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शिवाजी विद्यापीठ, कोल्हापूर ४१६ ००४, महाराष्ट्र
दूरध्वनी - इपीबीएक्स - २०६०९०००, अभ्यासमंडळे विभाग : ०२३१- २६०९०९४. २६०९४८७
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Estd. 1962
"A++" Accredited by NAAC (2021)
With CGPA 3.52

SU/BOS/Sci & Tech/ 183 **Date: 10/06/2026**

The Principal / Director,
All Concerned Affiliated Colleges / Institutions,
Shivaji University, Kolhapur.

Subject: Regarding revised syllabus of **B. Tech.** degree **Programme (Affiliated Colleges)** under the Faculty of Science and Technology as per NEP 2020.

Sir/Madam,

With reference to the subject mentioned above, I am directed to inform you that the university authorities have accepted and granted approval to the revised syllabi, Nature of Question paper and equivalence of B. Tech. degree programme under the Faculty of Science & Technology as per National Education Policy 2020 (NEP 2020).

Sr. No.	B. Tech Course Syllabus	
1	Civil Engineering	Part-III
2	Mechanical Engineering	Part-III
3	Mechanical and Mechatronic Engineering (Additive Manufacturing)	Part-III
4	Electrical Engineering	Part-III
5	Electrical and Computer Engineering	Part-III
6	Electronics and Telecommunication Engineering	Part-III
7	Electronics & Computer Science Engineering	Part-III
8	Computer Science and Engineering	Part-III
9	Computer Science and Engineering (Artificial Intelligence & Machine Learning) (AIML)	Part-III
10	Computer Science and Engineering (Data Science) (DS)	Part-III
11	Computer Science and Engineering (Artificial Intelligence & Data Science) (AIDS)	Part-III
12	Electronics and communication Engineering (Bio-Medical Engineering)	Part-II

This Syllabus, nature of question and equivalence shall be implemented from the academic year **2026-27** onwards. A soft copy containing the syllabus is attached herewith and it is available on university website **www.unishivaji.ac.in>Syllabus>Syllabus as per NEP-2020.**

The question papers on the pre-revised syllabi of above-mentioned course will be set for the examinations to be held in October/ November 2026 & March / April 2027. These chances are available for repeater students, if any

You are, therefore, requested to bring this to the notice of all students and teachers concerned.

Thanking you,

Yours faithfully,

Dy. Registrar

Copy to: for Information and necessary action

1	The I/c Dean, Faculty of Science & Technology	7	Appointment A & B Section
2	Director, Board of Examinations & Evaluation	8	Affiliation (T.1) (T.2) Section
3	The Chairperson, Respective Board of Studies	9	P.G.Admission Section,
4	Other Exam 4 Section,	10	P.G Seminar Section
5	Eligibility Section,	11	Computer Centre/ IT Cell
6	Internal Quality Assurance Cell (IQAC)		

Shivaji University Kolhapur

Revised Syllabus as per
National Education Policy -2020

T. Y. B. Tech.

Mechanical and Mechatronics Engineering

(Additive Manufacturing)

To be implemented from

Academic Year 2026-27

SHIVAJI UNIVERSITY, KOLHAPUR

NANE OF FACULTY: SCIENCE AND TECHNOLOGY

PROGRAMME NAME AND CODE: MECHANICAL AND MECHTRONICS ENGINEERING (ADDITIVE MANUFACTURING)

PART: THREE

1	**YEAR OF IMPLEMENTATION**	2026-27
2	**PREANMBLE**	Page No.02
3	**PROGRAMME LEARNING OUTCOMES (PLOs)**	Page No.03
4	**COURSE OUTCOMES (COs)**	Before the syllabus of respective course
5	**PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)**	Page No.04
6	**DURATION OF THE PROGRAMME / COURSE**	Four Year / One Semester
7	**MEDIUM OF INSTRUCTION**	English
8	**ELIGIBILITY FOR ADMISSION**	Page No.05,06
9	**SCHEME OF TEACHING AND EXAMINATION PATTERN (Theory/Practical/Internal)**	Before the syllabus of respective course
10	**EQUIVALENCE OF THE PAPERS**	Not Applicable
11	**STRUCTURE OF PROGRAMME**	Before the syllabus of respective Semester
12	**STANDARD OF PASSING AND DETERMINATION OF SGPA/CGPA, GRADING AND DECLARATION OF RESULT**	Page No.07,08,09
13	**NATURE OF QUESTION PAPER, DURATION AND SCHEME OF MARKING**	Page No.10
14	**SYLLABUS:** **COURSE TITLE, CODE, CREDITS, VERTICAL NAME REFERENCES etc.**	Mentioned in the Syllabus

Preamble

The curriculum of Third Year B. Tech. Mechanical and Mechatronics Engineering (Additive Manufacturing) is designed to provide students with comprehensive knowledge of core Mechanical Engineering principles along with Mechatronics exposure to modern technologies and industrial practices. The syllabus aims to develop technically competent, innovative, and industry-ready engineers capable of addressing real-world engineering challenges in manufacturing, thermal systems, design, automation, maintenance, and energy sectors.

The programme emphasizes a strong foundation in subjects such as Design of Machine Elements, Fluid Mechanics and Machinery, Industrial Fluid Power, Metrology and Quality Control, Mechanical System Design, and Thermal Engineering. These subjects help students to understand the principles of Machine Design, Manufacturing Processes, Fluid Systems, Quality Assurance, and Energy Conversion techniques essential for modern engineering applications. Laboratory work and practical sessions are incorporated to strengthen experimental skills, analytical abilities, and hands-on learning.

In view of rapid technological advancements and Industry 4.0 requirements, the syllabus also integrates emerging areas such as Artificial Intelligence (AI), Machine Learning (ML), Computational Fluid Dynamics (CFD), Additive Manufacturing, Failure Analysis, Smart Maintenance Systems, and Total Productive Maintenance. This multidisciplinary approach enables students to apply data-driven techniques, simulation tools, intelligent monitoring systems, and optimization methods for solving complex engineering problems efficiently.

The curriculum promotes Outcome-Based Education (OBE) by focusing on critical thinking, problem-solving, teamwork, communication skills, professional ethics, and lifelong learning. Through assignments, seminars, mini-projects, industrial visits, internships, and project-based learning, students gain practical exposure to industrial environments and develop the ability to work effectively in multidisciplinary teams.

The programme also encourages innovation, research orientation, entrepreneurship, and sustainable engineering practices. Students are trained to design efficient systems, improve productivity, reduce energy consumption, and adopt environmentally responsible engineering solutions. The elective courses and skill-oriented courses provide flexibility for students to explore specialized domains according to their interests and career goals.

Overall, the syllabus is structured to bridge the gap between academic learning and industrial requirements by nurturing technically skilled, socially responsible, and globally competent Mechanical and Mechatronics engineers prepared for higher education, research, entrepreneurship, and professional careers in diverse engineering industries.

Program Learning Outcomes (PLOs) / Program Outcomes (POs)

- **PO1: Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
- **PO2: Problem Analysis:** Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
- **PO3: Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
- **PO4: Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis and interpretation of data to provide valid conclusions. (WK8).
- **PO5: Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
- **PO6: The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
- **PO7: Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national and international laws. (WK9)
- **PO8: Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
- **PO9: Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
- **PO10: Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.
- **PO11: Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

Program Educational Objectives (PEOs)

1. **Professional Competence and Technical Expertise**
   Graduates will apply the principles of mechanical, mechatronics, automation, CAD/CAM, robotics, and additive manufacturing engineering to solve industrial and societal problems effectively.

2. **Professionalism, Innovation, and Leadership**
   Graduates will demonstrate professional ethics, teamwork, communication, leadership, entrepreneurial abilities, and innovative thinking in multidisciplinary engineering environments.

3. **Lifelong Learning and Sustainable Development**
   Graduates will engage in lifelong learning, research, and skill enhancement to adapt to emerging Industry 4.0 technologies and develop sustainable, cost-effective, and environmentally responsible manufacturing solutions.

Eligibility for Admission-

Eligibility for F.Y. B. Tech.

(First Year - Engineering or Technology (4 years duration))

(1) Maharashtra State Candidature Candidate.-

The candidate,-

(i) should be a citizen of India;

(ii) (ii) should have Passed 10+2 examination or its equivalent examination with Physics and Mathematics as compulsory subjects along with Chemistry or Biotechnology or Biology or Technical Vocational subject or Computer Science or Information Technology or Informatics Practices or Agriculture or Engineering Graphics or Business Studies or Electronics or Entrepreneurship and obtained at least forty five per cent marks (at least forty per cent marks, in case of Reserved categories, Economically Weaker Section and Persons with Disability candidates belonging to the Maharashtra State only) in the above subjects taken together and The Candidate should have appeared in all the subjects in PCM MHT-CET 2026 and obtained non zero score in PCM MHT-CET 2026 conducted by the Competent Authority; (There candidates are eligible to apply for all 29 major disciplines declared by AICTE)

Or

(iii) Should have passed 10+2 examination or its equivalent examination with Physics and Chemistry as compulsory subjects along with the Mathematics or Biotechnology or Biology or Technical Vocational subject or Computer Science or Information Technology or Informatics Practices or Agriculture or Engineering Graphics or Business Studies or Electronics or Entrepreneurship as one of the subject and obtained at least forty five per cent marks (at least forty per cent marks, in case of Reserved categories, Economically Weaker Section and Persons with Disability candidates belonging to the Maharashtra State only) in the above subjects taken together and the candidate should have appeared in all the subjects in MHT-CET 2025 and obtained non zero score in Physics, Chemistry and Biology (PCB) MHT-CET 2025 conducted by the Competent Authority is eligible for admission to any of the following Courses under major disciplines declared by concerned Appropriate Authority or All India Council for Technical Education (AICTE), namely:-
(a)Agriculture Engineering; (b)Biotechnology; (c)Food Engineering; (d)Leather Technology; (e)Packaging Technology; (f) Pharmaceutical Engineering; (g)Printing Engineering; (h)Fashion Technology; or (i) Textile Chemistry;

Or

(iv) Should have passed minimum three years Diploma in Engineering and Technology and obtained at least forty five per cent marks (at least forty per cent marks, in case of Reserved categories, Economically Weaker Section and Persons with Disability candidates belonging to the Maharashtra State only) ;

Or

(v) Passed three years Diploma of Vocation (D.Voc.) stream in the same or allied sector;

Eligibility for Direct Second Year B.Tech.

(Direct Second Year (Lateral Entry)- Engineering /Technology (3 Years duration)

The candidate,-
should be a citizen of India;
should have passed minimum three years or two years (Lateral Entry) Diploma Course in Engineering and Technology with at least forty five per cent. marks (at least forty per cent. marks in case of Candidates of Reserved categories, Economically Weaker Section and Persons with Disability category belonging to Maharashtra State) in any branch of Engineering and Technology from an All India Council for Technical Education (AICTE) or Central Government or State Government approved Institution or its equivalent;

Or

should have passed B.Sc. Degree from a University Grants Commission (UGC) or Association of Indian Universities recognized University with at least forty five per cent. marks (at least forty per cent. marks in case of candidates of Reserved categories, Economically Weaker Section and Persons with Disability category belonging to Maharashtra State) and passed HSC or its equivalent examination with Mathematics as a subject;

Or

should have passed three years D.Voc. Stream in the same or allied sector;
and Any other eligibility criteria and requirement declared from time to time by the appropriate authority as defined under the Act.

STANDARD OF PASSING AND DETERMINATION OF SGPA/CGPA, GRADING AND DECLARATION OF RESULTS

Passing criteria:

1. Passing with 40% marks is mandatory in ESE theory. The duration of ESE theory examination will be 02:30 Hrs. For Engineering Graphics subject of F. Y. B. Tech, it will be of 03:00 Hrs. Combined passing marks (MSE+ISE/CA+ESE) for theory course are 40%.
2. MSE will be based on 50% syllabus from beginning (First Three Units).
3. No compulsory passing for MSE.
4. Compulsory passing percentage for ISE/CA of theory and practical is 40%.
5. Compulsory passing percentage for ESE practical / oral examination 40%.
6. Student should clear all first year passing heads before admits to third year and clear all second year passing heads before admits to fourth year.
7. Aggregate of a particular year (both the semesters) shall considered as a separate head of passing for the result of that concerned year and 45 % aggregate score is mandatory. The student not fulfilling this criterion can improve the score of 45% aggregate through appearing in re-examination for maximum of three theory courses.
8. If student fails to improve the score of 45% aggregate through appearing in re-examination then he/she can improve the score of 45% aggregate by re-appearing in subsequent concern odd semesters (3, 5, 7) or concern even semesters (4, 6, 8) ESE of theory course examination in next academic year.

The Semester Grade Point Average (SGPA) shall be calculated for each semester and Cumulative Grade Point Average (CGPA) shall be calculated at the end of all semesters.
The standard of passing shall be in accordance with the following table :

Marks Obtained	**Numerical Grade (Grade Point)**		**CGPA**	**Letter Grade**
Absent	0 (zero)		-	-
0 – 39	0 (zero)		0.0 – 4.99	F (Fail)
40 – 49	5		5.00 – 5.49	C
50 – 59	6		5.50 – 6.49	B
60 – 69	7		6.50 – 7.49	B+
70 – 79	8		7.50 – 8.49	A
80 – 89	9		8.50 – 9.49	A+
90 – 100	10		9.50 – 10.0	O (Outstanding)

Note :
The award of the final Grade for the degree of B. Tech. shall be calculated based on CGPA.

Calculation of SGPA and CGPA:

1. Semester Grade Point Average **(SGPA)**

$$\textbf{SGPA} = \frac{\sum(\text{Course credits} \times \text{Grade points obtained}) \text{ of a Semester}}{\sum(\text{Course credits}) \text{ of respective Semester}}$$

2. Cumulative Grade Point Average **(CGPA)**

$$\textbf{CGPA} = \frac{\sum(\text{Total credits of a Semester} \times \text{SGPA of respective Semester}) \text{ of all Semesters}}{\sum(\text{Total course credits}) \text{ of all Semesters}}$$

1. Marks obtained > = 0.5 shall be rounded off to next higher digit.
2. The SGPA & CGPA shall be rounded off to 2 decimal points.
3. CGPA will be calculated cumulatively from Sem. I to Sem. VIII for regular students and from Sem. III to Sem. VIII for lateral entry students.

Note: An equivalent certificate of CGPA to percentage of marks will be provided to student on candidate's demand after remitting prescribed fees by Shivaji University.

Awards of Grades for Re-Examination:

1. There will be Re-examination for all failure ESE theory/practical courses in a year after even semester immediately the result declaration of ESE and before the commencement of next academic year.
2. A student will apply for re-examination before the last date of such application and will appear for re-examination.
3. In such cases In Semester Examination performance of a student will not be wiped out.
4. The weightage similar to ESE will be given to re-examination.
5. A student who is eligible for re-examination but remains absent for re-examination will be given grade 'Absent'.
6. If the student fails in an odd semesters (1, 3, 5, 7) and/or even semesters (2, 4, 6, 8) in ESE of theory/practical credit course in an academic year shall be allowed to appear for re-examination.
7. There will be ESE examination of theory and practical courses of semester 1, 3, 5 and 7 at the end of odd semester, there will be ESE examination of theory and practical courses of semester 2, 4, 6 and 8 at the end of even semester and there will be re-examination for all ESE theory and practical courses from semester 1 to semester 8 after one month of declaration of result of even semester.

8. If the student fails to clear the ESE of theory/practical course even in re-examination conducted after even semesters (2, 4, 6, 8) in a year, he/she shall have to re-appear in subsequent concern odd semesters (3, 5, 7) or concern even semesters (4, 6, 8) ESE of theory/practical credit course examination in next academic year for the failed ESE of theory/practical credit course examination of concern odd semester or concern even semester that she/he has failed in previous academic year.
9. The candidate can apply for revaluation of photocopy of re-examination for ESE of theory/practical course conducted after even semesters (2, 4, 6, 8).
10. A student will be awarded a grade given in Table of **R. R. B. Tech. 9** depending upon the cumulative marks obtained by him/her in Re-examination.

Shivaji University, Kolhapur

T. Y. B. Tech (NEP2.0 Pattern)

Question Paper Patten

Question Number	Chapter	Marks	Total Marks	Details
Q.No.01	01,02,03	05	15	Solve any 03 out of 04
Q. No. 02	04	05	15	Solve any 03 out of 04
Q. No. 03	05	05	15	Solve any 03 out of 04
Q. No. 04	06	05	15	Solve any 03 out of 04

Q.1 Solve any Three (5*3)=15 Marks
a)
b)
c)
d)
Q.2 Solve any Three (5*3)=15 Marks
a)
b)
c)
d)
Q.3 Solve any Three (5*3)=15 Marks
a)
b)
c)
d)
Q.4 Solve any Three (5*3)=15 Marks
a)
b)
c)
d)

Second Year Exit: Teaching Methodology, Assessment and Evaluation

[I] As per R. R. B. Tech. 12.2 Rule: Award of Degree

If a student passes all the courses of first year, second year and earns the requisite number of credits, the student will become entitled to Undergraduate Diploma (Two years or four semesters) in the programme of his/her major subject. If he/she wants to exit, can exit the programme with UG Diploma certificate. However, for the award of two years UG Diploma Certificate in Major with 88 credits, an additional 8 credits from Exit Courses are required to earn.

[II] Second Year Exit Course:

Methodology 1:

1. The students should complete two online certification courses (NPTEL) related to their programme, each of 3 credits. In addition to this, they will also need to complete 2 credits worth of two Virtual Lab work related to online certification courses. These additional 8 credits earn by students shall be based upon skill based vocational courses or internship/Apprenticeship.

2. The NPTEL courses are likely to be available online and can be completed at the student's own pace. The content will be specific to the student's field of study or programme. The skill based vocational courses shall be analogous to the Baskets/Areas provided by the concerned BoS.

3. The student must complete two virtual lab work that adds 2 credits to simulate practical or experimental learning experiences in a controlled virtual environment.

4. **Examination scheme:** The marks gained from the two NPTEL Courses (3 credits each) are converted to a total of 100 marks. The report for the two Virtual Lab work of 2 credits will be

evaluated for 25 marks. The report should include a detailed write-up and analysis of the virtual lab experiments conducted, encompassing the methodology, results, and conclusions.

5. There may be uncertainty in availability of the NPTEL courses offered by concerned BoS as there is continuous updatation of the NPTEL courses. The students can choose equivalent NPTEL course of the required duration with prior permission from the concerned institute. The concerned institute should communicate to Concerned BoS for their permission. For NPTEL course registration, the students are required to visit to website https://swayam.gov.in and create their account. Log in the account and join the required course and follow the instructions to compete the course. Similarly, for Virual Lab, the students are required to visit to website https://www.vlab.co.in and create their account. Log in the account and join the required lab and follow the instructions to compete the course (need to perform all listed experiments under that Lab). To fulfill the requirement of 06 credits, students can go for two courses each of 12 weeks.

Methodology 2:

1. The students should complete two online certification courses (NPTEL) related to their programme, each carrying 2 credits. In addition to this, they will also need to complete 4 credits worth of two physical internship/Apprenticeship (each of 40 hrs) work from relevant industry. These additional 8 credits earned by the students shall be based upon skill based vocational courses or internship/Apprenticeship.

2. The NPTEL courses are likely to be available online and can be completed at the student's own pace. The content will be specific to the student's field of study/programme. The skill-based vocational courses shall be analogous with the list provided by the concerned BoS.

3. The student should complete two physical internship/Apprenticeship (each of 40 hrs) work from relevant industrial practices that adds 4 credits to simulate practical or experimental learning experiences in a controlled virtual environment.

4. **Examination scheme:** The marks gained from the two NPTEL Courses (2 credits each) are converted to a total of 100 marks. The report for the performed two physical internship/Apprenticeship (each of 40 hrs) work from relevant industrial practices of 4 credits will be evaluated for 25 marks. The report should include a detailed write-up and analysis of two physical internship/Apprenticeship (each of 40 hrs) work along with certificate of internship/Apprenticeship from relevant industrial practices conducted, encompassing the methodology, results, and conclusions.

5. There may be uncertainty in availability of the NPTEL courses offered by concerned BoS as there is continuous updatation of the NPTEL courses. The students can choose equivalent NPTEL course of the required duration with prior permission from the concerned institute. The concerned institute should communicate to Concerned BoS for their permission. For NPTEL course registration, the students are required to visit to website https://swayam.gov.in and create their account. Log in the account and join the required course and follow the instructions to compete the course.

Guidelines for Open Elective Courses: Teaching Methodology, Assessment and Evaluation

Open Elective (OE) courses other than faculty of Science and Technology through Massive Open Online Courses (MOOCs) allowing students to engage with a broad spectrum of ideas and knowledge areas. The OE courses are likely to be available online and can be completed at the student's own pace within a set timeframe. For OE course, students are required to visit to the website https://swayam.gov.in for registration and create an account. Afterward, students should Login the account and join the course assigned by the course coordinator and follow the instructions to compete the course through self-learning mode. Additionally, the respective institution should download the relevant study materials to ensure students have access to them as needed. Minimum 25 students can register for one OE course in the concerned institute. There will be one course coordinator for one OE course. Students need to cover OE Courses of 08 credits. These 08 credits over semesters III to V. OE courses are chosen from faculty other than Faculty of Science and Technology. It is offered in Second and Third year as per Semester wise credit distribution table. Students need to take up the courses of 08 credits over semesters III to V.

1. **For Semester-III,** OE theory course of 3 credits consists of Mid Semester Examination (MSE) of 30 Marks, In Semester Evaluation/Continuous Assessment (ISE/CA) of 10 Marks and End Semester Examination (ESE) of 60 Marks.
2. **For Semester-III,** OE practical lab course of 1 credit consists of In Semester Evaluation/Continuous Assessment (ISE/CA) of 25 Marks

and End Semester Examination-Practical Oral Examination (ESE-POE) of 25 Marks. Course Coordinator assigned by Institute should complete the selected course practical through expert of that course. The lab exercises and demonstrations prepared by concern expert must be aligned with the specific OE course that the students have chosen.

3. **For Semester-IV,** OE theory course of 2 credits consists of Mid Semester Examination (MSE) of 30 Marks, In Semester Evaluation/Continuous Assessment (ISE/CA) of 10 Marks and End Semester Examination (ESE) of 60 Marks.
4. **For Semester-V,** OE theory course of 2 credits consists of Mid Semester Examination (MSE) of 30 Marks, In Semester Evaluation/Continuous Assessment (ISE/CA) of 10 Marks and End Semester Examination (ESE) of 60 Marks.
5. The Mid Semester Examination (MSE) of 30 Marks based on selected OE Course will be conducted by Concerned Departmental Course Coordinator. The course expert of concerned faculty should set question paper of MSE and evaluate the same.
6. Online submitted assignments by students using SWAYAM platform for concerned OE course will be used for In Semester Evaluation/Continuous Assessment (ISE/CA) of 10 Marks by Concerned Departmental Course Coordinator appointed for particular course by Principal of the Institute. Assignments may be of varied in nature for OE course.
7. The ESE of OE courses will be conducted by the University. The setting of question papers for both MSE and ESE, as well as the evaluation of the concerned OE course, should be carried out by the

course expert from the Board of Studies (BoS) of the respective faculty in accordance with the provisions under Panel of Paper Setters, Examiners, and Moderators – Clauses 41(f) and 48(3)(a).

