terms and concepts of application Security, Threats, and Attacks
2	The countermeasures for the threats wrt Application security.
3	The Secure Coding Practices
4	The Secure Application Design and Architecture
5	The different Security Scanning and testing techniques
6	The threat modeling approaches

Course Outcomes:

Sr. No.	Course Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Enumerate the terms of application Security, Threats, and Attacks	L1
2	Describe the countermeasures for the threats with respect to Application security.	L1
3	Discuss the Secure Coding Practices.	L2
4	Explain the Secure Application Design and Architecture.	L2
5	Review the different Security Scanning and testing techniques.	L2
6	Discuss the threat modeling approaches.	L2

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	Operating System, DBMS, Computer Network, Web Programming, OOP	**02**	-

I	**Introduction to Application Security, Threats, and Attacks**	Introduction to Web Application Reconnaissance, Finding Subdomains, API Analysis, Identifying Weak Points in Application Architecture **Offense:** Cross-Site Scripting (XSS), Cross-Site Request Forgery (CSRF), XML External Entity (XXE) Injection, Injection Attacks, Denial of Service (DoS), Cross-Origin Resource Sharing Vulnerabilities **Self-learning Topics: Simulate the attacks using open-source tools in virtual environment**	**05**	CO1
II	**Defence and tools**	Securing Modern Web Applications, Secure Application Architecture, Reviewing Code for Security, Vulnerability Discovery, Defending Against XSS Attacks, Defending Against CSRF Attacks, Defending Against XXE, Defending Against Injection attacks, Defending Against DoS, Defending against CORS based attacks **Self-learning Topics: Implement the countermeasures to the attacks using open-source tools**	**09**	CO2
III	**Secure Coding Practices**	Security Requirements, Encryption, Never Trust System Input, Encoding and Escaping, Third-Party Components, Security Headers: Seatbelts for Web Apps, Securing Your Cookies, Passwords, Storage, and Other Important Decisions, HTTPS Everywhere, Framework Security Features, File Uploads, Errors and Logging, Input Validation and Sanitization, Authorization and Authentication, Parameterized Queries, Least Privilege, Requirements Checklist **Self-learning Topics: OWASP Secure Coding Practices**	**09**	CO3
IV	**Secure Application Design and Architecture**	**Secure Software Development Lifecycle** Averting Disaster Before It Starts, Team Roles for Security, Security in the Software Development Lifecycle, **Design Flaw vs. Security Bug,** **Secure Design Concepts,** **Segregation of Production Data,**	**09**	CO4

		Application Security Activities **Self-learning Topics: Secure Hardware architecture**		
V	**Security Scanning and testing**	Testing Your Code, Testing Your Application, Testing Your Infrastructure, Testing Your Database, Testing Your APIs and Web Services, Testing Your Integrations, Testing Your Network, Dynamic Web Application Profiling **Self-learning Topics: Open-source Application Security Tools, IAST, RASP and WAF, Selenium**	**09**	CO5
VI	**Threat Modeling**	**Objectives and Benefits of Threat Modeling**, Defining a Risk Mitigation Strategy, Improving Application Security, Building Security in the Software Development Life Cycle **Existing Threat Modeling Approaches** Security, Software, Risk-Based Variants **Threat Modeling Within the SDLC** Building Security in SDLC with Threat Modeling, Integrating Threat Modeling Within the Different Types of SDLCs, **Self-learning Topics: The Common Vulnerability Scoring System (CVSS)**	**09**	CO6

Text Books:

1.Alice and Bob Learn Application Security, by Tanya Janca Wiley; 1st edition (4 December 2020)

2. Web Application Security, A Beginner's Guide by Bryan Sullivan McGraw-Hill Education; 1st edition (16 January 2012)

3. Web Application Security: Exploitation and Countermeasures for Modern Web Applications by Andrew Hoffman Shroff/O'Reilly; First edition (11 March 2020)

4. The Security Development Lifecycle by Michael Howard Microsoft Press US; 1st edition (31 May 2006)

5. Risk Centric Threat Modeling Process for Attack Simulation And Threat Analysis, Tony Ucedavélez and Marco m. Morana, Wiley

6. Iron-Clad Java: Building Secure Web Applications (Oracle Press) 1st Edition by Jim Manico

References:

1. Software Security: Building Security In by Gary McGraw Addison-Wesley Professional; 1st edition (January 23, 2006)
2. A Guide to Securing Modern Web Applications by Michal Zalewski
3. Threat Modeling: A Practical Guide for Development Teams by Izar Tarandach and Matthew J. Coles Dec 8, 2020

Online References:

Sr. No.	Website Name
1.	https://owasp.org/www-project-top-ten/
2.	https://owasp.org/www-pdf-archive/OWASP_SCP_Quick_Reference_Guide_v2.pdf
3.	https://pentesterlab.com/
4.	https://app.cybrary.it/browse/course/advanced-penetration-testing
5.	https://www.udemy.com/
6.	https://www.coursera.org/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Augmented Reality and Virtual Reality

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Augmented Reality and Virtual Reality (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HARVRC501: Virtual Reality**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HARVRC601: AR and Mix Reality**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HARVRC701: ARVR Application-I**	04	--	--	20	80	--	--	100	04
	HARVRSBL701: ARVR Lab (SBL)	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HARVRC801: Game Development with VR**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Augmented Reality and Virtual Reality: Sem V								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HARVRC501	**Virtual Reality**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HARVRC501	**Virtual Reality**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To understand primitives of computer graphics fundamental.
2	To analyze various Hardware devices suitable for VR.
3	To analyze visual physiology and issues related to it.
4	To apply the knowledge of Visual rendering.
5	To evaluate problems faced due to audio scattering in VR.
6	To create different interface in VR environment.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Solve Computer Graphics Problems.	L1
2	Analyze application of VR hardware and software components.	L1, L2, L3
3	Identify issues related to visual physiology.	L1, L2
4	Integrate various shading and rendering techniques.	L6
5	Solve problems due to Audio distortions.	L5
6	Create User Interface for VR.	L6

Prerequisite: Basic C programming

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Functioning of human sensory organs – EYE, Ear, Touch etc.	**02**	--

		Light and Lenses Basic functioning of camera Matrix multiplication		
I	**Geometry of Virtual World**	Geometric Modeling, 2D transformations, Homogenous coordinate system, 3D rotation and 6 degree of freedom, Viewport Transformation **Self:** Eye Transformation, demo of 2D transformation	**10**	**CO1**
II	**Introduction to VR**	Introduction to VR and definitions and its components., Hardware components: Display devices: LCD, OLED Audio: Speakers, Earphones, Bone conduction Touch: Haptic Device GPU and CPU, Input devices like game controller, data glows, Joysticks Tracking Hardware: Industrial measurement Unit-IMU, Gyroscope, accelerometer Software component: Java3D, VRML **Self:** Feedback mechanisms in VR environment	**07**	**CO2**
III	**Visual Physiology, perception and tracking**	Functioning of Eye with photoreceptors, Resolution for VR, Eye movements and issues with it in VR, Neuroscience of vision, Depth and motion perception, Frame rates and display, Orientation tracking, tilt and yaw drift correction, Tracking with camera **Self:** Light House approach	**08**	**CO3**
IV	**Visual Rendering**	Overview, shading models, rendering pipelines, rasterization, pixel shading, Distortion shading, post rendering image wrap **Self:** Rendering for VR application	**09**	**CO4**
V	**Audio**	Physics of Audio, Auditory Perception, localization, rendering, Problems due to scattering of audio **Self:** Study reaction of audio and other senses for VR environment	**10**	**CO5**
VI	**Interfaces**	Locomotion, Manipulation, system control, social interaction using open-source tool like Gopro VR etc. **Self:** Explore tools for UI in VR	**06**	**CO6**

Text Books:

1. Hearn and Baker, "Computer Graphics- C version", 2nd edition, Pearson, 2002.
2. R. K Maurya, "Computer Graphics with Virtual Reality", 3rd Edition, Wiley India, 2018.
3. Steven M. LaVelle," Virtual Reality", Cambridge University press, 2019

4. Grigore Burdea, Philippe Coiffet, "Virtual Reality Technology", 2nd Edition, Wiley India, 2003
5. Vince, "Virtual Reality Systems", 1st Edition, Pearson Education, 2002

References:

1. George Mather, "Foundations of Sensation and Perception", Psychology Press book; 3rd Edition, 2016
2. Tony Parisi, "Learning Virtual Reality", 1st edition, O'Reilly, 2015
3. Alan Craig and William Sherman," Understanding virtual reality: Interface, application and design", 2nd Edition, Morgan Kaufmann Publisher, 2019
4. Peter Shirley, Michael Ashikhmin, and Steve Marschner, "Fundamentals of Computer Graphics", A K Peters/CRC Press; 4th Edition, 2016.

Online Resources:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/121/106/121106013/#
2.	http://msl.cs.uiuc.edu/vr/
3.	http://lavalle.pl/vr/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

- **Question paper format**

  - Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**

  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)

  - A total of **four questions** need to be answered

Augmented Reality and Virtual Reality: Sem VI								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HARVRC601	**AR and Mix Reality**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HARVRC601	**AR and Mix Reality**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To understand the concepts of Augmented Reality and related technologies.
2	To understand the AR tracking system and use of computer vision in AR/MR.
3	To describe the technology for multimodal user interaction and authoring in AR.
4	To use different AR toolkits and apply them to develop AR applications.
5	To demonstrate AR Applications using Mobile AR Toolkits and SDKs.
6	To understand the use of AR/MR in interdisciplinary immersive applications.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Identify and compare different Augmented Reality and Mixed Reality Technologies.	L1, L2
2	Apply concepts of Computer Vision for tracking in AR and MR Systems.	L3
3	Model different interfaces and authoring in AR/MR.	L3
4	Design AR/MR applications using open source platforms and toolkits.	L6
5	Design Mobile based AR Applications.	L6
6	Apply insights of AR/MR in different applications.	L3

Prerequisite: Programming Language, Computer Graphics, Virtual Reality

DETAILED SYLLABUS:

Module	**Title**	**Description**	**Hours**	**CO**
0	**Pre-requisite**	Basics of Computer Graphics, Coordinate Systems, VR Introduction, Tracking in VR	**02**	--

I	**Introduction to Augmented Reality and Mixed Reality**	Definition and Scope, A Brief History of Augmented Reality, AR Architecture, Related Fields of AR (like Mixed Reality, Virtual Reality, Immersive Reality, Extended Reality) and Their comparison, General Architecture of Mixed Reality System, Algorithm Steps in Mixed Reality **Self-Learning Topics**: How AR/MR are related to Ubiquitous Computing, Multidimensional Systems.	**06**	CO1
II	**Tracking and Computer Vision for AR and MR**	Multimodal Displays; Visual Perception; Spatial Display Model; Visual Displays; Tracking, Calibration and Registration; Coordinate Systems; Characteristics of Tracking Technology; Stationary Tracking Systems; Mobile Sensors; Optical Tracking; Sensor Fusion; Marker Tracking; Multiple Camera Infrared Tracking; Natural Feature Tracking by Detection; Incremental Tracking; Simultaneous Localization and Tracking; Outdoor Tracking **Self-Learning Topics**: Indoor Tracking, Full Body Tracking	**07**	CO2
III	**Interaction, Modeling and Annotation and Authoring**	Output Modalities, Input Modalities, Tangible Interfaces, Virtual User Interfaces on Real Surfaces, Multi-view Interfaces, Haptic Interaction, Multimodal Interaction, Specifying Geometry, Specifying Appearance, Semi-automatic Reconstruction, Free-form Modeling, Annotation, Requirement of AR Authoring, Elements of Authoring, Stand-alone Authoring Solutions, Plug-in Approaches, Web Technology **Self-Learning Topics**: Case Study on Object Annotation in Real Time, Avatar Modeling.	**08**	CO3
IV	**Software Architecture in AR and AR Development Toolkits**	AR Application Requirements, Software Engineering Requirements, Distributed Object Systems, Data Flow, Scene Graphs; Developer Support: Parameter Configuration, Declarative Scripting, Procedural Scripting, Mixed Language Programming, Runtime Reconfiguration, Choosing an AR Platforms and Toolkits; AR Non-programming Frameworks, AR Programming Frameworks, Programming AR using ARToolkit. **Self-Learning Topics**: Commercial AR Frameworks, AR Related Markup Languages	**10**	CO4
V	**Mobile AR**	Types of Mobile Apps, AR Browsers for Smartphones, Point of Interests (POI) in Mobile AR, POI Authoring and Publishing Tools, AR Applications for Android, AR Games for Android, Mobile AR Toolkits and SDKs, Developing Mobile AR Applications, AR Application Development for Android Smartphone **Self-Learning Topics**: AR Applications for iOS, AR Games for iOS, AR Application Development for iOS Smartphone	**10**	CO5
VI	**Applications of AR/MR and Human**	Applications of AR/MR in: Edutainment, Medical, Military, Production and Manufacturing, Navigation, Astronomical Observation, E-commerce; What are Human Factors, Physical	**07**	CO6

	Factors, Legal and Social Considerations	Side Effects, Visual Side Effects, Legal Considerations, Moral and Ethical Considerations. **Self-Learning Topics**: Applications of AR/MR in Civil Construction and Architecture, Collaboration, Information Control and Big Data Visualization		

Textbooks:

1. Dieter Schmalsteig and Tobias Hollerer, "Augmented Reality- Principles and Practice", Pearson Education, Inc. 2016 Edition.
2. Chetankumar G Shetty, "Augmented Reality- Theory, Design and Development", Mc Graw Hill, 2020 Edition.
3. Alan B. Craig, "Understanding Augmented Reality – Concepts and Applications", Morgan Kaufmann, Elsevier, 2013 Edition.

References:

1. Borko Furht, "Handbook of Augmented Reality", Springer, 2011 Edition.
2. Erin Pangilinan, Steve Lukas, and Vasanth Mohan, "Creating Augmented and Virtual Realities- Theory and Practice for Next-Generation Spatial Computing", O'Reilly Media, Inc., 2019 Edition.
3. Jens Grubert, Dr. Raphael Grasset, "Augmented Reality for Android Application Development", PACKT Publishing, 2013 Edition.

Online Resources:

Sr. No.	Website Name
1.	www.nptel.ac.in
2.	www.coursera.org

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

- **Question paper format**

  - Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Augmented Reality and Virtual Reality: Sem VII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HARVRC701	**ARVR Application-I**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test 1	**Test 2**	**Avg**					
HARVRC701	**ARVR Application-I**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To learn the underlying concepts of Virtual Reality, Augmented Reality and related technologies.
2	To analyse the principles of VR design, prototype.
3	To analyse the principles of AR design, prototype.
4	To design Graphical User interface using VR
5	To identify trends in XR, key issues in XR and XR Tools.
6	To analyse privacy, ethical, social concern on AR/VR problem.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Apply modelling techniques on Augmented Reality applications..	L1, L2, L3
2	Gets an overview of guidelines, methods, tools and pick design problems in Virtual Reality.	L1, L2
3	Gets an overview of guidelines, methods, tools and pick design problems in Augmented Reality.	L1, L2
4	Evaluate designs based on theoretical frameworks and build Graphical User interface using VR, Tools	L3, L4
5	Apply the appropriate XR development Approach on problem	L3
6	Analyse main concerns with respect to designed solutions and discuss the privacy, ethical, social concerns.	L3, L4

Prerequisite: Programming Language, Computer Graphics, Virtual Reality

DETAILED SYLLABUS:

Module	**Title**	**Description**	**Hours**	**CO**

0	**Prerequisite**	Fundamental Concept and Components of Virtual Reality, Augmented Reality and Mixed Reality Technologies, Authoring in AR	**02**	--
I	**AR/VR Concepts and Technologies**	Difference between AR and VR, Rendering for VR/AR, Challenges with AR,AR systems and functionality **Augmented Reality Application Development**: Types of Augmented Reality Application (Location Based AR Apps Marker-Based AR Applications), three-dimensional modeling and computer vision, displays & tracking technologies **Self-learning Topic:** Case study on Retail shopping using AR	**08**	CO1
II	**VR Design Overview**	Principles of VR design, Overview of guidelines, methods, tools & design problem, Physical Prototyping for VR- Physical prototype of potential solution, Digital Prototyping for VR-tool choices, digital prototype of (key aspects of) solution **Self-learning Topic:** Study of 3D navigation , layout and contents	**09**	CO2
III	**AR Design Overview**	Principles of AR design, Overview of guidelines, methods, tools & design problem, Physical Prototyping for AR - Physical prototype of potential solution, Digital Prototyping for AR-tool choices, digital prototype of (key aspects of) solution. **Self-learning Topic:** Use of Anchors in AR	**09**	CO3
IV	**3 D interaction with VR**	3 D interaction Overview and types, Navigation in VR, Object interaction, Graphical User interface using VR, Challenges in VR interaction, Tools **Self-learning Topic:** Case study of Mobile applications using 3D interface	**10**	CO4
V	**XR Application Development**	XR overview, XR development Approach, XR design process, Trends in XR, key issues in XR, Tools **Self-learning Topic:** Difference between, AR, VR, MR and XR	**10**	CO5
VI	**Privacy and security**	Privacy, Ethical, and Social Implications, and the Future of AR/VR **Self-learning Topic:** Case study on Privacy and security issues using AR and VR	**04**	CO6

Textbooks:

1. John Vince, " Virtual Reality Systems", Pearson publication
2. Tony Parisi, " Learning Virtual Reality", O'REILLY'
3. Dieter Schmalsteig and Tobias Hollerer, "Augmented Reality- Principles and Practice", Pearson Education, Inc. 2016 Edition.
4. Chetankumar G Shetty, "Augmented Reality- Theory, Design and Development", Mc Graw Hill, 2020 Edition.
5. Alan B. Craig, "Understanding Augmented Reality – Concepts and Applications", Morgan Kaufmann, Elsevier, 2013 Edition.

References:

1. Borko Furht, “Handbook of Augmented Reality”, Springer.
2. Erin Pangilinan, Steve Lukas, and Vasanth Mohan, “Creating Augmented and Virtual Realities- Theory and Practice for Next-Generation Spatial Computing”, O’Reilly Media, Inc., 2019 Edition.
3. Jens Grubert, Dr. Raphael Grasset, “Augmented Reality for Android Application Development”, PACKT Publishing.

Online Resources:

Sr. No.	Website Name
1	www.nptel.ac.in
2	www.coursera.org

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test.

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Augmented Reality and Virtual Reality: Sem VII								
		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	**Course Title**	Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HARVRSBL701	**ARVR Lab (SBL)**	--	**4**	--	--	**2**	--	**2**

Course Code	Course Title	Examination Scheme						
		Theory Marks				Term Work	Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test2	Avg.				
HARVRSBL601	**ARVR Lab (SBL)**	--	--	--	--	**50**	**50**	**100**

Lab Objectives:

Sr. No.	Lab Objectives
The lab course aims:	
1	To Understand the definition and significance of the VR,AR and MR.
2	To Design various applications in VR .
3	To Examine various audio tools for audio embedded in scene
4	To Explore AR and MR applications in real world
5	To develop interface for VR and AR applications
6	To Explore the interconnection and integration of the physical world and able to design & develop Mobile applications.

Lab Outcomes

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of course, learner/student will be able to:		
1	Adapt different tools to implement VR,AR and MR.	L1,L2
2	Demonstrate the working of VR background design.	L1,L2
3	Apply audio tools and developed real world application.	L1,L2,L3
4	Adapt different techniques for Integrating AR and MR concepts in applications.	L5
5	Create interface for selected application	L6
6	Create application and interface for mobile application /desktop version	L6

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. PC i3/i5/i7 Processor or above. 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card	1. Unity 2. Python 3.OpenCV 4. Solidity	1. Internet Connection.

Prerequisite: VR, AR and MR concepts

Suggested List of Experiments

ARVR lab will describe the Designing of VR and AR applications using different Tools. It starts with installation of software and then learner learn how to design background of various application. Now a day's audio implementation in VR scenes is also getting lots of attention so this aspect is also covered in the lab experiments. AR and MR are important concepts where learner design the applications for desktop as well as mobile environment.

Sr. No.	Detailed Content	LO Mapping
1	To install Open source software /Unity with its functionality	**LO1**
2	Select real world application and design background for the same	**LO2**
3	To add sound in the selected application using Open source software /Unity software	**LO3**
4	To study interface requirements and apply for the selected application	**LO3**
5	Creating Your Digital Prototype of your objects/environment – (WebVR/ Sketchup / Blender/Unity/Keynote/Figma)	**LO6**
6	To implement a depth map with Python and OpenCV and using Unity	**LO5**
7	Identify multiple surfaces and move objects between them using ARCore	**LO3**
8	To study Interact with AR objects and detect collisions.	**LO2**
9	Marker less Object Placement - WebAR	**LO4**
10	In a group of three to five students develop one real world application in VR/ AR or MR with object details and sound with good user interface	**LO6**

Text Books/ References:

1. Hearn and Baker, "Computer Graphics- C version", 2nd edition, Pearson, 2002.
2. R. K Maurya, "Computer Graphics with Virtual Reality", 3rd Edition, Wiley India, 2018.
3. Dieter Schmalsteig and Tobias Hollerer, "Augmented Reality- Principles and Practice", Pearson Education, Inc. 2016 Edition.
4. Chetankumar G Shetty, "Augmented Reality- Theory, Design and Development", Mc Graw Hill, 2020 Edition.
5. Alan B. Craig, "Understanding Augmented Reality – Concepts and Applications", Morgan Kaufmann, Elsevier, 2013 Edition.

Online Resources:

Sr. No.	Website Name
1.	https://nptel.ac.in/courses/121/106/121106013/#
2.	http://msl.cs.uiuc.edu/vr/
3.	http://lavalle.pl/vr
4.	http://nptel.ac.in
5.	www.coursera.org

Term Work:

The Term work shall consist of at least 10 to 12 practical based on the above syllabus. The term work Journal must include at least 2 assignments. The assignments should be based on real world applications which cover concepts from all above syllabus**.**

Term Work Marks: 50 Marks (Total marks) = 40 Marks (Experiment) + 5 Marks (Assignments/tutorial/write up) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above syllabus.

Augmented Reality and Virtual Reality: Sem VIII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HARVRC801	**Game Development with VR**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HARVRC801	**Game Development with VR**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives

Sr. No.	**Course Objectives**
The course aims:	
1	The different genres of game and explain the Unity UI Basics.
2	The use of navigation and cursor control to create a game environment.
3	How to import assets, interact with them using action objects and manage object states.
4	To build transitions by scripting events ,using physics, particle systems, and other Unity functionality action sequences with UnityGUI design.
5	To build the game project together by handling mecanim ,using dialogue trees, creating and setting up the game environment and menus for the game.
6	The VR development in Unity.

Course Outcomes

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Identify the different genres of game and explain the Unity UI Basics	L1,L2
2	Make use of navigation and cursor control to create a game environment	L3
3	Apply how to import assets ,interact with them using action objects and manage object states	L3
4	Build transitions by scripting events ,using physics, particle systems, and other Unity functionality action sequences with UnityGUI design	L3
5	Build the game project together by handling mecanim ,using dialogue trees,creating and setting up the game environment and menus for the game	L3
6	Explain VR development in Unity	L2

Prerequisite: Basics of VR

DETAILED SYLLABUS:

Sr. No.	Module	Detailed Content	Hours	CO Mapping
0	**Prerequisite**	VR Basic concepts	**02**	-
I	**Game Development and Unity UI Basics**	The Adventure Genre, Fast Forward to Real-Time, What Draws People to This Genre? Designing Your Game: Defining a Style, Compartmentalizing Environments, First-Person or Third? Animation, Basic Human Characteristics Make for Fun? Managing Your Project, Tips for Completing the Game, Real Time vs. Pre-render.AI in Gaming-AI Guidelines, a simple workflow. Unity UI: The Layout, Toolbar, Menus, Creating Simple Objects, Selecting and Focusing, Transforming Objects In 3D, Snaps, Scene Gizmo.Lights,3D Objects, Materials Scripting: What is a script? Components of a Script, Picking an Object in the Game, Conditionals and State, Order of Evaluation **Self-learning Topics:** Understanding the role of AI in gaming	**08**	CO1
II	**Navigation and Cursor Control**	Creating Environments, Navigation-Arrow Navigation and Input, Fun with Platforms, Collision Walls, Cursor visibility, Custom cursors, GUI Texture Cursor, Hardware Cursor, UnityGUI Cursor, Object-to-Object Communication, Mouseover Cursor Changes, Object Reaction to Mouseover **Self-learning Topics:** Multimodal Gaming for Navigation Skills in Players Who Are Blind	**06**	CO2
III	**Imported Assets, Objects & Managing states**	Imported Assets:3D Art Assets, Setting Up Materials, Shadows. Action Objects: Colliders, Triggering Animation, Adding Sound F/X, Managing States: Identifying the Action Objects, Developing a State Machine, Lookup Table, Scripting in Unity, Picking a script Editor, Fundamentals of scripting in Unity. The Object Lookup Script, Action-Related Messages **Self-learning Topics:** Study the new Asset Import Pipeline: Solid foundation for speeding up asset imports, Effects of scripting on dialogues.	**09**	CO3
IV	**Transitions, Text Management**	Processing the Auxiliary Objects, Handling Object Visibility, Ensuring Player Focus, Adding New Assets, Physics, Combining Physics and Keyframe Animation, Particle systems, GUI Skin, Text Visibility, Using Layers, Creating the Inventory Screen, Adding Inventory Icons, Managing the inventory. **Self-learning Topics:** Importance of effective Text management in Gaming	**09**	CO4

V	**Game Deployment**	Dialogue Trees, The Scenario, Starting a Conversation, Mecanim and Characters, Game Environment, Setting up the game, Menus and levels **Self-learning Topics:** Branching dialogue trees and its effect in Gaming. Study of different UI designs for Menus in Games.	**09**	CO5
VI	**XR development in Unity**	Unity platform and services, XR Getting started with AR development in Unity, Getting started with VR development in Unity, XR Plug-in Framework, Configuring your Unity Project for XR, Universal Render Pipeline compatibility in XR, XR API reference, Single Pass Stereo rendering (Double-Wide rendering), VR Audio Spatializers, VR frame timing ,Unity XR SDK, Open-source repositories using Bitbucket, Asset Store Publishing, use of unity as library in other application. **Self-learning Topics:** Study any open source tool for VR Development	**09**	CO6

Text Books:

1. Beginning 3D Game Development with Unity 4 All-in-one Multi-platform Game development, 2nd Edition, Apress, Sue Backman
2. Game Development with Unity 2nd Edition, Michelle Menard and Bryan Wagstaff
3. Unity Game development Essentials, Will Goldstone, PACKT Publishing
4. Unity Game Development Cookbook-Essentials for every Game, O'reilly, Paris Buttfield-Addison, Jon Manning-Tim Nugent.