8. MSE will be based on 50% syllabus from beginning (First 50% Weeks).
9. ESE paper setting weightage will be 25% on syllabus covered for MSE (First 50% Weeks) and 75% on remaining syllabus (Last 50% Weeks). The number of optional questions marks in a theory paper shall be 25 to 30 percent of the maximum marks.

Note: One OE course may be floated by the institute for 60 intake.

Open Electives Courses Offered to the students under Faculty of Science and Technology

In line with New Education Policy 2020

(Effective from Academic year 2025-26)

Open Electives

The students need to cover Open Elective Courses (OE) of 08 credits. These 08 credits over semesters III to V.

Semester wise credit distribution table for OE is given below

Sr. No.	Semester	Open Elective	Teaching scheme			Credits
			L	T	P	
01	III	OE-01	3	-	-	3
	III	OE-01 Lab	-	-	2	1
	IV	OE-02	2	-	-	2
02	V	OE-03	2	-	-	2
	Total		**7**	**-**	**2**	**8**

Semester wise baskets of OE from faculty other than Faculty of Science and Technology, Viz. Faculty of Commerce and Management, Faculty of Humanities and Faculty of Interdisciplinary Studies is given below

List of Open Elective Courses might be taken by students under Faculty of Science and Technology

Semester – III

Note: Choose any one course from the below basket of other than faculty in such way that the course with same name should not comes under or taught by major programme or the MDM.

Sr. No.	Name of the Course	Category	Duration (Weeks)	Credit Points	Institute Offering Course	Name of Professor/ Resource person	Link
01	Principles of Economics	Economics	12	03	IIT Madras	Prof. Sabuj Kumar Mandal	https://onlinecourses.nptel.ac.in/noc25_ec15/preview
02	German - I	Humanities and Social Science	12	03	IIT Madras	Prof. Milind Brahme	https://onlinecourses.nptel.ac.in/noc25_hs121/preview
03	Science, Technology and Society	Humanities and Social Science	12	03	IIT Guwahati	Prof. Sambit Mallick	https://onlinecourses.nptel.ac.in/noc25_hs189/preview
04	Environment and Development	Humanities and Social Science	12	03	IIT Guwahati	Prof. Ngamjahao Kipgen	https://onlinecourses.nptel.ac.in/noc25_hs195/preview
05	Logistics & Supply Chain Management	Humanities and Social Science	12	03	IIT Kharagpur	Prof. Vikas Thakur	https://onlinecourses.nptel.ac.in/noc25_hs205/preview
06	Introduction to Film Studies	Humanities and Social Sciences English studies	12	03	IIT Madras	Prof. Aysha Viswamohan	https://onlinecourses.nptel.ac.in/noc25_hs138/preview
07	Entrepreneurship	Management	12	03	IIT Madras	Prof. C Bhaktavatsala Rao	https://onlinecourses.nptel.ac.in/noc25_mg81/preview
08	Managerial Skills for Interpersonal Dynamics	Management	12	03	IIT Roorkee	Prof. Santosh Rangnekar	https://onlinecourses.nptel.ac.in/noc25_mg91/preview
09	Automation in Production Systems and Management	Management	12	03	IIT Kharagpur	Prof. Pradip Kumar Ray	https://onlinecourses.nptel.ac.in/noc25_mg135/preview
10	Numerical Methods for Engineers	Multidisciplinary	12	03	IIT Madras	Prof. Niket Kaisare	https://onlinecourses.nptel.ac.in/noc25_ge59/preview

Semester – IV

Note: Choose any one course from the below basket of other than faculty in such way that the course with same name should not comes under or taught by major programme or the MDM.

Sr. No.	Name of Course	Category	Duration (Weeks)	Credit Points	Institute Offering Course	Name of Professor/ Resource person	Link
01	Indian Business History	Humanities And Social Sciences	08	02	IIT Guwahati	Prof. Vipul Dutta	https://onlinecourses.nptel.ac.in/noc25_hs32/preview
02	Probability and Stochastic for Finance	Economic Sciences	08	02	IIT Kanpur	Prof. Joydeep Dutta	https://onlinecourses.nptel.ac.in/noc25_ma58/preview
03	Enhancing Soft Skills and Personality	Humanities and Social Sciences	08	02	IIT Kanpur	Prof. T. Ravichandran	https://onlinecourses.nptel.ac.in/noc25_hs87/preview
04	Mastering Speaking and Presentations: A case Based Approach	Humanities and Social Sciences	08	02	IIT Kharagpur	Prof. Seema Singh	https://onlinecourses.nptel.ac.in/noc25_hs96/preview
05	The Science of Happiness and Wellbeing	Humanities and Social Sciences	08	02	IIT Kharagpur	Prof. Priyadarshi Patnaik Prof. Manas K Mandal	https://onlinecourses.nptel.ac.in/noc25_hs103/preview
06	Philosophical Foundations Of Social Research	Humanities And Social Sciences	08	02	IIT Guwahati	Prof. Sambit Mallick	https://onlinecourses.nptel.ac.in/noc25_hs63/preview
07	Emotional Intelligence	Humanities and Social Science	08	02	IIT Kharagpur	Prof. Rabindra Kumar Pradhan	https://onlinecourses.nptel.ac.in/noc25_hs16/preview
08	Employment Communication: A Lab based course	Humanities and Social Science	08	02	IIT Kharagpur	Prof. Seema Singh	https://onlinecourses.nptel.ac.in/noc25_hs17/preview
09	Soft Skill Development	Humanities and Social Science	08	02	IIT Kharagpur	Prof. Priyadarshi Patnaik Prof. V. N. Giri Prof. D. Suar	https://onlinecourses.nptel.ac.in/noc25_hs72/preview
10	Social Behavior and the Brain: An Introduction to Social Neuroscience	Humanities and Social Science, Psychology, Neuroscience, Cognitive Science	08	02	IIT Kanpur	Prof. Ark Verma	https://onlinecourses.nptel.ac.in/noc25_hs101/preview
11	Economic Growth And Development	Humanities and Social Sciences	08	02	IIT Guwahati	Prof. Rajshree Bedamatta	https://onlinecourses.nptel.ac.in/noc25_hs11/preview

12	Effective Writing	Humanities and Social Sciences	08	02	IIT Roorkee	Prof. Binod Mishra	https://onlinecourses.nptel.ac.in/noc25_hs14/preview
13	Centre-State Relations in India	Law	08	02	IIT Kharagpur	Prof. Uday Shankar	https://onlinecourses.nptel.ac.in/noc25_lw04/preview
14	Foundation Course in Managerial Economics	Management	08	02	IIT Kharagpur	Prof. Barnali Nag	https://onlinecourses.nptel.ac.in/noc25_mg25/preview
15	International Marketing	Management	08	02	IIT Kharagpur	Prof. Biswarup Ghosh	https://onlinecourses.nptel.ac.in/noc25_mg32/preview
16	Introduction to System Dynamics Modeling	Management	08	02	IIT Bombay	Prof. Jayendran Venkateswaran	https://onlinecourses.nptel.ac.in/noc25_mg37/preview
17	Management of New Products and Services	Management	08	02	IIT Kharagpur	Prof. KBL Srivastava	https://onlinecourses.nptel.ac.in/noc25_mg44/preview
18	Business Forecasting	Management	08	02	IIT Bombay	Prof. Pankaj Dutta	https://onlinecourses.nptel.ac.in/noc25_mg66/preview
19	Yoga and Positive Psychology for Managing Career and Life	Management	08	02	IIT Bombay	Prof. Ashish Pandey	https://onlinecourses.nptel.ac.in/noc25_mg75/preview
20	Roadmap for patent creation	Multidisciplinary	08	02	IIT Kharagpur	Prof. Gouri Gargate	https://onlinecourses.nptel.ac.in/noc25_ge30/preview

Semester – V

Note: Choose any one course from the below basket of other than faculty in such way that the course with same name should not comes under or taught by major programme or the MDM.

Sr. No.	Name of Course	Category	Duration (Weeks)	Credit Points	Institute Offering Course	Name of Professor/ Resource person	Link
01	Enhancing Study Skills	Multidisciplinary	08	02	Indira Gandhi National Open University, New Delhi	Dr. P. Lakshmi; Dr. G. Mythili	https://onlinecourses.swayam2.ac.in/nou25_ge69/preview
02	Community Engagement and Social Responsibility	Multidisciplinary	10	02	Dayalbagh Educational Institute, Agra, Uttar Pradesh	Prof. Akshay Kumar Satsangi	https://onlinecourses.swayam2.ac.in/ugc25_ge10/preview
03	Economic Environment and Business Strategy	Economics	8	02	IIT Kanpur	Prof. Sukumar Vellakkal	https://onlinecourses.nptel.ac.in/noc25_ec16/preview
04	Corporate Social Responsibility	Management	8	02	IIT Kharagpur	Prof. Aradhna Malik	https://onlinecourses.nptel.ac.in/noc25_mg139/preview
05	Soft Skill Development	Humanities and Social Science	8	02	IIT Kharagpur	Prof. Priyadarshi Patnaik, Prof. V. N. Giri, Prof. D. Suar	https://onlinecourses.nptel.ac.in/noc25_hs142/preview
06	Developing Soft Skills and Personality	Humanities and Social Science	8	02	IIT Kanpur	Prof. T Ravichandran	https://onlinecourses.nptel.ac.in/noc25_hs174/preview
07	Introduction to Advanced Cognitive Processes	Humanities and Social Science	8	02	IIT Kanpur	Prof. Ark Verma	https://onlinecourses.nptel.ac.in/noc25_hs177/preview
08	Entrepreneurship and IP Strategy	Humanities and Social Science	8	02	IIT Kharagpur	Prof. Gouri Gargate	https://onlinecourses.nptel.ac.in/noc25_hs213/preview
09	Artificial Intelligence, Law and Justice	Law	8	02	NALSAR University of Law	Prof. Krishna Ravi Srinivas	https://onlinecourses.nptel.ac.in/noc25_lw12/preview
10	Innovation, Business Models and Entrepreneurship	Management	8	02	IIT Roorkee	Prof. Rajat Agrawal Prof. Vinay Sharma	https://onlinecourses.nptel.ac.in/noc25_mg95/preview
11	Organization Development and Change in 21st Century	Management	8	02	IIT Bombay	Prof. Ashish Pandey	https://onlinecourses.nptel.ac.in/noc25_mg103/preview

Guidelines for Multidisciplinary Minor (MDM) Programmes

As per the directives of the Government of Maharashtra, engineering colleges are encouraged to update their curricula in alignment with the guidelines of the National Education Policy (NEP) 2020. As part of this transformative initiative, the 'Minor Programme' has been introduced to promote multidisciplinary learning at the undergraduate level. These programmes are structured to provide students with interdisciplinary knowledge, enhancing their core academic disciplines and preparing them to meet the evolving demands of the global job market.

Minor programmes across various disciplines have been introduced to provide students with the opportunity to explore fields beyond their core B. Tech curriculum. These programmes enable students from specific branches to broaden their knowledge and skill sets. For example, a student pursuing Mechanical Engineering can opt for a Minor in Computer Science and Engineering, thereby acquiring interdisciplinary expertise that enhances both academic depth and professional flexibility. However, students enrolled in the Computer Science and Engineering (CSE) programme are restricted from choosing MDM's in Artificial Intelligence and Data Science, CSE (Data Science), and CSE (Artificial Intelligence and Machine Learning) in order to prevent overlap between the core curriculum of CSE and the content of these minors, ensuring that students gain diverse and non-redundant knowledge through their minor specializations. **(Refer Table: MDM Courses)**

Common guidelines to students:

1. The Multidisciplinary Minor (MDM) must be compulsorily chosen from engineering discipline different from the student's Major engineering programme. Students should take MDM from the list of MDM Offered by Other Departments/Branches/ programmes only. Ex: A Student of Mechanical Engineering should take MDM from other departments/branches/Programmes except MDM offered by Mechanical Engineering Dept. **(Refer Table: MDM Courses)**
2. The entry point for any compulsory MDM programme is the 3rd semester. The required credits for MDM courses must be acquired from the 3rd semester of second year to the final year of UG Programme.
3. A student is required to continue with the selected Minor programme consistently throughout all six semesters.
4. No changes to the selected Minor programme will be permitted under any circumstances.
5. A student may choose only one Minor programme (track), from the list of MDM courses offered by the institute.
6. The allotment of the MDM course will be based on the marks obtained by the student in the first year for Sem-I and Sem-II combinely.
7. The compulsory MDM programme will admit a maximum of 75 students into its minor course, with selection strictly based on first-year academic merit. Preference order for allocating MDM minor will follow the hierarchy: Candidates with no backlogs first, then those with one backlog, followed by those with two backlogs, and so on.

8. All students must complete the Google form provided by the Institute, indicating their preferences to MDM programme within the specified deadline. Students should ensure that they enter their accurate first year marks in the form along with the attachment of marksheets of Sem-I and Sem-II to avoid any discrepancies.

(Refer Table: MDM Courses)

List of S. Y. B. Tech. and T.Y.B.Tech MDM Courses Offered by the Various Programmes under the Faculty of Science and Technology at Shivaji University, Kolhapur

Sr. No.	Name of the Programme (Major) Offering MDM	Name of the corresponding Minor Programme to be offered	Semester	Name of the MDM Course offered by the Major Programme	Teaching scheme			Credits
					L	T	P	
01	Mechanical Engineering	1. Computer Science and Engineering 2. Electronics and Computer Science 3. Computer Science and Engineering (AIML) 4. Civil Engineering 5. Electronics and Telecommunication Engineering 6. Computer Science and Engineering (Data Science) 7. Electrical Engineering 8. Artificial Intelligence & Data Science 9. Electrical and Computer Engineering	III	MDM 01: Thermodynamics	2	-	-	2
			IV	MDM 02: Theory of Machines	2	-	-	2
			V	MDM 03:Heat Power Engineering	3	-	2	4
			VI	MDM 04: Machine Design	2	-	-	2
02	Computer Science and Engineering	1. Mechanical Engineering 2. Civil Engineering 3. Electronics and Telecommunication Engineering 4. Electrical Engineering 5. Mechanical and Mechatronics Engineering (Additive Manufacturing)	III	MDM 01: Data Structures using C	2	-	-	2
			IV	MDM 02: Object Oriented Programming	2	-	-	2
			V	MDM 03: Java Programming	3	-	2	4
			VI	MDM 04: Database Engineering	2	-	-	2

03	Electronics and Computer Science	1. Mechanical Engineering 2. Civil Engineering 3. Electrical Engineering 4. Mechanical and Mechatronics Engineering (Additive Manufacturing)	III	MDM 01: Logic Design	2	-	-	2
			IV	MDM 02: Electronics Measurements	2	-	-	2
			V	MDM 3 : Microprocessor and Microcontroller	3	-	2	4
			VI	MDM 4 : Introduction to IOT	2	-	-	2
04	Computer Science and Engineering (AIML)	1. Mechanical Engineering 2. Civil Engineering 3. Electronics and Telecommunication Engineering 4. Electrical Engineering 5. Mechanical and Mechatronics Engineering (Additive Manufacturing)	III	MDM 01: Object Oriented Programming	2	-	-	2
			IV	MDM 02: Introduction to AI	2	-	-	2
			V	MDM 03: Database Management	3	1	-	4
			VI	MDM 04: Internet of Things	2	-	-	2
05	Civil Engineering	1. Mechanical Engineering 2. Computer Science and Engineering 3. Electronics and Computer Science 4. Computer Science and Engineering (AIML) 5. Electronics and Telecommunication Engineering 6. Computer Science and Engineering (Data Science) 7. Electrical Engineering 8. Artificial Intelligence & Data Science 9. Electrical and Computer Engineering 10. Mechanical and Mechatronics Engineering (Additive Manufacturing)	III	MDM 01: Building Construction	2	-	-	2
			IV	MDM 02: Waste Management	2	-	-	2
			V	MDM 3 : Infrastructure Engineering	3	-	2	4
			VI	MDM 4: Concrete Technology	2	-	-	2

06	Electronics and Telecommunication Engineering	1. Mechanical Engineering 2. Computer Science and Engineering 3. Computer Science and Engineering (AIML) 4. Civil Engineering 5. Computer Science and Engineering (Data Science) 6. Electrical Engineering 7. Artificial Intelligence & Data Science 8. Electrical and Computer Engineering 9. Mechanical and Mechatronics Engineering (Additive Manufacturing)	III	MDM 01: Electronics System	2	-	-	2
			IV	MDM 02: Electronics Measurements	2	-	-	2
			V	MDM-3: Communication Engineering	3	-	2	4
			VI	MDM-4:Mobile Technology	2	-	-	2
07	Computer Science and Engineering (Data Science)	1. Mechanical Engineering 2. Civil Engineering 3. Electronics and Telecommunication Engineering 4. Electrical Engineering 5. Mechanical and Mechatronics Engineering (Additive Manufacturing)	III	MDM 01: C Programming	2	-	-	2
			IV	MDM 02: Python Programming	2	-	-	2
			V	MDM 03:Programming using Java	3	-	2	4
			VI	MDM 4:Database concepts and Design	2	-	-	2
08	Electrical Engineering	1. Mechanical Engineering 2. Computer Science and Engineering 3. Electronics and Computer Science 4. Computer Science and Engineering (AIML) 5. Civil Engineering 6. Electronics and Telecommunication Engineering 7. Computer Science and Engineering (Data Science) 8. Artificial Intelligence & Data Science 9. Mechanical and Mechatronics Engineering (Additive Manufacturing)	III	MDM 01: Introduction to Electrical and Electronics Circuits	2	-	-	2
			IV	MDM 02: Electrical Power System	2	-	-	2
			V	MDM 03:Electrical Machines	3	-	2	4
			VI	MDM 04:Power Electronics and Embedded System	2	-	-	2

09	Artificial Intelligence & Data Science	1. Mechanical Engineering 2. Civil Engineering 3. Electronics and Telecommunication Engineering 4. Electrical Engineering 5. Mechanical and Mechatronics Engineering (Additive Manufacturing)	III	MDM 01: Fundamentals of AI	2	-	-	2
			IV	MDM 02: Python for Data Science	2	-	-	2
			V	MDM 03: Machine Learning	3	-	2	4
			VI	MDM 04: Deep Learning	2	-	-	2
10	Electrical and Computer Engineering	1. Mechanical Engineering 2. Civil Engineering 3. Electronics and Telecommunication Engineering 4. Mechanical and Mechatronics Engineering (Additive Manufacturing)	III	MDM 01: Renewable Energy Sources	2	-	-	2
			IV	MDM 02: Python Programming	2	-	-	2
			V	MDM 03: Operating System	3	-	2	4
			VI	MDM 04: Electrical Design Estimation And Costing	2	-	-	2
11	Mechanical and Mechatronics Engineering (Additive Manufacturing)	1. Computer Science and Engineering 2. Electronics and Computer Science 3. Computer Science and Engineering (AIML) 4. Civil Engineering 5. Electronics and Telecommunication Engineering 6. Computer Science and Engineering (Data Science) 7. Electrical Engineering 8. Artificial Intelligence & Data Science 9. Electrical and Computer Engineering	III	MDM 01: Computer Aided Design (CAD)	2	-	-	2
			IV	MDM 02: Product Design & Development	2	-	-	2
			V	MDM 03: Fundamentals of Design for Product Manufacturing (FDPM)	3	-	2	4
			VI	MDM 04:Ergonomics & Human Factors	2	-	-	2

Third Year Exit: Teaching Methodology, Assessment and Evaluation

[I] As per R. R. B. Tech. 12.3 Rule: Award of Degree

If a student passes all the courses of first year, second year and third year and earns the requisite number of credits, the student will become entitled to three years Bachelor's Degree in Vocational in the faculty of his/her major subject. If he/she wants to exit, can exit the programme with three years Bachelor's Degree in Vocational. However, for the award of three years Bachelor's Degree in Vocational in the faculty of his/her major subject with 132 credits, an additional 8 credits from Exit Courses are required to earn.

[II] Third Year Exit Course:

Methodology 1:

1. The students should complete two online certification courses (NPTEL) related to their programme, each of 3 credits. In addition to this, they will also need to complete 2 credits worth of two Virtual Lab work related to online certification courses. These additional 8 credits earn by students shall be based upon skill based vocational courses or internship/Apprenticeship.
2. The NPTEL courses are likely to be available online and can be completed at the student's own pace. The content will be specific to the student's field of study or programme. The skill based vocational courses shall be analogous to the Baskets/Areas provided by the concerned BoS.

3. The student must complete two virtual lab work that adds 2 credits to simulate practical or experimental learning experiences in a controlled virtual environment.
4. **Examination scheme:** The marks gained from the two NPTEL Courses (3 credits each) are converted to a total of 100 marks. The report for the two Virtual Lab work of 2 credits will be evaluated for 25 marks. The report should include a detailed write-up and analysis of the virtual lab experiments conducted, encompassing the methodology, results, and conclusions.
5. There may be uncertainty in availability of the NPTEL courses offered by concerned BoS as there is continuous updatation of the NPTEL courses. The students can choose equivalent NPTEL course of the required duration with prior permission from the concerned institute. The concerned institute should communicate to Concerned BoS for their permission. For NPTEL course registration, the students are required to visit to website https://swayam.gov.in and create their account. Log in the account and join the required course and follow the instructions to compete the course. Similarly, for Virual Lab, the students are required to visit to website https://www.vlab.co.in and create their account. Log in the account and join the required lab and follow the instructions to compete the course (need to perform all listed experiments under that Lab). To fulfill the requirement of 06 credits, students can go for two courses each of 12 weeks.

Methodology 2:

1. The students should complete two online certification courses (NPTEL) related to their programme, each carrying 2 credits. In addition to this, they will also need to complete 4 credits worth of two physical internship/Apprenticeship (each of 40 hrs) work from relevant industry. These additional 8 credits earned by the students shall be based upon skill based vocational courses or internship/Apprenticeship.
2. The NPTEL courses are likely to be available online and can be completed at the student's own pace. The content will be specific to the student's field of study/programme. The skill-based vocational courses shall be analogous with the list provided by the concerned BoS.
3. The student should complete two physical internship/Apprenticeship (each of 40 hrs) work from relevant industrial practices that adds 4 credits to simulate practical or experimental learning experiences in a controlled virtual environment.
4. **Examination scheme:** The marks gained from the two NPTEL Courses (2 credits each) are converted to a total of 100 marks. The report for the performed two physical internship/Apprenticeship (each of 40 hrs) work from relevant industrial practices of 4 credits will be evaluated for 25 marks. The report should include a detailed write-up and analysis of two physical internship/Apprenticeship (each of 40 hrs) work along with certificate of internship/Apprenticeship from

relevant industrial practices conducted, encompassing the methodology, results, and conclusions.

5. There may be uncertainty in availability of the NPTEL courses offered by concerned BoS as there is continuous updatation of the NPTEL courses. The students can choose equivalent NPTEL course of the required duration with prior permission from the concerned institute. The concerned institute should communicate to Concerned BoS for their permission. For NPTEL course registration, the students are required to visit to website https://swayam.gov.in and create their account. Log in the account and join the required course and follow the instructions to compete the course.