Reference Books:

1. Introduction to Gam Development, Second Edition, Steve Rabin, CENGAGE Learning
2. Sams Teach Yourself Unity Game Development in 24 Hours-Mike Geig

Online References:

Sr. No.	Website Name
1.	https://docs.unity3d.com/Manual/VROverview.html
2.	https://www.coursera.org/
3.	https://www.udemy.com/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

University of Mumbai

Syllabus for

Honours/Minor Degree Program

In

Artificial Intelligence and Machine Learning

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Artificial Intelligence and Machine Learning (AI&ML) (With effect from 2022-23)										
Year & Sem	Course Code & Course Title	Teaching Scheme Hrs / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar / Tutorial	Practical	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	HAIMLC501: Mathematics for AI & ML	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**	**-**	**-**		**100**	**04**
										Total Credits = 04
TE Sem VI	HAIMLC601: Game Theory using AI & ML	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**	**-**	**-**		**100**	**04**
										Total Credits = 04
BE Sem VII	HAIMLC701: AI&ML in Healthcare	04	--	--	20	80	--	--	100	04
	HAIMLSBL701: AI&ML in Healthcare: Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
										Total Credits = 06
BE Sem VIII	HAIMLC801: Text, Web and Social Media Analytics	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Artificial Intelligence and Machine Learning: Sem V								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HAIMLC501	Mathematics for AI&ML	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme							
		Theory Marks				Exam Duration In Hours	Term Work	Practical and Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test1	Test2	Avg.					
HAIMLC501	Mathematics for AI&ML	20	20	20	80	03	--	--	100

Course Prerequisites:	
Applied Mathematics, Discrete mathematics	
Course Objectives:	
1	To build an intuitive understanding of Mathematics and relating it to Artificial Intelligence, Machine Learning and Data Science.
2	To provide a strong foundation for probabilistic and statistical analysis mostly used in varied applications in Engineering.
3	To focus on exploring the data with the help of graphical representation and drawing conclusions.
4	To explore optimization and dimensionality reduction techniques.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Use linear algebra concepts to model, solve, and analyze real-world problems.
2	Apply probability distributions and sampling distributions to various business problems.
3	Select an appropriate graph representation for the given data.
4	Apply exploratory data analysis to some real data sets and provide interpretations via relevant visualization
5	Analyze various optimization techniques.
6	Describe Dimension Reduction Algorithms

Module No.		Topics	Hrs.
1.0		**Linear Algebra**	**05**
	1.1	Vectors and Matrices, Solving Linear equations, The four Fundamental Subspaces, Eigenvalues and Eigen Vectors, The Singular Value Decomposition (SVD).	
2.0		**Probability and Statistics**	**09**
	2.1	Introduction, Random Variables and their probability Distribution, Random Sampling, Sample Characteristics and their Distributions, Chi-Square, t-, and F-Distributions: Exact Sampling Distributions, Sampling from a Bivariate Normal Distribution, The Central Limit Theorem.	
3.0		**Introduction to Graphs**	**10**

	3.1	Quantitative vs. Qualitative data, Types of Quantitative data: Continuous data, Discrete data, Types of Qualitative data: Categorical data, Binary data, Ordinary data, Plotting data using Bar graph, Pie chart, Histogram, Stem and Leaf plot, Dot plot, Scatter plot, Time-series graph, Exponential graph, Logarithmic graph, Trigonometric graph, Frequency distribution graph.	
4.0		**Exploratory Data Analysis**	**09**
	4.1	Need of exploratory data analysis, cleaning and preparing data, Feature engineering, Missing values, understand dataset through various plots and graphs, draw conclusions, deciding appropriate machine learning models.	
5.0		**Optimization Techniques**	**10**
	5.1	Types of optimization-Constrained and Unconstrained optimization, Methods of Optimization-Numerical Optimization, Bracketing Methods-Bisection Method, False Position Method, Newton's Method, Steepest Descent Method, Penalty Function Method.	
6.0		**Dimension Reduction Algorithms**	**05**
	6.1	Introduction to Dimension Reduction Algorithms, Linear Dimensionality Reduction: Principal component analysis, Factor Analysis, Linear discriminant analysis.	
	6.2	Non-Linear Dimensionality Reduction: Multidimensional Scaling, Isometric Feature Mapping. Minimal polynomial	
		Total	**48**

Text Books:

1 Linear Algebra for Everyone,
2 Gilbert Strang, Wellesley Cambridge Press.
3 An Introduction to Probability and Statistics, Vijay Rohatgi, Wiley Publication
4 An introduction to Optimization, Second Edition, Wiley-Edwin Chong, Stainslaw Zak.
5 Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Cambridge University Press.
6 Exploratory Data Analysis, John Tukey, Princeton University and Bell Laboratories.

References:

1 Introduction to Linear Algebra, Gilbert Strang.
2 Advanced Engineering Mathematics, Erwin Kreyszig
3 Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. Foundations of Machine Learning. MIT Press, 2018.
4 Shai Shalev-Shwartz and Shai Ben-David. Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press, 2014
5 Last updated on Sep 9, 2018.
6 Mathematics and Programming for Machine Learning with R, William B. Claster, CRC Press,2020

Useful Links:

1 https://math.mit.edu/~gs/linearalgebra/
2 https://www.coursera.org/learn/probability-theory-statistics
3 https://nptel.ac.in/courses/111/105/111105090/
4 https://onlinecourses.nptel.ac.in/noc21_ma01/preview
5 https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/video-lectures/

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.

2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning: Sem VI								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC601	**Game Theory using AI & ML**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration In Hours**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC601	**Game Theory using AI & ML**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Knowledge of probability theory, discrete mathematics, and algorithm design is required.	
Course Objectives:	
1	To acquire the knowledge of game theory.
2	To understand the basic concept of AI, strength and weakness of problem solving and search
3	To study about various heuristic and game search algorithms
4	To optimize the different linear methods of regression and classification
5	To interpret the different supervised classification methods of support vector machine.
6	To acquire the knowledge of different generative models through unsupervised learning
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Understand basic concept of game theory.
2	Evaluate Artificial Intelligence (AI) methods and describe their foundations
3	Analyze and illustrate how search algorithms play vital role in problem solving, inference, perception, knowledge representation and learning
4	Demonstrate knowledge of reasoning and knowledge representation for solving real world problems
5	Recognize the characteristics of machine learning that makes it useful to realworld problems and apply different dimensionality reduction techniques
6	Apply the different supervised learning methods of support vector machine and tree based models

Module No.		**Topics**	**Hours.**
1.0		**Introduction to Game Theory**	**05**
	1.1	Introduction, The theory of rational choice, Games with Perfect Information, Nash Equilibrium: Theory, Prisoner's Dilemma, Stag Hunt, Matching pennies, BOS, Multi NE, Cooperative and Competitive Games, Strict and Non Strict NE, Best response functions for NE.	
	1.2	Nash Equilibrium: Illustrations, Cournot's model of oligopoly, Bertrand's model of oligopoly, Electoral competition, The War of Attrition, Auctions, Mixed Strategy Equilibrium, Strategic games in which players may randomize, Dominated actions, Extensive Games with Perfect Information	

2.0		**Games with Imperfect Information**	**09**
	2.1	Bayesian Games, Introduction, Motivational examples, General definitions, two examples concerning information, Strictly Competitive Games and Maxminimization, Rationalizability	
	2.2	Evolutionary Equilibrium, Monomorphic pure strategy equilibrium, Mixed strategies and polymorphic equilibrium, Repeated games: The Prisoner's Dilemma, Infinitely repeated games, Strategies, General Results,	
3.0		**Introduction to AI & Problem Solving**	**10**
	3.1	**Definitions** – Foundation and History of AI, Evolution of AI - Applications of AI, Classification of AI systems with respect to environment. Artificial Intelligence vs Machine learning,	
	3.2	**Heuristic Search Techniques:** Generate-and-Test; Hill Climbing; Properties of A* algorithm, Best first Search; Problem Reduction.	
	3.3	**Beyond Classical Search:** Local search algorithms and optimization problem, local search in continuous spaces, searching with nondeterministic action and partial observation, online search agent and unknown environments	
4.0		**Knowledge and Reasoning**	**09**
	4.1	**Knowledge and Reasoning:** Building a Knowledge Base: Propositional logic, first order Logic, situation calculus. Theorem Proving in First Order Logic, Planning, partial order planning. Uncertain Knowledge and Reasoning, Probabilities,	
	4.2	Bayesian Networks. Probabilistic reasoning over time: time and uncertainty, hidden Markova models, Kalman filter, dynamic bayesian network, keeping track of many objects	
5.0		**Introduction to ML**	**10**
	5.1	Introduction to Machine Learning, Examples of Machine Learning Applications, Learning Types, **Supervised Learning** -Learning a Class from Examples, Vapnik- Chervonenkis (VC) Dimension, Probably Approximately Correct (PAC) Learning, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization, Dimensions of a Supervised Machine Learning Algorithm	
	5.2	Introduction, Linear Regression Models and Least Squares, Subset Selection, Shrinkage Methods, **Logistic Regression-** Fitting Logistic Regression Models, Quadratic Approximations and Inference, L1 Regularized Logistic Regression, **SVM**-Introduction to SVM, The Support Vector Classifier, Support Vector Machines and Kernels- Computing the SVM for Classification	
6.0		**Unsupervised Learning**	**05**
	6.1	Introduction, Association Rules-Market Basket Analysis, The Apriori Algorithm, Unsupervised as Supervised Learning, Generalized Association Rules, Cluster Analysis Proximity Matrices, **Clustering Algorithms**-K-mean, Gaussian Mixtures as Soft K-means Clustering, Example: Human Tumor Microarray Data, Vector Quantization, K-medoids, Hierarchical Clustering, Self-Organizing Maps, PCA-Spectral Clustering	
	6.2	**Hidden Markov Models**-Introduction, Discrete Markov Processes, Hidden Markov Models, Three Basic Problems of HMMs, Evaluation Problem, Finding the State Sequence, Learning Model Parameters, Continuous Observations, The HMM with Input, Model Selection in HMM	
		Total	**48**

Text Books:

1 Martin Osborne, An Introduction to Game Theory, Oxford University Press.
2 Russell, S. and Norvig, P. 2015. Artificial Intelligence - A Modern Approach, 3rd edition,Prentice Hall
3 Introduction to Machine Learning Edition 2, by Ethem Alpaydin

References:

1 Thomas Ferguson, Game Theory, World Scientific, 2018.
2 Stef Tijs. Introduction to Game Theory, Hindustan Book Agency
3 J. Gabriel, Artificial Intelligence: Artificial Intelligence for Humans (Artificial Intelligence, Machine Learning), Create Space Independent Publishing Platform, First edition , 2016
4 Introduction to Artificial Intelligence & Expert Systems, Dan W Patterson, PHI.,2010 2. S Kaushik, Artificial Intelligence, Cengage Learning, 1st ed.2011
5 Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997

Assessment:

Internal Assessment: (20)

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

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning: Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC701	**AI&ML in Healthcare**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration In Hours**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC701	**AI&ML in Healthcare**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Artificial Intelligence, Machine Learning	
Course Objectives: The course aims	
1	To understand the need and significance of AI and ML for Healthcare.
2	To study advanced AI algorithms for Healthcare.
3	To learn Computational Intelligence techniques .
4	To understand evaluation metrics and ethics in intelligence for Healthcare systems,
5	To learn various NLP algorithms and their application in Healthcare,
6	To investigate the current scope, implications of AI and ML for developing futuristic Healthcare Applications.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Understand the role of AI and ML for handling Healthcare data.
2	Apply Advanced AI algorithms for Healthcare Problems.
3	Learn and Apply various Computational Intelligence techniques for Healthcare Application.
4	Use evaluation metrics for evaluating healthcare systems.
5	Develop NLP applications for healthcare using various NLP Techniques..
6	Apply AI and ML algorithms for building Healthcare Applications

Module		**Topics**	**Hours.**
1.0		**Introduction**	**04**
	1.1	Overview of AI and ML,A Multifaceted Discipline, Applications of AI in Healthcare - Prediction, Diagnosis, personalized treatment and behavior modification, drug discovery, followup care etc,	
	1.2	Realizing potential of AI and ML in healthcare, Healthcare Data - Use Cases.	
2.0		**AI, ML, Deep Learning and Data Mining Methods for Healthcare**	10
	2.1	Knowledge discovery and Data Mining, ML, Multi classifier Decision Fusion, Ensemble Learning, Meta-Learning and other Abstract Methods.	
	2.2	Evolutionary Algorithms, Illustrative Medical Application-Multiagent Infectious Disease Propagation and Outbreak Prediction, Automated Amblyopia Screening System etc.	
	2.3	Computational Intelligence Techniques, Deep Learning, Unsupervised learning, dimensionality reduction algorithms.	

3.0		**Evaluating learning for Intelligence**	06
	3.1	Model development and workflow, evaluation metrics, Parameters and Hyperparameters, Hyperparameter tuning algorithms, multivariate testing, Ethics of Intelligence.	
4.0		**Natural Language Processing in Healthcare**	**08**
	4.1	NLP tasks in Medicine, Low-level NLP components, High level NLP components, NLP Methods.	
	4.2	Clinical NLP resources and Tools, NLP Applications in Healthcare. Model Interpretability using Explainable AI for NLP applications.	
5.0		**Intelligent personal Health Record**	**04**
	5.1	Introduction, Guided Search for Disease Information, Recommending SCA's. Recommending HHP's , Continuous User Monitoring.	
6.0		**Future of Healthcare using AI and ML**	**07**
	6.1	Evidence based medicine, Personalized Medicine, Connected Medicine, Digital Health and Therapeutics, Conversational AI, Virtual and Augmented Reality, Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	
	6.2	Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	
		Total	**48**

Textbooks:

1 Arjun Panesar, "Machine Learning and AI for Healthcare", A Press.

2 Arvin Agah, "Medical applications of Artificial Systems ", CRC Press

References:

1 Erik R. Ranschaert Sergey Morozov Paul R. Algra, "Artificial Intelligence in medical Imaging-Opportunities, Applications and Risks", Springer

2 Sergio Consoli Diego Reforgiato Recupero Milan Petković,"Data Science for Healthcare-Methodologies and Applications", Springer

3 Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, "Emerging technologies for health and medicine", Wiley.

4 Ton J. Cleophas • Aeilko H. Zwinderman, "Machine Learning in Medicine- Complete Overview", Springer

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.

2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.

3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.

2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.

3 Remaining questions will be mixed in nature and randomly selected from all the modules.

4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning: Sem VIII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC801	**Text, Web and Social Media Analytics**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration In Hours**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC801	**Text, Web and Social Media Analytics**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Python, Data Mining	
Course Objectives: The course aims	
1	To have a strong foundation on text, web and social media analytics.
2	To understand the complexities of extracting the text from different data sources and analysing it.
3	To enable students to solve complex real-world problems using sentiment analysis and Recommendation systems.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Extract Information from the text and perform data pre-processing
2	Apply clustering and classification algorithms on textual data and perform prediction.
3	Apply various web mining techniques to perform mining, searching and spamming of web data.
4	Provide solutions to the emerging problems with social media using behaviour analytics and Recommendation systems.
5	Apply machine learning techniques to perform Sentiment Analysis on data from social media.

Module		**Topics**	**Hours.**
1.0		**Introduction**	**06**
	1.1	**Introduction to Text Mining:** Introduction, Algorithms for Text Mining, Future Directions	
	1.2	**Information Extraction from Text**: Named Entity Recognition, Relation Extraction, Unsupervised Information Extraction	
	1.3	**Text Representation:** tokenization, stemming, stop words, NER, N-gram modelling	
2.0		Clustering and Classification	10

	2.1	**Text Clustering**: Feature Selection and Transformation Methods, distance based Clustering Algorithms, Word and Phrase based Clustering, Probabilistic document Clustering	
	2.2	**Text Classification**: Feature Selection, Decision tree Classifiers, Rule-based Classifiers, Probabilistic based Classifiers, Proximity based Classifiers.	
	2.3	**Text Modelling:** Bayesian Networks, Hidden Markovian Models, Markov random Fields, Conditional Random Fields	
3.0		**Web-Mining:**	05
	3.1	**Introduction to Web-Mining:** Inverted indices and Compression, Latent Semantic Indexing, Web Search,	
	3.2	**Meta Search:** Using Similarity Scores, Rank Positons	
	3.3	**Web Spamming**: Content Spamming, Link Spamming, hiding Techniques, and Combating Spam	
4.0		**Web Usage Mining:**	**05**
	4.1	Data Collection and Pre-processing, Sources and types of Data, Data Modelling, Session and Visitor Analysis, Cluster Analysis and Visitor segmentation, Association and Correlation Analysis, Analysis of Sequential and Navigational Patterns, Classification and Prediction based on Web User Transactions.	
5.0		**Social Media Mining**:	**05**
	5.1	Introduction, Challenges, Types of social Network Graphs	
	5.2	Mining Social Media: Influence and Homophily, Behaviour Analytics, Recommendation in Social Media: Challenges, Classical recommendation Algorithms, Recommendation using Social Context, Evaluating recommendations.	
6.0		**Opinion Mining and Sentiment Analysis**:	**08**
	6.1	The problem of opinion mining,	
	6.2	**Document Sentiment Classification**: Supervised, Unsupervised	
	6.3	**Opinion Lexicon Expansion:** Dictionary based, Corpus based	
	6.4	**Opinion Spam Detection**: Supervised Learning, Abnormal Behaviours, Group Spam Detection.	
		Total	**48**

Textbooks:

1 Daniel Jurafsky and James H. Martin, “Speech and Language Processing,” 3rd edition, 2020

2 Charu. C. Aggarwal, Cheng Xiang Zhai, Mining Text Data, Springer Science and Business Media, 2012.

3 BingLiu, “Web Data Mining-Exploring Hyperlinks, Contents, and Usage Data”, Springer, Second Edition, 2011.

4 Reza Zafarani, Mohammad Ali Abbasiand Huan Liu, “Social Media Mining- An Introduction”, Cambridge University Press, 2014

Assessment:

Internal Assessment: (20)

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

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning:Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLSBL701	**AI&ML in Healthcare: Lab**	**--**	**04**	**--**	**--**	**02**	**--**	**02**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLSBL701	**AI&ML in Healthcare: Lab**						**50**	**50**	**100**

Course Prerequisites:	
Python	
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Students will be able to understand computational models of AI and ML.
2	Students will be able to develop healthcare applications using appropriate computational tools.
3	Students will be able to apply appropriate models to solve specific healthcare problems.
4	Students will be able to analyze and justify the performance of specific models as applied to healthcare problems.
5	Students will be able to design and implement AI and ML-based healthcare applications.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Collect, Clean, Integrate and Transform Healthcare Data based on specific disease.
2	Perform Exploratory data analysis of Healthcare Data.
3	AI for medical diagnosis based on MRI/X-ray data.
4	AI for medical prognosis .
5	Natural language Entity Extraction from medical reports.
6	Predict disease risk from Patient data.
7	Medical Reviews Analysis from social media data.
8	Explainable AI in healthcare for model interpretation.
9	Mini Project-Design and implement innovative web/mobile based AI application using Healthcare Data.
10	Documentation and Presentation of Mini Project.

Useful Links:

1. https://www.coursera.org/learn/introduction-tensorflow?specialization=tensorflow-in-practice
2. https://www.coursera.org/learn/convolutional-neural-networks-tensorflow?specialization=tensorflow-in-practice
3. https://datarade.ai/data-categories/electronic-health-record-ehr-data
4. https://www.cms.gov/Medicare/E-Health/EHealthRecords
5. https://www.coursera.org/learn/tensorflow-sequences-time-series-and-prediction?specialization=tensorflow-in-practice

Term Work:

1. Term work should consist of 8 experiments and a Mini Project.
2. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3. Total 50Marks (Experiments: 30-Marks, Mini Project-15 Marks, Attendance- Theory & Practical: 05-marks)

Oral & Practical exam

1. Based on the entire syllabus of **AI ML for Healthcare**

University of Mumbai

Syllabus for

Honours/Minor Degree Program

In

Data Science

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Data Science (With effect from 2022-23)										
Year & Sem	Course Code & Course Title	Teaching Scheme Hrs / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar / Tutorial	Practical	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	HDSC501: Mathematics for Data Science	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**	**-**	**-**	**-**	**100**	**04**
										Total Credits = 04
TE Sem VI	HDSC601: Statistical Learning for Data Science	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**	**-**	**-**	**-**	**100**	**04**
										Total Credits = 04
BE Sem VII	HDSC701: Data Science for Health and Social Care	04	--	--	20	80	--	--	100	04
	HDSSBL701: Data Science for Health and Social Care: Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
										Total Credits = 06
BE Sem VIII	HDSC801: Text, Web and Social Media Analytics	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Data Science: Sem V								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSC501	**Mathematics for Data Science**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSC501	**Mathematics for Data Science**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
1	Applied Mathematics, Discrete Mathematics
Course Objectives:	
1	To build an intuitive understanding of Mathematics and relating it to Data Analytics.
2	To provide a strong foundation for probabilistic and statistical analysis mostly used in varied applications in Engineering.
3	To focus on exploring the data with the help of graphical representation and drawing conclusions.
4	To explore optimization and dimensionality reduction techniques.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Use linear algebra concepts to model, solve, and analyze real-world problems.
2	Apply probability distributions and sampling distributions to various business problems.
3	Select an appropriate graph representation for the given data analysis.
4	Apply exploratory data analysis to some real data sets and provide interpretations via relevant visualization
5	Analyze various optimization techniques for data analysis.
6	Describe Dimension Reduction Algorithms in analytics

Module		**Topics**	**Hours.**
1.0		**Linear Algebra**	**05**
	1.1	Vectors and Matrices, Solving Linear equations, The four Fundamental Subspaces, Eigenvalues and Eigen Vectors, The Singular Value Decomposition (SVD).	
2.0		**Probability and Statistics**	**09**
	2.1	Introduction, Random Variables and their probability Distribution, Random Sampling, Sample Characteristics and their Distributions, Chi-Square, t-, and F-Distributions: Exact Sampling Distributions, Sampling from a Bivariate Normal Distribution, The Central Limit Theorem.	
3.0		**Introduction to Graphs**	**10**
	3.1	Quantitative vs. Qualitative data, Types of Quantitative data: Continuous data, Discrete data, Types of Qualitative data: Categorical data, Binary data, Ordinary data, Plotting	

		data using Bar graph, Pie chart, Histogram, Stem and Leaf plot, Dot plot, Scatter plot, Time-series graph, Exponential graph, Logarithmic graph, Trigonometric graph, Frequency distribution graph.	
4.0		**Exploratory Data Analysis**	**09**
	4.1	Need of exploratory data analysis, cleaning and preparing data, Feature engineering, Missing values, understand dataset through various plots and graphs, draw conclusions, deciding appropriate machine learning models.	
5.0		**Optimization Techniques**	**10**
	5.1	Types of optimization-Constrained and Unconstrained optimization, Methods of Optimization-Numerical Optimization, Bracketing Methods-Bisection Method, False Position Method, Newton's Method, Steepest Descent Method, Penalty Function Method.	
6.0		**Dimension Reduction Algorithms**	**05**
	6.1	Introduction to Dimension Reduction Algorithms, Linear Dimensionality Reduction: Principal component analysis, Factor Analysis, Linear discriminant analysis.	
	6.2	Non-Linear Dimensionality Reduction: Multidimensional Scaling, Isometric Feature Mapping. Minimal polynomial	
		Total	**48**

Text Books:

1 Linear Algebra for Everyone,
2 Gilbert Strang, Wellesley Cambridge Press.
3 An Introduction to Probability and Statistics, Vijay Rohatgi, Wiley Publication
4 An introduction to Optimization, Second Edition, Wiley-Edwin Chong, Stainslaw Zak.
5 Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Cambridge University Press.
6 Exploratory Data Analysis, John Tukey, Princeton University and Bell Laboratories.

References:

1 Introduction to Linear Algebra, Gilbert Strang.
2 Advanced Engineering Mathematics, Erwin Kreyszig
3 Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. Foundations of Machine Learning. MIT Press, 2018.
4 Shai Shalev-Shwartz and Shai Ben-David. Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press, 2014
5 Last updated on Sep 9, 2018.
6 Mathematics and Programming for Machine Learning with R, William B. Claster, CRC Press,2020

Useful Links:

1 https://math.mit.edu/~gs/linearalgebra/
2 https://www.coursera.org/learn/probability-theory-statistics
3 https://nptel.ac.in/courses/111/105/111105090/
4 https://onlinecourses.nptel.ac.in/noc21_ma01/preview
5 https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/video-lectures/

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.
2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.

3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Data Science: Sem VI								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSC601	**Statistical Learning for Data Science**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSC601	**Statistical Learning for Data Science**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
1	Engineering Mathematics, Probability and Statistics
Course Objectives:	
1	To understand basic statistical foundations for roles of Data Scientist.
2	To develop problem-solving skills.
3	To infer about the population parameters using sample data and perform hypothesis testing.
4	To understand importance and techniques of predicting a relationship between data and determine the goodness of model fit.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Develop various visualizations of the data in hand.
2	Analyze a real-world problem and solve it with the knowledge gained from sampling and probability distributions.
3	Analyze large data sets and perform data analysis to extract meaningful insights.
4	Develop and test a hypothesis about the population parameters to draw meaningful conclusions.
5	Fit a regression model to data and use it for prediction.

Module No.		**Topics**	**Hours.**
1.0		**Introduction**	**08**
	1.1	**Data and Statistics**: Elements, Variables, and Observations, Scales of Measurement, Categorical and Quantitative Data, Cross-Sectional and Time Series Data, Descriptive Statistics, Statistical Inference, Descriptive Statistics: Tabular and Graphical Summarizing Categorical Data, Summarizing Quantitative Data, Cross Tabulations and Scatter Diagram.	
	1.2	**Descriptive Statistics: Numerical Measures**: Measures of Location, Measures of Variability, Measures of Distribution Shape, Relative Location, and Detecting Outliers, Box Plot, Measures of Association Between Two Variables	

2.0		**Probability**	**08**
	2.1	**Probability :** Experiments, Counting Rules, and Assigning Probabilities, Events and Their Probabilities, Complement of an Event, Addition Law Independent Events, Multiplication Law, Baye's theorem	
	2.2	**Discrete Probability Distributions** Random Variables, Discrete Probability Distributions, Expected Value and Variance, Binomial Probability Distribution, Poisson Probability Distribution	
	2.3	**Continuous Probability Distributions:** Uniform Probability Distribution, Normal Curve, Standard Normal Probability Distribution, Computing Probabilities for Any Normal Probability Distribution	
3.0		**Sampling and Sampling Distributions**	05
	3.1	Sampling from a Finite Population, Sampling from an Infinite Population, Other Sampling Methods, Stratified Random Sampling, Cluster Sampling, Systematic Sampling, Convenience Sampling, Judgment Sampling	
	3.2	Interval Estimation: Population Mean: Known, Population Mean: Unknown, Determining the Sample Size, Population Proportion	
4.0		**Hypothesis Tests**	**05**
	4.1	Developing Null and Alternative Hypotheses, Type I and Type II Errors, Population Mean: Known Population Mean: Unknown Inference About Means and Proportions with Two Populations-Inferences About Population Variances, Inferences About a Population Variance, Inferences About Two Population Variances	
	4.2	Tests of Goodness of Fit and Independence, Goodness of Fit Test: A Multinomial Population, Test of Independence	
5.0		**Regression**	**08**
	5.1	**Simple Linear Regression:** Simple Linear Regression Model, Regression Model and Regression Equation, Estimated Regression Equation, Least Squares Method, Coefficient of Determination, Correlation Coefficient, Model Assumptions, testing for Significance, Using the Estimated Regression Equation for Estimation and Prediction Residual Analysis: Validating Model Assumptions, Residual Analysis: Outliers and Influential Observations	
	5.2	**Multiple Regression:** Multiple Regression Model, Least Squares Method, Multiple Coefficient of Determination, Model Assumptions, Testing for Significance, Categorical Independent Variables, Residual Analysis	
6.0		**Time Series Analysis and Forecasting**	**05**
	6.1	Time Series Patterns, Forecast Accuracy, Moving Averages and Exponential Smoothing, Trend Projection, Seasonality and Trend and Time Series Decomposition	
	6.2	**Nonparametric Methods** Sign Test, Wilcoxon Signed-Rank Test, Mann-Whitney-Wilcoxon Test, Kruskal-Wallis Test, Rank Correlation	
		Total	**48**

Text Books:

1. https://static1.squarespace.com/static/5ff2adbe3fe4fe33db902812/t/6009dd9fa7bc363aa822d2c7/1611259312432/ISLR+Seventh+Printing.pdf
2. Data Science from Scratch, FIRST PRINCIPLES WITH PYTHON, O'Reilly, Joel Grus,
3. Data Science from Scratch (oreillystatic.com)
4. Practical Time Series Analysis, Prediction with statistics and Machine Learning, O'Reilly, Aileen Nielsen [DOWNLOAD] O'Reilly Practical Time Series Analysis PDF (lunaticai.com)
5. R for data science: Import, Tidy, Transform, Visualize, And Model Data, O'Reilly , Garrett Grolemund, Hadley Wickham
6. Python for Data Analysis, 2nd Edition, O'Reilly Media, Wes McKinney.
7. https://static1.squarespace.com/static/5ff2adbe3fe4fe33db902812/t/6009dd9fa7bc363aa822d2c7/1611259312432/ISLR+Seventh+Printing.pdf

References:

1. Data Science for Dummies Paperback, Wiley Publications, Lillian Pierson
2. Storytelling with Data: A Data Visualization, Guide for Business Professionals, Wiley Publications, Cole Nussbaumer Knaflic
3. Probability and Statistics for Engineering and the Sciences, Cengage Publications Jay L. Devore.

Assessment:

Internal Assessment: (20)

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

End Semester Theory Examination: (80)

1. Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2. **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3. Remaining questions will be mixed in nature and randomly selected from all the modules.
4. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5. **Total 04 questions** need to be solved.

Data Science: Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSC701	**Data Science for Health and Social Care**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSC701	**Data Science for Health and Social Care**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Artificial Intelligence, Machine Learning	
Course Objectives: The course aims	
1	To gain perspective of Data Science for Health and Social Care.
2	To understand different techniques of Biomedical Image Analysis.
3	To learn NLP techniques for processing Clinical text.
4	To understand the role of social media analytics for Healthcare data .
5	To learn advanced analytics techniques for Healthcare Data.
6	To investigate the current scope, potential, limitations, and implications of data science and its applications for healthcare.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Identify sources and structure of healthcare data.
2	Apply structured lifecycle approach for handling Healthcare data science projects.
3	Analyze the data, create models, and identify insights from Healthcare data.
4	Apply various data analysis and visualization techniques for Healthcare and social media data.
5	Apply various algorithms and develop models for Healthcare data science projects.
6	To Provide data science solutions for solving problems of Health and Social Care.

Module		**Topics**	**Hours.**
1.0		**Data Science for Healthcare**	**05**
	1.1	Introduction, Healthcare Data Sources and Data Analytics for Healthcare, Applications and Practical Systems for Healthcare.	
	1.2	Electronic Health Records(EHR), Components of EHR, Benefits of EHR, Barriers to Adopting EHR, Challenges of using EHR data, Phenotyping Algorithms	
2.0		**Biomedical Image Analysis**	06
	2.1	Biomedical Imaging Modalities, Object detection ,Image segmentation, Image Registration, Feature Extraction	
	2.2	Mining of Sensor data in Healthcare, Challenges in Healthcare Data Analysis	
	2.3	Biomedical Signal Analysis, Genomic Data Analysis for Personalized Medicine.	
3.0		**Data Science and Natural Language Processing for Clinical Text**	06

	3.1	NLP, Mining information from Clinical Text, Information Extraction, Rule Based Approaches, Pattern based algorithms, Machine Learning Algorithms.	
	3.2	Clinical Text Corpora and evaluation metrics, challenges in processing clinical reports, Clinical Applications.	
4.0		**Social Media Analytics for Healthcare**	**06**
	4.1	Social Media analysis for detection and tracking of Infectious Disease outbreaks.	
	4.2	Outbreak detection, Social Media Analysis for Public Health Research, Analysis of Social Media Use in Healthcare.	
5.0		**Advanced Data Analytics for Healthcare**	**08**
	5.1	Review of Clinical Prediction Models, Temporal Data Mining for Healthcare Data	
	5.2	Visual Analytics for Healthcare Data, Information Retrieval for Healthcare- Data Publishing Methods in Healthcare.	
6.0		**Data Science Practical Systems for Healthcare**	**08**
	6.1	Data Analytics for Pervasive Health, Fraud Detection in Healthcare	
	6.2	Data Analytics for Pharmaceutical discoveries, Clinical Decision Support Systems	
	6.3	Computer-Assisted Medical Image Analysis Systems- Mobile Imaging and Analytics for Biomedical Data.	
		Total	**48**

Textbooks:

1 Chandan K. Reddy and Charu C Aggarwal, “Healthcare data analytics”, Taylor & Francis, 2015.

2 Hui Yang and Eva K. Lee, “Healthcare Analytics: From Data to Knowledge to Healthcare Improvement, Wiley, 2016.

References:

1 Madsen, L. B. (2015). Data-driven healthcare: how analytics and BI are transforming the industry. Wiley India Private Limited

2 Strome, T. L., & Liefer, A. (2013). Healthcare analytics for quality and performance improvement. Hoboken, NJ, USA: Wiley

3 McNeill, D., & Davenport, T. H. (2013). Analytics in Healthcare and the Life Sciences: Strategies, Implementation Methods, and Best Practices. Pearson Education.

4 Rachel Schutt and Cathy O’Neil, “Doing Data Science”, O’Reilly Media

5 Joel Grus, Data Science from Scratch: First Principles with Python, O'Reilly Media

6 EMC Education Services,”Data Science and Big Data Analytics”,Wiley

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.

2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.

3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.

2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.

3 Remaining questions will be mixed in nature and randomly selected from all the modules.

4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

5 **Total 04 questions** need to be solved.

Data Science: Sem VIII								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HDSC801	Text, Web and Social Media Analytics	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme							
		Theory Marks				Exam Duration	Term Work	Practical and Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test1	Test2	Avg.					
HDSC801	Text, Web and Social Media Analytics	20	20	20	80	03	--	--	100

Course Prerequisites:	
Python, Data Mining	
Course Objectives: The course aims	
1	To have a strong foundation on text, web and social media analytics.
2	To understand the complexities of extracting the text from different data sources and analysing it.
3	To enable students to solve complex real-world problems using sentiment analysis and Recommendation systems.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Extract Information from the text and perform data pre-processing
2	Apply clustering and classification algorithms on textual data and perform prediction.
3	Apply various web mining techniques to perform mining, searching and spamming of web data.
4	Provide solutions to the emerging problems with social media using behaviour analytics and Recommendation systems.
5	Apply machine learning techniques to perform Sentiment Analysis on data from social media.

Module No.		Topics	Hours.
1.0		**Introduction**	**06**
	1.1	**Introduction to Text Mining:** Introduction, Algorithms for Text Mining, Future Directions	
	1.2	**Information Extraction from Text**: Named Entity Recognition, Relation Extraction, Unsupervised Information Extraction	
	1.3	**Text Representation:** tokenization, stemming, stop words, NER, N-gram modelling	
2.0		Clustering and Classification	10

	2.1	**Text Clustering**: Feature Selection and Transformation Methods, distance based Clustering Algorithms, Word and Phrase based Clustering, Probabilistic document Clustering	
	2.2	**Text Classification**: Feature Selection, Decision tree Classifiers, Rule-based Classifiers, Probabilistic based Classifiers, Proximity based Classifiers.	
	2.3	**Text Modelling:** Bayesian Networks, Hidden Markovian Models, Markov random Fields, Conditional Random Fields	
3.0		**Web-Mining:**	05
	3.1	**Introduction to Web-Mining:** Inverted indices and Compression, Latent Semantic Indexing, Web Search,	
	3.2	**Meta Search:** Using Similarity Scores, Rank Positons	
	3.3	**Web Spamming**: Content Spamming, Link Spamming, hiding Techniques, and Combating Spam	
4.0		**Web Usage Mining:**	**05**
	4.1	Data Collection and Pre-processing, Sources and types of Data, Data Modelling, Session and Visitor Analysis, Cluster Analysis and Visitor segmentation, Association and Correlation Analysis, Analysis of Sequential and Navigational Patterns, Classification and Prediction based on Web User Transactions.	
5.0		**Social Media Mining**:	**05**
	5.1	Introduction, Challenges, Types of social Network Graphs	
	5.2	Mining Social Media: Influence and Homophily, Behaviour Analytics, Recommendation in Social Media: Challenges, Classical recommendation Algorithms, Recommendation using Social Context, Evaluating recommendations.	
6.0		**Opinion Mining and Sentiment Analysis**:	**08**
	6.1	The problem of opinion mining,	
	6.2	**Document Sentiment Classification**: Supervised, Unsupervised	
	6.3	**Opinion Lexicon Expansion:** Dictionary based, Corpus based	
	6.4	**Opinion Spam Detection**: Supervised Learning, Abnormal Behaviours, Group Spam Detection.	
		Total	**48**

Textbooks:

1 Daniel Jurafsky and James H. Martin, “Speech and Language Processing,” 3rd edition, 2020

2 Charu. C. Aggarwal, Cheng Xiang Zhai, Mining Text Data, Springer Science and Business Media, 2012.

3 BingLiu, “Web Data Mining-Exploring Hyperlinks, Contents, and Usage Data”, Springer, Second Edition, 2011.

4 Reza Zafarani, Mohammad Ali Abbasiand Huan Liu, “Social Media Mining- An Introduction”, Cambridge University Press, 2014

Assessment:

Internal Assessment: (20)

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

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Data Science: Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSSBL701	**Data Science for Health and Social Care: Lab**	**--**	**04**	**--**	**--**	**02**	**--**	**02**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSSBL701	**Data Science for Health and Social Care: Lab**						**50**	**50**	**100**

Course Prerequisites:	
Python	
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Students will be able to, Identify sources of data, suggest methods for collecting, sharing and analyzing Healthcare data.
2	Students will be able to Clean, integrate and transform healthcare data.
3	Students will be able to apply various data analysis and visualization techniques on healthcare data.
4	Students will be able to apply various algorithms and develop models for healthcare data Analytics.
5	Students will be able to implement data science solutions for solving healthcare problems.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
	Introduction
1	Clean, Integrate and Transform Electronic Healthcare Records.
2	Apply various data analysis and visualization techniques on EHR.
3	Bio Medical Image Preprocessing, Segmentation.
4	Bio Medical Image Analytics.
5	Text Analytics for Clinical Text Data.
6	Diagnose disease risk from Patient data.
7	Social Media Analytics for outbreak prediction/ Drug review analytics.
8	Visual Analytics for Healthcare Data.

9	Implement an innovative Data Science application based on Healthcare Data.
10	Documentation and Presentation of Mini Project.

Useful Links:

1. http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=MachineLearning
2. http://www.cse.wustl.edu/~kilian/cse517a2010/
3. https://datarade.ai/data-categories/electronic-health-record-ehr-data
4. https://www.cms.gov/Medicare/E-Health/EHealthRecords
5. https://onlinecourses.nptel.ac.in/noc20_ee40

Term Work:

1. Term work should consist of 8 experiments and a Mini Project.
2. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3. Total 50Marks (Experiments: 30-Marks, Mini Project-15 Marks, Attendance- Theory & Practical: 05-marks)

Oral & Practical exam

1. Based on the entire syllabus of **Data Science for Health and Social Care**

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Internet of Things

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023

University of Mumbai
Internet of Things
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HIoTC501: IoT Sensor Technologies**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HIoTC601: IoT System Design**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HIoTC701: Dynamic Paradigm in IoT**	04	--	--	20	80	--	--	100	04
	HIoTSBL701: Interfacing & Programming with IoTLab (SBL)	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HIoTC801: Industrial IoT**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Internet of Things: Sem V								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HIoTC501	**IoT Sensor Technologies**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg**					
HIoTC501	**IoT Sensor Technologies**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To provide in depth knowledge about the sensing mechanism.
2	To make students understand about the use of sensors in design of IoT based systems.
3	To familiarize students various types of sensors used to measure the physical quantities.
4	To develop reasonable level of competence in the design, construction and development of sensor suitable to the system requirements.
5	To Introduce students the current state of the art in sensor technology.
6	To familiarize students with electronics used to interface with sensors.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Understand the sensing mechanism and structural details of sensors.	L1, L2
2	Explain principles and working of the sensors.	L1,L2
3	Evaluate the performance of various types of sensors.	L5
4	Select the sensor suitable to system requirements.	L5
5	Interface the sensors with microcontrollers and Arduino	L6
6	Understand the current state of the art in sensor technology.	L2

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	1. Basics of Electrical and Electronics Engineering 2. Applied Mechanics 3. Applied Physics, Applied Chemistry	2	CO 1, CO2, CO3, CO4, CO5

I	**Sensor Fundamentals and Properties**	**Sensor Fundamentals and Properties:** Introduction to IoT, Need for sensors in IoT, Data Acquisition – sensor characteristics – electric charges, fields, potentials – capacitance – magnetism – inductance – resistance – piezoelectric – pyroelectric – Hall effect thermoelectric effects – sound waves – heat transfer – light – dynamic models of sensors. Need of actuators, all types of actuators and their working. Identification of sensor and actuator for real-time application **Self-learning Topics: IoT Systems, Transfer function and modelling of sensors**	**8**	CO1, CO2
II	**Optical, radiation and Displacement sensors**	**Optical, radiation and Displacement sensors** Photosensors: Photodiode, phototransistor and photo resistor, imaging sensors, UV detectors, Basic Characteristics of radiation sensors, Thermal infrared sensors, X-ray and Nuclear Radiation Sensors, Fibre Optic Sensors, Capacitive and Inductive Displacement Sensor, Electromagnetism and Inductance, Magnetic Field Sensors **Self-learning Topics: Optical sources and detectors, Sensors based on polymer optical fibers, Micro-structured and solid fibers**	**8**	CO1, CO2, CO3, CO4
III	**Presence, force, Pressure, Flow Sensors**	**Presence, force, Pressure, Flow Sensors** Potentiometric Sensors, Piezoresistive Sensors, Capacitive Sensors for presence, Inductive and Magnetic Sensors, Strain gages, Pressure sensitive films, piezoelectric force sensor, Piezoelectric Cables, Concept of Pressure, Mercury Pressure Sensor, Bellows, Membranes, and Thin Plates, Piezo resistive Sensors, Capacitive Sensors, VRP Sensors, Optoelectronic Pressure Sensors, Indirect Pressure Sensor, Vacuum Sensors, Basics of Flow Dynamics, Pressure Gradient Technique, Thermal Transport Sensors, Ultrasonic Sensors, Level Sensors **Self-learning Topics: Vibration energy harvesting with Piezoelectric, MEMS systems. Develop a sensor system for force measurement using piezoelectric transducer. Develop** Resistance Temperature Detector	**9**	CO1, CO2, CO3, CO4
IV	**Humidity, Moisture Chemical and Biological Sensors**	**Humidity, Moisture Chemical and Biological Sensors** Microphones: Characteristics, Resistive, condenser, Electret, Optical, Pizoelectric, Dynamic, Concept of humidity, Capacitive Humidity Sensors, Resistive Humidity Sensors, Thermal Conductivity Sensors, Optical Hygrometers, Oscillating Hygrometer, Soil Moisture Chemical Sensor Characteristics, Electrical and Electrochemical Sensors, Photoionization Detectors, Physical	**8**	CO1, CO2, CO3, CO4, CO5

		Transducers, Spectrometers, Thermal Sensors, Optical Transducers, Multi-sensor Arrays Artificial Microsystems for Sensing Airflow, Temperature, and Humidity by Combining MEMS and CMOS Technologies **Self-learning Topics: Biosensors for biomedical applications**		
V	**Interface Electronic Circuits**	**Interface Electronic Circuits** Introduction, Signal Conditioners, Sensor Connections, Excitation Circuits, Analog to Digital Converters, Integrated Interfaces, Data Transmission, Noise in Sensors and Circuits, Batteries for Low-Power Sensors, Types of Single board computers, various sensor interfacing with Arduino, Embedded C Programming. data communication protocol interfacing, study the properties of LDR, Build a simple LED light intensity controller, Linux on Raspberry Pi, Interfaces, and Programming. **Self-learning Topics: Python Programming to interface sensors**	**8**	CO1, CO2, CO5
VI	**Current Trends in sensors and Technology**	**Current Trends in sensors and Technology** Smart Sensors: Introduction, Primary sensors, Excitation, Amplification, Filters, Converters, Compensation, Information Coding/Processing, Data Communication, Standards for Smart Sensor Interface, The Automation Sensor Technologies: Introduction, Film Sensors, Thick Film Sensors, Thin Film Sensors, Semiconductor IC Technology—Standard Methods, Microelectromechanical Systems (MEMS), Nano-sensors Sensor Applications: Onboard Automobile sensors, Home appliances sensors, Aerospace Sensors, Sensors for Environmental Monitoring **Self-learning Topics: Energy Harvesting, Self-powered Wireless Sensing in ground, Ground penetrating sensors**	**9**	CO1, CO2, CO3, CO4, CO5, CO6

Text Books:

1. Jacob Fraden, “Hand Book of Modern Sensors: physics, Designs and Applications”, 2015, 3rd edition, Springer, New York.
2. Jon. S. Wilson, “Sensor Technology Hand Book”, 2011, 1st edition, Elsevier, Netherland
3. D. Patranabis – Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003
4. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”,1st Edition, VPT, 2014

References:

1. Edited by Qusay F Hasan, Atta ur rehman Khan, Sajid A madani, “Internet of Things Challenges, Advances, and Application”, CRC Press
2. Triethy HL - Transducers in Electronic and Mechanical Designs, Mercel Dekker, 2003
3. Gerd Keiser,”Optical Fiber Communications”, 2017, 5th edition, McGraw-Hill Science, Delhi.

4. John G Webster, Halit Eren, “Measurement, Instrumentation and sensor Handbook”, 2014, 2nd edition, CRC Press, Taylor and Fransis Group, New York.
5. Adrian McEwen, “Designing the Internet of Things”, Wiley Publishers, 2013, ISBN: 978-1-118-43062-0
6. Nathan Ida, “Sensors, Actuators and their Interfaces: A Multidisciplinary Introduction”, Second Edition, IET Control, Robotics and Sensors Series 127, 2020

Online References:

Sr. No.	Website Name
3.	https://nptel.ac.in/courses/108/108/108108123/
4.	https://nptel.ac.in/courses/108/108/108108098/
3.	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ee41/
4.	https://nptel.ac.in/courses/108/106/108106165/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Internet of Things: Sem VI								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HIoTC601	**IoT System Design**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HIoTC601	**IoT System Design**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To learn basic principles, concepts, and technologies for internet of things.
2	To understand various architectures of IOT.
3	To train the students to build IoT systems using sensors, single board computers and open source IoT platform for given application.
4	To learn and implement various networking and communication protocols.
5	To design and analyze IoT for given applications.
6	To Evaluate performance of given IoT system.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Able to explain principles, concepts, and technologies for internet of things.	L1, L2
2	Able to identify various building blocks of IoT system	L1,L2
3	Able to analyze and evaluate various networking and communication protocols used in IoT system	L3,L4
4	Able to select appropriate interface for given application	L3
5	Able to design and analyze IoT system for given application	L4,L5
6	Able to evaluate performance of given IOT System	L5

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Comment (Prerequisite syllabus should not be considered for paper setting) Basics of Embedded System, IoT Sensors, Digital design	**2**	--

I	**Overview of IoT System**	What is IoT System? IoT Impact, Current Trends in IoT, IoT Challenges, Comparing IoT Architectures, A Simplified IoT Architecture, The Core IoT Functional Stack How are IoT Systems different from traditional system Values and Uses of IoT Functional View and Infrastructure view of IoT Systems **Self-learning Topics:** *Understanding the Issues and Challenges of a More Connected World*	**6**	CO1, CO2
II	**Networking Protocols**	OSI Model for the IoT/M2M System Lightweight M2M Communication Protocols, Internet based Communications, IP addressing in IoT, Network Model, TCP & UDP, Client-Server architecture **Self-learning Topics:** *How to choose correct protocol for our network.*	**8**	CO3
III	**Communication Protocols**	IoT Edge to Cloud protocols: HTTP, REST APIs, WebSocket, MQTT, COAP, Comparison of Protocols.M2M Communication Protocols, Bluetooth BR/EDR and Bluetooth low energy. RFID IoT System , RFID IoT Network Architecture, ZigBee IP/ZigBee SE2.0, Wifi(WLAN), Message Communication protocols for connected devices Data exchange formats: JSON & XML, Node-Red, Flow control using Node-Red, learning the different nodes of Node-RED for implementing the Communication Protocols **Self-learning Topics:** *Types of Communication*	**10**	CO3,CO4
IV	**Sensor Interfaces**	Digital Interfaces: UART, Serial Peripheral Interface (SPI), I2C (Inter-Integrated Circuit), Controller Area Network (CAN), Middleware Technologies, Communication Protocols and Models. Practical Components Programming with interface in Arduino, MBed and Raspberry Pi **Self-learning Topics:** *SMART SENSOR INTERFACES*	**10**	CO4
V	**Design principles for prototyping**	Design solution for ubiquitionos and utility, Interface design for user experience, Designing for data privacy, Interfacing – Apps & Webs, Designing for Affordability, Cost v/s Ease of Prototyping, Prototypes and Production, Selection of embedded platform, Prototype and Mass personalization, Open Source v/s Closed Source ,Amplification and Signal Conditioning- Integrated Signal Conditioning- Digital conversion- MCU Control MCUs for Sensor Interface- Techniques and System Considerations- Sensor Integration **Self-learning Topics:** *Principles for Prototyping and moving towards Product Development*	**8**	CO5
VI	**IoT, case studies**	Arduino Programming for Ethernet and Wifi connectivity, Networking and Data logging with Raspberry Pi Applications-Agriculture, Medical, Fire detection, Air pollution prediction, Earthquake early detection; for smart environmental care, smart traveling, Home Automation **Self-learning Topics**: *IoT enabled Business solution in Supply Chain*	**8**	CO6

Text Books:

1. S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press.

2. Adrian McEwen and Hakim Cassimally, —Designing the Internet of Things‖, John Wiley and Sons Ltd, UK, 2014.

3. Milan Milenkovic, Internet of Things: Concepts and System Design, Springer International Publishing,May 2020cation

4. Dr.Raj Kamal,Internet of Things(IoT) , Architecture and Design Principles.McGraw Hill Education.

References:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things
2. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.
3. Editors OvidiuVermesan Peter Friess,'Internet of Things – From Research and Innovation to Market
4. Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies Sensors for the Internet of Things Businesses & Market Trends 2014 -2024',Yole Development Copyrights ,2014