Exit Course for Mechanical Engineering after 2nd Year

<table>
<tr><th colspan="5">Exit option : Award of UG Certificate in Major with 44 credits and an additional 8 credits from following Exit Courses</th></tr>
<tr><th>Sr. No</th><th>Course Code</th><th>Course Title</th><th>Mode</th><th>Credits</th></tr>
<tr><td>1</td><td>ME-EC-0203</td><td>Certificate Course in CNC Operations</td><td rowspan="3">Online NPTEL,MOOCS
To earn 8 credits, the student must complete two NPTEL courses and two virtual labs related to CNC Operations or Computer Aided Drafting.</td><td>8</td></tr>
<tr><td colspan="3">OR</td><td>OR</td></tr>
<tr><td>2</td><td>ME-EC-0204</td><td>Certificate Course in Computer Aided Drafting</td><td>8</td></tr>
</table>

S.Y. Exit Course

To earn 8 credits, the student must complete two NPTEL courses and two virtual labs related to CNC Operations or Computer Aided Drafting

1. Certificate Course in CNC Operations (8)

NPTEL Courses Like

1. An Overview of CNC Machines (3)
2. CNC Machine Tools and Operations (3)
3. CNC of Machine tools and Processes (3)
4. Elements of metal cutting, Machine tools, gear cutting and CNC machining (3)
5. CNC Programming and Operation (3)

Virtual Labs Like

1. Virtual Lab on CNC Machining (IIT Roorkee) (1)
2. Manufacturing Process Virtual Lab (IIT Kanpur) (1)
3. Machine Tools Virtual Lab (IIT Roorkee) (1)
4. Manufacturing Processes –II Virtual Lab (IIT Kanpur) (1)

2. Certificate Course in Computer Aided Drafting (8)

NPTEL Courses Like

1. Engineering Graphics and Design with CAD Tools (3)
2. Computer Aided Design (3)
3. Computer Aided Engineering: Design, Analysis and Manufacturing (3)
4. CAD and Product Design (3)
5. Computer Integrated Manufacturing (3)

Virtual labs Like

1. Engineering Drawing and Computer Graphics (IIT Kharagpur) (1)
2. Engineering Graphics and Design (IIT Delhi) (1)
3. Computer Aided Design and Manufacturing (IIT Delhi) (1)
4. Computer Aided Engineering Design (IIT Kanpur) (1)

Emerging (Specialization) Minor (18 Credits) in Mechanical and Mechatronics Engineering (Additive Manufacturing)

(Advanced Intelligent Robotics Systems)

to be implemented from Academic Year 2026-27

(As per GR NEP-2022(67/23) / Tanshi -2, Dated 04th July 2023)

Year and Semester	Second Year B. Tech - Semester III Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Emerging Minor				
Title of Course	**Basics of Robotics**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	--	--	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic of Mechanical Engineering, Basic of Electrical Engineering

Course Objectives: The objectives of the course are to

1. Introduce fundamental concepts, history and importance of robotics.
2. Understand different types of robots and their applications in various fields.
3. Learn basic robot components like sensors, actuators and controllers.
4. Explain robot structure, configurations and degrees of freedom.
5. Develop basic understanding of robot motion and simple kinematics.
6. Provide exposure to simple robotic systems and their real-world applications.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain basic concepts and importance of robotics	II
CO2	Describe types and applications of robots.	II
CO3	Identify components of robotic systems.	II
CO4	Explain robot configuration and motion basics	II
CO5	Understand simple kinematics concepts.	II
CO6	Apply robotics concepts to simple systems.	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Robotics** • Definition of robot • History and development of robotics • Need and importance of robotics • Laws of robotics • Advantages and limitations of robots	CO 1	07 Hrs
Unit 2	**Types and Applications of Robots** • Types of robots: industrial, mobile, service robots • Robot generations • Applications in industry, healthcare, agriculture • Examples of real-life robotic systems	CO 2	07 Hrs
Unit 3	**Components of Robot** • Basic structure of robot • Sensors (position, proximity, vision) • Actuators (motors, hydraulic, pneumatic) • Controller • Power supply systems	CO 3	07 Hrs
Unit 4	**Robot Configuration and Motion** • Robot anatomy (links and joints) • Types of joints • Degrees of Freedom (DOF) • Work envelope (concept only) • Basic robot configurations (Cartesian, cylindrical, spherical, articulated)	CO 4	07 Hrs
Unit 5	**Basic Kinematics** • Introduction to robot motion • Types of motion (linear, rotational) • Basic concept of forward kinematics. • Simple position and movement examples • Applications in pick-and-place robots	CO 5	07 Hrs
Unit 6	**Industrial Applications of Robotics** • Working of simple robotic systems • Pick and place robot (concept) • Line follower robot (concept) • Industrial robot example • Introduction to basic control concept	CO 6	07 Hrs

Note - The ISE/CA is carried out through the assignments on each topic.

Text Books	
1	**"Introduction to Robotics"**, S. K. Saha, Tata McGraw-Hill Education, 2nd Edition.
2	**"Robotics for Engineers",** Yoram Koren , McGraw-Hill, 1st Edition.
3	**"Industrial Robotics",**Mikell P. Groover, McGraw-Hill Education, 1st Edition.
4	**"Robotics Basics",** Peter Corke, Springer, 2nd Edition.
5	**"Fundamentals of Robotics: Analysis and Control",** Robert J. Schilling, Prentice Hall,1st Edition.

Reference Books	
1	**"Modern Robotics: Mechanics, Planning and Control"**, Kevin M. Lynch, Frank C. Park, Cambridge University Press 1st Edition.
2	**"Introduction to Autonomous Robots"** Nikolaus Correll, Bradley Hayes, et al. MIT Press,1st Edition.
3	**"Springer Handbook of Robotics"** Bruno Siciliano, Oussama Khatib Springer ,2nd Edition
4	**"Robotics: Control, Sensing, Vision and Intelligence"** K. S. Fu, R. C. Gonzalez, C. S. G. Lee McGraw-Hill, 1st Edition
5	**"Robot Modeling and Control"** Mark W. Spong, Seth Hutchinson, M. Vidyasagar ,Wiley 1st Edition

Year and Semester	Second Year B. Tech - Semester IV Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Emerging Minor				
Title of Course	**Fundamentals of Automation**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	--	--	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic Electrical Engineering, Basic Electronics Engineering. Basic Mechanical Engineering
Course Objectives: The objectives of the course are to
1. Introduce basic concepts of automation systems.
2. Understand the role of sensors and actuators.
3. Learn basic control system principles.
4. Provide knowledge of Programmable Logic Controllers (PLC).
5. Develop ability to read simple automation diagrams.
6. Understand industrial applications of automation.

Course Outcomes:		
COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Understand basic concepts of automation.	I
CO2	Identify sensors and actuators used in automation.	II
CO3	Explain open-loop and closed-loop control systems.	III
CO4	Understand basics of Programmable Logic Controllers (PLC).	I
CO5	Draw simple automation circuits and diagrams.	V
CO6	Know the importance of automation in industry.	I

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Introduction to Automation** Definition and need of automation Types of automation (Fixed, Programmable, Flexible) Advantages and limitations Applications in industry	**CO1**	**08Hrs**
Unit 2	**Sensors and Actuators** Definition and types of sensors Working of basic sensors (temperature, pressure, proximity) Actuators: types (electric, hydraulic, pneumatic) Applications of sensors and actuators	**CO2**	**06 Hrs**
Unit 3	**Control Systems** Basic concepts of control systems Open-loop and closed-loop systems Examples and comparison Block diagram representation	**CO3**	**06 Hrs**
Unit 4	**Basics of Programmable Logic Controllers (PLCs)** Introduction to PLC Components of PLC (CPU, memory, I/O modules) Working principle Applications of PLC	**CO4**	**08 Hrs**
Unit 5	**Automation Circuits and Logic** Basics of logic gates (AND, OR, NOT) Truth tables Ladder diagrams Simple control circuits	**CO5**	**06 Hrs**
Unit 6	**Industrial Automation Applications** Introduction to industrial automation systems Basics of robotics Automated manufacturing systems Advantages of automation in industry	**CO3**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments/Case study on each unit.

Text Books	
1	—**Industrial Automation**‖Vikalp Joshi
2	—**Industrial Automation from Scratch**‖ Olushola Akande
3	—**Industrial Process Automation Systems** B.R. Mehta and Y. Jaganmohan Reddy
4	—**Lessons in Industrial Instrumentation**‖ Tony R. Kuphaldt
5	—**Industrial Automation and Robotics: Techniques and Applications** Kaushik Kumar and B. Sridhar Babu

Reference Books	
1	— **Fundamentals of Industrial Automation** Sree Raj M. Rajkumar and Easwarapillai
2	—**Introduction to Industrial Automation** Stamatios Manesis and George Nikolakopoulos
3	—**Industrial Process Automation Systems** B.R. Mehta and Y. Jaganmohan Reddy
4	—**Industrial Automation from Scratch** Olushola Akande
5	—**Instrumentation Reference Book** Walt Boyes

Year and Semester	Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Emerging Minor				
Title of Course	**Collaborative Robotics**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	--	--	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basics of Robotics, Manufacturing Processes, Mechatronics fundamentals, Sensors and Actuators basics

Course Objectives: The objectives of the course are to

1. Introduce fundamentals of collaborative robotics and human–robot interaction.
2. Understand force-limited and vision-based collaborative robots.
3. Study safety standards and development strategies in SMEs.
4. Learn hand-guiding and intuitive robot programming methods.
5. Understand flexible manufacturing using cobots.
6. Analyze real industrial applications of collaborative robots.

Course Outcomes:

COs	At the end of this course, student will be able to	**Blooms Taxonomy Level**
CO1	Understand fundamentals of collaborative robots and applications	II
CO2	Explain safe human–robot interaction principles	II
CO3	Analyze force-limited and vision-based cobots	II
CO4	Deploy cobots in SMEs and flexible manufacturing systems	II
CO5	Demonstrate hand-guiding and no-code programming	II
CO6	Evaluate collaborative robotics industrial case studies	III

SYLLABUS

Unit No	Content	Co's	Hours
Unit 1	**Introduction to Collaborative Robotics**		
	Definition and evolution of collaborative robots ,Conventional industrial robots vs collaborative robots ,Characteristics of collaborative robots ,Types of human–robot collaboration , Components of collaborative robot system , Applications in manufacturing and service industries , Advantages and limitations of cobots , Future trends in collaborative robotics.	**CO 1**	**06 Hrs**
Unit 2	**Safe Human–Robot Interaction**		
	Fundamentals of human–robot interaction , Human robot collaboration modes ,Safety standards and regulations ISO 10218 ,ISO/TS 15066 ,Risk assessment techniques , Workspace design for collaborative robots ,Safety sensors and devices , Emergency stop and fail-safe mechanisms ,Ergonomics in collaborative workstations	**CO 2**	**08 Hrs**
Unit 3	**Force-Limited Collaborative Robots**		
	Concept of force-limited robots ,Force and torque sensing principles ,Joint torque sensing vs external sensors , Compliance control techniques , Impedance control and admittance control , Collision detection methods ,Contact detection and reaction strategies , Payload monitoring and adaptive control , Applications of force-controlled cobots ,Industrial case examples	**CO 3**	**06 Hrs**
Unit 4	**Vision-Based Collaborative Robots**		
	Introduction to machine vision ,Vision system components , Camera types for cobots ,2D camera , 3D camera , Depth camera , Lighting techniques Image , , processing basics , Object recognition and localization ,Pick-and-place using vision , Vision-guided assembly operations , AI and deep learning in collaborative robots ,Industrial applications of vision-based cobots.	**CO 4**	**06 Hrs**
Unit 5	**Deployment in SMEs and Flexible Manufacturing**		
	Cobots for small and medium enterprises , Flexible automation concepts , Reconfigurable manufacturing systems **,** Work cell layout design for cobots **,** End effectors and grippers **,** Tool changers and accessories **,** Integration with CNC and conveyor systems , Productivity improvement using cobots **,** ROI and CO'st justification , Case studies in SMEs .	**CO 5**	**06 Hrs**
	Hand-Guiding and No-Code Programming		
Unit 6	Introduction to intuitive robot programming , Lead-through programming , Hand-guiding operation , Teaching by demonstration , Waypoint programming , Graphical programming interface , Block-based programming , No-code and low-code programming tools , Drag-and-drop robot programming Basic applications , Industrial case studies , Future trends in no-code robotics	**CO 6**	**06 Hrs**

Note - The ISE/CA is carried out through the assignments on each topic.

Text Books	
1	Mikell P. Groover - Industrial Robotics: Technology, Programming and Applications - McGraw Hill
2	Peter Corke - Robotics, Vision and Control: Fundamental Algorithms in MATLAB – Springer
3	Saeed B. Niku - Introduction to Robotics: Analysis, Control and Applications – Wiley
4	Frank Lamb - Collaborative Robots - Apress

Reference Books	
1	Bruno Siciliano and Oussama Khatib - Springer Handbook of Robotics – Springer
2	Rajiv Dubey - Introduction to Robotics - Tata McGraw Hill
3	K.S. Fu, R.C. Gonzalez and C.S.G. Lee - Robotics: Control, Sensing, Vision and Intelligence - McGraw Hill
4	Yoram Koren - Robotics for Engineers - McGraw Hill
5	ISO/TS 15066 - Robots and Robotic Devices Collaborative Robot Safety Requirements - ISO Standard

Year and Semester	Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Emerging Minor				
Title of Course	**Robot Operating System (ROS)**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	--	--	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Sensors, Transducers and Actuators

Course Objectives: The objectives of the course are to

1. To introduce basic concepts of robotics and the role of ROS.
2. To understand ROS architecture in a simple and practical manner.
3. To familiarize students with robot components like sensors and actuators.
4. To develop understanding of simulation and visualization tools.
5. To provide basic exposure to simple ROS programming.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain the basic concepts of ROS and its importance in robotics.	II
CO2	Describe ROS architecture, components, and working principles.	II
CO3	Identify and understand sensors and actuators used in ROS-based systems.	II
CO4	Demonstrate basic robot simulation and visualization concepts.	III
CO5	Understand robot navigation and real-world applications of ROS.	II
CO6	Develop simple ROS programs for basic robot operations.	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Basics of Robotics and ROS**		
	• Introduction to Robotics • Types of robots (industrial, mobile, service robots) • Need of ROS in modern robotics • Basic concept of Robot Operating System • Advantages of ROS (modularity, flexibility) • Simple examples of ROS-based robots	**CO 1**	**08 Hrs**
Unit 2	**ROS Architecture**		
	• Basic structure of ROS (simple block diagram approach) • Concept of Nodes (explained with real-life analogy) • Topics (data sharing concept) • Messages (basic idea only) • ROS Master (central coordination concept) • Simple working of ROS system	**CO 2**	**08 Hrs**
Unit 3	**Sensors and Actuators in Robotics**		
	• Introduction to sensors (distance, vision, motion) • Basic sensors used in robots (ultrasonic, IR, camera, IMU) • Actuators (motors, servos) • Role of sensors and actuators in ROS • Simple signal flow: sensor → processing → actuator • Examples from mobile robots and industrial robots	**CO 3**	**08 Hrs**
Unit 4	**Simulation and Visualization**		
	• Need for simulation in robotics • Introduction to simple simulation tools (concept only) • Basic idea of Gazebo (no deep technical details) • Visualization concept using RViz • Robot models (basic introduction to URDF – concept only) • Demonstration examples (mobile robot simulation)	**CO 4**	**08 Hrs**
Unit 5	**Applications of ROS**		
	• ROS in industrial automation • ROS in autonomous vehicles • ROS in drones and service robots • ROS in healthcare and agriculture • Future trends in ROS and robotics	**CO 5**	**05 Hrs**

Unit 6	**Basic ROS Programming**		
	• Introduction to ROS commands (basic idea) • Running simple ROS examples (demo-based learning) • Concept of publisher and subscriber (no deep coding) • Writing a very simple program (Python – basic structure only) • Running and testing simple node	**CO 6**	**05 Hrs**

Note - The ISE/CA is carried out through the Assignments on each unit.

Text Books	
1	Robot Operating System for Beginners – Lentin Joseph
2	Learning ROS for Robotics Programming – Aaron Martinez
3	ROS Basics in 5 Days – The Construct (Learning Material)
4	Introduction to Robotics – S. K. Saha
5	Robotics for Engineers – Yoram Koren

Reference Books	
1	Programming Robots with ROS – Morgan Quigley
2	Modern Robotics – Kevin M. Lynch and Frank Park
3	Springer Handbook of Robotics – Siciliano and Khatib
4	Robotics: Control, Sensing, Vision and Intelligence – K. S. Fu
5	Introduction to Autonomous Robots – Nikolaus Correll

Year and Semester	Final Year B. Tech - Semester VII Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Emerging Minor				
Title of Course	**AI Driven Robotics**			Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	--	--	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic Programming (Python preferred), Sensors & Actuators, Control Systems, and Linear Algebra.

Course Objectives: The objectives of the course are to

1. Understand the integration of Artificial Intelligence with robotic hardware.
2. Study Machine Learning and Deep Learning algorithms for robot perception and decision-making.
3. Analyze computer vision techniques for object recognition and spatial awareness.
4. Learn autonomous navigation, path planning, and SLAM (Simultaneous Localization and Mapping).
5. Explore the Robot Operating System (ROS) as a framework for AI robotics development.

Course Outcomes:

COs	After successful completion of this course, students will be able to:	Blooms Taxonomy Level
CO1	Explain the architecture of AI-driven robotic systems and ML fundamentals.	I, II
CO2	Implement computer vision algorithms for robot sensing and perception.	III, IV
CO3	Develop path planning and navigation strategies for autonomous mobile robots.	III, IV
CO4	Utilize ROS for simulating and controlling intelligent robotic agents.	II, III
CO5	Apply reinforcement learning and deep learning for robot motion control.	III, IV
CO6	Identify emerging applications like Cobots, Swarm robotics, and Industry 4.0.	III, IV

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Introduction to AI in Robotics**		
	Foundations of AI and Robotics integration; Machine Learning basics: Supervised, Unsupervised, and Reinforcement Learning; Mathematical models for robotic intelligence; Robot anatomy for AI.	**CO1**	**07 Hrs**
Unit 2	**Computer Vision & Perception**		
	Image processing fundamentals; Object detection and tracking; Point cloud processing and 3D vision; Sensor fusion (Camera + LiDAR) for environmental awareness.	**CO2**	**07 Hrs**
Unit 3	**Robot Software Frameworks (ROS)**		
	Introduction to Robot Operating System (ROS); Nodes, Topics, Services, and Messages; Simulation environments (Gazebo, Webots); Integrating Python-based AI models with ROS.	**CO3**	**07 Hrs**
Unit 4	**Autonomous Navigation & Path Planning**		
	Classical path planning (A*, Dijkstra, RRT); SLAM (Simultaneous Localization and Mapping); Obstacle avoidance and trajectory generation; Probabilistic robotics and Kalman Filters.	**CO4**	**07 Hrs**
Unit 5	**Deep Learning for Motion Control**		
	Neural networks for robot kinematics and dynamics; Deep Reinforcement Learning for dexterous manipulation; Behavioral cloning and Imitation learning in robotics.	**CO5**	**07 Hrs**
	Applications of AI-Driven Robotics		
Unit 6	Collaborative Robots (Cobots); Swarm Robotics; Digital Twins in manufacturing; AI in Additive Manufacturing; Ethics and Safety in AI-driven robotics.	**CO6**	**07 Hrs**

Note - The ISE/CA is carried out through the Assignment on each unit.

Text Books	
1	Joseph, L., 1st Edition, Robot Operating System (ROS) for Absolute Beginners, Apress, New York.
2	Choset, H., Lynch, K.M., Hutchinson, S., Kantor, G., Burgard, W., Kavraki, L.E. and Thrun, S., 1st Edition, Principles of Robot Motion: Theory, Algorithms, and Implementation, MIT Press, Cambridge.
3	Murphy, R.R., 2nd Edition, Introduction to AI Robotics, MIT Press, Cambridge.
4	Siciliano, B. and Khatib, O. (Eds.), 2nd Edition, Springer Handbook of Robotics, Springer-Verlag, Berlin.
5	Niku, S.B., 3rd Edition, Introduction to Robotics: Analysis, Control, Applications, John Wiley and Sons, Hoboken.

Reference Books	
1	Russell, S. and Norvig, P., 4th Edition, Artificial Intelligence: A Modern Approach, Pearson Education, London.
2	Siegwart, R., Nourbakhsh, I.R. and Scaramuzza, D., 2nd Edition, Introduction to Autonomous Mobile Robots, MIT Press, Cambridge.
3	Corke, P., 3rd Edition, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer International Publishing, Cham.
4	Thrun, S., Burgard, W. and Fox, D., 1st Edition, Probabilistic Robotics, MIT Press, Cambridge.
5	Govers, F.X., 2nd Edition, Artificial Intelligence for Robotics, Packt Publishing Limited, Birmingham.

Year and Semester	Final Year B. Tech - Semester VIII Mechanical and Mechatronics Engineering (Additive Manufacturing)				
Course Category	Emerging Minor				
Title of Course	**Humanoid Robots**			Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	--	--	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30	10	60	100	

Prerequisites: Basic understanding of science, simple mechanics, and general awareness of how Machines and technology work.