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

- **Question paper format**

  - Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Internet of Things: Sem VII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HIoTC701	**Dynamic Paradigm in IoT**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HIoTC701	**Dynamic Paradigm in IoT**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To explore the role of the cloud in Internet of Things deployment.
2	To introduce the usage of different machine learning algorithms on IoT Data.
3	To explore data analytics and data visualization on IoT Data.
4	To explore the role of Fog computing in Internet of Things.
5	To explore design issues and working principles of various security measures and various standards for secure communication in IoT.
6	To develop the ability to integrate IoT with Dev-ops.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Identify the need for the cloud in IoT deployment and describe different Cloud provider's architecture.	L1,L2
2	Use and correlate machine learning techniques on IoT Data.	L3,L4
3	Apply IoT analytics and data visualization.	L3
4	Recognize the use of Fog Computing in the Internet of things.	L1,L2
5	Explain the need of security measures in the Internet of Things.	L4
6	Apply the knowledge of Dev-ops in IoT applications.	L3

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Basics of Cloud Computing, Basics of Machine learning and primitives of cryptography	**2**	--

I	**IoT and CLOUD**	**Cloud Computing Concept, Grid/SOA and Cloud Computing, Cloud Middleware** **NIST's SPI Architecture and Cloud Standards, The Cloud of Things--** The Internet of Things and Cloud Computing **The Cloud of Things Architecture**-- Four Deployment Models, Vertical Applications, Fifteen Essential Features, Four Technological Pillars, Three Layers of IoT Systems, Foundational Technological Enabler **Cloud Providers and Systems** -- Microsoft Azure IoT, Amazon Web Services, Google's cloud IoTs. **Self-learning Module:** IBM Watson Cloud	**10**	CO1
II	**IoT and Machine Learning**	**Advantages of IoT and Machine Learning Integration,** I**mplementation of Supervised Algorithm-** Regression (Linear and Logistic), SVM for IoT-Neural Network **on case study:** Agriculture and IoT, Smart Home etc. **Self-Learning Module:** Regression, SVM	**6**	CO2
III	**IoT and Data Analytics**	**Defining IoT Analytics, IoT Analytics challenges, IoT analytics for the cloud**-Microsoft Azure overview– Strategies to organize Data for IoT Analytics, Linked Analytics Data Sets, Managing Data lakes, The data retention strategy. **Communicating with Others- Visualization and Dash boarding-** Designing visual analysis for IoT data, creating a dashboard –creating and visualizing alerts. **Self-learning Topics:** Study real time case study on IoT Analytics.	**8**	CO3
IV	**IoT and Fog Computing**	**Fog computing Basics, The Hadoop philosophy for Fog computing, Fog Computing versus Edge Computing versus cloud computing, Open Fog Reference Architecture Application services**-- Application support, Node management and software backplane, Hardware virtualization, Open Fog node security, Network Accelerators Compute, Storage Hardware platform infrastructure, Protocol abstraction, Sensors, actuators, and control systems, Fog Topology. **Self-learning Module:** Amazon Green grass and Lambda (implementation)	**8**	CO4
V	**IoT and it's Security**	Cyber security vernacular Attack and threat terms, Defense terms, Anatomy of IoT cyber attacks – Mirai, Stuxnet, Chain Reaction, Physical and hardware security, Root of Trust, Key management and trusted platform modules, Processor and memory space, Storage security, Network stack – Transport Layer Security, Software defined perimeter, Software-Defined Perimeter architecture, **Self-learning Module:** OWASP-Existing Security attacks and its prevention methods.	**8**	CO5
VI	**IoT and Devops**	Introduction to DevOps, DevOps application - business scenarios, DevOps process -- Source Code Management (SCM), Code review, Configuration Management, Build management, Artifacts repository management, Release management, Test automation, Continuous integration, Continuous delivery, Continuous deployment, Infrastructure as Code, Routine automation, Key application performance monitoring/indicators. DevOps frameworks--DevOps maturity life cycle, DevOps maturity map, DevOps progression	**10**	CO6

		framework/readiness model, DevOps maturity checklists, Agile framework for DevOps process projects, Agile ways of development **Tool for IoT—**Chef and Puppet, Setting up Chef and Puppet, Multi-tier Application Deployment, NETCONF-YANG Case Studies- Steps for IoT device management with NETCONF-YANG, Managing Smart irrigation IoT system with NETCONF-YANG, Managing Home Intrusion Detection IoT system with NETCONF-YANG **Self-learning Topics:** Compare different tool of IoT.		

Text Books:

1. The Internet of Things in the Cloud A Middleware Perspective, Honbo Zhou – CRC Publication.
2. Analytics for the Internet of Things (IoT), Andrew Minteer, Packt Publication 2017
3. Internet of Things- Hands on Approach, Arshdeep Bagha, Vijay Medisetti, Published by Arshdeep Bagha and Vijay Medisetti,2014.
4. Hands-on DevOps, Sricharan Vadapalli, Packt Publication, 2017
5. Internet of things For Architects, Perry Lea Packt Publication,2018

References:

1. Enterprise Cloud Computing, Gautam Shroff, Cambridge,2010
2. Mastering Cloud Computing -Foundations and Applications Programming, Raj Kumar Buyya, Christian Vecchiola, S. Thamarai Selvi, MK Publication, 2013.
3. Machine Learning in Action‖, Peter Harrington, DreamTech Press
4. Introduction to Machine Learning‖, Ethem Alpaydın, MIT Press
5. Learning AWS IoT- Effectively Manage Connected Devices on the AWS Cloud Using Services Such as AWS Greengrass, AWS Button, Predictive Analytics and Machine Learning, Agus Kurniawan, Packt Publication,2018
6. Practical Dev-Ops, Joakim Verona, Packt Publication, 2016

Online References:

Sr. No.	Website Name
1.	https://hub.packtpub.com/25-datasets-deep-learning-iot/
2.	https://data.world/datasets/iot
3.	https://dashboard.healthit.gov/datadashboard/data.php
4.	https://www.data.gov/
5.	https://dev.socrata.com/data/
6.	https://www.kaggle.com/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Internet of Things: Sem VII								
		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HIoTSBL701	Interfacing & Programming with IoT Lab (SBL)	--	4	--	--	2	--	02

Course Code	Course Title	Examination Scheme						
		Theory Marks				Term Work	Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
HIoTSBL701	Interfacing & Programming with IoT Lab (SBL)	--	--	--	--	50	50	100

Lab Objectives:

Sr. No.	Lab Objectives
The Lab aims:	
1	To Understand the definition and significance of the Internet of Things.
2	To Discuss the architecture, operation, and business benefits of an IoT solution.
3	To Examine the potential business opportunities that IoT can uncover.
4	To Explore the relationship between IoT, cloud computing, and DevOps.
5	To Identify how IoT differs from traditional data collection systems.
6	To Explore the interconnection and integration of the physical world and able to design & develop IOT Devices.

Lab Outcomes:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of lab, learner/student will be able to:		
1	Adapt different techniques for data acquisition using various IoT sensors for different applications.	L6
2	Demonstrate the working of actuators based on the collected data.	L2
3	Use different IoT simulators and correlate working of IoT protocols.	L3
4	Adapt different techniques for Integrating IoT services to other third-party Clouds.	L6
5	Execute DevOps methodologies for continuous integration and continuous deployment of IoT application.	L3
6	Implement IoT protocols like MQTT for communication to realize the revolution of internet in mobile devices, cloud and sensor networks.	L3

Prerequisite:

IoT introduction course: Basics of IoT, Introduction to Embedded systems

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. Intel PIV Processor 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card 5. Sensors 6. IoT Kit (Arduino/ARM/Raspberry Pi)	1. Windows or Linux Desktop OS 2. DeVops 3.Python 4. IoT Simulator/Emulator (open source)	1. Internet Connection for installing additional packages if required

This lab will describe the market around the Internet of Things (IoT), the technology used to build these kinds of devices, how they communicate, how they store data, and the kinds of distributed systems needed to support them. Divided into four main modules, we will learn by doing. We will start with simple examples and integrate the techniques we learn into a class project in which we design and build an actual IoT system. The client will run in an emulated ARM environment, communicating using common IoT protocols with a cloud enabled backend system with DevOps integration.

Suggested List of Experiments

Sr. No.	Detailed Content	Hours	LO Mapping
1	To study and implement interfacing of different IoT sensors with Raspberry Pi/Arduino/ModeMCU	**4**	LO1
2	To study and implement interfacing of actuators based on the data collected using IoT sensors. (like led switch ON/OFF, stepper word)	**4**	LO2
3	To study and demonstrate Contiki OS for RPL (like Create 2 border router and 10 REST clients, Access border router from other network (Simulator))	**4**	LO3
4	To study and demonstrate use of IoT simulators (like Beviswise) on any real time device (LED/stepper motor)	**4**	LO3
5	Select any one case study (in a group of 2-3) and perform the experiments 5 to 10. The sample case studies can be as follows: 1. Smart home automation system 2. Healthcare management system 3. Smart traffic management system & so on… Write a program on Raspberry Pi to push and retrieve the data from cloud like thingspeak, thingsboard, AWS, Azure etc.	**8**	LO4
6	To install MySQL database on Raspberry Pi and perform basic SQL queries for analysis data collected.	**6**	LO4
7	To study and implement IoT Data processing using Pandas.	**4**	LO4

8	To study and implement Continuous Integration using Jenkins on IoT data and also perform interfacing of Raspberry Pi into Jenkins.	**6**	LO6
9	To study and implement Continuous Deployment (Infrastructure as a code) for IoT using Ansible.	**6**	LO6
10	To study MQTT Mosquitto server and write a program on Arduino/Raspberry Pi to publish sensor data to MQTT broker.	**6**	LO5

Books / References:

1. Jake VanderPlas,“ Python Data Science Handbook”, O’Reilly publication,2016
2. Joakim Verona,” Practical DevOps”, PACKT publishing, 2016
3.Honbo Zhou,” The internet of things in the cloud”, CRC press, Taylor and Francis group, 2012
4. Perry Lea,” Internet of things for architects”, PACKT publishing, 2018

Online Resources:

Sr. No.	Website Name
1.	https://spoken-tutorial.org/watch/Arduino/Introduction+to+Arduino/English/
2.	https://pythonprogramming.net/introduction-raspberry-pi-tutorials/
3.	https://iotbytes.wordpress.com/basic-iot-actuators/
4.	http://www.contiki-os.org/
5.	https://www.bevywise.com/iot-simulator/
6.	https://mqtt.org/

Term Work:

The Term work shall consist of at least 10 practical based on the above list. The term work Journal must include at least 2 assignments. The assignments should be based on real world applications which cover concepts from all above list**.**

Term Work Marks: 50 Marks (Total marks) = 40 Marks (Experiment) + 5 Marks (Assignments/tutorial/write up) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above syllabus.

Internet of Things: Sem VIII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HIoTC801	**Industrial IoT**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HIoTC801	**Industrial IoT**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To learn the concepts of Industry 4.0 and IIOT.
2	To learn reference Architecture of IIOT.
3	To learn Industrial Data Transmission and Industrial Data Acquisition.
4	To learn middleware and WAN technologies.
5	To learn IIOT Block chain and Security.
6	To learn different applications and securities in IIOT.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Understand the concepts of Industry 4.0 and IIOT.	L1,L2
2	Understand reference Architecture of IIOT.	L1,L2
3	Understand Industrial Data Transmission and Industrial Data Acquisition.	L1,L2
4	Understand middleware and WAN technologies in IIOT.	L1,L2
5	Understand the concepts of Blockchain and Security in IIOT.	L1,L2
6	Apply security in IIOT applications.	L3

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	IOT Concepts, Sensor Technology, IOT Stack and Protocols, Design IoT systems, WSN etc.	**02**	--

I	**Introduction**	Overview of Industry 4.0 and Industrial Internet of Things, Industry 4.0: Industrial Revolution: Phases of Development, Evolution of Industry 4.0, Environment impacts of industrial revolution, Industrial Internet, Basics of CPS, CPS and IIOT, Design requirements of Industry 4.0, Drivers of Industry 4.0, Sustainability Assessment of Industries, Smart Business Perspective, Cyber security, Impacts of Industry 4.0, Industrial Internet of Things: Basics, IIOT and Industry 4.0, Industrial Internet Systems, Industrial Sensing, Industrial Processes, IIOT Challenges – Identifying Things within the internet, Discovering Things and the Data they possess, Managing massive amount of data, Navigating Connectivity Outages, IIOT Edge - Leveraging the Power of Cloud Computing, Communicating with Devices on the Edge, Determining a Request/Response Model **Self-learning Topics:** Study real time IIoT challenges in industry.	**06**	CO1
II	**IIOT Reference Architecture**	The IIC Industrial Internet Reference Architecture - Industrial Internet Architecture Framework (IIAF),Industrial Internet Viewpoints -Functional, Operational, Information Application and Business Domain of IIAF. The Three-Tier Topology, Key Functional Characteristics of Connectivity. Software Architectural Style for the Industrial Internet of Things - Software Architecture Practice, Advanced Architectural Styles, Systems of Systems, Challenges of Software Engineering in IIoT, Principles for Software Architecture design in IIoT, The Principled Decomposition, The Architectural Style **Self-learning Topics:** Study IIoT Architecture.	**08**	CO2
III	**Industrial Data Transmission and Industrial Data Acquisition**	Introduction, (Features and Components of - Foundation Fieldbus, Profibus, HART,Interbus, Bitbus, CC-Link, Modbus, Batibus, DigitalSTROM, Controller Area Network, DeviceNet, LonWorks, ISA 100.11a, Wireless HART, LoRa and LoRaWAN) NB-IoT, IEEE 802.11AH, Distributed Control System, PLC, SCADA **Self-learning Topics:** Study SCADA, PLC in detail.	**10**	CO3
IV	**IIOT Middleware and WAN Technologies**	(From Industrial Application Perspective) Examining Middleware Transport Protocols (TCP/IP, UDP, RTP, CoAP), Middleware Software Patterns (Publish Subscribe Pattern, Delay Tolerant Networks), Software Design Concepts – Application Programming Interface – A Technical Perspective, Why Are APIs Important for Business? Web Services, IIOT Middleware Platforms – Middleware Architecture	**10**	CO4

		IIOT WAN Technologies and Protocols - IIoT Device Low-Power WAN Optimized Technologies for M2M, SigFox,LoRaWAN,nWave, Dash7 Protocol, Ingénue RPMA, Low Power Wi-Fi, LTE Category-M, Weightless, Millimeter Radio **Self-learning Topics:** Study different IIoT Middleware and WAN Technologies.		
V	**IIOT Blockchain and Security**	Blockchains and cryptocurrencies in IoT, Bitcoin (blockchain-based), IOTA- distributed ledger (directed a cyclical graph-based), Government regulations and intervention, US Congressional Bill – Internet of Things (IoT) Cyber security Improvement Act of 2017, Other governmental bodies, IoT security best practices, Holistic security. **Self-learning Topics:** Case study on IIoT Block chain and Security.	**08**	CO5
VI	**IIOT Applications and Securities**	The IoT Security Lifecycle- The secure IoT system implementation lifecycle, Implementation and integration, IoT security CONOPS document, Network and security integration, System security verification and validation (V&V), Security training, Secure configurations, Operations and maintenance, Managing identities, roles, and attributes, Security monitoring, Penetration testing, Compliance monitoring, Asset and configuration management, Incident management, Forensics, Dispose, Secure device disposal and zeroization, Data purging, Inventory control, Data archiving and records management Securing the Industrial Internet - Security in Manufacturing, PLCs and DCS, Securing the OT (Operation Technology), Network, System Level: Potential Security Issues, Identity Access Management Develop New Business Models – Adopt Smart Architectures and Technologies, Sensor-Driven Computing, Industrial Analytics, Intelligent Machine Applications, Transform the Workforce Case Studies – Healthcare Applications in Industries – Challenges associated with Healthcare, Introduction, Smart Devices, Advanced technologies used in Healthcare. Inventory Management and Quality Control – Introduction, Inventory Management and IIOT, Quality Control Manufacturing Industry, Automotive Industry and Mining Industry **Self-learning Topics:** Study real time IIoT application.	**08**	CO6

Text Books:

1. "Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress)
2. "Introduction to Industrial Internet of Things and Industry 4.0",by Sudip Misra, Chandana Roy And Anandarup Mukherjee, CRC Press (Taylor & Francis Group)
3. "Internet **of Things** Principles and Paradigms", by Rajkumar Buyya, Amir Vahid Dastjerdi, ELSEVIER Inc.
4. Internet of things For Architects, Perry Lea Packt Publication,2018

References:

1. "Practical Internet of Things Security", by Brian Russell, Drew Van Duren (Packt Publishing)
2. "Industrial Internet of Things and Communications at the Edge", by Tony Paine, CEO, Kepware Technologies
3. "Architectural Design Principles For Industrial Internet of Things", Hasan Derhamy, Luleå University of Technology, Graphic Production

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc20_cs69/preview
2.	https://www.coursera.org/specializations/developing-industrial-iot
3.	https://www.coursera.org/lecture/advanced-manufacturing-enterprise/the-industrial-internet-of-things-iiot-59EvI
4.	https://www.coursera.org/lecture/industrial-iot-markets-security/segment-12-blockchains-l4aG9

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Waste Technology

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Waste Technology (With effect from 2022-23)										
Year and Sem	**Course Code and Course Title**	**Teaching Scheme Hours/ Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	**Seminar/ Tutorial.**	**Pract.**	**Internal Assessment**	**End Sem Exam**	**Term Work**	**Oral**	**Total**	**Credits**
TE Sem V	**HCWC501: Solid And Hazardous Waste Management**	4	–	–	20	80	–	–	100	4
	Total	**4**	**–**	**–**	**100**		**–**	**–**	**100**	**4**
										Total Credits=04
TE Sem VI	**HCWC601: Liquid Effluent Management**	4	–	–	20	80	–	–	100	4
	Total	**4**	**–**	**–**	**100**		**–**	**–**	**100**	**4**
										Total Credits=04
BE Sem VII	**HCWC701: Waste Volorization I**	4	–	–	20	80	–	–	100	4
	HCWSBL701: Waste Technology .Skill Based Lab -1	–	–	2	–	–	50	50	100	2
	Total	**4**	**–**	**2**	**100**		**50**	**50**	**200**	**6**
										Total Credits=06
BE Sem VIII	**HCWC801: Sustainable Waste Volorization II**	4	–	–	20	80	–	–	100	4
	Total	**4**	**–**	**–**	**100**		**–**	**–**	**100**	**4**
										Total Credits=04
Total Credit for Semester V+VI+VII+VIII=18										

Waste Technology: Semester V		
Course Code	**Course Name**	**Credits**
HCWC501	**SOLID AND HAZARDOUS WASTE MANAGEMENT**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

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

Course Objectives:

1. To recognize the relevant, regulations that apply for facilities used for disposal and destruction of waste.
2. To provide in depth knowledge of municipal solid waste management
3. To provide in-depth knowledge of hazardous waste management
4. To provide in-depth knowledge of Physico-chemical processes useful for the treatment of municipal and solid wastes
5. To provide in-depth knowledge of biological processes useful for the treatment of municipal and solid wastes.
6. Know the necessity of environment risk assessment.

Module	Content	Hours
1	**Rules and Regulations** Municipal solid waste (management and handling) rules, hazardous waste (management and handling) rules, biomedical waste handling rules, fly ash rules, recycled plastics usage rules, batteries (management and handling) rules	4
2	**Municipal Solid Waste Management** Need for management, sources, composition, generation rates, collection of waste, separation, transfer and transport of waste, treatment and disposal options, source reduction of wastes, recycling and reuse.	9
3	**Hazardous Waste Management** Need for management, hazardous characterization of waste, compatibility and flammability of chemicals, waste sampling, TCLP tests, fate and transport of chemicals, health effects	9
4	**Physicochemical Treatment of Solid and Hazardous Waste** Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes), physicochemical processes for hazardous wastes (soil vapour extraction, air stripping, chemical oxidation), ground water contamination and remediation	9

5	**Biological Treatment of Solid and Hazardous Waste** Composting, bioreactors, anaerobic decomposition of solid waste, principles of biodegradation of toxic waste, inhibition, co-metabolism, oxidative and reductive processes, slurry phase bioreactor, in-situ remediation. Landfill design for solid and hazardous wastes, leachate collection and removal, landfill covers, incineration	14
6	**Environmental Risk Assessment** Defining risk and environmental risk, methods of risk assessment, case studies	7

Course Outcome:

On completion of the course the students will:

1 understand rules and regulations for handling solid waste.
2 understand principals of municipal solid waste management.
3 understand hazardous waste management.
4 learn physicochemical treatment of solid and hazardous waste.
5 understand biological treatment of solid and hazardous waste.
6 understand environment risk assessment.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.**

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

End Semester Examination (80 marks):

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

Test Books/Reference Books:

1 Tchobanoglous G., Theisen H. and Vigil S.A., "Integrated Solid Waste Management", McGraw-Hill International editions.
2 Bhide A.D. and Sundaresan B.B., "Solid Waste Management, Collection, Processing and Disposal", Nagpur.
3 "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, Government of India.
4 Management and Handling Rules for: municipal solid waste, biomedical waste, hazardous waste and radioactive wastes, Government of India Publications.
5 Solid Waste Management Hand Book – Pavoni

Waste Technology: Semester VI		
Course Code	**Course Name**	**Credits**
HCWC601	**LIQUID EFFLUENT MANAGEMENT**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

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

Course Objectives:

1 To learn how to minimize waste and study available treatment options.
2 To know concept of pollution control.
3 To learn ion exchange process and various adsorption techniques.
4 To study advanced methods for effluent management.
5 To know methods of waste reduction and how to recover byproducts.
6 To learn concepts and design of natural treatment system.

Module	Contents	Hours
1	**Waste Minimization and Treatment options** Methods of waste volume and strength reductions, Waste minimization - 4 R concepts, Waste audit, Classification of treatment and development of treatment flow sheets.	9
2	**Pollution control** Zero discharge concept. Concept of common effluent treatment plant- objectives, types of CETP, technical and financial aspects. Rural wastewater systems – septic tanks, two-pit latrines, ecotoilet, soak pits.	8
3	**Ion Exchange and Adsorption** Ion exchange process, ion exchange resins, exchange capacity, ion exchange, chemistry and reactions, Design of ion exchange units, Disposal of concentrate waste streams. Types of adsorption, adsorption isotherms, activated carbon adsorption kinetics, analysis and design of adsorption column.	9
4	**Advanced methods for effluent management** Ozonation, photocatalysis, wet air oxidation, evaporation, reverse osmosis, biological treatment for toxic waste	9
5	**Waste Reduction/Byproduct recovery** Waste reduction/ byproduct recovery for sugar, paper mill, petroleum and oil refineries, steel and engineering industries, fertilizer and pesticide industries, organic & inorganic manufacturing industries	9

6	**Natural Treatment Systems** Constructed wetland and aquatic treatment systems; Types- free water surface and subsurface constructed wetlands, selection of plants, removal mechanisms, applications, design procedure for constructed wetlands, management of constructed wetlands	8

Course Outcomes:

1 Understand minimizing the waste and available treatment options.
2 Understand concept of pollution control.
3 Understand ion exchange process/design and adsorption techniques.
4 Advanced methods for effluent management.
5 Waste reduction/byproducts recovery for manufacturing industries.
6 Concepts and design of natural treatment system.

Assessment

Internal Assessment (20 Marks):

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

End Semester Examination (80 marks):

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

Text Books and References:

1 Eckenfelder, W.W., Industrial Water Pollution Control, McGraw-Hill, 1999.
2 Arceivala, S.J., Wastewater Treatment for Pollution Control, McGraw-Hill, 1998.
3 Frank Woodard, Industrial waste treatment Handbook, Butterworth Heinemann, New Delhi, 2001

Waste Technology: Semester VII		
Course Code	**Course Name**	**Credits**
HCWC701	**WASTE VALORIZATION I**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

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

Course Outcomes:

1. To know waste valorization process used for reduce, reuse and recycle.
2. To learn biovalorization of industrial waste.
3. To know concept of biorefineries and related factors.
4. To learn recent trends and vermiculture.
5. To know biovalorisation of agriculture biomass.
6. To study case studies based on waste recycling.

Module	Contents	Hours
1	**Wastes valorization processes:** Preparation for reuse, recycling, and other valorisation processes. Analysis of advantages and limitations.	5
2	**Bio-valorisation of industrial wastes:** Anaerobic bio-valorisation of leather industry solid waste and production of high value-added biomolecules and biofuels, Anaerobic bio-valorisation of pulp and paper mill waste, Bio-valorisation of winery industry waste to produce value-added products, Conversion of textile effluent wastewater into fertilizer using marine cyanobacteria along with different agricultural waste.	12
3	**Biorefineries:** Biorefinery for hydrocarbons and emerging contaminants, Biodesulfurization of petroleum wastes, Microbial leaching of heavy metals from e- waste, opportunities and challenges.	8
4	**Biovalorisation of agricultural biomass:** Recent trends in biorefinery-based valorisation of lignocellulosic biomass, Protein engineering approaches for lignocellulosic ethanol biorefinery, Biovalorization potential of agro forestry/industry biomass for optically pure lactic acid fermentation, Opportunities and challenges, Agro-based sugarcane industry wastes for production of high-value bioproducts	11
5	**Recent trends and vermiculture** Recent trends and challenges in bioleaching technologies, membrane separation technologies for downstream processing. Definition, scope and importance – common species for culture	8

	– environmental requirements – culture methods- applications of vermiculture-Potentials and constraints for composting in India-large scale and decentralized plants.	
6	**Case studies on waste recycling** Recycling technologies for paper, glass, metal, plastic, used lead acid battery, end of life vehicle recycling, electronic waste recycling, waste oil, recycling solvent recovery, drivers and barriers for material recycling, social, legal and economic factors, environmental impacts of waste recycling, design for the environment the life cycle approach.	8

Course Outcomes:

On completion of this course students will

1 understand the waste valorization process to reduce, reuse and recycle.
2 understand Biovalorization of industrial waste
3 understand concept of biorefineries, their opportunities and challenges
4 understand recent trends and vermiculture.
5 understand biovalorisation of agriculture biomass.
6 understand waste recycling using case studies.

Assessment

Internal Assessment (20 Marks):

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

End Semester Examination (80 marks):

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

Text Books/ Reference Books

1 Aarne Veslind and Alan E Rimer (1981), Unit operations in Resource Recovery Engineering , Prentice Hall Inc., London
2 Manser A G R, Keeling A A (1996). Practical handbook of processing and recycling on municipal waste. Pub CRC Lewis London, ISBN 1-56670-164
3 Chiumenti, Chiumenti, Diaz, Savage, Eggerth, and Goldstein, Modern Composting Technologies JG Press October 2005
4 Charles R Rhyner (1995),Waste Management and Resource Recovery, Lewis

Waste Technology: Semester VII		
Course Code	**Course Name**	**Credits**
HCWSBL701	**WASTE TECHNOLOGY SKILL BASED LAB**	**02**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**04**	**-**	**--**	**02**	**-**	**02**

Theory					Term Work / Practical/Oral		Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	Oral	
Test-I	Test-II	Average					
-	-	-	-	----------	50	50	100

Course Objectives:-

Students will able to

1 Understand analyze properties of MSW
2 Understand vermicomposting on a lab scale.
3 Understand aerobic and anaerobic digesting of solid waste.
4 Will know of incineration process and handling of HSW.
5 Understand ecology baseline and impact of waste on environment.
6 Understand process of project report preparation based on case studies.

List of Experiments (minimum eight)

Waste Technology based experiments should be conducted.

1. Determination of pH of MSW
2. Determination of Total Solids, fixed solids and volatile solids
3. Determination of nutrient value (NPK)
4. Lab scale study on vermicomposting
5. Lab scale study of aerobic and anaerobic digesting of solid wastes (Both industrial & Municipal)
6. A Visit to the Hazardous waste Generation or disposal site.
7. Practical knowledge and working of incinerators
8. Visit to Industrial area, especially the handling of Hazardous materials
9. Ecology baseline and impact of waste – disposal on vegetation

10. Preparation of Project report based on a case study of one hospital Study of the source, generation rates and characteristics of hazardous wastes and their regulation, handling, treatment, and disposal. Special emphasis is placed on process design of waste handling, treatment and disposal systems.

Course Outcomes:

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

1 Learn to analyze properties of MSW.
2 To study vermicomposting on a lab scale.
3 To carry out aerobic and anaerobic digesting of solid waste.
4 To acquire knowledge of incineration process and handling of HSW.
5 Learn to analyze ecology baseline and impact of waste.
6 Learn about project report preparation based on case studies.

Term work (25 marks)

Term work should be evaluated based on performance in practical/Assignments.

Practical Journal/Assignments:	45 marks
Attendance:	05 marks
Total:	50 marks

End Semester Oral Examination (50 marks)

- A student will become eligible for Oral examination after completing 8 out of 10 experiments/Assignments

Waste Technology: Semester VIII		
Course Code	**Course Name**	**Credits**
HCWC801	**WASTE VALORIZATION II**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

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

Course Objective:

1 To know concept of energy from waste.
2 To study devices for converting waste into energy.
3 To undertake case studies based on impact of pollution on environmental and health.
4 To learn biohydrogen processes its applications and briquetting techniques.
5 To know microalgal biovalorization.
6 To learn process of converting biomass to energy.

Module	Contents	Hours
1	**Introduction to Energy from waste** Present status of technologies for conversion of waste into energy, design of waste to energy plants for cities, small townships and villages. Sources of energy generation, Classification of waste as fuel – agro based, forest residue, industrial waste	8
2	**MSW –conversion devices** Incinerators, gasifiers, digestors. , land fill gas generation and utilization, ,Anaerobic Digestion: Biogas production	9
3	**Environmental and health impacts-case studies** Environmental and health impacts of waste to energy conversion, case studies of commercial waste to energy plants, waste to energy- potentials and constraints in India, eco-technological alternatives for waste to energy conversions.	10
4	**Briquetting** Industrial Application of Gasifiers-Utilization and Advantages of Briquetting, environmental and health impacts of incineration; strategies for reducing environmental impacts.	9
5	**Biohydrogen**: Overview on Processes involved, and from Biohydrogen and applications.	8
6	**Microalgal biovalorization:** Conventional and nonconventional approach, Integration of wastewater valorization with microalgae for biofuel production,	8

Course Outcome:

Students will be able to

1 understand the concept of energy from waste.

2 understand various devices to convert energy from waste.
3 understand environmental and health impacts using case studies.
4 understand biohydrogen processes, applications and briquetting techniques.
5 understand concept of microalgal biovalorization.
6 understand process for biomass to energy.

Assessment

Internal Assessment (20 Marks):

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

End Semester Examination (80 marks):

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

Textbooks /References

1 Rada E.C. Waste Management and Valorization: Alternative Technologies., CRC Press, Taylor and Francis Group, 2016.
2 Rathinam N.K. and Sani, R.K. Biovalorisation of Wastes to Renewable Chemicals and Biofuels. Elsevier Inc. 2020.

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Electric Vehicles

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Electric Vehicles (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HEVC501: Vehicular Systems and Dynamics**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HEVC601: EV Drive and Energy Sources**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HEVC701: Automotive Controllers and Auxiliary Systems**	04	--	--	20	80	--	--	100	04
	HEVSBL701: Electric Vehicles Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits =	**06**
BE Sem. VIII	**HEVC801: Electric Vehicle System Design**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

'Electric Vehicle' - SEM-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HEVC501	**Vehicular Systems and Dynamics**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HEVC501	**Vehicular Systems and Dynamics**	20	20	20	80	03	-	100

Course Objectives	1. To study different automotive components and subsystems 2. To explore and compare the transition of automotive domain from ICE to electric vehicles
Course Outcomes	**Upon successful completion of this course, the learner will be able:** 1. To Illustrate the general configuration and identify various components of automobile. 2. To define the functionality and working principles of different types of Automotive Powertrains 3. To illustrate the working of various automotive transmission systems 4. To identify and illustrate the various hybrid electric powertrains and their different modes of operations 5. To explain the basic and state of the art of Electric vehicles and its major parts. 6. To compare and contrast the performance of ICE vehicles, HEVs and EVs.

Module	Contents	Hours
1.	**Vehicle Mechanics:** History of Vehicle Development, General Configuration of Automobile, Body and Chassis Fundamentals: General Packaging, Types of Structural System, Backbone Construction; Body and Chassis Materials. Automotive Powertrain, Mechanical Suspensions system, Steering System, NVH, Control System Integration and Implementation. Front-Wheel Drive (FWD) Powertrains, Rear-Wheel Drive Powertrains (RWD), Multi-Wheel Drive Powertrains (AWD and 4WD)	10
2.	**Transmission Systems:** Transmission gears, Manual Transmission (MT), Automatic Transmission (AT), Automated Manual Transmissions (AMT) and Continuously Variable Transmissions (CVT); Manual Transmissions Powertrain Layout and Manual Transmission Structure, Power Flows and Gear Ratios, Manual Transmission Clutch and its structure. Drivetrain and Differential	10
3.	**Automotive Subsystems:** Automotive Aero-dynamics, Vehicle Power Demand Analysis; Types of suspension and drive, Braking systems; Tyre Mechanics: Tyres and wheels, Tyre characteristics; Vehicle handling & stability; Automotive instrumentation	06
4.	**ICE Performance Characteristics:** Power and torque generation, specific fuel consumption; Engine emissions, control and norms; Efficiencies- fuel conversion efficiency, mechanical efficiency, volumetric efficiency	06

5.	**Hybrid Powertrain:** Series HEVs, Parallel HEVs, Series–Parallel HEVs, Complex HEVs, Operating Modes, Degree of Hybridization, Comparison of HEVs, Plug-in Hybrid Electric Vehicles (PHEVs); Real Life examples of HEVs	10
6.	**Electric Vehicles:** Basics of Electric Vehicles, Current Status and Trends for EVs, Battery Electric Vehicles (BEVs), Fuel-Cell Electric Vehicles (FCEVs), Electric Machines for EV applications, EV Transmission: Single-Speed EV Transmission, Multiple Ratio EV Transmissions. Comparison of ICE vehicle with HEVs and EVs. National Policy for adoption of EVs	10

Text Books:-

1. Vehicle Powertrain Systems by Behrooz Mashadi and David Crolla, Wiley, 2012
2. Automotive Aerodynamics by Joseph Katz, Wiley, 2016
3. Automotive Chassis Engineering, by David C. Barton and John D. Fieldhouse, Springer, 2018
4. Automotive Engineering Powertrain, Chassis System and Vehicle Body Edited by David A. Crolla, Elsevier, 2009
5. Automotive Power Transmission Systems by Yi Zhang and Chris Mi, Wiley, 2018
6. Linear Electric Machines, Drives, and MAGLEVs Handbook, by Ion Boldea, CRC Press. 2013
7. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles by Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, and Ali Emadi, CRC Press 2005
8. Electric Vehicle Technology Explained by James Larminie and John Lowry, John Wiley, 2003
9. Electric and Hybrid Vehicles- Design Fundamentals by Iqbal Husain, CRC Press, 2005

Reference Books:-

1. Encyclopaedia of Automotive Engineering edited by David Crolla et al, Wiley, 2014
2. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
3. The Automotive Transmission Book by Robert Fischer, Ferit Küçükay, Gunter Jürgens, Rolf Najork, and Burkhard Pollak, Springer, 2015
4. Noise and Vibration Control in Automotive Bodies by Jian Pang, Wiley, 2019

Website Reference / Video Courses:

1. NPTEL Web course: Fundamentals of Automotive Systems, by Prof. C.S. Shankar Ram, IIT Madras, https://nptel.ac.in/courses/107/106/107106088/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'Electric Vehicle' - SEM-VI						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HEVC601	**EV Drive and Energy Sources**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HEVC601	**EV Drive and Energy Sources**	20	20	20	80	03	-	100

Course Objectives	1. To explore and understand various traction motors, power drives and control strategies used in EVs. 2. To get conversant with the energy sources used in EVs and their state of the art. 3. To understand the various battery charging and management systems
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. To identify and assess various traction motors along with their suitability in various EV segments 2. To describe and differentiate various power converters and their control used in EV drives 3. To evaluate the battery specifications using various design considerations for EVs 4. To illustrate different battery charging methods and protocols 5. To explain the impact of large scale integration of EV charging infra in existing grid and its mitigation techniques. 6. To illustrate the need and importance of drive cycles used in testing of automobiles.

Module	Contents	Hours
1.	**Introduction to Traction Motors:** DC Machines- Brushed and Brushless DC motors (BLDC); AC Motors: Induction motors (IM), permanent-magnet ac synchronous motor-surface-permanent-magnet (SPM) motors and interior-permanent-magnet (IPM) motors; PM Materials; Switched Reluctance Motor (SRM); Basic construction details and working principles of each of the machine. In-Wheel Motors Comparison of Traction Machines; Specifications of the motors, Characteristic Curves of a Machines: Constant-Torque Mode, Constant-Power Mode; Efficiency Map; Suitability of each machine in Electric vehicle domain for 2W, 3W, 4 wheeler and large size vehicles. Real life examples; Review of advancement in EV Motors and Drives.	10
2.	**Power Converters for EV drive:** Power Conversion –Basic Principle, review of DC-DC converters, DC-AC Converters used in EV applications; Power topologies for IM, BLDC, PMSM and SRM motors. Traction Drives, Modulation schemes: Sinusoidal Pulse Width Modulation, SPWM with third harmonic injection, Space vector modulation, comparison of modulation techniques. Converter / Inverter Loss calculation, Heat-sinking: passive and active cooling.	08

3.	**Control of Power converters and Motors:** Induction Motor Control: Variable-Voltage Variable-Frequency Control (VVVF), Field-Oriented Control (FOC), Direct Torque Control (DTC); PM Synchronous Motor Control: Field-Oriented Control of PMSM, Flux-Weakening Control of PMSM, Position Sensorless Control of PMSM. SRM motor control: Current chopping control (CCC), Torque-Ripple Minimization Control BLDC Motor Control*:* Trapezoidal back EMF BLDC motor control	10
4.	**Energy Sources for EV:** Overview of energy sources for electric vehicle: Batteries, Fuel Cell, Ultra-capacitor and flywheel energy storage; Hybridization of energy sources for electric and hybrid vehicles; Comparison of sources. Batteries: Lead-acid battery, Nickel-based batteries, Sodium based batteries, lithium batteries Metal/air batteries; Battery parameters, Battery pack formation and testing, SoC & SoH, Estimation of SoC. Battery cell balancing, Battery management System (BMS), Thermal and safety considerations in battery pack design. Voltage and AHr/ kWhr ratings of ES for EV applications: Major design considerations	10
5.	Battery charging Infrastructure: AC and DC charging, CC-CV charging, Pulse charging; On-board and off-board charging; Standards and protocols for charging; Fast DC chargers, Home and Public charging infrastructure; Wireless power transfer (WPT) technologies for EVs, Move-and-charge technology. Charging Infrastructure-standardization and connectivity issues; SAE J1772, CHAdeMo, GB/T, CCS2 battery charging protocols. OCPP protocol Impact on existing power grid, G2V and V2X- Vehicle-to-home (V2H), vehicle-to-vehicle (V2V), and vehicle-to-grid (V2G) energy systems. Renewable Energy Based Charging infra.	10
6.	**EV Drive Cycle Testing:** Need for a driving cycle, different Drive Cycles: NEDC, EUDC, EPA, WLTP, and FTP-75; Testing of EV for range per charge for a given drive cycle	04

Text/Reference Books:-

1. Fundamentals And Applications Of Lithium-Ion Batteries In Electric Drive Vehicles by Jiuchun Jiang and Caiping Zhang, Wiley, 2015
2. Battery Management Systems for Large Lithium-Ion Battery Packs, by Davide Andrea, Artech House Publication, 2010
3. Electric Vehicle Battery Systems by Sandeep Dhameja, Newens, 2002
4. Fundamentals And Applications Of Lithium-Ion Batteries In Electric by Jiuchun Jiang and Caiping Zhang, Wiley, 2015
5. Optimal Charging Control of Electric Vehicles in Smart Grids by Wanrong Tang and Ying Jun Zhang, Springer, 2017
6. Plug In Electric Vehicles in Smart Grids Charging Strategies Edited by Sumedha Rajakaruna, Farhad Shahnia and Arindam Ghosh, Springer 2015
7. Technologies and Applications for Smart Charging of Electric and Plug-in Hybrid Vehicles edited by Ottorino Veneri, Springer, 2017
8. Solar Powered Charging Infrastructure for Electric Vehicles A Sustainable Development Edited by Larry E. Erickson, Jessica Robinson, Gary Brase, and Jackson Cutsor, CRC Press, 2017
9. Energy Systems for Electric and Hybrid Vehicles Edited by K.T. Chau, IET, 2016

10. Handbook of Automotive Power Electronics and Motor Drive Edited by Ali Emadi, CRC Press, 2005
11. Electric And Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure And The Market by Gianfranco Pistoia, Elsevier, 2013
12. AC Motor Control and Electrical Vehicle Applications, Second Edition by Kwang Hee Nam CRC Press, 2019

Website Reference / Video Courses:

1. NPTEL Web Course: Electric Vehicles - Part 1 by PROF. AMIT KUMAR JAIN Department of Electrical Engineering IIT Delhi; https://nptel.ac.in/courses/108/102/108102121/
2. NPTEL Web Course: Fundamentals of Electric vehicles: Technology & Economics: by Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras, https://nptel.ac.in/courses/108/106/108106170/
3. NPTEL Web Course: Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati, https://nptel.ac.in/courses/108/103/108103009/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'Electric Vehicle' - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HEVC701	**Automotive Controllers and Auxiliary Systems**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HEVC701	**Automotive Controllers and Auxiliary Systems**	20	20	20	80	03	-	100

Course Objectives	1. To Identify functionalities of various automotive controllers and auxiliary systems 2. To study various automotive sensors and actuators 3. To explore details of energy sources management system, thermal management system and overall system integration in EVs/ HEVs
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To illustrate functionality of various auxiliary subsystems used EVs 2. To demonstrate the use of VCUS and ECUS in automobile 3. To describe the need and functionality of automotive sensors / actuators and networking 4. To illustrate the design and management aspects of EV energy sources 5. To describe the various heat losses, and thermal management systems incorporated in EVs 6. To elaborate on System Integration and resource optimization in EVs

Module	Contents	Hours
1.	**Introduction:** Review of Automotive electrical, electronic, communication and thermal subsystems; Review of Energy Storage (Power Plant) system, Main Traction Inverter, On-Board Charger (OBC), LV Auxiliary Power Source, HV Battery Disconnect; Vehicle Control Unit (VCU) and ECUs. Braking Systems: Energy Consumption in Braking, Braking Power and Energy on Front and Rear Wheels, Brake System of EVs and HEVs, Series Brake-Optimal Feel, Series Brake-Optimal Energy Recovery; Parallel Brake; Antilock Brake System (ABS); Fundamentals of Regenerative Braking. Steering System: In-car system networking, Steering ratio characteristic, Steering Stabilization, Over-steer, understeer, Electric-Power-Assisted Steering (EPAS); Autonomous vehicles, Principle of object detection.	12
2.	**Vehicle Control Unit and Electronic Control Unit:** VCU functionality: Inverter control, battery management, charging control, vehicle functions in transmission and engine control; Advanced Driver Assistance System (ADAS); Electronic control units (ECUs): Various Section ECUs and their networking; Body and Lighting ECU (Key-less Entry, Sonar, HID, LED Lamps), Body ECU (Airbag).	08
3.	**Automotive sensors / actuators and networking:** Radar Sensor Detectors for Vehicle Safety Systems; Airborne Ultrasonic Imaging: SONAR Based Image Generation for Autonomous Vehicles, Motor angle sensor, Steering angle sensor, Tyre Pressure Monitoring Systems (TPMS);	10

	In Vehicle communication system: CAN, LIN, Ethernet, Flexray	
4.	**Energy Storage (Power Plant) Management system:** Battery cell packaging, Battery Management System (BMS), Design of battery pack and safety considerations; High voltage cabling and cut-outs; Battery pack installation. Use of Battery-UC Hybrid source; Fuel Cell (FC): FC management and Hydrogen storage in EV.	10
5.	**Thermal Management System:** Heat Calculation in various subsystems; HVAC system: HVAC compressor drive; Liquid cooling system for Battery, Electric drive and On board charger. Design considerations for thermal management system	06
6.	**System Integration and Implementation:** Vehicular Power Control Strategy and Energy Management: A Generic Framework, Definition, and Needs, Methodologies for Optimization, Cost Function Optimization, Benefits of Energy Management.	06

Text/Reference Books:-

1. Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles by John G. Hayes and G. Abas Goodarzi, Wiley, 2018.
2. Handbook of Automotive Power Electronics and Motor Drive Edited by Ali Emadi, CRC Press, 2005
3. Encyclopaedia of Automotive Engineering edited by David Crolla *et al.*, Wiley, 2014
4. Electric and Hybrid Vehicles Technologies, Modeling and Control: A Mechatronic Approach by Amir Khajepour, Saber Fallah and Avesta Goodarzi, Wiley, 2014.
5. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives, Second Edition Chris Mi and M. Abul Masrur, Wiley 2018.
6. Autonomous Vehicles Intelligent Transport Systems And Smart Technologies edited by Nicu Bizon, Lucian Dascalescu and Naser Mahdavi Tabatabaei, Nova Publishers, 2014
7. Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles by Sheldon S. Williamson, Springer, 2013
8. Electric and Hybrid Buses for Urban Transport Energy Efficiency Strategies, by Bogdan Ovidiu Varga, Calin Iclodean and Florin Mariasiu, Springer, 2016

Website Reference / Video Courses:

1. NPTEL Web Course: Electric Vehicles - Part 1 by PROF. AMIT KUMAR JAIN Department of Electrical Engineering IIT Delhi; https://nptel.ac.in/courses/108/102/108102121/
2. NPTEL Web Course: by Fundamentals of Electric vehicles: Technology & Economics: Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur,Prof. Kaushal Kumar Jha andProf. L Kannan, IIT Madras, https://nptel.ac.in/courses/108/106/108106170/
3. NPTEL Web Course: Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati, https://nptel.ac.in/courses/108/103/108103009/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'Electric Vehicle' - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
HEVSBL701	**Electric Vehicles Lab**		04	--	02	02

Course code	Course Name		Examination Scheme						
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)			
		Test 1	Test 2	Avg.					
HEVSBL701	**Electric Vehicles Lab**	-	-	-	-	-	50	50	100

Course Objectives	1. To provide hands-on with various major components used in EV/HEVs 2. To explore EV drives & control implementation along with analysis using simulation tool or with hardware. 3. To study various auxiliary systems commonly used in EV.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Compare and contrast conventional vehicles and EV/HEVs. 2. Illustrate operations and features of Conventional, hybrid electric vehicle and electrical vehicle Powertrains. 3. Describe the working of EV drives used for different kinds of electric motors. 4. Illustrate battery characteristics and working of BMS. 5. Describe the operation of On-board and Off-board EV chargers 6. Demonstrate the use of simulations tools along with hardware implementation for evaluation of EV subsystems.

Contents

Electric Vehicles Lab: Experimental study based on the following topics

1. Conventional and electrical vehicle sub-systems and components
2. Conventional, hybrid electric vehicle and electrical vehicle Powertrains
3. Motor performance test - for BLDC /PMSM/ IM/SRM motors;
4. EV drive for BLDC/PMSM/IM /SRM motors
5. Battery cell and module- characterization
6. Battery Management System (BMS)
7. On-board and Off-board charger for EV
8. Study of Automotive Electronics-HVAC control, Steering Control, VCU; 2/3 or 4 Wheeler EV.

(or any other experiments based on EV/HEV related systems/ subsystems)

Use of software tools:

Use of tools like ADVISOR, MATLAB, SEMIKRON SEMISEL, Python, C, Java platforms (or similar) etc. for the following

1. Simulation/ Emulation of Vehicle performance analysis for Conventional and Electrical Vehicle
2. Design simulation of a battery pack with given specifications and constraints.
3. Simulation/ Emulation of BLDC motor drive for performance analysis

4. Simulation/ Emulation of PMSM motor drive for performance analysis
5. Simulation/ Emulation of IM motor drive for performance analysis
6. Simulation/ Emulation of SRM motor drive for performance analysis
7. Simulation/ Emulation of On board and Off board charger.
8. Simulation/ Emulation of regenerative breaking.