Course Objectives: The objectives of the course are to

1. Understand what humanoid robots are and where they are used.
2. Learn about the body parts and materials of humanoid robots.
3. Know how humanoid robots sense their environment.
4. Understand how humanoid robots move and walk.
5. Understand how robots think, decide, and interact with humans.
6. Learn about the future of humanoid robots, their ethical issues, and career opportunities in a simple way.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Students will be able to explain humanoid robots and give examples of their uses.	II
CO2	Students will be able to identify robot body parts, joints, and materials.	II
CO3	Students will be able to explain different sensors and how robots sense their surroundings.	II
CO4	Students will be able to describe actuators and show how robots move and walk.	II
CO5	Students will be able to explain basic AI in robots and how they interact with humans.	II
CO6	Students will be able to discuss simple ethical issues, safety, and future trends in humanoid robotics.	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Humanoid Robots** • Definition and concept of humanoid robots • Difference between humanoid and other robots • Brief history and key milestones • Famous robots: ASIMO, Atlas, Sophia, Optimus • Applications: healthcare, industry, disaster response, social interaction	CO1	07Hrs
Unit 2	**Body Structure of Humanoid Robots** • Introduction to humanoid robot body parts (head, torso, arms, legs). • Functions of each body part with simple examples. • Introduction to joints (what is a joint, why it is needed). • Types of joints (rotation, sliding, multi-direction movement). • Concept of Degrees of Freedom (simple idea of how parts move in different ways). • Materials used in robots (metals, plastics, soft materials). • Simple real-life examples.	CO2	07Hrs
Unit 3	**Sensing and Perception** • Introduction to sensors and their importance. • Camera (vision) sensors – how robots see. • Touch and sound sensors – how robots feel and hear. • Distance (proximity) sensors – how robots detect nearby objects. • Balance sensors – how robots stay stable. • Using multiple sensors together (sensor fusion – simple idea). • Simple real-life examples.	CO3	07Hrs
Unit 4	**Actuation and Movement** • Introduction to actuation (robot movement like human muscles). • Electric motors – simple idea and use. • Hydraulic and pneumatic systems – basic understanding. • How robots walk (basic balance concept). • Walking steps (simple gait cycle explanation). • Other movements (arms, hands, running, climbing). • Power sources with simple examples	CO4	07Hrs

Unit 5	**Intelligence and Human-Robot Interaction**		
	• Introduction to robot control system. • Basics of Artificial Intelligence (AI). • Machine learning – simple idea of learning from experience. • Speech recognition – how robots understand voice. • Face and gesture recognition. • Autonomous vs remote-controlled robots. • simple real-life examples.	**CO5**	**07Hrs**
Unit 6	**Future Trends, Ethics and Challenges**		
	• Introduction to current humanoid robots. • Future trends in robotics (simple ideas). • Ethical issues (job loss, privacy, human feelings). • Safety in robots (basic safety ideas). • Rules and laws for robots. • Career opportunities in robotics. • Real-life examples.	**CO6**	**07Hrs**

Note - The ISE/CA is carried out through six Assignments based on six units

Text Books	
1	Introduction to Robotics by S. K. Saha Publication: McGraw Hill Education India, 2017 ISBN: 978-9332902800.
2	Automation and Robotics by Khushdeep Goyal and Deepak Bhandari Publication: S. K. Kataria and Sons, 2024 ISBN: 978-93-5014-246-2.
3	Foundations of Robotics and Automation (Theory and Practice) by Indian Authors (Khanna Publication Team) Publication: Khanna Publishing House, 2025 ISBN: 978-93-55388-00-1
4	Robotics Simplified by Dr. Jisu Elsa Jacob and Manjunath N Publication: BPB Publications, 2022 ISBN: 978-9391030261.
5	Robots and Robotics by M. R. Chidambara Publication: National Book Trust India, 2022 ISBN: 978-8123709147.
6	Foundations of Robotics and Automation **(**Theory and Practice**)** by Khanna Publishing Authors Publication: Khanna Publishing House, 2025 ISBN: 978-9355388001

Reference Books	
1	Control Systems Engineering by I. J. Nagrath and M. Gopal Publication: New Age International Publishers, 2018 ISBN: 978-8122435968.
2	Artificial Intelligence by S. Kaushik Publication: Cengage Learning India, 2011 ISBN: 978-8131510991.
3	Robotics Technology and Flexible Automation by S. R. Deb Publication: McGraw Hill Education India, 2009 ISBN: 978-0070077911.
4	Robotics: Fundamental Concepts and Analysis by Ashitava Ghosal Publication: Oxford University Press India, 2006 ISBN: 978-0195673913

Design Thinking Course: Teaching Methodology, Assessment, and Evaluation

- The Non Credit Course under Design Thinking Category is offered to the students in Fifth or Sixth Semester through Massive Open Online Courses (MOOCs), and students may select a course from the following list or relevant course available on the respective online platform at that time. The course should have duration of not less than 4 weeks and not more than 6 weeks with minimum of 20 lectures and maximum of 30 lectures.
- The course is learned in online mode and can be completed by the student at their own pace within the prescribed duration.
- For enrollment, students are required to visit the SWAYAM or Coursera platform, register, and create their individual accounts.
- After successful registration, students must log in to their accounts, enroll in the course, and follow all instructions provided to complete the course.
- A Departmental Course Coordinator shall be appointed for the respective course.
- Students must submit all weekly assignments available on the respective platform, or those assigned by the Course Coordinator with prior approval from the respective Course Coordinator for assessment and evaluation.
- The Institute shall issue a Course Completion Certificate to students only after fulfilment of the following requirement:

    - Successful Completion and submission of 100% of the weekly assignments.

- Students are expected to adhere to all course guidelines and complete the course within the stipulated timeframe specified on the respective platform or by the Course Coordinator.

Online Platform- Swayam

1] Course Title- Design Thinking

Instructor-

Dr. Rajeshwari Patil, Dr. Manisha Shukla, Dr. Deepali Raheja, Dr. Mansi Kapoor

Sri Balaji University Pune

Course Information-

Welcome to the captivating world of Design Thinking! This online course is designed to introduce you to the essential principles and techniques of Design Thinking—a powerful approach to problem-solving and innovation that has gained widespread recognition across various sectors in today's contemporary era.

In this course, you will discover that Design Thinking is much more than mere thinking. It is a mindset—an innovative and human-centric approach to identifying problems, designing effective solutions, and delivering outcomes that address unmet human needs.

Are you ready to unlock your creative potential and become a visionary leader in the business world? Join us on an exhilarating journey as we dive deep into the transformative power of design thinking through our immersive MOOC course on "Design Thinking."

Prepare to embark on a dynamic adventure where you will explore cutting-edge methodologies, challenge conventional thinking, and develop the essential skills to drive innovation. By participating in this course, you will be equipped with actionable strategies to tackle complex problems, discover untapped opportunities, and create value in today's ever-evolving business landscape.

Get ready to unleash your imagination, collaborate with like-minded individuals, and revolutionize your approach to problem-solving. Enroll now and embrace the boundless possibilities that await you!

This course adopts the Learner-Centric Model approach developed by IIT Bombay while planning, designing, and conducting this MOOC.

Learning Objectives-

This course will help you gain a strong foundation in design thinking principles and equip you with the necessary skills to apply this methodology in your future endeavors. Also, this course will help you to develop a problem-solving mindset and the ability to approach challenges from a human-centered perspective.

Course outline-

Week 0: Welcome to the course

Week 1: Foundation of Design Thinking

Week 2: Empathy-Foundation and Tools of Empathy

Week 3: Define-Foundation and Tools

Week 4: Ideate-Foundation and Tools

Week 5: Prototype & Foundation and Tools

Week 6: Learn From Practitioner

Syllabus-

Week/ Module	Topics
Week 0	• Demo Video • Welcome to the course • Course Schedule ● Grading Policy ● Exam Details ● FAQ
Week 1	**Foundation of Design Thinking** • Introduction to Design Thinking • Significance of Design Thinking • Key Tenets of Design Thinking • Design Thinking Process- 4 Critical Questions • Design Thinking Process • Wicked Problems • How Design Thinking is Different from Traditional Thinking • The Knowledge Funnel • Cognitive Bias: What Design Thinkers Should Avoid
Week 2	**Empathy-Foundation and Tools of Empathy** • Foundation of Empathy • Purpose of empathy • Observation as a tool of empathy • Methods of Observation • Empathetic Interview • Stakeholder maps • Jobs to be done • Empathy Maps
Week 3	**Define- Foundation and tools** • Rules of Defining • Importance of Defining • Customer Journey Map • Customer experience • Persona
Week 4	**Ideate-Foundation and Tools** • Introduction to Ideation • Double Diamond • Brainstorming • Rules for Brainstorming • Mind Mapping • Worst Possible Idea

Week 5	**Prototype -Foundation and Tools** • Concept of Prototyping • Paper prototype • Story Board prototype • Scenario prototype • Low fidelity and high fidelity Test Foundation and Tools • Introduction to Test
Week 6	**Learn from Practitioner** • Interview 1) Mr Rohit Dubepatil - Director ORAH Nutrichem.Pvt.Ltd • Interview 2) Dr Bala Ramadurai • Interview 3) Mr Abhijeet Kumar- Founder StepBeta • Interview 4) Ms Savita Rajiv

Online Platform- Coursera

Course Title- Design Thinking and Innovation

Instructor:

B K Chakravarthy –

IIT Bombay

Syllabus-

Module 1-Innovation by Design:

Introducing the fundamental concepts of design thinking and the 7 Concerns for Innovation. This module will establish the foundation for understanding how design can solve complex problems by focusing on user needs and iterative innovation. Understand the principles of design thinking. Familiarize yourself with the 7 Concerns for Innovation. Recognize the importance of collaboration in the innovation process.

Module 2- The resolve to solve a problem:

Every design project is initiated by a ‗need', which becomes ‗The Cause' of the entire journey that follows. This need may be a commercial requirement, a social necessity or a specific niggling problem with an existing product. The recognition of such a need is a key trigger for the project and it can be identified by any of the stakeholders connected to the product – a product manufacturer or marketer, a user or a product designer.

Module 3- Understanding the problem space:

To study and understand an existing product or similar products in the market, it is critical that the environment in which the product is used, which designers like to call 'The Context' is understood comprehensively. This means that a designer must study the users and their perspectives on the product. Often, this involves several rounds of interaction and observation.

Module 4- Arriving at a Design insight:

At this stage, the designer analyses all the information gathered and methodically lists out their observations and perceptions of any notable issues in the use of the product. Such analysis results in the thorough, all-round 'Comprehension' of the product as it functions within the context of its use. The design insights thus arrived at give rise to creative ideas, and form the basis of the intervention that follows.

Module 5- Creating a product brief:

The Check' is an essential step in understanding what requirements the product should ultimately meet and what problems the design intervention should address. The check, which is often a document in the form of a product brief, is created from the design insights and must be approved by the client. The product brief is an important point of reference throughout the journey as concepts and prototypes are created and evaluated.

Module 6- Generating ideas and concepts:

At this stage called 'The Conception' , designer arrives at multiple ideas to come up with solutions for the problems listed using the product brief. At this crucial stage, ideas are proposed and grouped into clusters. This makes possible the consideration of multiple concepts. Finally, the team zeros in on one all-encompassing concept that best addresses all aspects of the product.

Module 7- Building Mockups and prototypes:

The final concept is further refined with reference to criteria like materials available or desirable, and the conditions in which the product is to be manufactured. At this penultimate stage, the designer creates several style options according to the user profile and selects one that best addresses all the aesthetic concerns. The chosen product design is showcased by 'Crafting' small-scale mock-up models, CAD models, or working prototypes. A final version of the product that meets all conditions in the product brief is then taken up for mass production.

Module 8- Delighting the user:

The last but critically important concern is 'The Connection' the new product makes with the user. This connection or the bond between the user and the product is formed only when the user is satisfied with the product‘s performance and begins to cherish it, which in turn creates an increasing demand for the product. In fact, it is the customer‘s satisfaction that makes a winning project and functions as the most important criterion for innovation.

SCHEME OF INSTRUCTION & SYLLABI

Programme Mechanical & Mechatronics Engineering (Additive Manufacturing)

Scheme of Instructions: Third Year B.Tech. in Mechanical and Mechatronics Engineering (Additive Manufacturing)

Semester – V

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/Wk	Course Credits	EXAM SCHEME			
									MSE	ISE/CA	ESE	TOTAL
1	PCC	MME0251	Machine Design	3	--	--	3	3	30	10	60	100
2	PCC	MME0252	Sensors, Transducers and Actuators	3	--	--	3	3	30	10	60	100
3	PCC	MME0253	Additive Manufacturing	3	--	--	3	3	30	10	60	100
4	PEC	MME0254	PEC - 1	3	--	--	3	3	30	10	60	100
5	MDM	MME0255	Multi-disciplinary Minor-03	3	--	--	3	3	30	10	60	100
6	OE	MME0256	Open Elective-03	2	--	--	2	2	30	10	60	100
7	PCC	MME0257	Sensors Lab	--	--	2	2	1	-	25	25	50
8	PCC	MME0258	Additive Manufacturing Lab	--	--	2	2	1	-	25	25	50
9	PEC	MME0259	PEC – 1 lab	--	--	2	2	1	-	25	--	25
10	MDM	MME02510	Multi-disciplinary Minor-03 Lab	--	--	2	2	1	-	50	--	50
11	EL	MME02511	Minor Project 01	--	--	2	2	1	-	25	--	25
			Total	**17**	**--**	**10**	**27**	**22**	**180**	**210**	**410**	**800**

L- Lecture T-Tutorial P-Practical

MSE- Mid Semester Examination ISE/CA- In Semester Evaluation/Continuous Assessment ESE- End Semester Examination (For Laboratory End Semester performance)

Course Category	Basic Science Courses (BSC)	Engineering Science Courses (ESC)	Programme Core Course (PCC)	Programme Elective Course (PEC)	Open Elective other than particular program (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Humanities Social Science and Management (HSSM)	Experiential Learning (EL)	Co-curricular And Extracurricular Activities (CCA)
Last Sem. Cumulative Sum	**16**	**16**	**25**	**-**	**10**	**07**	**12**	**-**	**02**
Semester Credits	**-**	**-**	**11**	**04**	**06**	**-**	**-**	**01**	**-**
Cumulative Sum	**16**	**16**	**36**	**04**	**16**	**07**	**12**	**02**	**02**

PROGRESSIVE TOTAL CREDITS: 88+22=110

Programme Elective Course-1 (PEC-1) List

Sr. No	Name of Programme Elective Course-1 (PEC-1)
01	Design for Manufacturing and Assembly
02	Computational Fluid Dynamics
03	Advanced Manufacturing Processes
04	Engineering Economics and Costing

Programme Elective Course-1 Lab (PEC-1 Lab) List

Sr. No	Name of Programme Elective Course-1 Lab (PEC-1 Lab)
01	Design for Manufacturing and Assembly Lab
02	Computational Fluid Dynamics Lab
03	Advanced Manufacturing Processes Lab
04	Engineering Economics and Costing Lab

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC)			Course Code: MME0251		
Course Title: **Machine Design**					
Teaching Scheme	L	T	P	Contact Hrs/Week	Credits
	03	--	--	03	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic Mechanical Engineering, Theory of Machine and Analysis of Mechanical Elements

Course Objectives: The objectives of the course are to

1. **Fundamentals of Machine Design:** To understand loads, factor of safety, theories of failure and engineering material selection.
2. **Static Load Design:** Design machine elements such as knuckle joints, levers and power screws under static loading.
3. **Power Transmission Elements:** Design shafts, keys and couplings for safe power transmission.
4. **Fatigue Design:** Apply fluctuating load and fatigue concepts using S–N curves, endurance strength and Goodman criteria.
5. **Rolling Contact Bearings:** Design and select ball and roller bearings based on load, life, speed and reliability.
6. **Sliding Contact Bearings and Tribology:** Understand friction, wear, lubrication and hydrodynamic bearing design.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO 1	**Design Fundamentals:** Explain machine design concepts, types of loads, failure theories and material selection.	II
CO 2	**Static Load Components:** Design basic machine elements like knuckle joints, levers and power screws under static loading.	III
CO 3	**Power Transmission Elements:** Analyze and design shafts, keys and couplings for safe power transmission.	III
CO 4	**Fatigue Analysis:** Analyze components under fluctuating loads using fatigue theories, S–N curves and Goodman criteria.	IV
CO 5	**Rolling Bearings:** Select and design rolling contact bearings considering load, life and reliability.	III
CO 6	**Sliding Bearings & Tribology:** Understand and apply tribological principles in sliding contact and hydrodynamic bearing design.	II

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Fundamentals of Machine Design**		
	Concept of Machine design, Types of loads, Factor of safety- its selection and significance, Theories of failure(Maximum Principle stress, Maximum shear stress and Maximum Distortion Energy), Phases of design of machine elements, Review and selection of various engineering material properties and I.S. coding for ferrous materials, Factors governing selection of Engineering materials.	**CO 1**	**06 Hrs**
Unit 2	**Design of Mechanical Elements**		
	Design of machine elements under static loading- Knuckle joint, Turn buckle and bell crank Lever. (Numerical on Knuckle Joint and Bell crank Lever). Forms of threads, Terminology of threads, Trapezoidal and Acme thread, Design of power screw and nuts, Introduction to Recirculating ball Screw. (Numerical on Power Screw with Square thread).	**CO 2**	**09 Hrs**
Unit 3	**Design of Shaft, Keys, and Couplings**		
	Design of solid and hollow shafts, splined shafts, ASME code for shaft design, Types and Design of Keys, Types of Couplings, Rigid Coupling, flexible bushed pin type flanged coupling.	**CO 3**	**06 Hrs**
Unit 4	**Design for Fluctuating Loads**		
	Stress concentration - causes and remedies, Fluctuating stresses, S-N. diagram under fatigue load, Endurance limit, Notch sensitivity, Endurance strength- modifying factors, Design for finite and infinite life under reversed stresses, Cumulative damage in fatigue failure, Goodman diagram, Modified Goodman diagram, Fatigue design for components under combined stresses such as shafts, Thin pressure vessels, Beams subjected to point loads etc.	**CO 4**	**07 Hrs**
Unit 5	**Design of Rolling Contact Bearings**		
	Rolling Contact Bearing: Types, Static and dynamic load capacities, Steinbeck's equation(No Derivation), Equivalent bearing load, Load-life relationship, Bearing life, Load factor, Selection of bearing from manufactures catalogue, Ball and Roller bearing, Design for variable load and speed, Bearings with probability of survival other than 90 %. Lubrication and mountings, Dismounting and preloading of bearings, Oil seal and packing.	**CO 5**	**07 Hrs**
	Design of Sliding Contact Bearings		
Unit 6	Introduction to Tribological consideration in design friction, Wear, Lubrication. Sliding Contact Bearing: Bearing material and their properties: Sintered bearing materials, bearing types and their construction details. Hydro-Dynamic Lubrication: Basic theory, Thick and thin film lubrication, Reynolds's equation (**No Derivation)**, Sommerfield Number, Design consideration in hydrodynamic bearings, Raimondi and Boyd method relating bearing variables, Heat balance in journal bearings, Temperature rise	**CO 6**	**07 Hrs**

Note - The ISE/CA is carried out through the Term work.

1) Case study of components (include selection of materials for various components showing their IS codes, composition and properties).
2) Design and Drawing of Knuckle joint.

3) Write ASME code for design of shaft with suitable examples.
4) Study of Ball bearing mountings and its selection preloading of bearings.
5) Write a tribological consideration in design of bearing.

Text Books	
1	**"Design of Machine Elements"**, V.B.Bhandari., Tata McGraw Hill Publication, 3rd Edition.
2	**"Machine Design"**, R.K.Jain, Khanna Publication.
3	**"A Textbook of Machine Design"**, R.S. Khurmi and J.K. Gupta, S. Chand Publication.
4	**"Design of Machine Elements"**, V.B. Bhandari, McGraw Hill Education (India) Pvt. Ltd., 4th Edition.
5	**"Design of Machine Elements",** Kamlesh Purohit and C.S. Sharma, PHI Learning Pvt. Ltd.

Reference Books	
1	**"Design of Machine Element"**, J.F. Shigley, Tata McGraw Hill Publication.
2	**"Design of Machine Element"** M.F.Spotts, Pearson Education Publication, 6th Edition.
3	**"Mechanical Engineering Design"**, Joseph E. Shigley, Richard G. Budynas, Tata McGraw Hill Publication.
4	**"Fundamentals of Machine Component Design"**, Robert C. Juvinall and Kurt M. Marshek, Wiley India Pvt. Ltd., 6th Edition
5	**"Machine Design – An Integrated Approach"**, Robert L. Norton, Pearson Education Publication, 5th Edition.

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC)			Course Code: MME0252		
Course Title: **Sensors, Transducers and Actuators**					
Teaching Scheme	L	T	P	Contact Hrs/Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic Electrical Engg, Basic Electronics Engg, Electrical Machine, signal processing

Course Objectives: The objectives of the course are to

- Understand the fundamental principles of sensors, transducers, and actuators used in engineering systems.
- Study various sensing mechanisms for mechanical, thermal, electrical, and optical parameters.
- Analyze static and dynamic characteristics of sensors and transducers.
- Learn signal conditioning techniques and interfacing methods.
- Understand different types of actuators and their applications in automation and control systems.
- Apply sensor and actuator concepts in mechanical and mechatronic system design.

Course Outcomes:

COs	After successful completion of this course, students will be able to:	Blooms Taxonomy Level
CO1	Explain basic concepts, classification, and characteristics of sensors and transducers.	I, II
CO2	Analyze performance parameters and error characteristics of sensors.	III, IV
CO3	Select appropriate sensors for measurement of mechanical and thermal quantities.	III, IV
CO4	Explain working principles of electrical, optical, and smart sensors.	II, III
CO5	Explain working principles of electrical, optical, and smart sensors.	III, IV
CO6	Identify and apply suitable actuators in mechanical and mechatronic systems.	III, IV

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Introduction to Sensors and Transducers**		
	• Definition and classification of sensors and transducers, Active and passive transducers, Primary and secondary transducers • Static characteristics: sensitivity, accuracy, precision, linearity, hysteresis • Dynamic characteristics: time constant, response time, bandwidth • Errors and calibration • Block Diagram and description of Instrumental System • Advantage and Disadvantage and Application of sensor and transducers	CO1	07 Hrs
Unit 2	**Measurement of Mechanical Quantities**		
	• Displacement sensors: Potentiometers, LVDT, RVDT • Strain gauges: working principle, gauge factor, bridge circuits • Force, torque, and pressure sensors • Load cells • Accelerometers and vibration sensors	CO2	07 Hrs
Unit 3	**Thermal and Fluid Sensors**		
	• Temperature sensors: RTD, thermistors, thermocouples • Heat flux and radiation sensors, Bernoulli's Equation • Flow measurement: orifice, turbine, ultrasonic flow sensors, venturi tube • Level sensors: capacitive, ultrasonic, float type, DP cell	CO3	07 Hrs
Unit 4	**Electrical, Optical, and Smart Sensors**		
	• Proximity sensors: inductive, capacitive, photoelectric • Hall effect sensors, Magneto resistive, Magneto transistor, Piezoelectric sensor • Optical sensors and encoders • MEMS sensors • Smart sensors and IOT-based sensors	CO4	07 Hrs
Unit 5	**Signal Conditioning and Data Acquisition**		
	• Signal conditioning: Introduction, Need and function • Wheatstone bridge circuits • Analog to Digital and Digital to Analog converters • Data acquisition systems (DAS): Introduction, Block Diagram and Application • Sensor interfacing with microcontrollers	CO5	07 Hrs

	Actuators		
Unit 6	• Classification of actuators • Electrical actuators: DC motors, stepper motors, servo motors • Pneumatic and hydraulic actuators • Piezoelectric actuators • Shape Memory Alloy (SMA) actuators • Applications in automation and robotics	**CO6**	**07 Hrs**

Note - The ISE/CA is carried out through the Assignment on each unit.

Text Books	
1	Patranabis, D., 2nd Edition, Sensors and Transducers, PHI Learning Private Limited, Delhi.
2	De Silva, C.W., 2nd Edition, Sensors and Actuators: Engineering System Instrumentation, CRC Press, Boca Raton, FL.
3	Sawhney, A.K., 11th Edition, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Co., New Delhi.
4	Nakra, B.C. and Chaudhry, K.K., 4th Edition, Instrumentation, Measurement and Analysis, McGraw-Hill Education (India) Pvt. Ltd., New Delhi.
5	Bentley, J.P., 4th Edition, Principles of Measurement Systems, Pearson Education, London.

Reference Books	
1	Webster, J.G. (Ed.), 3rd Edition, Measurement, Instrumentation, and Sensors Handbook, CRC Press, Boca Raton, FL.
2	Doebelin, E.O., 5th Edition, Measurement Systems: Application and Design, McGraw-Hill, New York.
3	Neubert, H.K.P., 2nd Edition, Instrument Transducers, Oxford University Press, New Delhi.
4	Liptak, B.G., 3rd Edition, Process Measurement and Analysis, Chilton Book Company / CRC Press.
5	Sinclair, I., 3rd Edition, Sensors and Transducers, Elsevier India Pvt. Ltd., New Delhi.