(or any other simulation based on EV/HEV related systems/ subsystems)

Visit to industrial/ manufacturing facility:

1. Visit to EV manufacturing facility.
2. Visit to Battery pack /BMS design facility
3. Visit to battery Charger facility
4. Visit to Automotive Research Association of India (ARAI), Pune EV COE

(or a visit to any facility / industry / research institute carrying out work in the domain of EV)

Course Project

Course project to be carried out to design /fabricate/ program one of the vehicular sub-systems used in EV

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below. The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. https://www.vlab.co.in/broad-area-mechanical-engineering - Energy Storage Labs, Solar Energy lab, Wind Energy Lab

Term work:

Term work shall consist of minimum eight experiments, at least one plant visit, and one course project. The distribution of marks shall be as follows:

Journal / Experiments Performance	: 25 marks
Attendance	: 05 marks
Plant Visit report	: 10 marks
Course Project report	: 10 Marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire lab work of HCEVSBL701-Electric Vehicles Lab

'Electric Vehicle' - SEM-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HEVC801	**Electric Vehicle System Design**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HEVC801	**Electric Vehicle System Design**	20	20	20	80	03	-	100

Course Objectives	1. To illustrate the design philosophies used in the EV domain. 2. To explore the selection of power and control architecture of EV drives 3. To study the design aspects of EV battery packs and other auxiliary systems
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. To select and size the electric motor for a particular EV application and performance criteria 2. To select and size the battery pack to meet desired EV performance and 3. To design the EV drive system with functional safety considerations. 4. To illustrate the use of hybrid energy source for EV performance improvement 5. To illustrate the design aspects of Automotive Subsystem 6. To design the EV chargers and charging infrastructure

Module	Contents	Hours
1.	**Selection/ Sizing of EV Electric Motors:** Electric Vehicle modelling, Tractive force calculations, Design considerations for 2W, 3W and 4W EVs; Torque, power and Speed requirement, Traction Limit, Maximum Acceleration Limit, Maximum Grade Limit, Vehicle Power Demand Vehicle Performance Envelope, and Vehicle Power Envelope; Vehicle Power Demand during Driving Cycles. Design considerations for EV motors and their cooling system. Application Examples of EV /HEV motors with vehicles and motor specifications.	08
2.	**Selection/ Sizing of Battery pack and other Energy Resource:** Selection of type of Battery pack for 2W, 3W and 4W EVs; Battery pack sizing: Design considerations: Range per charge, range anxiety, EV motor power requirement; Impact of road conditions, environmental conditions and traffic conditions. High-Voltage Cabling and Disconnects, Safety in Battery Design, Testing for safety. Accelerated Reliability Testing of Electric Vehicles, Battery Cycle Life versus Peak Power and Rest Period. Selection and sizing of Fuel cell for FCEV, design considerations; Battery-ultra-capacitor hybrid combination sizing, performance analysis. Design considerations for Ultra-capacitor based EV, requirement of charging infra. Flywheel selection and sizing for EV/HEV applications.	12
3.	**Automotive Subsystem Design:** Electronic Control Unit (ECU) and its Control Features, Communications between ECUs, Control Software Development: Software-in-the-Loop (SIL) Simulation and Hardware-in-the-Loop (HIL) Simulation. Acceleration and braking control, regenerative braking; Automotive Steering Systems.	06

	Design considerations of HVAC controller	
4.	**EV System integration:** EMC design on ECU level, EMC design on system level and in special subsystems, Radiated emissions and Conducted emissions, EMI EMC measurements.	06
5.	**Design of Charging Infrastructure:** Design considerations for AC charger: vehicle interface and charging protocol design. applicable charging standards Design of On-Board Charger (OBC)-Schematic, power topology and control, Power capacities, regenerative braking control. Design considerations of DC fast charger: vehicle interface and charging protocol design. Connectivity and applicable charging standards Installation guidelines and grid requirement for charger installations.	12
6.	**Design with Functional Safety of Automotive Electronics:** Functional Safety requirements of Automotive Electronics; ASIL identification and safety goal finalization, ISO 26262. Energy Storage integrity / protection: rupture and toxic gas management; low energy stranding, Unintended vehicle movement, shock protection, and Elimination of potential thermal/ explosive event. Hazard and Risk Analysis (HARA) for different situations, Testing of vehicles for compliance of safety norms	08

Text/Reference Books:-

1. Design and Control of Automotive Propulsion Systems by Zongxuan Sun and Guoming Zhu, CRC Press, 2015
2. Electric Vehicle Machines and Drives Design, Analysis and Application by K. T. Chau, IEEE Press, and Wiley, 2015
3. EMC and Functional Safety of Automotive Electronics by Kai Borgeest, IET, 2018

Website Reference / Video Courses:

1. NPTEL Web Course: Electric Vehicles - Part 1 by PROF. AMIT KUMAR JAIN Department of Electrical Engineering IIT Delhi; https://nptel.ac.in/courses/108/102/108102121/
2. NPTEL Web Course: Fundamentals of Electric vehicles: Technology & Economics, by Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras, https://nptel.ac.in/courses/108/106/108106170/
3. NPTEL Web Course: Introduction to Hybrid and Electric Vehicles by Dr. Praveen Kumar and Prof. S. Majhi, IIT Guwahati, https://nptel.ac.in/courses/108/103/108103009/

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Microgrid Technology

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Microgrid Technology (With effect from 2022-23)										
Year & Sem	**Course Code and Course Title**	**Teaching Scheme Hours / Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HMTC501: Futuristic Power Systems**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
TE Sem. VI	**HMTC601: Power Electronic Converters for Energy Sources**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
BE Sem. VII	**HMTC701: Microgrid Power and Control Architecture**	04	--	--	20	80	--	--	100	04
	HMTSBL701: Microgrid and RES Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits =	**06**
BE Sem. VIII	**HMTC801: Microgrid System Design**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits =	**04**
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

'Microgrid Technology - SEM-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HMTC501	**Futuristic Power Systems**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HMTC501	**Futuristic Power Systems**	20	20	20	80	03	-	100

Course Objectives	1. To explore the state of the art and future trends in power systems. 2. To understand the technical, economic and social challenges in power system evolution. 3. To realize the role and importance of Microgrids if futuristic power systems.
Course Outcomes	Upon successful completion of this course, the learner will be able: 1. To solicit the importance of large scale renewable energy integration with existing grid infrastructure. 2. To understand the importance and utility of Energy storage systems in futuristic power systems. 3. To explore large scale micro-grid deployment with RES and ESS integration. 4. To understand the role of communication and IT Infrastructure in power system and related challenges. 5. To explore the potential of Microgrids and its importance in Indian context.

Module	Contents	Hours
1.	**Introduction:** Present status of worldwide scenario of electricity generation, transmission and distribution; Energy infrastructure-Resilience and Security; Social, Technical and economic challenges; Major trends driving power system evolution; State of the art technologies in power system.	06
2.	**Renewable Energy Integration:** Review of renewable energy (RE) resources and systems: Solar- PV, Solar Thermal, Wind, Biomass, Micro-hydro and Fuel Cell, comparison of various RE resources; Renewable Energy Policies and present status of integration with existing grid; Large scale integration of renewable energy-Technical challenges, enabling technologies, International requirements; Renewable energy forecasting	12
3.	**Energy Storage Systems (ESS):** Review of energy storage components: Battery, VRB, Ultra-capacitor, Fuel Cells, Pumped Hydro-Storage and flywheels, comparison of ESS technologies; Importance of ESS in futuristic power systems; Aggregated ESS, Distributed ESS; Applications of ESS: Energy Management (Load Leveling and Peak Shifting), Fluctuation Suppression (Intermittency Mitigation), Uninterruptible Power System Low-Voltage Ride Through; Placement of the ESS to Improve Power Quality, Voltage Regulation Using ESS, ESS as Spinning Reserve.	12
4.	**Micro-grid and Smart-grid** Micro-grid evolution: Micro-grid concept, importance in futuristic power system, basic architectures and control, objectives and state of the art technologies; Microgrid as a building block of Smart-grid; Smart-grid concept, Smart Grid versus conventional electrical networks, Smart-grid infrastructure, Smart Grid communication system and its cyber security, International standard IEC 61850 and its application to Smart-grid;	12

	Microgrids /smart grid and Electric Vehicles integration. Technical, Economic, Environmental and Social Benefits of Microgrid Operation.	
5.	**Communication and IT infrastructure:** Requirements of Communication and IT infrastructure in futuristic power systems: various communication protocols, comparison of performance; IEEE standard: IEEE 802.11 Mesh Networking, IEEE 802.15.4-Wireless Sensor Networks; Communications Technologies for Smart metering; Cyber security issues and mitigation techniques.	05
6.	**Microgrids in India:** Microgrids for Rural Electrification, Review of Microgrid Best Practices through Case Studies: Strategic Planning, Operations: Commercial and Financial Considerations; Technical and Social Context.	05

Text Books:-

1. Microgrids Architectures and Control Edited by Nikos Hatziargyriou, IEEE and Wiley, 2014
2. Energy Storage for Sustainable Microgrid by David Wenzhong Gao, Elsevier, 2015
3. Introduction to the Smart Grid- Concepts, Technologies and Evolution by Salman K. Salman, IET, 2017
4. Energy Storage Systems and Components by Alfred Rufer, CRC Press, 2018

Reference Books:-

1. Energy Efficiency and Renewable Energy Handbook Edited by D. Yogi Goswami and Frank Kreith, 2nd Edition-2016, CRC
2. Clean Energy Microgrids, Edited by Shin'ya Obara and Jorge Morel IET, 2017
3. Hybrid-Renewable Energy Systems in Microgrids- Integration, Developments and Control edited by Hina Fathimaby *et al*., Elsevier WoodHead Publishing, 2018
4. Smart Microgrids: Lessons from Campus Microgrid Design and Implementation edited by Hassan Farhangi, CRC Press 2017

Website Reference / Video Courses:

1. NPTEL Web Course on: DC Microgrid And Control System Prof. Avik Bhattacharya, IIT Roorkee
2. NPTEL Web Course on Electronics and Distributed Generation Dr. Vinod John Department of Electrical Engineering IISc Bangalore
3. NPTEL Web Course on Introduction to Smart Grid, PROF. N.P. PADHY Department of Electrical Engineering IIT Roorkee PROF. PREMALATA JENA Department of Electrical Engineering
4. NPTEL Web Course on Electric vehicles and Renewable energy, Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'Microgrid Technology - SEM-VI						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HMTC601	**Power Electronic Converters for Energy Sources**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HMTC601	**Power Electronic Converters for Energy Sources**	20	20	20	80	03	-	100

Course Objectives	1. To illustrate the design philosophies used in the domain of microgrid power converters. 2. To explore the control implementations in power converters for voltage, current and power regulation for various DC and AC energy sources
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Select and size various passive and active components for power converters 2. Design power converters used with DC energy resources with their control implementation 3. Design power converters used with AC energy resources with their control implementation 4. Understand the design considerations of power conditioning unit for ESS, SPV and Wind applications. 5. Understand the design and selection aspects of various auxiliary systems and components used in PCUs

Module	Contents	Hours
1.	**Selection of components for Power Electronics Converters (PEC):** Selection and Sizing of capacitors and magnetic components for PECs, design of Magnetic Components; Selection and sizing of Power Devices, Commonly used software tools for selection and sizing; Heatsink- selection and sizing.	06
2.	**Design and Control of DC-DC Converters:** Design of Buck and Boost converters, Design examples; Design of Bidirectional Converters. Design of gate driver circuits; Review of DC-DC converter modelling; Closed loop PI controller design for buck and boost converters; Current control mode and voltage control mode.	10
3.	**Design and Control of DC-AC converters:** Design of Inverter for standalone applications; Design of grid connected Inverter with different grid synchronization strategies- ZCD, PLL; Strategies for Control of voltage, current and power output.	10
4.	**Design of PCU for SPV and Wind Application:** Various topologies of Power Converter Unit (PCU) for SPV and Wind energy systems. Design considerations of PCU for SPV and Wind energy Systems and Design Examples.	10
5.	**Design of PCU for ESS Applications:** Design consideration for BDC converter based PCU for batteries and Ultra-capacitors.	08
6.	**Design of Auxiliary System and Interfaces:**	08

	Design of current and voltage sensor interfaces; Design considerations for auxiliary power supplies; Design of protection and snubber components: Introduction to Digital Signal Processors (DSP) and microcontroller interfaces	

Text Books:-

1. Microgrids Design and Implementation edited by Antonio Carlos Zambroni de Souza and Miguel Castilla, Springer, 2019
2. Power Electronic Converters for Microgrids by Suleiman M. Sharkh, Mohammad A. Abusara, Georgios I. Orfanoudakis Babar Hussain, IEEE and Wiley, 2014
3. Microgrids Architectures and Control Edited by Nikos Hatziargyriou, IEEE and Wiley, 2014
4. Energy Storage for Sustainable Microgrid by David Wenzhong Gao, Elsevier, 2015
5. Control Circuits In Power Electronics Practical Issues In Design And Implementation Edited by Miguel Castilla, IET, 2016
6. Control and Dynamics in Power Systems and Microgrids by Lingling Fan, CRC Press, 2017
7. Integrated Power Electronic Converters and Digital Control, by Ali Emadi, Alireza Khaligh, Zhong Nie, and Young Joo, Lee 2009, CRC Press.

Reference Books:-

1. Cooperative Synchronization in Distributed Microgrid Control by Ali Bidram, Vahidreza Nasirian Ali Davoudi, and Frank L. Lewis, Springer, 2017
2. Hybrid-Renewable Energy Systems in Microgrids- Integration, Developments and Control edited by Hina Fathimaby et al., Elseiver WoodHead Publishing, 2018
3. Smart Microgrids- Lessons from Campus Microgrid Design and Implementation edited by Hassan Farhangi, CRC Press 2017
4. Energy Storage Systems and Components by Alfred Rufer, CRC Press, 2018

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'Microgrid Technology - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HMTC701	**Microgrid Power and Control Architecture**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HMTC701	**Microgrid Power and Control Architecture**	20	20	20	80	03	-	100

Course Objectives	1. To study various power and control architectures adopted in DC and AC Microgrids. 2. To explore various control strategies used in power control 3. To take insight into operations stability and protection issues related to Microgrids
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Understand various types Microgrids based on applications, power and control architecture. 2. Illustrate various power control strategies adopted in DC, AC and Hybrid Microgrids 3. Compare and contrast various control architectures used DC, AC and Hybrid Microgrids 4. Illustrate the various operational challenges in Microgrids 5. Comprehend the various aspects related to the stability in Microgrids 6. Understand the protection challenges in Microgrids along with various protection methods to overcome these challenges,

Module	Contents	Hours
1.	<u>Microgrid Power Architecture:</u> Types of Microgrid system, AC and DC and Hybrids Microgrids, Application based Suitability of Microgrid type; Review of power architecture of various Microgrids deployed world-wide. Comparison of various Microgrid power architectures.	08
2.	<u>AC Microgrid and Control Architecture:</u> Black-start operation, Grid Synchronisation- various Grid synchronization methods, Grid forming and grid following operations; Power Control- Real and reactive power control in AC Microgrid, simple droop control and other variants of droop control, Unit Power Flow Control, Feeder power flow control and Mixed mode control, source optimization; Centralized, decentralised, distributed and hierarchical control architecture, Local and system / supervisory level control strategies, Multi Agent System (MAS) Based Control; Control approaches used in AC Microgrids deployed worldwide. Microgrid standards IEEE 1547 series. Communication in AC Microgrids	12
3.	<u>DC Microgrid and Control Architecture:</u> Power sharing in DC Microgrids, source optimization; Control approaches: Centralized, decentralised, distributed and hierarchical control architecture. Control approaches used in hybrid Microgrids. Communication in DC/Hybrid Microgrids	08

4.	Operational Control in Microgrids: Energy management in Microgrids, coordinated control, load management, grid synchronisation and islanding, Anti-islanding schemes; Various Architectural and Operational Challenges in Microgrid, Optimal operation of Microgrids.	08
5.	Microgrid Stability Steady-state and dynamic stability in AC and DC Microgrids, Methods to improve the stability in Microgrids; introduction to small signal and large signal stability analysis in Microgrids.	06
6.	Protection in Microgrids Fault scenarios in DC and AC Microgrids, Protection in DC and AC Microgrids, adaptive protection, Fault current source (FCS) based protection; Protection challenges in islanded and autonomous modes of operation and ways to mitigate.	10

Text/Reference Books:-

1. Microgrids Design and Implementation edited by Antonio Carlos Zambroni de Souza and Miguel Castilla, Springer, 2019
2. Microgrids Architectures and Control Edited by Nikos Hatziargyriou, IEEE and Wiley, 2014
3. Cooperative Synchronization in Distributed Microgrid Control by Ali Bidram, Vahidreza Nasirian Ali Davoudi, and Frank L. Lewis, Springer, 2017
4. Control Circuits In Power Electronics Practical Issues In Design And Implementation Edited by Miguel Castilla, IET, 2016
5. Control and Dynamics in Power Systems and Microgrids by Lingling Fan, CRC Press, 2017
6. Hybrid-Renewable Energy Systems in Microgrids- Integration, Developments and Control edited by Hina Fathimaby et al., Elseiver WoodHead Publishing, 2018
7. Urban DC Microgrid Intelligent Control and Power Flow Optimization by Manuela Sechilariu and Fabrice Locment, 2016 Elsevier
8. Integrated Power Electronic Converters and Digital Control, by Ali Emadi, Alireza Khaligh, Zhong Nie, and Young Joo, Lee 2009, CRC Press.
9. Island Power Systems by Lukas Sigrist, Enrique Lobato, Francisco M. Echavarren Ignacio Egido, and Luis Rouco, CRC Press, 2016

Website Reference / Video Courses:

1. NPTEL Web Course on: DC Microgrid and Control System Prof. Avik Bhattacharya, IIT Roorkee
2. NPTEL Web Course on Electronics and Distributed Generation Dr. Vinod John Department of Electrical Engineering IISc Bangalore
3. NPTEL Web Course on Introduction to Smart Grid, PROF. N.P. PADHY Department of Electrical Engineering IIT Roorkee PROF. PREMALATA JENA Department of Electrical Engineering
4. NPTEL Web Course on Electric vehicles and Renewable energy, Prof. Ashok Jhunjhunwala, Prof. Prabhjot Kaur, Prof. Kaushal Kumar Jha and Prof. L Kannan, IIT Madras

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

Microgrid Technology - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical	Theory	Practical	Total
HMTSBL701	**Microgrid and RES Lab**	--	04	--	02	02

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)			
		Test 1	Test 2	Avg.					
HMTSBL701	**Microgrid and RES Lab**	--	--	--	--	--	50	50	100

Course Objectives	1. To provide hands-on with power converters used in AC, DC Microgrids 2. To explore various control implementation incorporated in Microgrids in simulation or with hardware 3. To study various auxiliary systems commonly used in Microgrids.
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Test the various power converters used AC, DC Microgrids 2. Illustrate various operational modes of power converters 3. Illustrate various operational modes of Microgrid. 4. Describe the working of various auxiliary system interfaces (communication / sensors) 5. Analyse the steady-state and transient behaviour of Microgrid 6. Demonstrate the design the Microgrid and its sub-systems.

Contents
Microgrid / RES Lab: Experimental Setups (Any Five of the following) 1. Testing of Power Conversion Unit for DC Microgrid 2. Testing of Power Conversion Unit for AC Microgrid 3. DC Microgrid: Power Sharing between the sources 4. AC Microgrid: Power Sharing between the sources 5. Grid Connected Inverter 6. Grid Forming Inverter 7. Grid Interactive Inverter 8. Solar MPPT Control 9. Islanding detection 10. Island mode of operation of DC or AC Microgrid 11. Data transfer through Microgrid Communication Interfaces 12. Standalone Microgrid operation 13. Voltage and current sensing circuits 14. DSP / Microcontroller interface circuits 15. DSP / Microcontroller programming for converter control. (or any other experiments based on Microgrid related systems/ subsystems) Use of software tools: (Any three of the following) Use of tools like MATLAB, Scilab, PSIM, LTSPice, python, C, Java platforms etc. for the following

1. Simulation/ Emulation of DC Microgrid with steady state performance analysis.
2. Simulation/ Emulation of AC Microgrid with steady state performance analysis.
3. Simulation/ Emulation of DC Microgrid ith transient performance analysis.
4. Simulation/ Emulation of AC Microgrid with transient performance analysis.
5. Microgrid Stability analysis with study of impact of ESS on stability

(or any other simulations based on Microgrid related systems/ subsystems)

Plant Visit:

Visit to existing Microgrid facility or a Solar PV/ Wind Installation or a power converters manufacturing / research facility.

Course Project

Course project to be carried out to design /fabricate/ program one of the PCU used in Microgrid.

Note: Students and teachers are encouraged to use the virtual labs whose links are as given below. The remote-access to Labs in various disciplines of Science and Engineering is available. Students can conduct online experiments which would help them in learning basic and advanced concepts through remote experimentation.

Virtual Lab Website Reference

1. http://vlab.co.in/broad-area-electrical-engineering
2. https://www.vlab.co.in/broad-area-mechanical-engineering - Energy Storage Labs, Solar Energy lab, Wind Energy Lab

Term work:

Term work shall consist of minimum eight experiments, at least one plant visit, and one course project. The distribution of marks shall be as follows:

Journal / Experiments Performance	: 25 marks
Attendance	: 05 marks
Plant Visit report	: 10 marks
Course Project report	: 10 Marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire lab work of HCMTSBL701-Microgrid and RES Lab

'Microgrid Technology - SEM-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
HMTC801	**Microgrid System Design**	04	-	04	-	04

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
HMTC801	**Microgrid System Design**	20	20	20	80	03	-	100

Course Objectives	1. To illustrate the design philosophies used in the domain of Microgrid. 2. To explore the selection of power and control architecture of Microgrids 3. To study the design aspects of AC Microgrid, DC Microgrid and their auxiliary systems
Course Outcomes	Upon successful completion of this course, the learner will be able to: 1. Select and size various Microgrid energy resources 2. Select the power and control architecture of the Microgrid 3. Select and design the Microgrid's communication architecture. 4. Illustrate the design aspects DC Microgrids with their control strategies. 5. Illustrate the design aspects AC Microgrids with their control strategies. 6. Illustrate the implementation of the Microgrid islanding detection and anti-islanding scheme/ blackstart operation

Module	Contents	Hours
1.	**Selection/ Sizing of Microgrid Energy Resources** Factors affecting the selection and sizing of energy resources for Microgrid applications, dependency on type of loads connected, Selection/ Sizing: Renewable energy resources, Energy Storage components. Hybrid combination of RES and ESS.	07
2.	**Selection of Power and Control Architecture:** Factors affecting the selection of Microgrid power and control architecture; Design Consideration for control implementation; Sensors: Selection of sensors and design of sensor Interfaces, design of control Interfaces. Design considerations for DSP/ Microcontroller interfaces	07
3.	**Selection and Design of Communication Architecture** Design considerations for selection of communication network for Microgrid applications; Design and implementation of communication links/ interfaces. Microg4controller programming for Data transfer on communication network. Practical design considerations for Communication networks.	08
4.	**Design of DC Microgrid** Design DC Power Conditioning Units for RES and ESS, Unidirectional and Bidirectional Converter design, implementation of Control loop with DSP; Programming for Power sharing and Energy Management algorithms; Design of Protection system for DC Microgrid	12

5.	**Design of AC Microgrid** Design AC Power Conditioning Units for RES and ESS, Unidirectional and Bidirectional Converter design, implementation of Control loop with DSP; Grid Synchronization. Programming for Power sharing and Energy Management algorithms; Design of Protection system for AC Microgrid.	12
6.	**Islanding in Microgrids** Selection and implementation of Islanding detection and anti-islanding scheme; Black-start and Autonomous operations in Microgrids;	06

Text Books:-

1. Microgrids Design and Implementation edited by Antonio Carlos Zambroni de Souza and Miguel Castilla, Springer, 2019
2. Microgrids Architectures and Control Edited by Nikos Hatziargyriou, IEEE and Wiley, 2014
3. Power Electronic Converters For Microgrids by Suleiman M. Sharkh, Mohammad A. Abusara, Georgios I. Orfanoudakis Babar Hussain, IEEE and Wiley, 2014

Reference Books:-

1. Energy Storage for Sustainable Microgrid by David Wenzhong Gao, Elsevier, 2015
2. Cooperative Synchronization in Distributed Microgrid Control by Ali Bidram, Vahidreza Nasirian Ali Davoudi, and Frank L. Lewis, Springer, 2017
3. Energy Efficiency and Renewable Energy Handbook Edited by D. Yogi Goswami and Frank Kreith, 2nd Edition-2016, CRC
4. Control Circuits In Power Electronics Practical Issues In Design And Implementation Edited by Miguel Castilla, IET, 2016
5. Hybrid-Renewable Energy Systems in Microgrids- Integration, Developments and Control edited by Hina Fathimaby et al., Elseiver WoodHead Publishing, 2018
6. Urban DC Microgrid Intelligent Control and Power Flow Optimization by Manuela Sechilariu and Fabrice Locment, 2016 Elsevier
7. Integrated Power Electronic Converters and Digital Control, by Ali Emadi, Alireza Khaligh, Zhong Nie, and Young Joo, Lee 2009, CRC Press.

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Robotics

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Robotics (With effect from 2022-23)										
Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar /Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HRBC501: Industrial Robotics**	04	--	--	20	80	--	--	100	04
	Total	04	-	--	100		-	-	100	04
Total Credits = 04										
TE Sem VI	**HRBC601: Mechatronics &IoT**	04	--	--	20	80	--	--	100	04
	Total	04	-	-	100		-	-	100	04
Total Credits = 04										
BE Sem VII	**HRBC701: Artificial Intelligence & Data Analysis**	04	--	--	20	80	--	--	100	04
	HRBSBL701: Robotics and Automation Lab	--	--	04	--	--	50	50	100	02
	Total	04	-	04	100		50	50	200	06
Total Credits = 06										
BE Sem VIII	**HRBC801: Autonomous Vehicle**	04	-	--	20	80	--	--	100	04
	Total	04	-	-	100		-	-	100	04
Total Credits = 04										
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Robotics - SEM-VI		
Course Code	Course Name	Credits
HRBC501	**Industrial Robotics**	4

Course Objectives:

1. To acquaint with significance of robotic system in agile and automated manufacturingprocesses.
2. To make conversant with robotic elements/ peripherals, their selection and interface with manufacturing equipment's.
3. To study the basics of robot kinematics

Course Outcomes: Upon successful completion the course, learner will be able to

1. Acquire skills in understanding robot language and programming.
2. Acquire skill in robot task planning for problem solving.
3. Develop skills in understanding various sensors, robot peripherals and their use & deployment in manufacturing system.
4. Develop skills in identifying areas in manufacturing where robotics can be deployedfor enhancing productivity.

Module	Details	Hours
1.	Introduction Automation, robotics, Robotic system & Anatomy,Classification and Future Prospects	2
2.	**Drives** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators and Power Transmission system. **Robot & its Peripherals** **End Effecters:** Type mechanical and other grippers, Tool as end effecter. **Sensors:** Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Vision systems and Equipment	10
3.	**Machine vision** Introduction, Low level & High level Vision, Sensing & Digitizing, Image Processing & analysis, Segmentation, Edge detection, Object Description & recognition, interpretationand Applications. **Programming for Robots** Method, Robot Programme as a path in space, Motion interpolation, motion & task level Languages, Robot languages, Programming in suitable languages and characteristics ofrobot.	10
4.	**Robot Kinematics** Forward, reverse & Homogeneous Transformations, Manipulator Path control and Robot Dynamics. **Introduction to wheeled and legged robots including humanoids**	10
5.	**Robot Intelligence & Task Planning** Introduction, State space search, Problem reduction, use of predictive logic, Means. Ends Analysis, Problem solving, Robot learning and Robot task planning.	10

6.	**Robot application in manufacturing Material transfer, machine loading & un loading, processing operation, Assembly & inspectors, robotic Cell design & control, Social issues & Economics of Robotics.**	10

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

Text/References

1. Industrial Robotics, Technology, Programming & Applications, Grover, Weiss, Nagel, Ordey,Mc Graw Hill.
2. Robotics: Control, Sensing, Vision & Intelligence, Fu, Gonzalex, Lee, Mc Graw Hill.
3. Robotic technology & Flexible Automation, S R Deb. TMH.
4. Robotics for Engineers, Yoram Koren , Mc Graw hill.
5. Fundamentals of Robotics, Larry Health.
6. Robot Analysis & Control, H Asada, JJE Slotine.
7. Robot Technology, Ed. A Pugh, Peter Peregrinus Ltd. IEE, UK. 8. Handbook of IndustrialRobotics, Ed. Shimon. John Wiley
8. Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza, “Introduction to AutonomousMobile Robots”, Bradford Company Scituate, USA

Robotics - SEM-VI		
Course Code	**Course Name**	**Credits**
HRBC601	**Mechatronics & IoT**	**4**

Course Objectives:

1. To associate a mechatronic System with IOT
2. To relate data analytics with IOT
3. To understand Cloud Computing in IOT

Course Outcomes: Upon successful completion of this course, the learner will be able to

1. Describe a Mechatronic System
2. Demonstrate the use of a Micro-controller
3. Understand an IOT System
4. Identify Wireless Technologies Supporting IOT
5. Use Data Analytics in conjunction with IOT &Cloud

Module	Details	Hours
1.	Introduction to Mechatronics: Traditional and Mechatronics Design, Mechatronics Key Elements, Basic Components of Mechatronic Systems , Integrated Design issues in Mechatronics, Mechatronics Design Process, Mechatronics System in Factory, Home and Business Applications, Objectives, Advantages and Disadvantages of Mechatronics	6
2.	Overview of Micro-processor ad Micro-controller: 8051 Micro-controllers, Functional Block Diagram and Architecture, Instruction set and Assembly Language Programming, Analog and Data Acquisition , Digital I/O interfacing, Special Function interfacing, Signal Conditioning, Special Utility Support hardware Interfacing of HEX – Keyboards, LCD Display, ADC, DAC andStepper Motor with 8051 Micro-controller	10
3.	Introduction and application to Internet of Things: Need of IoT, history of IOT, Objects of IOT, Level of IOT, Technologies in IOT, Introduction to Arduino and Raspberry Pi, understanding its components, recognizing the Input/Output, GPIO Connectivity	10
4.	Wireless Technologies Supporting IoT: Protocol Standardization for IoT, Machine to machine (M2M) and WSN protocols, Basics of RFID , RFID Protocols, Issues with IOT Saudization, Protocols – IEEE 802.15.4, Zigbee, IPv6 Technologies for IOT	10
5.	Data Analytics for IOT: Introduction Apache Hadoop, Using Hadoop MapReduce for Batch Data Analysis, Apache Oozie, Apache Spark, Apache Storm, Using Apache Storm for Real Tie Data Analysis, Structural Health Monitoring, Case Study: Chef Case Study, puppet Case Study	10
6.	Introduction to Cloud Computing, Difference between Cloud Computing and FOG Computing: The Next Evolution of Cloud Computing, Role of Cloud Computing in IOT, Connecting IoT to Cloud, Cloud Storage for IoT Challenge in Integration of IoT with Cloud	8

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

Text/Reference Books:

1. Bolton, William. Mechatronics: electronic control systems in mechanical and electricalengineering. Pearson Education, 2003.
2. De Silva, Clarence W. Mechatronics: an integrated approach. CRC press, 2004.
3. Ayala, Kenneth J. The 8051 microcontrollers. Thomson Delmar Learning, 2005.
4. Zhang, Dan, and Bin Wei, eds. Mechatronics and Robotics Engineering for Advanced andIntelligent Manufacturing. Springer International Publishing, 2017.
5. Greengard, Samuel. The internet of things. MIT press, 2021.
6. Chaouchi, Hakima, ed. The internet of things: Connecting objects to the web. John Wiley &Sons, 2013.
7. Hintz, Kenneth, and Daniel Tabak. Microcontrollers: architecture, implementation, andprogramming. McGraw-Hill, Inc., 1992.

Robotics - SEM-VII		
Course Code	**Course Name**	**Credits**
HRBC701	**Artificial Intelligence andData Analytics**	**04**

Course Objectives:

1. To gain perspective of AI, its foundations, agent architectures and properties of theenvironment.
2. To understand the basic principles of AI towards problem solving, inference, perception,knowledge representation, and learning.
3. To investigate probabilistic reasoning under uncertain and incomplete information.
4. To gain the perspective of the concepts of data Mining, modelling and visualization, data warehousing.
5. To understand various machine learning algorithms.

Course Outcomes: Upon successfully completion of this course, learner will able to...

1. Demonstrate knowledge of the building blocks of AI, intelligent agents and knowledgepresentation systems.
2. Explain artificial intelligence planning, reasoning, uncertainty handing and expert systems.
3. Describe the concept of data mining, big data, data analytics, business intelligence.
4. Comprehend and implement data mining and machine learning algorithms.

Module	Contents	Hours.
01	**Introduction to Artificial Intelligence (AI):** A. I. Representation, Representation of knowledge, knowledge base systems, state space search, production systems, problem characteristics, types of production systems, Intelligent Agents and Environments, nature of environments, structure of agents **Knowledge and Reasoning:** Knowledge Representation Systems, Properties of Knowledge Representation Systems, Propositional Logic (PL), First Order Logic: Syntax and Semantic, Inference in FOL, Forward v/s Backward Chaining	**6**
02	**Planning:** Introduction to Planning, Planning with State Space Search, Partial Ordered planning, Hierarchical Planning, Conditional Planning, Brief introduction to single layer and multiplayer networks **Reasoning Under Uncertainty:** Handling Uncertain Knowledge, Random Variables, Prior and Posterior Probability, Inference using Full Joint Distribution, Bayes' Rule and its use, Bayesian Belief Networks, Reasoning in Belief Networks **Introduction to Expert Systems:** Components of Expert System: Knowledge base, Inference engine, user interface, workingmemory, Development of Expert Systems	**10**

03	**Introduction to Data Mining:** What is Data Mining; Kind of patterns to be mined; Technologies used; Major issues in Data Mining, associative Rule Mining **Introduction to Big Data:** Big Data characteristics, types of Big Data, Traditional vs. Big Data business approach, Case Studies ofBig Data Solutions, Introduction to parallel Processing (MPP) architecture, Hadoop/HDFS and cloud based solutions **Introduction to Business Intelligence:** Business intelligence (BI): Managers and Decision Making, BI for Data analysis and Presenting Results	**8**
04	**Data Pre-processing:** Notion of data quality. Typical pre-processing operations: combining values into one, handling incomplete/ incorrect / missing values, recoding values, sub setting, sorting, transforming scale, determining percentiles, removing noise, removing inconsistencies, transformations, standardizing, normalizing - min-max normalization, z-score standardization. **Data Modeling and visualization:** Logic driven modeling, data driven modeling, basic what-if spreadsheet models **Data Warehousing:** What is a data warehouse, need for a data warehouse, architecture, data marts, OLTP vs OLAP	**10**
05	**Machine Learning:** Supervised and Unsupervised Learning, Concepts of Classification, Clustering and prediction **Performance Measures:** Measuring Quality of model- ConfusionMatrix, Accuracy, Recall, Precision, Specificity, F1 Score, RMSE	**8**
06	**Classification:** Rule based classification, classification by BayesianBelief networks, Hidden Markov Models. **Clustering:** Hebbian Learning rule, Expectation -Maximizationalgorithm for clustering **Dimensionality Reduction:** Principal Component Analysis FeatureSelection and Feature Extraction **Time Series Analysis and Forecasting:** Time series patterns,forecast accuracy, moving averages and exponential smoothing	**10**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

1. Weightage of each module in end semester examination will be proportional to the numberof

respective lecture hours mentioned in the curriculum.

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

Text Books:

1. Stuart J. Russell and Peter Norvig, "Artificial Intelligence A Modern Approach —SecondEdition" Pearson Education.
2. Elaine Rich and Kevin Knight —Artificial Intelligence‖ Third Edition, Tata McGraw-HillEducation Pvt. Ltd., 2008.
3. George F Luger "Artificial Intelligence" Low Price Edition, Pearson Education, Fourth edition.
4. Deepak Khemani, A first course in Artificial Intelligence, Mc GrawHill
5. P. N. Tan, M. Steinbach, Vipin Kumar, "Introduction to Data Mining", Pearson Education.
6. G. Shmueli, N.R. Patel, P.C. Bruce, "Data Mining for Business Intelligence: Concepts, Techniques, and Applications in Microsoft Office Excel with XLMiner", 2nd Edition, Wiley India.
7. Ethem Alpaydın, "Introduction to Machine Learning", MIT Press
8. Peter Flach, "Machine Learning", Cambridge University Press

Reference Books:

1. Tom M. Mitchell, "Machine Learning", McGraw Hill
2. Kevin P. Murphy, "Machine Learning — A Probabilistic Perspective", MIT Press
3. Stephen Marsland, "Machine Learning an Algorithmic Perspective", CRC Press
4. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning", CambridgeUniversity Press
5. Peter Harrington, "Machine Learning in Action", DreamTech Press
6. D. W. Patterson, Artificial Intelligence and Expert Systems, Prentice Hall.
7. Saroj Kaushik "Artificial Intelligence", Cengage Learning.

Links for online NPTEL/SWAYAM courses:

https://onlinecourses.nptel.ac.in/noc19_me71/previewhttps://onlinecourses.nptel.ac.in/noc22_cs56/preview

https://onlinecourses.nptel.ac.in/noc22_cs29/preview https://onlinecourses.nptel.ac.in/noc22_cs08/preview

Robotics - SEM-VII		
Course Code	**Course Name**	**Credits**
HRBSBL701	**Robotics and Automation Lab**	**2**

Course Objectives:

1. To learn the implementation of image processing algorithms.
2. To acquaint with programming of robots.
3. To acquaint with data acquisition over cloud environment
4. To demonstrate the working of machine learning algorithms for data prediction.

Course Outcomes: learner will able to...

1. Develop simple image processing algorithms.
2. Program robots for simple and inverse kinematics and trajectory planning.
3. Acquire sensor data over cloud using microcontroller.
4. Perform predictive data analysis using clustering, classification and regression models.

List of Experiments:

1. Edge detection / segmentation using image processing
2. programming the robots to solve direct and inverse kinematics problems
3. Trajectory planning for Robots
4. Acquisition of sensor data over cloud using microcontroller
5. Implementation of Clustering algorithm (K-means / K-medoids)
6. Data Classification using data prediction tool (classification tree / artificial neural networks,Support Vector Machines etc.) (Any One)
7. Linear Regression using data predictive tool (multiple regression / artificial neural networksetc.) (Any One)
8. PLC to operate actuators for automation application

Assessment:

Term Work

Term work shall consist of the experiments as mentioned above.The distribution of marks for term work shall be as follows:

1. Laboratory work (Experiments): 40 marks
2. Attendance: 10 marks

Oral Examination:

Oral examination will be based on entire lab work of **Robotics and Automation Lab**

Robotics - SEM-VIII		
Course Code	**Course Name**	**Credits**
HRBC801	**Autonomous Vehicle Systems**	**4**

Course Objectives:

1. To comprehend fundamental aspects of Autonomous Vehicles.
2. To Acquire knowledge of levels of automation of autonomous systems.
3. To Understand the Connectivity Aspects of autonomous automobiles

Course Outcomes: The student will be able to

1. Gain perspective of autonomous systems
2. Understand Automotive Electronics and the operation of ECUs.
3. Discuss about the use of computer vision and learning algorithms in vehicles.
4. Learn Localization, Perception, Prediction planning and control.
5. Summarize the aspects of connectivity
6. Understand cloud platform and ROS.

Module	Details	Hours
1	**An over view of autonomous driving technologies**: Algorithms, client systems, cloud Platforms	6
2	**Overview of Automotive Electronics**: Control Systems for Autonomous vehicles, Electronic Engine control, Chassis and Powertrain Electronics, Vehicle motion control, Instrumentation andTelematics & ADAS	8
3	**Sensing Technologies** Radar & Sonar, Camera, Lidar, GNSS.GPS/IMU Use of Sensor Data, Sensor Fusion and Kalman Filters	8
4	**Computer Vision and Deep Learning** Computer Vision Fundamentals -Advanced Computer Vision , Neural Networks for Image Processing , TensorFlow ,Convolutional Neural Networks	10
5	**Levels of Automation** Localization - GNSS, LiDAR, Wheel and Visual Odometry, sensorfusion Perception – Detection and Tracking, DrivingPerception and deeplearning Prediction and Routing- Trffic prediction and Lane level routing Decision, Planning and Control- Motion Planning,Feed back control Cloud System- Operating systems-ROS, Cloud Platforms	12
6	**Connected Car Technology:** Connectivity Fundamentals - DSRC (Direct Short Range Communication), Connectivity types -Vehicle-to-Vehicle, Vehicle-to-Roadside and Vehicle-to-Infrastructure, Vehicle-to-pedestrian, Vehicle- to-clous, Vehicle-to-everything, Applications -Security Issues Technical Issues, Security Issues, Moral and Legal Issues.	8

Text Books:

1. Shaoshan Liu, Liyun Li, “Creating Autonomous Vehicle Systems”, Morgan and Claypool Publishers,2017.
2. Liu, Shaoshan. Engineering autonomous vehicles and robots: the DragonFly modular-based approach. John Wiley & Sons, 2020.
3. Hong Cheng, “Autonomous Intelligent Vehicles: Theory, Algorithms and Implementation”, Springer,2011.
4. Williams. B. Ribbens: “Understanding Automotive Electronics”, 7th Edition, Elsevier Inc,2012.

Reference Books:

1. Marcus Maurer, J.Christian Gerdes, “Autonomous Driving: Technical, Legal andSocial Aspects”Springer, 2016.
2. Ronald.K.Jurgen, “Autonomous Vehicles for Safer Driving”, SAE International, 2013.
3. James Anderson, KalraNidhi, Karlyn Stanly, “Autonomous Vehicle Technology:A Guide forPolicymakers”, Rand Co, 2014.
4. Lawrence. D. Burns, Chrostopher Shulgan, “Autonomy – The quest to build thedriverless car andhow it will reshape our world”, Harper Collins Publishers, 2018

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

3D Printing

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai
3D Printing
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**H3DPC501: Introduction to CAD**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**H3DPC601: 3D Printing: Introduction & Processes**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**H3DPC701: Applications of 3D Printing**	04	--	--	20	80	--	--	100	04
	H3DPSBL701: Skill Based Lab – Digital Fabrication	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**H3DPC801: 3D Printing in Medical Technology**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
									Total Credits for Semesters V, VI, VII &VIII = 04+04+04+06 = 18	

'3D Printing':SEM-V						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
H3DPC501	**Introduction to CAD**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
H3DPC501	**Introduction to CAD**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To impart the 3D modelling skills for development of 3D models of basic engineering components. 2. To familiarize with basic concepts of computer graphics. 3. To familiarize with basic concepts of additive and subtractive manufacturing process.
Course Outcomes	**Upon successful completion of this course, the learner will be able:** 1. Illustrate basic understanding of design. 2. Create the CAM Toolpath for specific given operations. 3. Illustrate basic understanding of types of CAD model creation. 4. Generate assembly models of given objects using assembly tools of a modelling software. 5. Identify suitable computer graphics techniques for 3D modelling. 6. Transform, manipulate objects & store and manage data.

Module	Contents	Hours
1.	**Design thinking:** Identification of need, Embodiment of design, Generation of ideas and research topics	5
2.	**Subtractive Manufacturing:** Introduction to NC/CNC/DNC machines **Additive Manufacturing:** Introduction to 3D Printing, Limitations of Subtractive manufacturing, Digital fabrication	8
3.	**CAD Introduction:** History & Scope of CAD, CAD hardware and software, Advantages, Disadvantages and Applications of CAD	7
4.	**Introduction to 2D modelling:** CAD models Creation, Types and uses of models from different perspectives **Introduction to assembly drawing:** Types of assembly drawings, part drawings, drawings for catalogues and instruction manuals, patent drawings, drawing standards	12

5.	**Computer Graphics:** Overview of 2D and 3D Computer Graphics, Parametric representation of curves: Synthetic Curves - Bezier curves, Hermite Curves, B-spline curves **Geometric Modelling:** Wire Frame Modelling, Solid Modelling, Surface Modelling, Parametric Modelling, Feature based Modelling, Constraint Based Modelling.	12
6.	**Geometric Transformation:** 2D & 3D Transformations (Translation, Rotation, & Scaling & Reflection), Concatenations	8

Text/Reference Books:-

1. Machine Drawing by N.D. Bhatt.
2. A textbook of Machine Drawing by Laxminarayan and M.L.Mathur, Jain brothers Delhi
3. CAD/ CAM, Theory & Practice, Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications
4. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
5. CAD/CAM Computer Aided and Manufacturing, Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition
6. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.
7. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
8. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.

Website Reference / Video Courses:

1. https://nptel.ac.in/courses/112/102/112102101/
2. https://nptel.ac.in/courses/106/102/106102065/
3. https://nptel.ac.in/courses/106/102/106102065/
4. https://nptel.ac.in/courses/112/102/112102103/
5. https://nptel.ac.in/courses/112/105/112105211/
6. https://nptel.ac.in/courses/112/104/112104265/
7. https://www.youtube.com/watch?v=2cCMty9v3Tg
8. https://www.youtube.com/watch?v=2zPh26Q1BT8

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

'3D Printing' - SEM-VI						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
H3DPC601	**3D Printing: Introduction & Processes**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
H3DPC601	**3D Printing: Introduction & Processes**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To familiarise with importance of Rapid Prototyping. 2. To study programming aspects of subtractive manufacturing process. 3. To familiarize with basic process of additive manufacturing in particularly 3D printing.
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Illustrate understanding of various cost-effective alternatives for manufacturing productsand select the feasible RP process for specific technical applications 2. Build and create data for 3D printing of any given object using liquid based rapid prototypingand tooling processes 3. Build and create data for 3D printing of any given object using solid based rapid prototypingand tooling processes 4. Build and create data for 3D printing of any given object using powder based rapid prototyping and tooling processes 5. Select an appropriate material and tools to develop a given product using rapid prototypingmachine 6. Select proper rapid prototyping and reverse engineering techniques for specific technical applications. 7. Demonstrate basics of virtual reality

Module	Contents	Hours
1.	**Additive Manufacturing:** Introduction to AM, Classification of AM Processes, Advantages & disadvantages, AM Applications; in Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, and bio fabrication.	9

2.	**Liquid based systems:** **Stereo lithography apparatus (SLA):** Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. **Solid ground curing (SGC):** Models and specifications, process, working, principle, applications, advantages and disadvantages, case studies.	9
3.	**Solid based systems:** **Laminated object manufacturing (LOM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. **Fused Deposition Modeling (FDM):** Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies.	8
4.	**Powder Based Systems:** **Selective laser sintering (SLS):** Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. **Three-dimensional printing (3DP):** Models and specification, process, working principle, applications, advantages and disadvantages, case studies. **Electron Beam Melting (EBM):** Models and specification, process, working principle, applications, advantages and disadvantages, case studies.	8
5.	**Materials for Additive manufacturing** Types of material: polymers, metals, ceramics and composites, liquid-based materials, photo polymer development, solid based materials, powder-based materials. **Material properties** Colour, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties.	10
6.	**Reverse Engineering** Introduction to Digitizing Methods, Contact type and Non-contact type, Brief introduction to the types of medical imaging. Virtual reality: Definition, features of VR, Technologies used in VR, Introduction to Augmented reality	8

Text/Reference Books:-

1. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
2. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
3. Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Hauge, P M, Dickens, Wiley

4. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley
5. Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography by Paul F. Jacobs, McGraw Hill
6. Rapid Manufacturing by Pham D T and Dimov S S, Springer Verlog
7. "Rapid Prototyping" Chee Kai Chua, World Scientific Publishing

Website Reference / Video Courses:

NPTEL Web Course:

1. Rapid Manufacturing, By Prof. J. Ramkumar, Prof. Amandeep Singh, IIT Kanpur, https://onlinecourses.nptel.ac.in/noc20_me50/preview
2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

5. Question paper will comprise of 6 questions, each carrying 20 marks.
6. Total four questions need to be solved.
7. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
8. Remaining question will be randomly selected from all the modules.

‘3D Printing’ - SEM-VII						
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**		**Credits Assigned**		
		Theory	**Tutorial**	**Theory**	**Tutorial**	**Total**
H3DPC701	**Applications of 3D Printing**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
H3DPC701	**Applications of 3D Printing**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To familiarise with applications of 3D Printing technologies. 2. To acquaint with the process of using biomedical data for 3D modelling. 3. To familiarize with basic process of additive manufacturing in different industries.
Course Outcomes	**Upon successful completion of this course, the learner will be able:** 1. To understand the perspectives for 3D printing in Jewellery industries for selection of an appropriate material and tools to develop a given product using rapid prototyping techniques. 2. Develop 3D model using various types of available biomedical data. 3. To understand the perspectives for 3D printing in Aerospace industries for selection of an appropriate material and tools to develop a given product using rapid prototyping techniques. 4. Illustrate understanding of various cost-effective alternatives for manufacturing products. 5. Use rapid prototyping and tooling concepts in any real-life applications. 6. Contribute towards the Product Development at the respective domain in the industry

Module	Contents	Hours
1.	**Applications in Jewellery Industries** **Introduction to 3D Printing Jewellery:** Steps Involved in Jewellery 3D Printing, Why 3D Printing for Jewellery Making, Techniques Involved in Jewellery 3D Printing, 3D Printing Processes for Jewellery Designing, Challenges with Jewellery 3D Printing, 3D Printing vs Traditional Methods, Types of Jewellery can be 3D Printed, **3D Printers for Jewellery Making –** How They Work & Which to Choose	10
2.	**Medical Applications in Additive manufacturing** Presurgical Planning Models, Mechanical Bone Replicas, Teaching Aids and Simulators, Customized Surgical Implants, Prosthetics and Orthotics’, Anthropology, Forensics	8

3.	**Applications in Aerospace Industries** Use of AM in Aerospace, Metal AM in Aerospace, Super alloys, Non-Destructive Evaluation, Space technology	8
4.	**Applications in Tooling** **Methods of Rapid tooling:** Direct Soft Tooling, Indirect Soft Tooling, Direct Hard Tooling, Indirect Hard Tooling.	9
5.	**Applications in various industries** Automotive, Défense, Coin industries, Household appliance, Toy industry, Ship building, Un-manned Aerial Vehicles (UAV), Furniture, Construction and food	9
6.	**Applications in Design** Design for Additive Manufacturing (DFAM), Topology optimization for AM, Generative design **Applications in Engineering, Analysis and Planning**	8

Text/ Reference Books:-

1. Makers: The New Industrial Revolution (Telord 1403), by Chris Anderson
2. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
3. 3D Printing in Aerospace and Defense Standard Requirements, by Gerardus Blokdyk
4. Additive Manufacturing for the Aerospace Industry, by Francis Froes, Rodney Boyer
5. 3D Printing in Medicine, 1st Edition - April 1, 2017, by Deepak Kalaskar
6. An Update on Medical 3D Printing Hardcover – 1 January 2019, by Dr Raju Vaishya, Dr Abid Haleem, Dr Lalit Maini
7. 3D Printing in Medicine: A Practical Guide for Medical Professionals Hardcover – Import, 12 October 2017, by Frank J. Rybicki, Gerald T. Grant
8. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
9. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
10. Rapid Manufacturing – An Industrial revolution for the digital age by N.Hopkinson, R.J. M. Hauge, P M, Dickens, Wiley
11. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley

Website Reference / Video Courses:

NPTEL Web Course:

1. Rapid Manufacturing, By Prof. J. Ramkumar, Prof. Amandeep Singh, IIT Kanpur, https://onlinecourses.nptel.ac.in/noc20_me50/preview
2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

‘3D Printing’ - SEM-VIII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Tutorial	Theory	Tutorial	Total
H3DPC801	**3D Printing in Medical Technology**	**04**	**-**	**04**	**-**	**04**

Course code	Course Name	Examination Scheme						
		Theory					Term Work	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)		
		Test 1	Test 2	Avg.				
H3DPC801	**3D Printing in Medical Technology**	**20**	**20**	**20**	**80**	**03**	**-**	**100**

Course Objectives	1. To acquaint with the process of using biomedical data for 3D modeling. 2. To familiarize with basic process of additive manufacturing in particularly 3D printing
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Describe the creation of highly accurate physical models of human anatomy 2. Identify medical imaging for human body 3. Understand the modelling based on Biomedical data 4. Build and create data for 3D printing of any given object using rapid prototyping and tooling processes. 5. Illustrate the understanding of different manufacturing processes 6. To Identify the processes and tooling concepts in Biomedical

Module	Contents	Hours
1.	**Introduction** Stages of the medical modelling process, The human form, Basic anatomical terminology, technical terminology	8
2.	**Introduction to medical imaging** Computed tomography (CT), Cone beam CT (CBCT), Magnetic resonance (MR), Noncontact surface scanning, Medical scan data, Point cloud data	10
3.	**Working with medical scan data** Pixel data operations, Using CT data: a worked example, Point cloud data operations, Two-dimensional formats, Pseudo 3D formats, True 3D formats, File management and exchange	12
4.	**Physical reproduction** Basic principles of medical modelling: orientation, sectioning, separating and joining, trapped volumes	8

5.	Introduction to Additive manufacturing processes used for Bio-Modelling, Computer numerical controlled machining, Cleaning and Sterilizing medical models	8
6.	**Case Studies based on Bio-Modelling & Future Development**	6

Text/Reference Books:-

1. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
2. 3D Printing in Medicine, 1st Edition - April 1, 2017, by Deepak Kalaskar
3. An Update on Medical 3D Printing Hardcover – 1 January 2019, by Dr Raju Vaishya, Dr Abid Haleem, Dr Lalit Maini
4. 3D Printing in Medicine: A Practical Guide for Medical Professionals Hardcover – Import, 12 October 2017, by Frank J. Rybicki, Gerald T. Grant
5. Rapid Prototyping, Principles and Applications by Rafiq I. Noorani, Wiley & Sons
6. Rapid Prototyping: Principles and Applications by Chua C.K, Leong K.F and Lim C.S, 2nd Edition, World Scientific
7. Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototyping by Ian Gibson, Wiley

Website Reference / Video Courses:

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2. Fundamentals of Additive Manufacturing Technologies, By Prof. Sajan Kapil, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc21_me115/preview

Assessment:

Internal Assessment consists of two tests out of which; one should be compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Total four questions need to be solved.
3. Q.1 will be compulsory, based on entire syllabus wherein sub questions of 2 to 5 marks will be asked.
4. Remaining question will be randomly selected from all the modules.