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC)			Course Code:MME0253		
Course Title: **Additive Manufacturing**					
Teaching Scheme	L	T	P	Contact Hrs/Week	Credits
	03	--	--	03	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Computer Aided Design, Basic Mechanical Engineering and Material & Manufacturing Processes

Course Objectives: The objectives of the course are to

1. **Understand AM basics** – Learn principles, history and importance of additive manufacturing.
2. **Know AM technologies –** Identify and differentiate processes like FDM, SLA, SLS and SLM**.**
3. **Learn AM materials** – Study polymers, metals, composites and their selection for AM.
4. **Prepare digital data** – Understand CAD modeling, STL files, slicing and build orientation.
5. **Design for AM** – Apply design principles, optimization and process-specific guidelines.
6. **Explore applications and quality** – Learn industrial uses, post-processing, defects and quality control.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO 1	Understand the basic concepts of Additive Manufacturing, its working principle and its advantages and limitations	II
CO 2	Understand and compare major Additive Manufacturing technologies (FDM, SLA, SLS, SLM).	II
CO 3	Understand and select suitable materials for Additive Manufacturing based on their properties and limitations.	II
CO 4	Understand digital data processing in Additive Manufacturing, including CAD modeling, slicing, and data preparation.	III
CO 5	Understand design principles for Additive Manufacturing, including optimization and process-specific guidelines.	III
CO 6	Understand post-processing, quality control, and applications of Additive Manufacturing.	II

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Introduction to Additive Manufacturing** • Definition, history and evolution of additive manufacturing. • Differences between conventional and additive manufacturing. • Fundamental concept: layer-by-layer fabrication. • Advantages, limitations and industrial relevance.	CO 1	07 Hrs
Unit 2	**Classification of Additive Manufacturing Technologies** • Overview of major additive manufacturing technologies. • Fused Deposition Modeling (FDM) and Stereo Lithography (SLA): principles, materials and applications. • Selective Laser Sintering (SLS) / Selective Laser Melting (SLM): principles, materials and applications. • Comparison of technologies: accuracy, speed, CO'st and material suitability.	CO 2	07 Hrs
Unit 3	**Materials for Additive Manufacturing** • Polymers, metals, composites and ceramics. • Material properties affecting additive manufacturing: mechanical strength, melting point, shrinkage. • Selection criteria for different additive manufacturing processes. • Limitations and challenges in using additive manufacturing materials.	CO 3	07 Hrs
Unit 4	**Digital Data Processing for Additive Manufacturing** • Computer Aided Design (CAD) modeling principles for additive manufacturing • Stereo lithography file creation and pre-processing requirements • Slicing, layer thickness, support structures and build orientation • Common software tools and data preparation workflow	CO 4	07 Hrs
Unit 5	**Design for Additive Manufacturing** • Principles of designing for AM: minimal support, lightweight, complex shapes • Topology optimization and part consolidation • Process-specific design guidelines (FDM, SLA, SLS, SLM) • Limitations and constraints of AM in design	CO 5	07 Hrs
Unit 6	**Post-Processing and Quality in Additive Manufacturing** • Industrial applications: aerospace, automotive, medical and tooling. • Post-processing techniques: heat treatment, surface finishing and support removal. • Common defects and quality control methods. • Economic, environmental, and sustainability aspects.	CO 6	07 Hrs

Note - The ISE/CA is carried out through the assignments on each topic.

Text Books	
1	**"Additive Manufacturing Technology"**, Hari Prasad I, A.V. Suresh, Cengage Learning India Pvt Ltd, **1st Edition**.
2	**"Additive Manufacturing** C.P. Paul, A.N. Jinoop, McGraw Hill Education, **1st Edition**.
3	**"Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing",** Ian Gibson, David W. Rosen, Brent Stucker, Springer, 3rd Edition.
4	**"3D Printing and Additive Manufacturing: Principles and Applications",** Chee Kai Chua, Kah Fai Leong, World Scientific Publishing, 4th Edition.
5	**"Design for Additive Manufacturing",** Martin Baumers, Richard Hague, Peter Reeves, Wiley, 1st Edition.

Reference Books	
1	**"Additive Manufacturing"**, Amit Bandyopadhyay, Susmita Bose, CRC Press, Taylor and Francis Group, 3rd Edition.
2	**"Additive Manufacturing Fundamentals and Advancements",**Manu Srivastava, Sandeep Rathee, CRC Press, Taylor and Francis Group, 1st Edition.
3	**"Additive Manufacturing: Advanced Materials and Design Techniques",** Pulak Mohan Pandey, Nishant Kumar Singh, Yashvir Singh, CRC Press, Taylor and Francis Group, 1st Edition.
4	**"Additive Manufacturing: Applications and Innovations",** J. Paulo Davim, Rupinder Singh, CRC Press, Taylor and Francis Group, 1st Edition.
5	**"A Concise Encyclopedia of Additive Manufacturing",** Sanjay Kumar, Springer, 1st Edition.

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category :Program Elective course			Course Code:MME0254		
Course Title: **PEC-1 (Design for Manufacturing and Assembly (DFMA))**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Analysis of Mechanical Elements, Material and Manufacturing Processes.

Course Objectives: The objectives of the course are to

1. Introduce fundamentals and importance of Design for Manufacturing and Assembly in product development.
2. Understand the effect of manufacturing processes, materials, and tolerances on design.
3. Apply Design for Manufacturing principles for various manufacturing processes.
4. Analyze and evaluate product designs using Design for Assembly techniques.
5. Develop CO‘st-effective, reliable, and sustainable product designs.
6. Redesign existing products using DFMA methodologies.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain principles and need of DFM and DFA.	II
CO2	Analyze manufacturability issues related to materials and processes.	IV
CO3	Apply DFM guidelines in component and product design.	III
CO4	Evaluate designs using DFA methods to reduce assembly time and Cost.	V
CO5	Develop sustainable and economical designs using DFMA tools.	VI
CO6	Redesign existing products for improved manufacturability and assembly.	VI

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to DFMA**		
	• History of DFMA • Product life cycle and role of design • Need for DFMA in modern engineering • Design Cost vs Manufacturing Cost • Concurrent engineering concept • DFMA benefits for engineers	CO 1	06 Hrs
Unit 2	**Design for Manufacturing (DFM)**		

	• Material selection for manufacturability
	• Process selection and capabilities
	• Tolerances, surface finish, and standardization
	• Design guidelines for:
	  • Casting
	  • Forming
	  • Machining
	  • Injection molding
	• Introduction to Design for Additive Manufacturing (DFAM)
			08 Hrs

Unit 3	**Design for Manufacturing (DFM)**		
	• Types of assembly: manual, automated, robotic • DFA principles and reduction of part count • Assembly sequence planning • Fasteners and joining methods • Modular design concept • Design for ease of handling and insertion	CO 3	08 Hrs
Unit 4	**DFMA Analysis and CO'st Estimation**		
	• Boothroyd–Dewhurst DFA method • Assembly time estimation • Assembly efficiency calculation • CO'st estimation techniques • Introduction to DFMA software tools	CO 4	08 Hrs

Unit 5	**DFMA, Sustainability and Product Development**		
	• DFMA in concurrent and lean product development • Design for quality and reliability • Design for ergonomics • Design for environment (DfE) • Design for serviceability and disassembly • Life cycle CO‘st analysis		**06 Hrs**
Unit 6	**Industrial Applications of DFMA**		
	• CO‘st reduction through DFMA • DFMA in electronics, consumer products and automation systems • Sustainable and lean product design concepts • Application of tools like lean manufacturing, six sigma, poke-yoke, TPM, concurrent engineering in the perspective of DFMA.	**CO 6**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments on each unit.

Text Books	
1	Fundamentals of Design and Manufacturing (Pravin Kumar and Ramaswamy / S.K. Kataria)
2	Product Design and Manufacturing (A.K. Chitale and R.C. Gupta / PHI Learning)
3	Fundamentals of Design and Manufacturing, Pravin Kumar, M. Ramaswamy, S.K. Kataria and Sons
4	Engineering Design, George E. Dieter, Linda C. Schmidt, McGraw-Hill Education, 5th Edition
5	Product Design for Manufacture and Assembly, Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, CRC Press,3rd Edition

Reference Books	
1	Lean Manufacturing: Tools, Techniques and How to Use Them, William M. Feld, CRC Press, 1st Edition
2	Product Design and Manufacturing (A.K. Chitale and R.C. Gupta / PHI Learning)
3	Fundamentals of Design and Manufacturing, Pravin Kumar, M. Ramaswamy, S.K. Kataria and Sons
4	Engineering Design: A Systematic Approach, G. Pahl, W. Beitz, Springer, 3rd Edition
5	Design for Manufacturability Handbook, James G. Bralla, McGraw-Hill, 2nd Edition

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective course			Course Code:MME0254		
Title of Course:**PEC-1: Computational Fluid Dynamics (CFD)**					
Teaching Scheme	L	T	P	Contact Hrs/Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Thermal and Fluid Engg, C++ Numerical Methods and Programming Skills

Course Objectives: The objectives of the course are to

- Understand the fundamental concepts of fluid flow and heat transfer governing equations used in CFD.
- Develop knowledge of numerical methods for discretization and solution of fluid flow problems.
- Analyze different grid generation techniques and boundary condition treatments.
- Apply CFD methodologies to solve incompressible and compressible flow problems.
- Interpret CFD results for engineering applications using post-processing tools.
- Prepare students for industrial and research-oriented CFD applications.

Course Outcomes:

COs	**After successful completion of this course, students will be able to:**	**Blooms Taxonomy Level**
CO1	Explain the fundamentals, scope, and applications of Computational Fluid Dynamics.	I,II
CO2	Derive and interpret governing equations for fluid flow and heat transfer.	I,II
CO3	Apply numerical discretization techniques to fluid flow problems.	II,III
CO4	Analyze grid generation methods and boundary condition treatments.	IV,V
CO5	Solve laminar and turbulent flow problems using CFD solution algorithms.	II,III
CO6	Interpret CFD simulation results for real-world engineering applications.	IV,V

Unit No	Content	CO's	Hours
Unit 1	**Introduction to CFD**		
	• Overview and scope of CFD • Advantages and limitations of CFD • Classification of fluid flows • Applications of CFD in engineering • CFD solution procedure • Comparison of CFD with experimental and analytical methods	**CO1**	**04 Hrs**
Unit 2	**Governing Equations of Fluid Flow**		
	• Conservation of mass (Continuity equation) • Conservation of momentum (Navier–Stokes equations) • Conservation of energy, Equation of state • Classification of PDEs (elliptic, parabolic, hyperbolic)	**CO2**	**06 Hrs**
Unit 3	**Discretization Techniques**		
	• Need for discretization • Finite Difference Method (FDM) • Finite Volume Method (FVM) • Finite Element Method (FEM) • Comparison of discretization methods	**CO3**	**04 Hrs**
Unit 4	**Grid Generation and Boundary Conditions**		
	• Types of grids: structured, unstructured, hybrid • Grid quality and grid independence study • Boundary conditions: inlet, outlet, wall, symmetry • Initial conditions • Stability, convergence, and error analysis	**CO4**	**06 Hrs**
Unit 5	**Solution of Flow Problems**		
	• Solution algorithms: SIMPLE, SIMPLER, PISO • Pressure–velocity coupling • Laminar and turbulent flow modeling • Introduction to turbulence models (k–ε, k–ω) • Compressible and incompressible flows	**CO5**	**04 Hrs**
Unit 6	**Post-Processing and Applications**		
	• Residual monitoring and convergence criteria • Visualization techniques: contours, vectors, streamlines • Interpretation of CFD results • Case studies: internal and external flows • Industrial applications of CFD • Introduction to commercial CFD software (ANSYS Fluent / Open FOAM – theory only)	**CO6**	**06 Hrs**

Note - The ISE/CA is carried out through the Assigenment on each unit.

Text Books	
1	**Versteeg, H.K., and Malalasekera, W., 2nd Edition**, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education Limited, 2007, ISBN: 978-0131274983
2	**Anderson, J.D., 2nd Edition, Computational Fluid Dynamics:** The Basics with Applications, McGraw-Hill Education, New York, 1995, ISBN: 978-0070016859
3	**Muralidhar, K., and Sundararajan, T., 2nd Edition,** Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003, ISBN: 978-8173195213
4	**Ghoshdastidar, P.S., Computational Methods in Heat and Fluid Flow,** Tata McGraw-Hill Education, New Delhi, ISBN: 978-0074635049
5	**Patankar, S.V.,** ***Numerical Heat Transfer and Fluid Flow***, Hemisphere Publishing Corporation, 1980, ISBN: 978-0891165224
Reference Books	
1	**Ferziger, J.H., and Perić, M., 3rd Edition, Computational Methods for Fluid Dynamics,** Springer, 2002, ISBN: 978-3540420743
2	**Chung, T.J., 2nd Edition, Computational Fluid Dynamics,** Cambridge University Press, 2010, ISBN: 978-0521769693
3	**Hirsch, C., Numerical Computation of Internal and External Flows,** Butterworth-Heinemann, 2007, ISBN: 978-0750665940
4	**Fletcher, C.A.J., Computational Techniques for Fluid Dynamics,** Springer, 1991, ISBN: 978-3540522522
5	**Tannehill, J.C., Anderson, D.A., and Pletcher, R.H., 2nd Edition,** Computational Fluid Mechanics and Heat Transfer, Taylor and Francis, 1997, ISBN: 978-1560320463

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category : Program Elective Course			Course Code:MME0254		
Course Title: PEC-1:(**Advanced Manufacturing Processes (AMP))**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Material and Manufacturing Processes

Course Objectives: The objectives of the course are to

1. Understand the limitations of conventional manufacturing processes and the need for advanced and non-traditional manufacturing processes.
2. Explain the principles, mechanisms and process parameters of advanced manufacturing processes such as EDM, ECM, LBM, EBM, USM and additive manufacturing.
3. Analyze material removal mechanisms in advanced manufacturing processes and understand their applicability to different materials and industrial requirements.
4. Compare various advanced manufacturing processes in terms of accuracy, surface finish, productivity, Cost, and environmental impact.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain the principles and working mechanisms of various advanced and non-traditional manufacturing processes.	II
CO2	Analyze material removal mechanisms and process parameters involved in advanced manufacturing processes.	IV
CO3	Compare different advanced manufacturing processes based on accuracy, surface finish, productivity, Cost and applications.	IV
CO4	Select appropriate advanced manufacturing processes for specific materials, component geometries and industrial requirements.	III
CO5	Explain chemical and hybrid manufacturing processes for selecting appropriate manufacturing methods in engineering applications.	III
CO6	Explain the fundamentals of Additive Manufacturing	III

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Introduction to Advanced Manufacturing Processes**		
	• Limitations of conventional manufacturing processes need and classification of advanced manufacturing processes. • Mechanical, electrical, chemical, thermal energy based and hybrid processes. • Selection criteria for advanced manufacturing processes. • Applications and advantages	**CO 1**	**05 Hrs**
Unit 2	**Mechanical Energy based Processes**		
	Working principle, tool materials, Process parameters, material removal mechanism, applications, advantages and limitations of • Abrasive Jet Machining (AJM) • Water Jet Machining (WJM) • Ultrasonic Machining (USM)	**CO 2**	**08 Hrs**
Unit 3	**Electrical and Electrochemical Processes**		
	Working principle, tool materials, Process parameters, material removal mechanism, applications, advantages and limitations of • Electrical Discharge Machining (EDM) • Wire- cut EDM (WEDM) • Electrochemical Machining (ECM)	**CO 3**	**08 Hrs**
Unit 4	**Thermal Energy based Processes**		
	Working principle, tool materials, Process parameters, material removal mechanism, applications, advantages and limitations of • Laser Beam Machining (LBM) • Electron Beam Machining (EBM) • Plasma Arc Machining (PAM)	**CO 4**	**08 Hrs**
Unit 5	**Chemical and Hybrid Manufacturing Processes**		
	Working principle, tool materials, Process parameters, material removal mechanism, applications, advantages and limitations of • Chemical Machining (CHM) • Photochemical Machining (PCM) • Hybrid Manufacturing Processes (Concept and examples) • Micro-machining and Nano-manufacturing	**CO 5**	**08 Hrs**

Unit 6	**Additive Manufacturing**		
	• Introduction to Additive Manufacturing. • Additive Manufacturing processes classification. • Materials used in Additive Manufacturing processes. • Advantages, limitations and applications.	**CO 6**	**05 Hrs**

Note - The ISE/CA is carried out through the Assignments/Case study on each unit.

Text Books	
1	Manufacturing Processes – II, P. K. Mishra, P. Ranganathan, Pearson Education
2	Modern Machining Processes, P.K. Mishra, Narosa Publishing
3	Non-Traditional Machining Processes, V.K. Jain, Allied Publishers
4	Unconventional Machining Processes, M. K. Singh, New Age Publishers
5	Advanced Machining Processes, Hassan El-Hofy, McGraw Hill

Reference Books	
1	Advanced Manufacturing Processes, Ian Gibson, David Rosen, Brent Stucker, Springer, 2nd Edition
2	H.S. Shan and P.C. Pandey, Modern Machining Processes, Tata McGraw-Hill
3	Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker, Springer, 3rd Edition
4	Non-Traditional Machining Processes, V.K. Jain, Allied Publishers
5	Unconventional Machining Processes, M. K. Singh, New Age Publishers
6	Advanced Machining Processes, Hassan El-Hofy, McGraw Hill

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course			Course Code:MME0254		
Course Title: PEC-1: **Engineering Economics and Costing**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic mathematics: basic knowledge of Algebra, Percentages, Ratios. Introductory Economics: Demand and Supply, Cost and Revenue.

Course Objectives: The objectives of the course are to

1. Introduce the basic concepts and importance of engineering economics in engineering decision making
2. Understand the concept of time value of money and representation of cash flows.
3. Introduce basic methods used for economic comparison of alternatives.
4. Understand investment appraisal methods used in engineering projects
5. Understand economic evaluation of public and social projects.
6. Introduce Costing concepts and their role in managerial and engineering decisions.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain the role of engineering economics in engineering and industrial decisions.	II
CO2	Apply cash flows and time value of money to real-life problems.	III
CO3	Select suitable alternatives using basic economic comparison methods.	III
CO4	Use simple methods to evaluate engineering investments	III
CO5	Use benefit–Cost concepts to evaluate public projects	III
CO6	Explain Cost behavior and apply Costing concepts in engineering decisions.	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Engineering Economics** • Meaning and scope of engineering economics • Role of economics in engineering and industry • Types of economic decisions in engineering • Micro and macro-economic considerations (basic idea) • Engineering projects and economic feasibility • Ethical and sustainability considerations in economic decisions.	CO1	07 Hrs
Unit 2	**Time Value of Money and Cash Flow Concepts** • Concept of time value of money • Present value and future value (conceptual understanding) • Simple and compound interest (concept only) • Time value equivalence • Cash inflow and cash outflow • Cash flow diagrams and time line representation	CO2	07 Hrs
Unit 3	**Economic Comparison Techniques** • Meaning of economic alternatives • Present worth comparison (conceptual approach) • Future worth comparison • Comparison of alternatives with equal life • Comparison of alternatives with unequal and infinite life • Deferred investment decisions	CO3	07 Hrs
Unit 4	**Investment Decision and Project Evaluation** • Payback period method • Equivalent annual worth method • Rate of return – concept • Internal Rate of Return (IRR) – basic idea • Limitations and misconceptions of IRR • Comparison of investment evaluation methods	CO4	07 Hrs
Unit 5	**Public Project Evaluation and Benefit–Cost Analysis** • Characteristics of public projects • Identification of project costs and benefits • Tangible and intangible benefits • Benefit–cost analysis – concept and application • Cost-effectiveness analysis • Social, environmental and sustainability aspects	CO5	07 Hrs

Unit 6	**Costing, Depreciation and Economic Decision Making** • Meaning and classification of Costs • Fixed Cost and variable Cost • Product Costing and process Costing • Standard Costing – basic idea • Depreciation: meaning, causes and importance • Break-even analysis (conceptual) • Cost control and Cost reduction techniques	**CO6**	**07 Hrs**

Note - The ISE/CA is carried out through six Assignments based on six units

Text Books	
1	Engineering Economics and CO‘sting by N. V. Naidu and T. Krishna Rao Publication: I.K. International Publishing House, 2014 ISBN: 978-9382332835
2	Engineering Economics by R. K. Rajput Publication: Laxmi Publications, 2012 ISBN: 978-8131808146
3	Engineering Economics and Management by K. V. Bhosale and P. K. De Publication: Nirali Prakashan, 2010 ISBN: 978-8190639675
4	Engineering Economics and Accountancy by S. P. Jain and K. L. Narang Publication: Kalyani Publishers, 2013 ISBN: 978-9327245844
5	A Textbook of Engineering Economics by Dr. M. Mahajan Publication: Dhanpat Rai Publications, 2011 ISBN: 978-8187433842

Reference Books	
1	Engineering Economics by R. Panneer selvam Publication: PHI Learning, 2017 ISBN: 978-9352605586
2	Engineering Economics and Management by S. C. Sharma Publication: Khanna Publishers, 2012 ISBN: 978-8174092465
3	Engineering Economics by S. K. Duggal Publication: McGraw Hill Education India, 2010 ISBN: 978-0070681972
4	Engineering Economics and Cost Analysis by K. K. Dhawan Publication: S. Chand Publishing, 2011 ISBN: 978-8121928632
5	Engineering Economics and Project Management by K. K. Chitkara Publication: Tata McGraw Hill, 2010 ISBN: 978-0070145214

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Multidisciplinary Minor			Course Code:MME0255		
Course Title : MDM-03 : **Fundamentals of Design for Product Manufacturing (FDPM)**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Analysis of Mechanical Elements, Material and Manufacturing Processes.

Course Objectives: The objectives of the course are to

1. Introduce basic concepts of product design and DFMA in an easy and application-oriented way.
2. Help students understand how design decisions affect manufacturing, assembly, and CO‘st.
3. Develop the ability to simplify product design for ease of manufacturing and assembly.
4. Provide basic knowledge of materials, processes, and tolerances used in engineering products.
5. Expose students to DFMA applications in electronics, software-integrated products, and consumer devices.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain basic concepts of DFMA and its importance.	II
CO2	Identify design improvements for easier manufacturing and assembly	IV
CO3	Select basic materials and processes for simple product design	III
CO4	Simplify product structures by reducing parts and assembly steps	IV
CO5	Apply basic DFMA tools and guidelines in simple case studies	IV
CO6	Relate DFMA concepts to real-world products in electronics and computing	IV

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to DFMA**		
	• Meaning and importance of DFMA • Product life cycle (simple understanding) • Role of design in product Cost • Need of DFMA in modern industries • Examples from electronics and consumer products	**CO 1**	**06 Hrs**
Unit 2	**Basics of Manufacturing and Materials**		
	• Common materials: metals, plastics, composites (basic idea) • Overview of simple manufacturing processes: Casting, Machining, Molding • Selection of material for simple products • Cost considerations	**CO 2**	**08 Hrs**
Unit 3	**Design for Manufacturing (DFM)**		
	• Concept of manufacturability • Simple design guidelines: Avoid complexity, Use standard parts, Reduce machining operations • Design examples from PCB enclosures, mobile parts, etc. • Introduction to process limitations	**CO 3**	**08 Hrs**
Unit 4	**Design for Assembly (DFA)**		
	• Meaning of assembly efficiency • Reducing number of parts • Easy assembly principles: Symmetry, Standard fasteners, Modular design • Manual vs automated assembly (basic idea) • Case study: simple electronic product	**CO 4**	**08 Hrs**
Unit 5	**Tolerances and Product Quality**		
	• Basic concept of tolerance (very simplified) • Why tolerance is important • Fit and assembly issues • Effect of poor design on product quality • Introduction to error reduction	**CO 5**	**06 Hrs**

Unit 6	**DFMA Applications and Tools** • Introduction to simple tools: Lean concept (waste reduction), Poka-Yoke (mistake proofing) • DFMA in: Electronics products, Computer hardware, Consumer appliances • Cost reduction and sustainability basics	**CO 6**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments on each unit.

Text Books	
1	Boothroyd, G., Dewhurst, P., and Knight, W., Product Design for Manufacture and Assembly, CRC Press, 3rd Edition, 2010, ISBN: 978-1420089271.
2	Anderson, D. M., Design for Manufacturability, Productivity Press, 2nd Edition, 2020, ISBN: 978-1000764963.
3	Chitale, A. K., and Gupta, R. C., Product Design and Manufacturing, PHI Learning Pvt. Ltd., New Delhi.
4	Lal, G. K., Fundamentals of Design and Manufacturing, S. Chand Publications, New Delhi.
5	Otto, K., and Wood, K., Product Design: Techniques in Reverse Engineering and New Product Development, Pearson Education.

Reference Books	
1	Bralla, J. G., Handbook of Product Design for Manufacturing, McGraw Hill Publications.
2	Poli, C., Design for Manufacturing: A Structured Approach, Butterworth-Heinemann Publications.
3	Ulrich, K. T., and Eppinger, S. D., Product Design and Development, McGraw Hill Education.
4	Pahl, G., and Beitz, W., Engineering Design: A Systematic Approach, Springer Publication.
5	Dieter, G. E., Engineering Design, McGraw Hill International Edition.
6	Design for Manufacturability – Concepts, Standards and Methods by David M. Anderson
7	Design for Manufacturing: Strategies, Principles, and Techniques by Corrado Poli, Andrea C. Ranzi

Third Year B. Tech - Semester Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC) Lab			Course Code:MME0257		
Course Title :**Sensors Lab**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25 Marks	25 Marks	50 Marks	

Prerequisites: Basic Electrical Engg., Basic Electronics Engg., Electrical Machine, Signal Processing

Course Objectives: The objectives of the course are to

1. **Understand** the working principles of various sensors and transducers for mechanical, thermal, fluid, and electrical measurements.
2. **Demonstrate** calibration and measurement of physical quantities like displacement, force, torque, pressure, temperature, and flow.
3. **Operate** electrical, pneumatic, hydraulic, and SMA actuators and understand their applications in automation.
4. **Analyze** static and dynamic characteristics of sensors including sensitivity, linearity, hysteresis, response time, and accuracy.
5. **Interface** sensors and actuators with microcontrollers for basic data acquisition and control experiments.
6. **Develop** practical skills in instrumentation, measurement, and signal conditioning to solve real-world engineering problems.

Course Outcomes:

COs	**After completing this practical course, students will be able to:**	**Blooms Taxonomy Level**
CO1	Identify and classify various sensors, transducers, and actuators used in mechanical and mechatronics systems.	I,II
CO2	Measure mechanical quantities like displacement, force, torque, and vibration using appropriate sensors and instruments.	II,III
CO3	Measure thermal and fluid parameters using temperature, flow, and level sensors and interpret results.	II,III
CO4	Demonstrate the use of electrical, optical, Hall effect, and smart sensors for practical applications.	II,III,IV
CO5	Interface sensors and actuators with data acquisition systems and microcontrollers to monitor and control physical processes.	IV,V
CO6	Evaluate the performance of actuators (electrical, pneumatic, hydraulic, SMA) in automation and robotics applications.	V,VI

Unit No.	Content	COs	Hours
1	**Experiment 1: Study of Displacement Sensor** ● Measure displacement using LVDT. ● Observe the linearity and hysteresis of LVDT.	CO1	4
2	**Experiment 2: Strain Gauge and Load Cell Measurement** ● Connect a strain gauge to a Wheatstone bridge. ● Measure applied load and calculate gauge factor.	CO2	4
3	**Experiment 3: Measurement of Force, Torque, and Pressure** ● Measure force using a load cell. ● Measure torque using a torque transducer. ● Measure pressure using a pressure sensor.	CO3	4
4	**Experiment 4: Study Temperature and Flow Sensors** ● Measure temperature using RTD and thermocouple. ● Observe response of thermistor. ● Measure flow using orifice and turbine flow sensors.	CO4	4
5	**Experiment 5: Understand Proximity, Hall Effect, and Optical Sensors** ● Detect object using inductive/capacitive proximity sensors. ● Use Hall effect sensor to measure magnetic field. ● Read position with optical encoder.	CO5	4
6	**Experiment 6: Study of Electrical, Pneumatic, Hydraulic Actuator and Interfacing** ● Operate DC motor, Stepper motor, and Servo motor. ● Demonstrate Pneumatic or Hydraulic actuator operation. ● Observe SMA actuator actuation. ● Interface actuators with microcontroller (optional: Arduino/STM32).	CO6	4

Text Books	
1	**Patranabis, D.,** 2nd Edition, Sensors and Transducers, PHI Learning Private Limited, Delhi.
2	**De Silva, C.W.,** 2nd Edition, Sensors and Actuators: Engineering System Instrumentation, CRC Press, Boca Raton, FL.
3	**Sawhney, A.K.,** 11th Edition, A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Co., New Delhi.
4	**Nakra, B.C. and Chaudhry, K.K.,** 4th Edition, Instrumentation, Measurement and Analysis, McGraw-Hill Education (India) Pvt. Ltd., New Delhi.
5	**Bentley, J.P.,** 4th Edition, Principles of Measurement Systems, Pearson Education, London.

Reference Books	
1	**Webster, J.G. (Ed.),** 3rd Edition, Measurement, Instrumentation, and Sensors Handbook, CRC Press, Boca Raton, FL.
2	**Doebelin, E.O.,** 5th Edition, Measurement Systems: Application and Design, McGraw-Hill, New York.
3	**Neubert, H.K.P.,** 2nd Edition, Instrument Transducers, Oxford University Press, New Delhi.
4	**Liptak, B.G.,** 3rd Edition, Process Measurement and Analysis, Chilton Book Company / CRC Press.
5	**Sinclair, I.,** 3rd Edition, Sensors and Transducers, Elsevier India Pvt. Ltd., New Delhi.

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC) Lab			Course Code:MME0258		
Course Title :**Additive Manufacturing Lab**					
Teaching Scheme	L	T	P	Contact Hrs/Week	Credits
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25 Marks	25 Marks	50 Marks	

Prerequisites: Computer Aided Design, Basic Mechanical Engineering and Material and Manufacturing Processes

Course Objectives: The objectives of the course are to

1. **Understand AM machines** – Learn basic operation and safety of AM equipment..
2. **Create CAD models** – Develop simple 3D models for AM applications.
3. **Prepare print data** – Generate STL files and slicing parameters
4. **Fabricate AM parts** – Print components using AM machines.
5. **Perform post-processing** – Carry out support removal and surface finishing.
6. **Inspect printed parts** – Evaluate quality, accuracy and defects

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	**Operate additive manufacturing machines safely** and explain their basic working.	III
CO2	**Create suitable CAD models** for additive manufacturing applications.	VI
CO3	**Generate STL files and slicing parameters** for AM part fabrication.	III
CO4	**Fabricate components using AM processes** following correct procedures.	III
CO5	**Perform basic post-processing operations** on printed parts.	III
CO6	**Evaluate printed parts** for dimensional accuracy and common defects.	IV

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Additive Manufacturing Machines and Safety:**		
	Study of AM machine components, working principles, and safety practices.	CO 1	04 Hrs
Unit 2	**CAD Modeling for Additive Manufacturing:**		
	Creation of simple 3D CAD models suitable for AM processes.	CO 2	06 Hrs
Unit 3	**STL File Generation and Slicing:**		
	Conversion of CAD models into STL format and preparation of print parameters.	CO 3	06 Hrs
Unit 4	**Fabrication of AM Component:**		
	Printing of a simple component using an additive manufacturing process.	CO 4	04 Hrs
Unit 5	**Post-Processing of Printed Components:**		
	Removal of supports and basic surface finishing operations.	CO 5	04 Hrs
Unit 6	**Inspection of Printed AM Parts:**		
	Measurement of basic dimensions and visual quality check.	CO 6	04 Hrs

Term work:

1. Study of Additive Manufacturing Machine and Safety Practices.
2. CAD Modeling of a Component for Additive Manufacturing
3. STL File Generation and Slicing for Additive Manufacturing.
4. Fabrication of a Component Using Additive Manufacturing Process.
5. Post-Processing of Additively Manufactured Components.
6. Inspection of Additively Manufactured Parts.

Text Books	
1	**"Additive Manufacturing Technology",** Hari Prasad I, A.V. Suresh, Cengage Learning India Pvt Ltd, 1st Edition.
2	**"Additive Manufacturing"** C.P. Paul, A.N. Jinoop, McGraw Hill Education, 1st Edition.
3	**"Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing",** Ian Gibson, David W. Rosen, Brent Stucker, Springer, 3rd Edition.
4	**"3D Printing and Additive Manufacturing: Principles and Applications",** Chee Kai Chua, Kah Fai Leong, World Scientific Publishing, 4th Edition.
5	**"Design for Additive Manufacturing",** Martin Baumers, Richard Hague, Peter Reeves, Wiley, 1st Edition.

Reference Books	
1	**"Additive Manufacturing"**, Amit Bandyopadhyay, Susmita Bose, CRC Press, Taylor and Francis Group, 3rd Edition.
2	**"Additive Manufacturing Fundamentals and Advancements",**Manu Srivastava, Sandeep Rathee, CRC Press, Taylor and Francis Group, 1st Edition.
3	**"Additive Manufacturing: Advanced Materials and Design Techniques",** Pulak Mohan Pandey, Nishant Kumar Singh, Yashvir Singh, CRC Press, Taylor and Francis Group, 1st Edition.
4	**"Additive Manufacturing: Applications and Innovations",** J. Paulo Davim, Rupinder Singh, CRC Press, Taylor and Francis Group, 1st Edition.
5	**"A Concise Encyclopedia of Additive Manufacturing",** Sanjay Kumar, Springer, 1st Edition.

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective course (PEC-1) Lab			Course Code:MME0259		
Course Title :**Design for Manufacturing and Assembly (DFMA) Lab**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25	--	25	

Prerequisites: Analysis of Mechanical Elements, Material and Manufacturing Processes.

Course Objectives: The objectives of the course are to

1. Develop hands-on skills in analyzing product designs for manufacturability and assembly.
2. Enable students to identify and reduce part counts and assembly complexities.
3. Apply tolerance and fit concepts in practical product analysis.
4. Familiarize students with DFMA tools and CAD-based design evaluation.
5. Expose students to industrial case studies and cost-effective design improvements.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Apply DFMA principles to analyze and improve real products.	IV
CO2	Identify and reduce part counts and assembly difficulties in existing designs.	III
CO3	Select appropriate materials and manufacturing processes for improved manufacturability.	III
CO4	Evaluate tolerances, fits and assembly sequences to enhance product quality.	IV
CO5	Utilize DFMA tools and CAD-based methods for practical product redesign.	IV
CO6	Relate practical DFMA applications to industrial case studies for Cost and efficiency improvements.	IV

Unit No.	Content	CO's	Hours
1	**Study of DFMA Principles Using a Simple Product** Understand DFMA concepts and evaluate product life cycle and design Costs.	**CO 1**	4
2	**Tolerance Evaluation and Stack-Up Analysis** Understand functional vs manufacturing tolerances and evaluate their impact on assembly.	**CO 2**	4
3	**Material Selection and Manufacturing Process Mapping** Apply DFM principles to choose suitable materials and manufacturing processes	**CO 3**	4
4	**Product Redesign for Ease of Assembly** Apply DFA principles to redesign a product for simpler assembly.	**CO 4**	4
5	**DFMA Tool Application – Lean / Six Sigma / Poka-Yoke** Use DFMA tools to improve design and process efficiency.	**CO 5**	6
6	**Industrial Case Study Analysis of DFMA** Analyze real-world products for Cost reduction and improved design.	**CO 6**	6

Text Books	
1	Product Design and Manufacturing, Avinash K. Chitale and R.C. Gupta, PHI Learning Pvt. Ltd.
2	Product Design and Development, Karl T. Ulrich, Steven D. Eppinger, McGraw-Hill Education, 7th Edition
3	Product Design for Manufacture and Assembly, Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, CRC Press, 3rd Edition
4	Lean Manufacturing: Tools, Techniques & How to Use Them, B. Kumar / S. Gupta, Oxford Univiersity Press
5	Engineering Design, George E. Dieter, Linda C. Schmidt, McGraw-Hill Education, 5th Edition Year: 2013

Reference Books	
1	Product Design and Manufacturing, Avinash K. Chitale and R.C. Gupta, PHI Learning Pvt. Ltd.
2	Fundamentals of Design and Manufacturing, G.K. Lal, S. Chand Publications
3	Engineering Design and Product Development, P.S. Gill, S.K. Kataria and Sons
4	Lean Manufacturing: Tools, Techniques and How to Use Them, B. Kumar / S. Gupta, Oxford University Press
5	Manufacturing Processes for Engineering Materials, Serope Kalpakjian, Steven Schmid, Pearson Education, 6th Edition

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course -01 (PEC-1) Lab			Course Code:MME0259		
Course Title: **Computational Fluid Dynamics (CFD) Lab**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25 Mraks	--	25 Marks	

Prerequisites: Thermal and Fluid Engg, C++ Numerical Methods and Programming Skills

Course Objectives: The objectives of the course are to

1. **Understand** the CFD software interface, workflow, and basic simulation setup.
2. **Apply** numerical methods to simulate laminar and turbulent fluid flow problems.
3. **Analyze** the effect of grid generation, boundary conditions, and solver parameters on solution accuracy.
4. **Simulate** heat transfer and fluid flow phenomena for practical engineering applications.
5. **Interpret** CFD simulation results using post-processing tools for velocity, pressure, and temperature fields.
6. **Develop** skills to prepare detailed CFD reports and present engineering analysis for industrial applications

Course Outcomes:

COs	**After completing this practical course, students will be able to:**	**Blooms Taxonomy Level**
CO1	Demonstrate proficiency in CFD software for pre-processing, meshing, and solver setup.	I,II
CO2	Perform laminar and turbulent flow simulations and compare numerical results with analytical solutions.	II,III
CO3	Analyze the influence of mesh quality, grid refinement, and boundary conditions on simulation accuracy.	III
CO4	Simulate heat transfer and coupled flow problems for engineering systems	III,IV
CO5	Interpret and visualize CFD results using contours, vectors, streamlines, and plots.	IV,V
CO6	Prepare professional CFD reports and present findings for real-world engineering applications.	IV,V

Unit No.	Content	COs	Hours
1	**Experiment 1: Introduction to CFD Software** Familiarize with CFD software (ANSYS Fluent / Open FOAM) interface. • Learn GUI/command-line operations. • Explore geometry creation, meshing, and solver setup. • Run a simple 2D flow simulation (e.g., flow over a flat plate).	CO1	4
2	**Experiment 2: Mesh/Grid Generation Study** Understand structured and unstructured grid generation. • Create structured and unstructured meshes for simple geometries. • Studies mesh refinement effect on solution accuracy (grid independence study).	CO2	4
3	**Experiment 3: Laminar Flow Simulation** Simulate and analyze 2D laminar flow in a channel or pipe. • Solve incompressible laminar flow. • Plot velocity profiles and compare with analytical solutions.	CO3	4
4	**Experiment 4: Turbulent Flow Simulation** Study turbulence modeling in CFD. • Simulate turbulent flow using k–ε or k–ω models. • Compare velocity and pressure distribution for different turbulence models.	CO4	2
5	**Experiment 5: Heat Transfer Simulation** Analyze conduction and convection problems. • Solve 2D heat conduction in a solid block. • Simulate forced convection in a channel. • Compare numerical results with theoretical/analytical solutions.	CO4, CO5	4
6	**Experiment 6: Flow over a Cylinder / Bluff Body** Study external flow and vortex shedding effects. • Simulate flow over a cylinder at different Reynolds numbers. • Visualize velocity contours, streamlines, and pressure distribution.	CO5, CO6	2
7	**Experiment 7 (Optional): Compressible Flow Simulation** Understand supersonic and subsonic compressible flow behavior. • Simulate compressible flow in a nozzle. • Plot Mach number, pressure, and density distributions.	CO6	4

Text Books:	
1	Versteeg, H.K., and Malalasekera, W., 2nd Edition, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education Limited, 2007, ISBN: 978-0131274983
2	Anderson, J.D., 2nd Edition, Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill Education, New York, 1995, ISBN: 978-0070016859
3	Muralidhar, K., and Sundararajan, T., 2nd Edition, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003, ISBN: 978- 8173195213
4	Ghoshdastidar, P.S., Computational Methods in Heat and Fluid Flow, Tata McGraw-Hill Education, New Delhi, ISBN: 978-0074635049
5	Patankar, S.V., Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980, ISBN: 978-0891165224
Reference Books:	
1	Ferziger, J.H and Perić, M., 3rd Edition, Computational Methods for Fluid Dynamics, Springer, 2002, ISBN: 978-3540420743
2	Chung, T.J., 2nd Edition, Computational Fluid Dynamics, Cambridge University Press, 2010, ISBN: 978-0521769693
3	Hirsch, C., Numerical Computation of Internal and External Flows, Butterworth-Heinemann, 2007, ISBN: 978-0750665940
4	Fletcher, C.A.J., Computational Techniques for Fluid Dynamics, Springer, 1991, ISBN: 978-3540522522
5	Tannehill, J.C., Anderson, D.A., and Pletcher, R.H., 2nd Edition, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis, 1997, ISBN: 978-1560320463

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective course (PEC 1) Lab			Course Code:MME0259		
Course Title :**Advanced Manufacturing Processes Lab**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25 Marks	--	25 Marks	

Prerequisites: Material and Manufacturing Processes

Course Objectives: The objectives of the course are to

1. Understand and explore various advanced manufacturing processes through case studies and demonstrations.
2. Apply simulation and study-based techniques to analyze manufacturing processes where full-scale machines are not available.
3. Examine modern manufacturing technologies including micro-manufacturing and 3D printing for rapid prototyping.
4. Gain practical insights into industrial practices through visits and detailed reports on at least one advanced manufacturing process.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Identify and explain the working principles, applications and limitations of different advanced manufacturing processes.	II
CO2	Perform simulations and analyze case studies to understand process parameters, material removal and accuracy in machining operations.	IV
CO3	Demonstrate knowledge of micro-manufacturing techniques and rapid prototyping using 3D printing.	III
CO4	Evaluate industrial setups and prepare detailed reports, linking theoretical concepts to real-world manufacturing practices.	IV

Unit No.	Content	COs	Hours
1	**Case studies, demonstrations, simulations and study-based activities on any four of the following Advanced Manufacturing Processes (where full-scale machines are not available).**		
1.1	Abrasive Jet Machining (AJM)	**CO 1**	4 Hrs
1.2	Water Jet Machining (WJM)		4 Hrs
1.3	Electrical Discharge Machining (EDM)		4 Hrs
1.4	Wire- cut EDM (WEDM)		4 Hrs
1.5	Laser Beam Machining (LBM)		4 Hrs
1.6	Plasma Arc Machining (PAM)		4 Hrs
1.7	Chemical Machining (CHM)		4 Hrs
2	**Case study on Micro-manufacturing in the Electronics industry.**	**CO 2**	4 Hrs
3	**Case study on 3D printing for rapid prototyping.**	**CO 3**	4 Hrs
4	**Industrial visit and its report to study working of at least any one Advanced Manufacturing Process.**	**CO 4**	4 Hrs

Text Books	
1	Manufacturing Processes – II, P. K. Mishra, P. Ranganathan, Pearson Education
2	Modern Machining Processes, P.K. Mishra, Narosa Publishing
3	Non-Traditional Machining Processes, V.K. Jain, Allied Publishers
4	Unconventional Machining Processes, M. K. Singh, New Age Publishers
5	Advanced Machining Processes, Hassan El-Hofy, McGraw Hill

Reference Books	
1	Advanced Manufacturing Processes, Ian Gibson, David Rosen, Brent Stucker, Springer, 2nd edition
2	H.S. Shan and P.C. Pandey, Modern Machining Processes, Tata McGraw-Hill
3	Modern Machining Processes, P.K. Mishra, Narosa Publishing
4	Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker, Springer, 3rd edition
5	Unconventional Machining Processes, M. K. Singh, New Age Publishers

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective course (PEC)-01 Lab			Course Code:MME0259		
Course Title: **Engineering Economics and Costing Lab**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25 Marks	--	25 Marks	

Prerequisites: Basic understanding of Money, Cost, and Value, Simple Idea of Time (Past, Present, Future), Basic Knowledge of Profit, Loss, and Investment.