‘3D Printing’ - SEM-VII						
Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Practical/ Tutorial	Theory	Practical/ Tutorial	Total
H3DPSBL701	**Skill Based Lab – Digital Fabrication**		**04**	**--**	**02**	**02**

Course code	Course Name	Examination Scheme							
		Theory					Term Work	Oral	Total
		Internal Assessment			End Sem. Exam	Exam Duration (Hrs.)			
		Test 1	Test 2	Avg.					
H3DPSBL701	**Skill Based Lab – Digital Fabrication**	**-**	**-**	**-**	**-**	**-**	**50**	**50**	**100**

Course Objectives	1. To impart the geometric modeling skills for development of 3D models of engineering components. 2. To familiarize with production drawings with important features like GD &T, surface finish, heat treatments etc. 3. To familiarize with additive manufacturing process 4. To acquaint with basic process of 3D modeling using biomedical data.
Course Outcomes	**Upon successful completion of this course, the learner will be able to:** 1. Illustrate basic understanding of types of CAD model creation. 2. Build geometric model of a given object using 3D modeling software 3. Generate assembly models of given objects using assembly tools of a modeling software 4. Demonstrate CAM Tool path and prepare NC- G code 5. Develop 3D model using available biomedical data 6. Build any given real life object using 3D printing process

Module	Contents	Hours
1.	Geometric modeling of an Engineering component, demonstrating skills in sketching commands of creation (line, arc, circle etc.) modification (Trim, move, rotate etc.) and viewing using (Pan, Zoom, Rotate etc.)	06
2.	Demonstrating modeling skills using commands like Extrude, Revolve, Sweep, Blend, Loft etc. Mesh of curves, free form surfaces etc. Feature manipulation using Copy, Edit, Pattern, Suppress, History operations etc.	04
3.	Assembly: Constraints, Exploded views, interference check. Drafting (Layouts, Standard & Sectional Views, Detailing & Plotting).	04
4.	Solid modeling of any engineering component using any 3D modeling software.	04
5.	Non - Contact Scanning – Generation of CAD model using 3D scanning equipment.	04
6.	Reverse Engineering of a legacy component – Selection of components, 3D scanning, CAD model verification, 3D print of CAD model.	04

7.	Modeling of a component using 3D modelling software and development of G – Code output using Fractal Software.	06
8.	Design an object with free form surface using Autodesk Fusion 360 and development of G – Code output using Fractal Software.	04
9.	Segmentation in Slicer's Segment Editor module for the purpose of 3D printing.	04
10.	Creation of 3D model from 2D images using any image processing software and printing it. (3D Slicer open source) (Application: Any body organ like Heart, Gallbladder etc. as per available Dicom files)	04
11.	Development of physical 3D mechanical structure using any one of the Additive manufacturing processes – Material to be used Metal	06
12.	Development of physical 3D mechanical structure using any one of the Additive manufacturing processes - Material to be used Plastic	04

Text/Reference Books:-

1. Machine Drawing by N.D. Bhatt.
2. A textbook of Machine Drawing by Laxminarayan and M.L.Mathur, Jain brothers Delhi
3. Machine Drawing by K.I. Narayana, P. Kannaiah, K.Venkata Reddy
4. Medical Modelling - The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd
5. Biomaterials, artificial organs and tissue engineering, Edited by Larry L. Hench and Julian R. Jones, Woodhead Publishing and Maney Publishing, CRC Press 2005
6. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.

Website Reference / Video Courses:

1. https://www.autodesk.in/products/fusion-360/learn-support
2. https://knowledge.autodesk.com/support/inventor
3. https://www.slicer.org/wiki/Documentation/4.10/Training

Term work:

Term work shall consist of all twelve experiments.
The distribution of marks shall be as follows:

Experiments Performance	: 20 marks
Course Project	: 20 marks
Attendance	: 10 marks

The final certification and acceptance of term work ensures the minimum passing in the term work.

Oral Examination:

Oral examination will be based on entire lab work of **H3DPSBL701 - Skill Based Lab – Digital Fabrication**

University of Mumbai

Syllabus for

Honours/Minor Degree Program

In

Industrial Automation

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai
Industrial Automation
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar /Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	**HIAC501: Fundamentals of Industrial Automation**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
TE Sem. VI	**HIAC601: Industrial Internet of Thing (IIOT)**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
BE Sem VII	**HIAC701: AI and ML for Automation**	04	--	--	20	80	-	-	100	04
	HIASBL701: AI and ML for Automation-Lab	-	-	04	-	-	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**100**		**200**	**06**
										Total Credits = 06
BE Sem VIII	**HIAC801: Applied Predictive Analytics**	04	--	--	20	80	-	-	100	04
	Total	**04**	**-**	**-**	**100**		**-**		**100**	**04**
										Total Credits = 04
										Total Credits for Semesters V, VI, VII &VIII = 04+04+06+04 = 18

Industrial Automation : Sem. V								
Course code	**Course Name**	**Teaching scheme**			**Credit assigned**			
HIAC501	**Fundamentals of Industrial Automation**	**Theory**	**Pract.**	**Tut.**	**Theory**	**Pract**	**Tut.**	**Total**
		4	**-**	-	**4**	**-**	-	**4**

Course Code	**Course Name**	**Examination scheme**							
		Theory (out of 100)				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC501	**Fundamentals of Industrial Automation**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course objective	1. To impart knowledge of Industrial Automation. 2. To make the students learn industrial sensors. 3. To make the students learn various actuators. 4. To make the students learn about controller strategy and various automation tools like PLC. 5. To give the students an overview of DCS and HMI. 6. To give students an overview of communication protocols.
Course Outcome	The students will able to 1. Recognize Industrial automation. 2. Select and configure industrial sensors. 3. Comprehend and work with various actuators. 4. Know various automation tools. 5. Work with DCS and HMI. 6. Select various communication protocols.

Pre requisites: Sensors and Transducers basics

Module	**Contents**	**Hours.**	**CO**
1	**Introduction** Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, types of Automation, Hierarchical level in automation, Advanced automation functions, Automated flow lines and transfer mechanisms. Material handling and identification technologies, Conveyor system, Automated guided vehicle system, Automated storage systems, Automatic Identification Methods.	6	CO1

2	**Sensors** Introduction to Industrial Measurement, overview of sensors, classification, sensor characteristics, physical principles of sensing, sensor Materials and Technologies. Inductive sensors, capacitive sensors, vision sensors, ultrasonic sensors, Electronic SMART Digital remote sensor , Robotic sensors, Tactile sensing, Proximity sensors, Range sensor, Position sensors, Fibre optic sensors, Guided microwave sensor, wireless sensors, Electrical characteristics of sensors, specifications of sensors, performance testing, selection guidelines.	8	CO2
3	**Actuators** Pneumatic and hydraulic-directional and pressure control valves, cylinders, servo proportional control valves, rotary actuators. Electrical actuation: A.C and DC motors, stepper motors, mechanical switches and solid state switches. Mechanical Actuation: types of motion, kinematic chain, cams, gears, ratchets and pawl, belt and chain drives, bearings, mechanical aspects of motor selection, piezoelectric actuators, magneto-strictive actuators, memory metal actuators. Selection Criteria of Actuators	8	CO3
4	**Controller strategy / Automation Tools. PLC** Overview and Features, Types, specifications, PLC Architecture, PLC working, PLC SCAN, new trends in PLC, PLC programming Languages, PLC instructions set, Development of Ladder programme, case study Example, PLC Applications, Overview of Motion control.PLC Installation and wiring. **SCADA** Overview, SCADA Architecture, SCADA-Hardware functions, New trends in scada systems, applications, case study examples.	10	CO4
5	**DCS & HMI** DCS: Overview and Features of DCS, DCS Architecture, Hardware elements, working of DCS, DCS displays, DCS interfacing with PLC , DCS wiring diagram. Applications and suppliers. HMI : Overview, need, Types, wiring practice, Data Handling , configuration and interfacing with **PLC & PC, Communication standards. ASM Graphics**	10	**CO5**
6	**Communication protocols** Overview of sensor networks, AS interface,CAN, HART, FF, Profibus, Interbus, Mbus, Wireless sensor network, networks-IEEE, Zigbee, sensor interfaces.	6	**CO6**

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will consist of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 or 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weight age of each module will be proportional to number of respective Lecture hours as mentioned in the syllabus.

Text Books Recommended:

1. Jacob K Freden; Handbook of Modern sensors, Springer, 5th Edition
2. Tony Kuphaldt; Lessons in industrial instrumentation, version 4
3. Walt Boyes; Instrumentation Reference book, Fourth Edition.
4. William C Dunn; Fundamentals of Industrial Instrumentation and process control, McGraw Hill.
5. C.L. Albert and D.A. Coggan, Fundamentals of Industrial Control, ISA, 1992.
6. Bela G. Liptak, Instrument Engineer's HandBook – Process Measurement and Analysis, ISA CRC Press , 4th Edition, 2003.
7. Andrew Williams, Applied instrumentation in the process industries, 2nd Edition, Vol. 1 & 3, Gulf publishing company.
8. Douglas. M.Considine; Process Instruments & Control Handbook, McGraw-Hill
9. S C Mukhopadhyay; Intelligent sensing, Instrumentation and Measurement, Springer.

Industrial Automation : Sem. VI								
Course code	**Course Name**	**Teaching scheme**			**Credit assigned**			
HIAC601	**Industrial Internet of Thing (IIOT)**	**Theory**	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
		4	**-**	-	**4**	**-**	-	**4**

Course Code	**Course Name**	**Examination scheme**							
		Theory (out of 100)				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC601	**Industrial Internet of Thing (IIOT)**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course objective	1. Introduce how IoT has become a game changer in the new economy where the customers are looking for integrated value 2. Bring the IoT perspective in thinking and building solutions 3. Introduce the tools and techniques that enable IoT solution and Security aspects.
Course Outcome	The students will able to 1. Describe IOT, IIOT 2. Design and develop the real-life IoT applications using off the shelf hardware and software 3. Know various IoT Layers and their relative importance 4. Recognize various IoT platforms and Security 5. Realize the importance of Data Analytics in IoT 6. Design and thinking concepts of IIoT

Prerequisites: Microcontroller based Architecture and Programming			
Module	**Content**	**Hours**	**CO**
1	**Introduction:** Introduction of Industry 4.0, Elements of industry 4.0, Introduction to IOT, what is IIOT? IOT Vs. IIOT, History of IIOT, Components of IIOT - Sensors, Interface, Networks, People &Process, Hype cycle, IOT Market, Trends& future Real-life examples, Key terms – IOT Platform, Interfaces, API, clouds, Role of IIOT in Manufacturing Processes Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools Challenges & Benefits in implementing IIOT	6	CO1

2	**Architectures:** Overview of IOT components; Various Architectures of IOT and IIOT, Advantages & disadvantages, Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT	8	CO2
3	**Sensor and Interfacing:** Introduction to sensors, Transducers, Classification, Roles of sensors in IIOT, Various types of sensors, Design of sensors, sensor architecture, special requirements for IIOT sensors, Role of actuators, types of actuators, IT and OT Integration.	10	CO3
4	**Protocols and Cloud:** Need of protocols; Types of Protocols, Wi-Fi, Wi-Fi direct, Zigbee, Z wave, BACnet, BLE, Modbus, SPI , I2C, IIOT protocols –COAP, MQTT,6lowpan, lwm2m, AMPQ IIOT cloud platforms: Overview of cots cloud platforms, Predix, thingworks, azure etc. Data analytics, cloud services, Business models: Saas, Paas, Iaas.	8	CO4
5	**Cyber security for industry, Privacy, and Governance** Cyber physical system, cyber security life cycle, cyber security guidelines, standard IEC 62443 Introduction to web security, Conventional web technology and relationship with IIOT, Vulnerabilities of IoT, Privacy, Security requirements, Threat analysis, Trust, IoT security tomography and layered attacker model, Identity establishment, Access control, Message integrity, non-repudiation and availability, Security model for IoT.	8	CO5
6	**IOT Analytics and CASE study:** Role of Analytics in IOT, Data visualization Techniques, Introduction to R Programming, Statistical Methods. Internet of Things Applications: Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Home Automation, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector.	8	CO6

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be a compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

Theory Examination:

1. Question paper will consist of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 or 5 marks will be asked.

4. Remaining questions will be mixed in nature.
5. In question paper weight age of each module will be proportional to number of respective Lecture hours as mentioned in the syllabus.

Text Books:

1. Daniel Minoli, Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications, ISBN: 978-1-118-47347-4, Willy Publications 2. Bernd Scholz-Reiter, Florian
2. Michahelles, Architecting the Internet of Things, ISBN 978-3- 642-19156-5 e-ISBN 978-3-642-19157-2,Springer

Reference Books:

1. Hakima Chaouchi, The Internet of Things Connecting Objects to the Web, ISBN : 978-1-84821-140-7, Willy Publications
2. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2nd Edition, Willy Publications
3. Inside the Internet of Things (IoT), Deloitte University Press
4. Internet of Things- From Research and Innovation to Market Deployment; By Ovidiu & Peter; River Publishers Series
5. Five thoughts from the Father of the Internet of Things; by ByPhil Wainewright - Kevin Ashton
6. How Protocol Conversion Addresses IIoT Challenges: White Paper By Red Lion.

Industrial Automation: Sem. VII								
Subject Code	**Subject Name**	**Teaching Scheme**			**Credit Assigned**			
		Th	**Pract.**	**Tut.**	**Th**	**Pract.**	**Tut.**	**Total**
HIAC701	**Artificial Intelligence and Machine Learning for Automation**	**4**	**-**	**-**	**4**	**-**	**-**	**4**

Sub Code	**Subject Name**	**Examination scheme**							
		Theory				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC701	**Artificial Intelligence and Machine Learning for Automation**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course Objectives	1. To familiarize student with basic concepts of Artificial Intelligence and Machine learning. 2. To provide understanding of the concepts of regression, classification, clustering and deep learning algorithms. 3. To introduce the students to various applications of Artificial Intelligence and Machine learning for industrial automation
Course Outcomes	Students will be able to: 1. Introduce concepts of Artificial Intelligence and Machine learning 2. Explicate statistical tools and development of database for AI/ML. 3. Analyze the various algorithms for Regression, Classification and Clustering. 4. Evaluate metrics for ML/AI algorithms. 5. Examine the algorithms for deep learning. 6. Explain examples of ML/AI algorithms for industrial automation.

Module	**Contents**	**Hrs.**	**CO Mapping**
1.	**Introduction to Artificial Intelligence:** Evolution, definition, types, application examples, benefits/advantages, limitations/issues, comparison.	**06**	**CO1**
2.	**Review of statistical concepts:** Mean, variance, covariance, standard deviation, random variable, probability distribution, probability distribution function, normal distribution, binomial distribution, poisson distribution, central limit theorem, vector norms, principal component analysis. **Data collection and preparation:** Collecting, cleaning, normalization, standardization, missing data, underfitting and overfitting, neglecting outliers, annotation, labelling. Data Splitting: Training, Validation, and Test Datasets. Public datasets for machine learning.	**08**	**CO2**

3.	**Regression:** Simple Linear regression, Multiple Linear Regression, Polynomial Regression, Logistic regression. **Classifiers:** k-Nearest Neighbours, Decision trees, naïve Bayes, SVM for Linearly separable data, Kernel SVM for Non-Linearly separable data. **Clustering:** k-means clustering.	**10**	**CO3**
4.	**Evaluation Metrics**: True Positive, True Negative, False Positive, False Negative, accuracy, precision, recall or True Positive Rate, False Positive Rate, Receiver Operating Characteristic, Area Under the Curve, Confusion matrix, F-score.	**04**	**CO4**
5.	**Deep Learning:** Multilayer Perceptron (MLP), Convolutional Neural Network (CNN), Recurrent Neural Network (RNN)	**08**	**CO5**
6.	**Application in Industrial Automation**: **Robotics, Factory automation, Process control, Electrical Engineering** Challenges, Data Screening, Feature Engineering, Projected improvement, Model Design, Limitations, Future scope, References.	**12**	**CO6**

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on Minimum 02 Modules) and the other is either a class test or assignment on live problems or Course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 Marks.
2. Total 4 questions need to be solved.
3. Question No. 1 will be compulsory and based on entire syllabus wherein sub questions of 4 or 5 marks will be asked.
4. Remaining questions will be mixed in nature.
5. In question paper weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Text Books:

1. Harrington, Peter. *Machine learning in action*. Simon and Schuster, 2012.
2. Zheng, Alice, and Amanda Casari. *Feature engineering for machine learning: principles and techniques for data scientists*. " O'Reilly Media, Inc.", 2018.
3. Jiang, Hui. *Machine Learning Fundamentals: A Concise Introduction*. Cambridge University Press, 2021.
4. Huyen, C. *"Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications"*, O'Reilly Media, 2022.
5. Gupta, Itisha, and Garima Nagpal. *Artificial Intelligence and Expert Systems*. Stylus Publishing, LLC, 2020.

Reference Books:

1. Pandey, Yogendra Narayan, et al. *Machine Learning in the Oil and Gas Industry*. apress, Texas, 2020.
2. Bangert, Patrick, ed. *Machine learning and data science in the oil and gas industry: Best practices, tools, and case studies*. Gulf Professional Publishing, 2021.
3. Das, Santosh Kumar, et al., eds. *Machine learning algorithms for industrial applications*. Cham: Springer, 2021.

Industrial Automation: SEM VII								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Th	Pract.	Tut.	Th	Pract.	Tut.	Total
HIASBL701	Artificial Intelligence and Machine Learning for Automation Lab	-	4	-	-	4	-	2

Subject Code	Subject Name	Examination scheme						
		Theory (out of 100)				Term work	Oral	Total
		Internal Assessment			End sem Exam			
		Test1	Test2	Avg.				
HIASBL701	Artificial Intelligence and Machine Learning for Automation Lab	--	--	--	--	50	50	100

Course Objectives	1. To familiarize student with basic concepts of Artificial Intelligence and Machine learning. 2. To provide understanding of the concepts of regression, classification, clustering and deep learning algorithms. 3. To introduce the students to various applications of Artificial Intelligence and Machine learning for industrial automation
Course Outcomes	Students will be able to 1. Write programs based on data compression and dimensionality reduction. 2. Write programs for regression, classification and clustering. 3. Calculate evaluation metrics for various algorithms. 4. Write programs based on deep learning algorithms. 5. Demonstrate working of AI/ML in Robotics and Factory automation. 6. Validate working of AI/ML in Process control and Electrical Engineering.

Syllabus: Same as that of Subject HIAC701.

List of the Laboratory Experiments:

Sr. No.	Contents	CO Mapping
1.	Write a python program to perform PCA for dimension reduction or data compression.	CO1
2.	Develop/download database of any industrial machine/system. Explain hardware system used for data collection. Explain specifications/characteristics of collected data.	CO2

3.	Write a python program to implement linear regression with one variable, two variables for given dataset.	CO2
4.	Demonstrate the working of SVM classifier for a linearly separable data set.	CO2
5.	Demonstrate the working of Kernel SVM classifier for a non-linearly separable data set.	CO2
6.	Demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.	CO2
7.	Calculate evaluation metrics such as accuracy, precision, recall, confusion matrix, F-score, etc for regression, classification and clustering algorithms.	CO3
8.	Calculate evaluation metrics such as Receiver Operating Characteristic, Area Under the Curve, etc for regression, classification and clustering algorithms.	CO3
9.	Implement multilayer Perceptron (MLP) for predicting stock price. Time series forecasting.	CO4
10.	Implement Convolutional Neural Network (CNN) to recognize hand-written digits dataset.	CO4
11.	Implement Recurrent Neural Network (RNN) for speech recognition.	CO4
12.	Case study or mini project on application of AI/ML in Robotics.	CO5
13.	Case study or mini project on application of AI/ML in Factory automation.	CO5
14.	Case study or mini project on application of AI/ML in Process control.	CO6
15.	Case study or mini project on application of AI/ML in Electrical Engineering.	CO6

Any other experiment based on syllabus which will help students to understand topic/concept.

Oral Examination:

Oral examination will be based on entire syllabus.

Term Work:

Term work shall consist of minimum 12 experiments.
The distribution of marks for term work shall be as follows:
Laboratory work (Experiments): : 20 Marks
Laboratory work (programs / journal): 20 Marks
Attendance: : 10 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Industrial Automation: SEM VIII								
Subject code	**Subject Name**	**Teaching scheme**			**Credit assigned**			
HIAC801	**Applied Predictive Analytics**	**Theory**	**Pract.**	**Tut.**	**Theory**	**Pract.**	**Tut.**	**Total**
		4	**-**	-	**4**	**-**	-	**4**

Sub Code	**Subject Name**	**Examination scheme**							
		Theory (out of 100)				**Term work**	**Pract. and Oral**	**Oral**	**Total**
		Internal Assessment			**End sem Exam**				
		Test1	**Test2**	**Avg.**					
HIAC801	**Applied Predictive Analytics**	**20**	**20**	**20**	**80**	**-**	**-**	**-**	**100**

Course objective	1. To deliver Knowledge of core operations in Energy Vertical Solving complex issues analyzing available data in Operations, Maintenance, Reliability, Safety, Procurement, Inventory etc., 2. To introduce forecasting and predictive techniques.
Course Outcome	The students will able to 1. Identify the use of analytics and its tools 2. Interpret data and preparation of data 3. Use descriptive modeling techniques 4. Practice predictive modeling techniques such as decision tree, logistic regression and neural network 5. Apply and build models using clustering, regression and classification techniques and its corresponding algorithms 6. Discuss the case studies of Predictive Analytics and Predictive Maintenance

Pre requisites: Data Science concepts			
Module	**Content**	**Hours.**	**CO**
1	**Overview of Predictive Analytics:** What and Why Analytics, Predictive Analytics? Supervised vs. Unsupervised Learning, Parametric vs. Non-Parametric Models, Business Intelligence, Predictive Analytics vs. Business Intelligence, Predictive Analytics vs. Statistics, Statistics and Analytics, Predictive Analytics and Statistics Contrasted, Predictive Analytics vs. Data Mining, Challenges in Using Predictive Analytics. Concept of hb	06	CO1
2	**Data Understanding and Data Preparation:** Single Variable Summaries, Applying Simple Statistics in Data Understanding, Categorical Variable Assessment, Data Visualization in One Dimension, Two or Higher Dimensions. Data Preparation, Fixing Missing Data, Feature Creation, Simple Variable Transformations, Fixing Skew, Binning Continuous Variables, Numeric Variable	08	CO2

	Scaling, Nominal Variable Transformation, Ordinal Variable Transformations, Date and Time Variable Features, Multidimensional Features		
3	**Descriptive Modeling:** Data Preparation, Issues with Descriptive Modeling, Principal Component Analysis, The PCA Algorithm, Applying PCA to New Data, PCA for Data Interpretation, Additional Considerations before Using PCA, The Effect of Variable Magnitude on PCA Models, Clustering Algorithms, The K-Means Algorithm, Data Preparation for K-Means	07	CO3
4	**Predictive Modeling:** Decision Trees, The Decision Tree Landscape, Building Decision Trees, Logistic Regression, Interpreting Logistic Regression Models, Other Practical Considerations for Logistic Regression, Neural Networks, Building Blocks: The Neuron, Neural Network Training, The Flexibility of Neural Networks, Neural Network Settings, Neural Network Pruning, Interpreting Neural Networks, Neural Network Decision Boundaries, Other Practical Considerations for Neural Networks	09	CO4
5	**Predictive Modeling:** K-Nearest Neighbor, the k-NN Learning Algorithm, Distance Metrics for k-NN, Other Practical Considerations for k-NN, Naïve Bayes, Bayes' Theorem, The Naïve Bayes Classifier Interpreting Naïve Bayes Classifiers, Other Practical Considerations for Naïve Bayes, Regression Models, Linear Regression, Linear Regression Assumptions, Variable Selection in Linear Regression, Interpreting Linear Regression Models, Using Linear Regression for Classification, Other Regression Algorithms	09	CO5
6	**Assessing Predictive Models:** Batch Approach to Model Assessment, Percent Correct Classification, Rank-Ordered Approach to Model Assessment, Assessing Regression Models. **Case studies:** Quality Prediction in a Mining Process, predicting the consumption of electricity in the coming future (refer Kaggle data set) **Predictive Maintenance:** Find a defect in the production, Sensor Fault Detection(refer Kaggle data set), Boiler Fault Detection ((refer https://ieee-dataport.org/)	09	CO6

Internal Assessment:

Internal Assessment consists of two tests out of which, one should be compulsory class test (on Minimum 02 Modules) and the other is either a class test or assignment on live problems or Course project.

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

Text Books:

1. Dean Abbott, “Applied Predictive Analytics: Principles and Techniques for the Professional Data Analyst” , ISBN: 978-1-118-72796-6
2. P. Kaliraj, T. Devi, “Big Data Applications in Industry 4.0”, ISBN 9781032008110, Published February 10, 2022 by Auerbach Publications
3. Mahir Oner, Sultan Ceren Oner, “Data Analytics in Industry 4.0: In the Perspective of Big Data”.

Reference Books:

1. Gareth James, Daniela Witten, Trevor Hastie Robert Tibshirani. “An Introduction to Statistical Learning with Applications in R”
2. Joel Grus, “Data science from scratch”, Orielly publication, ISBN: 9781492041139, May 2019
3. David Roi Hardoon, Galit Shmueli, “Getting Started with Business Analytics: Insightful Decision-Making”, CRC Press, ISBN 9781498787413
4. James R Evans, “Business Analytics”, Pearson publication, ISBN: 9780135231678