Course Objectives: The objectives of the course are to

1. Understand the importance of engineering economics in engineering, industry, and society.
2. Understand the concept of time value of money using simple real-life examples.
3. Introduce the concept of cash inflows and cash outflows in simple projects.
4. Understand basic concepts used for comparing economic alternatives.
5. Understand basic investment decision methods and public project evaluation concepts.
6. Introduce basic Costing concepts and their role in decision making.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain the role of engineering economics in making ethical and sustainable engineering decisions.	II
CO2	Explain why money has different value at different times.	II
CO3	Understand and show cash coming in and going out using simple cash flow diagrams.	II
CO4	Understand and explain different options using basic economic comparison ideas.	II
CO5	Explain basic investment evaluation methods and identify project Costs and benefits.	II
CO6	Understand and explain Costs, depreciation, and break-even	II

Unit No.	Content	COs	Hours
1	**Assignment 1: Understanding Engineering Economics in Daily Life** **Aim:** To understand the importance of engineering economics in engineering and industrial decision making. **Activities:** • Discussion on meaning and scope of engineering economics • Identification of economic decisions in engineering projects • Role of economics in industry and society • Discussion on ethics and sustainability in engineering decisions	**CO1**	2
2	**Assignment 2: Time Value of Money – Conceptual Study** **Aim:** To understand the concept of time value of money without calculations. **Activities:** • Explanation of money value at different times • Present value and future value using real-life examples • Conceptual understanding of simple and compound interest • Drawing a simple time line	**CO2**	2
3	**Assignment 3: Cash Flow Identification and Representation Aim:** To identify and represent cash inflows and cash outflows **Activities:** • To identify and represent cash inflows and cash outflows. • Activities: • Identification of cash inflows and outflows in: • Small engineering project • Personal investment • Drawing simple cash flow diagrams • Interpretation of positive and negative cash flows	**CO3**	4
4	**Assignment 4: Economic Comparison of Alternatives** **a) Aim: To identify different economic alternatives and compare them using simple ideas of present worth and future worth.** **Activities:** • Identification of economic alternatives → List all possible options Understanding basic economic comparison → Compare options based on Cost and benefit	**CO4**	4

	• Concept of present worth (PW) → Check value of each option at present time • Concept of future worth (FW) → Check future value/benefits of each option • Simple comparison using PW and FW → Select the best alternative		
	b) Aim: To understand comparison of alternatives based on equal and unequal life and to study deferred (delayed) investment decisions. **Activities:** • Equal life alternatives → Compare options with same life directly • Unequal life alternatives → Adjust and compare options with different life • Comparison between different life options → Choose best based on overall performance • Concept of deferred investment decision → Decide whether to invest now or later • Factors affecting decision making → Consider CO‘st, time, risk, and future needs		4
5	**Assignment 5: Investment Decision and Project Evaluation** **a) Aim: To understand basic investment decision methods like payback period, annual worth, and rate of return.** **Activities:** • Conceptual study of payback period → Understand how long it takes to recover investment • Basic understanding of annual worth method → Understand yearly benefit or Cost of a project • Concept of rate of return and IRR → Understand how much profit an investment gives (no calculation)	**CO5**	4
	b) Aim: To understand evaluation of public projects based on Costs, benefits, and overall usefulness. **Activities:** • Identification of Costs and benefits in public projects → List all Costs and benefits • Discussion on benefit–Cost analysis → Compare total benefits with total Costs • Understanding sustainability → Check long-term usefulness and environmental impact.		4

6	**Assignment 6: Costing, Depreciation and Decision Making** **a) Aim: To understand different types of Costs and their behavior in simple decision making.** **Activities:** • Identification of different types of Costs → List various Costs (material, labor, etc.) • Fixed Cost examples → Identify Costs that do not change (rent, salary) • Variable Cost examples → Identify Costs that change with production (raw material, electricity).	**CO6**	2
	b) Aim: To understand depreciation, break-even concept, and Cost control methods for better decisions. **Activities:** • Meaning and importance of depreciation → Understand loss of value of assets over time • Concept of break-even point → Understand no profit, no loss situation • Cost control techniques → Identify ways to reduce unnecessary Costs • Cost reduction techniques → Find methods to permanently lower Costs		2

Text Books	
1	Engineering Economics and Management by V. L. Mote, S. G. Vaidya and K. V. Bhosale Publication: Tata McGraw Hill, 2009ISBN: 978-0070087613
2	Engineering Economics by S. P. Singh Publication: Dhanpat Rai and Co., 2012ISBN: 978-8187433729
3	Engineering Economics and Costing by P. K. De and A. K. Sengupta Publication: Oxford University Press India, 2010ISBN: 978-0198065806
4	Engineering Economics and Management by K. K. Chitkara Publication: Tata McGraw Hill, 2011 ISBN: 978-0070700239
5	Basics of Engineering Economics by R. K. Rajput Publication: Laxmi Publications, 2013 ISBN: 978-8131808146

Reference Books	
1	Engineering Economics by R. Panneerselvam, Publication: PHI Learning, 2017, ISBN: 978-9352605586
2	Engineering Economics and Costing by M. M. Gupta, Publication: Khanna Publishers, 2016, ISBN: 978-8121928206
3	Engineering Economics by B. N. Datta, Publication: Dhanpat Rai and Co., 2015, ISBN: 978-8177004929
4	Engineering Economics and Costing by T. R. Banga and S. C. Sharma, Publication: Khanna Publishers, 2014, ISBN: 978-8121928138
5	Cost Accounting and Financial Management by M. N. Arora, Publication: Vikas Publishing House, 2016, ISBN: 978-9325980389

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Multidisciplinary Minor (MDM)-03 Lab			Course Code:MME02510		
Course Title: **Fundamentals of Design for Product Manufacturing (FDPM) Lab**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	50 Marks	--	50 Marks	

Prerequisites: Analysis of Mechanical Elements, Material and Manufacturing Processes.

Course Objectives: The objectives of the course are to

1. Provide hands-on understanding of basic DFMA concepts using simple products.
2. Enable students to analyze and simplify product design for easy manufacturing and assembly.
3. Develop skills in identifying design inefficiencies in common engineering products.
4. Introduce basic tools for improving product quality and reducing Cost.
5. Expose students to real-world applications in electronics and consumer products.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Identify design issues affecting manufacturing and assembly	II
CO2	Analyze simple products for part count and assembly complexity	III
CO3	Suggest improvements for ease of manufacturing and assembly	III
CO4	Apply basic DFMA tools for product improvement	III
CO5	Evaluate simple tolerance and fit issues in products	III
CO6	Relate DFMA concepts to real-life electronics and consumer products	III

Unit No.	Content	COs	Hours
1	**Study of DFMA Principles Using a Simple Product** Select a simple product (remote, mouse, charger, etc.), Identify components and functions, Understand product structure.	**CO 1**	4
2	**Product Disassembly and Part Count Analysis** Disassemble a simple electronic/mechanical product, Count number of parts, Identify unnecessary components.	**CO 2**	4
3	**Assembly Process Study** Study assembly sequence of the product, Identify difficult assembly steps, Suggest improvements.	**CO 3**	4
4	**Material and Manufacturing Process Identification** Identify materials used in product components, Suggest suitable manufacturing processes, Compare alternatives (plastic vs metal, etc.)	**CO 4**	4
5	**Basic Tolerance and Fit Study** Observe fitting between parts, Identify loose/tight fits, Discuss impact on product performance	**CO 5**	4
6	**DFMA Tool Application (Simple Case Study)** Apply concepts like: Lean (waste reduction) Poka-Yoke (error prevention) Identify improvements in product/process.	**CO 6**	4

Text Books	
1	Fundamentals of Design and Manufacturing, G.K. Lal, S. Chand Publications
2	Engineering Design and Product Development, P.S. Gill, S.K. Kataria and Sons.
3	Chitale, A. K., and Gupta, R. C., Product Design and Manufacturing, PHI Learning Pvt. Ltd., New Delhi.
4	Lal, G. K., Fundamentals of Design and Manufacturing, S. Chand Publications, New Delhi.
5	Otto, K., and Wood, K., Product Design: Techniques in Reverse Engineering and New Product Development, Pearson Education.

Reference Books	
1	Product Design and Manufacturing, Avinash K. Chitale and R.C. Gupta, PHI Learning Pvt. Ltd.
2	Fundamentals of Design and Manufacturing, G.K. Lal, S. Chand Publications
3	Engineering Design and Product Development, P.S. Gill, S.K. Kataria and Sons
4	Lean Manufacturing: Tools, Techniques & How to Use Them, B. Kumar / S. Gupta, Oxford University Press
5	Design for Manufacturability – Concepts, Standards and Methods by David M. Anderson

Third Year B. Tech - Semester V Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Experiential Learning (EL)			Course Code:MME02511		
Course Title: **Minor Project 01**					
Teaching Scheme	L	T	P	Contact Hrs/Week	Credits
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	25 Marks	--	25 Marks	

Prerequisites: Basic Mechanical Engg., Thermal and Fluid Engg., Signal Processing, Fundamentals of Mechatronics

Course Objectives: The objectives of the course are to

1. Introduce the fundamentals of mechatronics systems and their applications.
2. Develop understanding of sensors, actuators, and control systems.
3. Provide knowledge of PLCs and microcontroller-based automation.
4. Enhance skills in system design and integration of mechanical and electronic components.
5. Develop problem-solving ability through real-life engineering applications.
6. Enable students to design, implement, and test a mini project.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Understand and explain basic concepts of mechatronics systems.	I
CO2	Select appropriate sensors and actuators for engineering applications.	II,III
CO3	Apply PLC and microcontroller concepts in automation systems.	II,III
CO4	Design and analyze simple mechatronic systems.	III,IV
CO5	Develop and implement a working prototype for a given problem.	III,V
CO6	Present project work effectively with proper documentation and analysis.	V,VI

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Unit 1: Introduction to Mechatronics Systems**		
	• Definition and scope of Mechatronics • Elements: Mechanical, Electrical, Electronics, Control • Modern applications (automation, robotics, CNC) • System approach and interdisciplinary design • Block diagrams of mechatronic systems	**CO 1**	**04 Hrs**
Unit 2	**Unit 2: Sensors and Transducers**		
	• Types: Mechanical, Electrical, Optical sensors • Displacement, temperature, pressure sensors • Signal conditioning basics • Calibration and characteristics • Industrial sensor applications	**CO 2**	**04 Hrs**
Unit 3	**Unit 3: Actuators and Drive Systems**		
	• Electrical actuators (DC/AC motors, stepper motors) • Hydraulic and pneumatic actuators • Solenoids and smart actuators • Drive selection criteria • Industrial automation examples	**CO 3**	**04 Hrs**
Unit 4	**Unit 4: Control Systems and PLC**		
	• Open-loop and closed-loop systems • Basics of feedback control • Introduction to PLC (Programmable Logic Controller) • Ladder diagrams and programming basics • SCADA overview	**CO3, CO4**	**04 Hrs**
Unit 5	**Unit 5: Microcontrollers and Embedded Systems**		
	• Introduction to microcontrollers (e.g., 8051 / Arduino) • Interfacing sensors and actuators • Basics of embedded programming • Data acquisition systems • Applications in automation	**CO5**	**04 Hrs**
Unit 6	**Unit 6: Mini Project Development**		
	• Problem identification (industry-based) • Design methodology • Component selection • Fabrication and assembly • Testing, debugging, and result analysis • Report writing and presentation	**CO6**	**08 Hrs**

Term work:

1.	Study of Mechatronics System Components and Applications	**CO1**
2.	Study of Sensors and Transducers used in Industrial Automation Systems	**CO2**
3.	Study of Actuators and Drive Mechanisms in Mechatronic Systems	**CO3**
4.	Study of PLC-based Control Systems and Ladder Programming	**CO4**
5.	Study of Microcontroller-based Automation System (Arduino/8051)	**CO5**
6.	Design and Implementation of a Mini Mechatronics Project	**CO6**

Text Books	
1	—Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering‖, Bolton, W., Pearson Education, 7th Edition (2018).
2	—Mechatronics System Design‖, Shetty, D. and Kolk, R.A., Cengage Learning, 2nd Edition (2012).
3	—Introduction to Mechatronics and Measurement Systems‖, Alciatore, D.G.; Histand, M.B., McGraw Hill, 5th Edition (2019).
4	—Industrial Automation and Robotics‖, Groover, M.P., McGraw Hill, 1st Edition (1989).
5	—Programmable Logic Controllers, Petruzella, F.D., McGraw Hill, 5th Edition (2016).

Reference Books	
1	—Mechatronics: Principles and Applications‖, Onwubolu, G.C., Elsevier, 1st Edition (2005).
2	—Automation, Production Systems and Computer-Integrated Manufacturing‖, Groover, M.P., Pearson, 4th Edition (2015).
3	—Sensors and Transducers‖, Patranabis, D., PHI Learning, 2nd Edition (2003).
4	—Microcontrollers: Theory and Applications‖, Mazidi, M.A.; Mazidi, J.G.; McKinlay, R.D., Pearson, 2nd Edition (2007).
5	—Control Systems Engineering‖, Nise, N.S., Wiley, 7th Edition (2015).

Shivaji University, Kolhapur

T. Y. B. Tech Syllabus

(As per NEP-2020)

Mechanical and Mechatronics Engineering
(Additive Manufacturing)

(2026-27)

Semester VI

SCHEME OF INSTRUCTION & SYLLABI

Programme Mechanical & Mechatronics Engineering (Additive Manufacturing)

Scheme of Instructions: Third Year B.Tech. in Mechanical & Mechatronics Engineering (Additive Manufacturing)

Semester – VI

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs/Wk	Course Credits	EXAM SCHEME			
									MSE	ISE/CA	ESE	TOTAL
1	PCC	MME0261	Industrial Automation Robotics	3	--	--	3	3	30	10	60	100
2	PCC	MME0262	Neural Network & Fuzzy Logic Control	3	1	--	4	4	30	10	60	100
3	PCC	MME0263	Micro & Nano Manufacturing System	3	--	--	3	3	30	10	60	100
4	PEC	MME0264	PEC - 2	3	--	--	3	3	30	10	60	100
5	PEC	MME0265	PEC - 3	3	--	--	3	3	30	10	60	100
6	MDM	MME0266	Multi-disciplinary Minor - 04	2	--	--	2	2	30	10	60	100
7	PCC	MME0267	Robot Operating System Lab	--	--	2	2	1	-	50	25	75
8	PCC	MME0268	Fabrication Lab	--	--	2	2	1	-	50	25	75
9	EL	MME0269	Minor Project 02 - Based On IAR	--	--	2	2	1	-	50	--	50
			Total	**17**	**1**	**8**	**26**	**22**	**180**	**210**	**410**	**800**

L- Lecture T-Tutorial P-Practical

MSE- Mid Semester Examination ISE/CA- In Semester Evaluation/Continuous Assessment ESE- End Semester Examination (For Laboratory End Semester performance)

Course Category	Basic Science Courses (BSC)	Engineering Science Courses (ESC)	Programme Core Course (PCC)	Programme Elective Course (PEC)	Open Elective other than particular (OE/MDM)	Vocational and Skill Enhancement Course (VSEC)	Humanities Social Science and Management (HSSM)	Experiential Learning (EL)	Co-curricular And Extracurricular Activities (CCA)
Last Sem. Cumulative Sum	**16**	**16**	**36**	**04**	**16**	**07**	**12**	**02**	**02**
Semester Credits	**-**	**-**	**12**	**06**	**02**	**--**	**-**	**01**	**-**
Cumulative Sum	**16**	**16**	**48**	**10**	**18**	**07**	**12**	**03**	**02**

PROGRESSIVE TOTAL CREDITS: 110+22 =132

Program Elective Course -2 (PEC-2) List

Sr. No	Name of Program Elective Course -2 (PEC-2)
01	Micro-Electro-Mechanical Systems
02	Design of Thermal System
03	Advanced Casting and Welding Techniques
04	Total Quality Management

Program Elective Course -3 (PEC-3) List

Sr. No	Name of Program Elective Course -3 (PEC-3)
01	Experimental Mechanics
02	Cryogenics
03	Production Management
04	Work study and Ergonomics

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC)			Course Code:MME0261		
Course Title: **Industrial Automation Robotics**					
Teaching Scheme	L	T	P	Contact Hrs/Week	Credits
	03	--	--	03	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic Mechanical Engineering, Basic Electrical Engineering and Signal Processing

Course Objectives: The objectives of the course are to

1. Understand the basic concepts, need, and applications of automation in modern manufacturing systems.
2. Explain the working of industrial control systems and transfer lines used in automated production.
3. Analyze different methods and layouts of assembly automation for mass and batch production.
4. Describe the fundamentals, configuration, and applications of industrial robots.
5. Identify and select suitable robotic end effectors and sensors for industrial tasks.
6. Demonstrate basic robot teaching methods and programming techniques for industrial operations.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO 1	Understand automation concepts, types, and economic aspects to design efficient systems.	II
CO 2	Understand industrial control systems and transfer lines in manufacturing.	II
CO 3	Understand assembly automation, including types, configurations, and product design for efficient automated assembly.	II
CO 4	Understand industrial robots, including specifications, control systems, and dynamic properties.	II
CO 5	Understand robotic end effectors and sensors for efficient operation and design	II
CO 6	Understand robot teaching methods, programming languages and application.	II

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Automation** Automated manufacturing systems, Fixed/programmable/flexible, Automation, Need of automation, Basic elements of automated systems- Power, program and control. Low Cost automation, Economic and social aspects of automation, Advanced automation functions, Levels of automation.	**CO 1**	**07 Hrs**
Unit 2	**Industrial Control and Transfer Line** a) Industrial control systems in process and discrete manufacturing industries, Continuous and discrete control; Computer process control. **b)** Fundamentals of transfer lines, Configurations, Transfer mechanisms, Storage buffers, Control, Applications	**CO 2**	**07 Hrs**
Unit 3	**Assembly Automation** Assembly Automation: Types and configurations, Parts delivery at workstations, Various vibratory and non-vibratory devices for feeding and orientation, Product design for automated assembly.	**CO 3**	**07 Hrs**
Unit 4	**Fundamentals of Industrial Robots** Specifications and Characteristics, Criteria for selection, Robotic Control Systems: Drives, Robot Motions, Actuators, Power transmission systems, Robot controllers Dynamic properties of robots-stability, Control resolution, Spatial resolution, Accuracy, Repeatability, Compliance, Work cell control, Interlocks	**CO 4**	**07 Hrs**
Unit 5	**Robotic End Effectors and Sensors** Transducers and sensors in robotics and their classification ,Touch (Tactile)sensors, Proximity and range sensors, Force and torque sensing, End Effectors-Types, grippers, Various process tools as end effectors; Robot End effectors interface, Active and passive compliance, Gripper selection and design.	**CO 5**	**07 Hrs**
Unit 6	**Robot Teaching** Introduction, Various teaching method, Task programming, Survey of Robot level programming languages, A Robot programs a Path in space, Motion interpolation WAIT,SIGNAL and DELAY commands, Branching, Robot language structure, Various textual robot, Languages such as VALII, Typical programming examples such as palletizing, Loading a machine etc., Application of Robot.	**CO 6**	**07 Hrs**

Note - The ISE/CA is carried out through the assignment on each topic.

Text Books	
1	**"Automation, Production Systems and Computer Integrated Manufacturing"**, Groover, M.P., Pearson Education, ISBN: 81-7808-511-9 2nd Edition (2004).
2	**"Industrial Robotics, Technology, Programming and Applications"**, Groover, M.P.; Weiss, M.; Nagel, R.N. and Odrey, N.G. , McGraw Hill Intl. Edition.,ISBN: 0-07-024989- X.
3	**"Introduction to Robotics: Mechanics and Control",** Craig, J.J., Pearson Education, 4th Edition (2018).
4	**"Robotics: Control, Sensing, Vision and Intelligence",** Fu, K.S.; Gonzalez, R.C.; Lee, C.S.G., McGraw Hill International Edition, 1st Edition (1987).
5	**"Principles of Industrial Robot Applications",** James G. Keramas, Delmar Cengage Learning, 1st Edition (1999).

Reference Books	
1	**"Robot Technology Fundamentals",** Keramas, James G, Thomson Learning– Delmar ISBN:981- 240-621-2,(1998).
2	**"Handbook of Robotics",** Noff, Shimon Y., John Wiley and Sons.
3	**"Introduction to Robotics: Mechanics and Control",** John J. Craig, Pearson Education, 4th Edition.
4	**"Industrial Robotics: Technology, Programming and Applications",** Mikell P. Groover, McGraw Hill Education, 1st Edition.
5	**"Robotics: Modelling, Planning and Control",** Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer, 1st Edition.

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC)			Course Code:MME0262		
Course Title :**Neural Networks and Fuzzy Logic Control**					
Teaching Scheme	L	T	P	Contact Hrs/Week	Credits
	03	01	--	04	04
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic knowledge of Mathematics (Linear Algebra, Probability), Signal Processing, and Programming (MATLAB/Python).

Course Objectives: The objectives of the course are to

1. Understand the fundamentals of **Artificial Intelligence techniques** applied to control systems.
2. Learn the working principles of **Artificial Neural Networks (ANN)** and **Fuzzy Logic Systems (FLS)**.
3. Design and analyze **neural network-based controllers** for dynamic systems.
4. Develop **fuzzy logic controllers** for nonlinear and uncertain systems.
5. Apply intelligent control techniques to **mechanical and mechatronic systems** such as motors, robots, and process control systems.
6. Use software tools like **MATLAB / Simulink** for modeling, simulation, and implementation

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO 1	Explain the fundamentals of neural networks and fuzzy logic systems	II
CO 2	Develop mathematical models of neural networks	V
CO 3	Design and train ANN for control and prediction tasks	IV
CO 4	Design fuzzy inference systems and fuzzy controllers	IV
CO 5	Apply intelligent control techniques to real-time engineering problems	II

SYLLABUS

Unit No.	Content	COs	Hours
Unit 1	**Introduction to Intelligent Control Systems** • Conventional vs Intelligent Control • Artificial Intelligence in Control • Applications in Mechanical and Mechatronics Engineering • Overview of Neural Networks and Fuzzy Logic • Hybrid Intelligent Systems	**CO1**	**07 Hrs**
Unit 2	**Artificial Neural Networks** a) Biological Neuron and Artificial Neuron b) McCulloch–Pitts Neuron Model c) Network architectures: a. Single-layer perceptron b. Multi-layer perceptron (MLP) d) Activation functions e) Learning methods: a. Supervised learning b. Unsupervised learning c. Reinforcement learning	**CO2**	**07 Hrs**
Unit 3	**Neural Network Training Algorithms** • Perceptron Learning Rule • Gradient Descent Algorithm • Backpropagation Algorithm • Convergence issues • Overfitting and generalization • Applications of ANN in control systems	**CO3**	**07 Hrs**
Unit 4	**Fuzzy Logic Systems** • Fuzzy sets and membership functions • Linguistic variables • Fuzzy operations • Fuzzy relations • Fuzzification and Defuzzification methods • Mamdani and Sugeno fuzzy inference systems	**CO4**	**07 Hrs**
Unit 5	**Fuzzy Logic Control** • Fuzzy control system architecture • Rule base design • Fuzzy PD, PI, and PID controllers • Stability and performance of fuzzy controllers • Applications in motor control, robotics, and process control	**CO5**	**07 Hrs**

Unit 6	**Neuro-Fuzzy and Applications**		

	• Adaptive Neuro-Fuzzy Inference System (ANFIS)
	• Neuro-fuzzy modeling
	• Intelligent control of:
	  ○ DC & AC motors
	  ○ Robotic manipulators
	  ○ Temperature and level control systems
	• Case studies
		CO 6	**07 Hrs**

Note - The ISE/CA is carried out through the assignment on each topic.

Text Books	
1	**Timothy J. Ross**, Fuzzy Logic with Engineering Applications, Wiley
2	**Simon Haykin**, Neural Networks and Learning Machines, Pearson
3	**S. N. Sivanandam**, Introduction to Neural Networks using MATLAB, McGraw Hil
4	B. Yegnanarayana, Artificial Neural Networks, PHI Learning Private Limited, New Delhi.
5	S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications, PHI Learning.

Reference Books	
1	**Jang, Sun and Mizutani,** Neuro-Fuzzy and Soft Computing, Pearson
2	**K. Mehrotra, C. K. Mohan,** Elements of Artificial Neural Networks, MIT Press
3	**Bose and Liang,** Neural Network Fundamentals, McGraw Hill
4	**Laurene Fausett**, Fundamentals of Neural Networks: Architectures, Algorithms and Applications, Pearson Education.
5	**H. J. Zimmermann**, Fuzzy Set Theory and Its Applications, Springer Science and Business Media.

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC)			Course Code:MME0263		
Course Title :**Micro and Nano Manufacturing Systems (MNMS)**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Material and Manufacturing Processes, Additive Manufacturing

Course Objectives: The objectives of the course are to

1. Introduce the fundamentals of micro and Nano manufacturing systems and their importance in modern engineering applications.
2. Understand design considerations and scaling effects at micro and Nano dimensions.
3. Familiarize students with micro and Nano fabrication processes and manufacturing techniques.
4. Develop the ability to select appropriate materials, tools and processes for micro and Nano manufacturing.
5. Expose students to applications of micro and Nano manufacturing systems in MEMS, sensors, biomedical and advanced engineering products.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain the principles and challenges of micro and Nano manufacturing systems.	II
CO2	Analyze scaling laws and design constraints at micro and Nano scales.	IV
CO3	Identify and compare various micro and Nano fabrication processes.	III
CO4	Apply appropriate design methodologies for micro and Nano manufacturing systems.	IV
CO5	Evaluate applications of micro and Nano manufacturing in mechanical and mechatronic systems.	IV
CO6	Analyze real-world applications of micro and Nano manufacturing systems and evaluate design considerations, performance and industrial feasibility in mechanical and mechatronic products.	IV

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Micro and Nano Manufacturing**		
	• Evolution of micro and nano manufacturing • Difference between conventional, micro and nano manufacturing • Top-down and bottom-up approaches • Scaling laws and size effects • Challenges in micro and nano system design	**CO 1**	**06 Hrs**
Unit 2	**Materials and Design Considerations at Micro and Nano Scale**		
	• Material behavior at micro and nano scale • Mechanical, thermal and electrical size effects • Surface forces and adhesion • Design constraints and tolerances in micro systems • Material selection for micro and nano manufacturing	**CO 2**	**08 Hrs**
Unit 3	**Micro Manufacturing Processes**		
	• Micro machining (micro milling, drilling, turning) • Micro forming and micro casting • Micro EDM and micro ECM • Laser-based micro machining • Applications of micro manufacturing	**CO 3**	**08 Hrs**
Unit 4	**Nano Manufacturing and Fabrication Techniques**		
	• Nanofabrication overview • Lithography techniques (Photo, electron beam, nano-imprint) • Thin film deposition techniques, Etching processes (wet and dry) • Bottom-up nano fabrication methods	**CO 4**	**08 Hrs**
Unit 5	**Design of Micro and Nano Manufacturing Systems**		
	• Design methodology for micro and nano systems • CAD tools for micro and nano design • Precision positioning and control • Metrology and inspection at micro and nano scale • Reliability and sustainability considerations	**CO 5**	**06 Hrs**

Unit 6	**Industrial Applications of MEMS and NEMS**		
	• MEMS and NEMS devices • Micro sensors and actuators • Biomedical and lab-on-chip applications • Micro and nano manufacturing in electronics and automation • Future trends and industrial challenges	**CO 6**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments on each unit.

Text Books	
1	Micro and Nano Manufacturing, R. Ganesh Narayanan, PHI Learning Pvt. Ltd. 1st Edition
2	Micro and Nano Manufacturing Engineering and Technology, Mark J. Jackson, Springer, 1st Edition
3	Nanomanufacturing Handbook, Mark J. Jackson, CRC Press, 1st Edition
4	Manufacturing Engineering and Technology, Serope Kalpakjian, Steven R. Schmid, Pearson Education, 7th Edition
5	Fundamentals of Microfabrication and Nanotechnology, Marc J. Madou, CRC Press, 3rd Edition

Reference Books	
1	Micro and Nano Manufacturing – R. Ganesh Narayanan, PHI Learning
2	Micro Manufacturing Processes, V. K. Jain, CRC Press, 1st Edition
3	Precision Engineering and Manufacturing – Raghuwanshi and Jain, Khanna Publishers
4	Micro and Nano Manufacturing – Mark J. Jackson, Springer
5	Nano Manufacturing, Wei Gao, Elsevier, 1st Edition
6	Handbook of Nanoscience, Engineering and Technology, William A. Goddard, Donald W. Brenner, Sergei E. Lyshevski, CRC Press, 3rd Edition

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course -2 (PEC-2)			Course Code:MME0264		
Course Title :**Micro-Electro-Mechanical Systems (MEMS)**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic Mathematics, Fluid and Thermal Engineering, Basic Knowledge of Heat Transfer, Electrical Machines

Course Objectives: The objectives of the course are to

1. Understand the concepts and context of MEMS
2. Understand various MEMS fabrication technologies
3. Understand MEMS-specific design issues, constraints and dynamics and modeling of Microsystems
4. Understand applications of micro sensors and micro actuators
5. Get access to fabrication and testing in academia and industry

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Understand the fundamentals of micromachining and MEMS, including IC fabrication techniques, scaling effects, and modeling approaches used in microsystems..	II
CO2	Analyze the working principles and applications of various micro-sensors (chemical, optical, pressure, thermal, magnetic) and micro-actuators (electrostatic, piezoelectric, thermal, and shape memory-based).	III
CO3	Demonstrate knowledge of micro fabrication processes such as lithography, etching (wet and dry), thin-film deposition, wafer bonding, and advanced techniques like LIGA and soft lithography..	III
CO4	Apply concepts of solid mechanics to MEMS structures, including stress-strain analysis, beam theory, residual stresses, thermal effects, and vibration analysis..	V
CO5	Evaluate thermal and fluid flow behavior in MEMS devices, including microfluidics, heat transfer in thin films, and performance of thermal sensors and actuators.	V
CO6	Understand the basics of semiconductor electronics and their integration with MEMS, along with packaging, testing, and reliability considerations of microsystems.	II

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction**		
	Introduction to Micromachining and MEMS, IC Fabrication, Essential technical background for lithography-based micromachining, Glimpses of Microsystems, Scaling effects, Distributed and lumped modelling approaches used in MEMS analysis and simulations	CO1	**06 Hrs**
Unit 2	**Micro sensors and Micro actuators**		
	Micro-sensors: Chemical sensors, Optical sensors, Pressure sensors, Thermal sensors – Thermopiles, Thermistors, Micro machined thermocouple probes, MEMS magnetic sensor, Micro actuators: Capacitance, Piezo mechanics, Piezo-actuators as grippers, Micro grippers, Micro motors, Micro valves, Micro pumps, Micro accelerometers, Shape memory alloy based optical switch, Thermally activated MEMS relay, Micro spring thermal actuator.	CO2	**08 Hrs**
Unit 3	**Micro fabrication Processes**		
	Structure of silicon, Silicon wafer processing, Thin-film deposition, Lithography, Wet etching and Dry etching, Process integration, Bulk micromachining and Surface micromachining, Wafer-bonding, LIGA and other moulding techniques, Soft lithography. Thick-film processing, Low temperature co-fired ceramic processing.	CO3	**07 Hrs**
Unit 4	**Mechanics of Solids**		
	Stresses and deformation: Bars and beams, Micro device suspensions: Lumped modeling, Residual stress and stress gradients, Poisson effect, Anticlastic curvature, Examples of micromechanical structures, Thermal loading: Bimorph effect, Dealing with large displacements, In-plane and 3D elasticity equations, Vibrations of bars and beams	CO4	**08 Hrs**
Unit 5	**Thermal, Fluid Flow in MEMS**		
	Thermal sensors and actuators and their analysis, Micro fluidics, Flow through micro channels, Miniature heat exchangers. Heat conduction in multi layered thin films, conduction in solids in sub micrometer scale.	CO5	**07 Hrs**
	Electronics and Packaging		
Unit 6	Semiconductor devices: Basics, Control and Microsystems, Vibration control of a beam, Integration of Microsystems and microelectronics, Packaging, Testing and reliability of Microsystems: Why and how?	CO6	**06 Hrs**

Note - The ISE/CA is carried out through any 7 Assignments from the following:

1. Case study of MEMS Sensors (Pressure sensor/ Accelerometer/Gyroscope).
2. Case-study of MEMS Actuators (Micro-pump/RF switch).
3. Case-study of System on chip Drug delivery system.
4. Visit to Micro fabrication facility.
5. Visit to MEMS characterization and testing facility.
6. Lumped modelling of MEMS sensors/actuators in MAT LAB Simulink.
7. Introductory modelling of MEMS in multi physics software e.g. ANSYSCOVENT
8. Study of Electrostatic Applications in MEMS like Electrostatic actuation (parallel plate), Electro static actuation (comb drive), Electro static sensing, Piezoelectric actuation, Piezo electric sensing.
9. Study of:-

i. Gyroscopic effect, Frequency response, Damping, Quality factor, Basic micro-flows for damping calculation.

ii. Op-Amp and Op-Amp circuits, Signal conditioning for micro System devices.

Text Books:	
1	—MEMS and MICROSYSTEMS: Design and Manufacture‖, Hsu, Tai-Ran, TMH,
2	—MEMS‖, Mahalik, N. P., TMH, ISBN: 0-07-063445-9, (2007).
3	Foundations of MEMS (Chang Liu) 2nd Edition pearson Publication
4	"Fundamentals of Microelectromechanical Systems (MEMS)" by Eun Sok Kim Mc Graw Hill 1st Edition Indian Version
5	"An Introduction to Microelectromechanical Systems Engineering" by Nadim Maluf and Kirt Williams 2nd Edition Artech House
Reference Books:	
1	—Introduction to Micro electronic Fabrication‖, Richard C. Jaeger, Prentice Hall, 2nd Edition, Volume V,ISBN:0-201-44494-7,(2002).
2	—Nano systems: Molecular Machinery, Manufacturing and Computation‖, KE Drexler, Wiley, ISBN0471575186,(1992).
3	—Microsystem Design‖, Stephen D. Senturia, Kluwer Academic Publishers, Boston, (2001).
4	"Fundamentals of Micro fabrication: The Science of Miniaturization" by Marc J Madou 2nd Edition Special Indian Edition CRC Press
5	"Micro and Smart Systems" by K. Anatha Suresh, K.J. Vinoy, S. Gopala Krishnan, et al. Wiley india

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course -2 (PEC-2)			Course Code:MME0264		
Course Title: **Design of Thermal Systems**					
Teaching Scheme	L	T	P	Contact Hrs / Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic Knowledge of Analysis of Mechanical Elements, Fluid and Thermal Engineering, Material and Manufacturing Processes, Basic Knowledge of Heat Transfer, Basic Knowledge of CAD/CAE Tools

Course Objectives: The objectives of this course are to

1. Learn Thermal system design methodology.
2. Understand real-life situations and be able to decide an approach for problem-solving.
3. Design simple thermal systems with advanced tools where integration of more than one component is required.

Course Outcomes:

COs	**After successful completion of this course, students will be able to:**	**Blooms Taxonomy Level**
CO1	Understand and apply the fundamentals of thermal system design, including design methodologies, classification, and component modeling for engineering applications.	II,III
CO2	Analyze and design refrigeration systems such as vapour compression and vapour absorption systems, including applications like household refrigerators and ice plants.	III,IV
CO3	Perform heat transfer analysis and design air conditioning systems, including load calculations, system selection, and industrial drying processes.	III,IV
CO4	Design and evaluate solar thermal systems, particularly solar-assisted water heating systems, including feasibility analysis and component design.	III,V
CO5	Develop advanced cooling solutions, including heat exchanger networks, electronic cooling systems, and applications of nano-fluids.	IV,VI
CO6	Design and conduct thermo-economic analysis of waste heat recovery systems, considering performance optimization and Cost-effectiveness.	IV,V

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Introduction to Thermal System Design**		
	Classification of design, Optimal and nearly optimal design, Methodology of design, Aspects of thermal system design, Assessment concept and creation, Component modeling.	CO1	**07 Hrs**
Unit 2	**Design of Refrigeration System**		
	Design of basic components of refrigeration system, Design of refrigeration systems: vapour compression system- Household refrigerator, Ice plant, Vapour absorption systems using waste heat and solar energy.	CO2	**07 Hrs**
Unit 3	**Heat Transfer and Design Analysis of Air Conditioning System**		
	Design of Air conditioning systems: Design considerations, Load calculations, Single unit room air conditioners, Central air conditioning plant, Industrial drying systems, Component selection and Computer Aided Piping Design.	CO3	**07 Hrs**
Unit 4	**Design of Solar System**		
	Design of solar assisted water heating systems, Preliminary specifications, Concepts development, Detailed design for feasibility study, Component design.	CO4	**07 Hrs**
Unit 5	**Design of Advanced Cooling Systems**		
	Design of advanced heat exchanger networks, Design of electronic miniature cooling systems, Utilization of Nano- Fluids for cooling systems.	CO5	**07 Hrs**
Unit 6	**Design and Economic Analysis of Waste Heat Recovery Systems**		
	Design of waste heat recovery systems, Design specifications, Specifications and component design, Thermo Economic Evaluation and additional Costing Considerations.	CO6	**07 Hrs**

Note - The ISE/CA is carried out through the Assignment on each unit.

Text Books	
1	—HVAC System Design Handbook‖ ASHRAE.
2	—Design and Optimization of Thermal Systems, Yogesh Jalurkar, CRC Press.
3	—Design and Simulation of Thermal Systems‖, N.V.Suryanarayana, Oner Arici, Tata McGraw-Hill Education.
4	Suryanarayana, N.V., and Arıcı, O., Design and Simulation of Thermal Systems, Tata McGraw-Hill Education, New Delhi, 2003, ISBN: 978-0070483002
5	Dossat, R.J., and Horan, T.J., Principles of Refrigeration, 5th Edition, Pearson Education, 2001, ISBN: 978-0130272706

Reference Books	
1	—Essentials of Thermal System Design‖, C. Balaji, CRC Press.
2	—Design of Fluid Thermal Systems‖, Janna W.S., Cengage Learning, 4th Edition.
3	Incropera, F.P., DeWitt, D.P., Bergman, T.L., and Lavine, A.S., Fundamentals of Heat and Mass Transfer, 7th Edition, Wiley, 2011, ISBN: 978-0470501979
4	Kakac, S., and Liu, H., Heat Exchangers: Selection, Rating, and Thermal Design, 2nd Edition, CRC Press, 2002, ISBN: 978-0849309021
5	Online Tutorials and ANSYS User Guide.

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course -2 (PEC-2)			Course Code:MME0264		
Course Title:	**Advanced Casting and Welding Techniques (ACW)**				
Teaching Scheme	L	T	P	Contact Hrs/Week	Credits
	03	--	--	03	3
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Analysis of Mechanical Elements, Thermal & Fluid Engineering, Material & Manufacturing Processes

Course Objectives: The objectives of the course are to

1. Provide knowledge of advanced casting and welding processes beyond conventional manufacturing methods.
2. Explain the principles, equipment and process parameters involved in advanced casting and welding techniques.
3. Enable students to analyze defects, quality issues and metallurgical aspects of castings and welds.
4. Develop the ability to select appropriate casting or welding processes for specific materials and applications.
5. Introduce automation, simulation and recent developments in casting and welding technology.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain the principles and working of advanced casting and welding techniques.	II
CO2	Analyze process parameters and material behavior in advanced casting and welding operations.	IV
CO3	Identify and analyze casting and welding defects and suggest suitable preventive measures.	IV
CO4	Select appropriate casting or welding processes for given materials, geometries, and industrial applications.	III
CO5	Evaluate weld quality, metallurgical aspects, and inspection techniques in welding processes.	V
CO6	Assess recent trends, automation, and sustainability aspects in advanced casting and welding technologies.	V

SYLLABUS

Unit No.	Content	COs	Hours
Unit 1	**Advanced Casting Processes** Limitations of conventional casting methods. Shell molding, investment casting, lost foam casting, Permanent mold casting and squeeze casting. Advantages, limitations and applications.	**CO1**	**08Hrs**
Unit 2	**Special Casting Techniques** Centrifugal casting (true, semi and centrifuging). Continuous casting – principle and applications. Vacuum casting and slush casting.	**CO2**	**06 Hrs**
Unit 3	**Casting Defects, Quality and Simulation** Types of casting defects and their causes. Inspection and testing of castings (NDT overview). Gating and risering design concepts. Casting simulation and solidification analysis.	**CO3**	**06 Hrs**
Unit 4	**Advanced Welding Processes** Gas Tungsten Arc Welding (GTAW / TIG), Gas Metal Arc Welding (GMAW/ MIG), Plasma Arc Welding (PAW), Submerged Arc Welding (SAW) Advantages and applications	**CO4**	**08 Hrs**
Unit 5	**Special and Solid-State Welding Techniques** Resistance welding (spot, seam, projection), Friction welding and friction stir welding (FSW), Diffusion welding, Ultrasonic welding Explosive welding (principle and applications)	**CO5**	**06 Hrs**
Unit 6	**Weld Quality, Automation and Recent Trends** Weld defects and inspection methods, Residual stresses and distortion. Robotic welding and welding automation. Welding metallurgy. Recent developments in casting and welding, Safety and sustainability aspects.	**CO3**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments/Case study on each unit.

Text Books	
1	Advanced Welding Technology Author: S. A. Rizvi Publisher: S. K. Kataria and Sons (India)Edition: 6th EditionYear: 2009 (latest reprint 2025)ISBN: 978-93-80027-39-5
2	Advanced Welding Techniques: Holistic View with Design Perspectives Authors: Mukti Chaturvedi, S. Arungalai Vendan Publisher: Springer Nature Singapore Year: 2021 ISBN: 978-981-33-6621-3
3	Advanced Welding Methods and EquipmentAuthors: Ruifeng Li, Taotao Li Publisher: Springer Singapore Year: 2024 ISBN: 978-981-97-4109-0
4	Advanced Welding Processes Author: J. Norrish Publisher: Woodhead Publishing / Elsevier Year: 2006 ISBN: 978-1-84569-130-1
5	Advanced Casting Technologies Editor: Thoguluva Raghavan Vijayaram Publisher: IntechOpen Year: 2018 ISBN: 978-1-78923-033-8

Reference Books	
1	R.W. Messler, Principles of Welding, Wiley
2	ASM Handbook – Casting and Welding Volume
3	A Course in Workshop Technology (Manufacturing Processes) – Volume 1 B. S. Raghuwanshi Publisher: Dhanpat Rai and Co.
4	Manufacturing Engineering and Technology, S. Kalpakjian and S. R. Schmid, *Pearson*
5	Cary and Helzer, Modern Welding Technology, Pearson

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course -2 (PEC-2)			Course Code:MME0264		
Course Title :**Total Quality Management**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic idea of making products, checking quality, and understanding customer needs and simple problems at work.

Course Objectives: The objectives of the course are to

1. Know the concept of total quality and role of quality assurance.
2. Know planning and controlling techniques for quality
3. Know product and system reliability,
4. Know some popular approaches to TQM
5. Know TQM leadership, tools and techniques of TQM.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Understand the process approach to Quality Assurance (Input Process Output).	II
CO2	Understand and apply the quality control tools to assure the product quality	III
CO3	Students will analyze the systems by using the tools like FMEA, FTA and Taguchi philosophy	III
CO4	Understand Deming's approach, Juran‘s trilogy of Total Quality Management	II
CO5	Understand role of HR in TQM, 5-S & Poka Yoke techniques in TQM	II
CO6	Understand and comprehend the Quality management Systems with reference to ISO 9001:2008, QS standards	II

SYLLABUS

Unit No.	Content	COs	Hours
Unit 1	**Quality Assurance System**		
	• Concept of total quality, role and objectives of Q.A. • Q.A. cycle, process approach to Q.A. (input-process-output). • Input-process-output model. • Information feedback, Significance of feedback. • Q.A., Significance of internal customer approach. • Defect prevention programs for Q. A	CO1	06Hrs
Unit 2	**Planning and Controlling Techniques for Quality**		
	• Planning for quality – The dimensions of Quality (quality of Design, conformance, performance and service), Vendor control procedures. • Quality planning with vendors. • Vendor-rating. Controlling techniques for quality. • Seven statistical tools. • Process capability analysis. • Problem solving new management tools. • Why-why analysis, six sigma- Concept, Need, Implementation.	CO2	07Hrs
Unit 3	**Robust and Reliable Product Approach for Quality**		
	• Product and system reliability: Basic concepts. • Prediction and evaluation of parallel, Series and combined system reliability. • Reliability tests (life testing, burn - in test, accelerated life testing). • FMEA. • FTA. • Taguchi‘s quality Philosophy System design, Parameter design, Tolerance design. • Orthogonal arrays, S/N ration, Loss functions	CO3	07Hrs
Unit 4	**Principles and Approaches to TQM**		
	• Basic concepts: definition of TQM. • TQM and traditional management approach, Principles. • Characteristics, and benefits of TQM. • Approaches to TQM: Deming‘s approach. • Juran‘s trilogy. • Crosby and quality improvement. • Ishikawa‘s CWQC.	CO4	07Hrs

Unit 5	**The Essentials of TQM** • Customer Focus, Customer perception of quality, Quality policy deployment, Quality function deployment. • Voice of customer, Customer satisfaction, Kano's model of satisfaction, Customer retention • TQM Leadership- Role and commitment and accountability of leadership, Quality policy and objectives. • Organizational structure for TQM, Role of HR in TQM. • Training for TQM, Developing quality culture. • Tools and Techniques for TQM:5-Scampaign, TEI, quality circles. • QFD, poka-yoke, KAIZEN	**CO5**	**07 Hrs**
	Current Trends in TQM		
Unit 6	• TQM in service sector: Definition and meaning and service, problems in defining service quality, attributes of service quality. • SERVQUAL model, Implementing TQM in service industries. • Measurement system for service quality. • Quality Management Systems: ISO9001:2008 Series Standards–Clauses, contents. • Interpretation and implementation. • Audit Sector Specific Standards–AS9100. • ISO/ TS 16949, TL9000, Quality Awards: National and International quality awards. • Criteria and case studies.	**CO6**	**08 Hrs**

Note - The ISE/CA is carried out through six Assignments based on six units:

Text Books	
1	Total Quality Management by N. V. Naidu and K. Rajendra Publication: New Age International, 2011 ISBN: 978-8122430462
2	Total Quality Management by R. S. Naagarazan Publication: New Age International, 2013 ISBN: 978-8122433814
3	Fundamentals of Total Quality Management by R. P. Mohanty and R. R. Lakhe Publication: Jaico Publishing House, 2012 ISBN: 978-8172249427
4	Total Quality Management by K. K. Chitkara Publication: Tata McGraw Hill, 2011 ISBN: 978-0070700239
5	TQM: Text and Cases by Dr. V. Jayakumar Publication: Laxmi Publications, 2014 ISBN: 978-9381159266

Reference Books	
1	Total Quality Management by K. Shridhara Bhat Publication: Himalaya Publishing House, 2016 ISBN: 978-9351425499.
2	Total Quality Management by Dale H. Besterfield, Carol Besterfield-Michna, Glen H. Besterfield & Mary Besterfield-Sacre Publication: Pearson Education, 2014 ISBN: 978-9332583817.
3	Total Quality Management by K. C. Arora Publication: S. K. Kataria and Sons, 2010 ISBN: 978-9350140119
4	Total Quality Management by Subburaj Ramasamy Publication: Tata McGraw Hill, 2012 ISBN: 978-0070704688
5	Total Quality Management by S. K. Sharma Publication: S. Chand Publishing, 2013 ISBN: 978-8121931847

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course -3 (PEC-3)			Course Code:MME0265		
Course Title: **Experimental Mechanics**					
Teaching Scheme	L	T	P	Contact Hrs./Week	Credits
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Analysis of Mechanical Elements, Fluid and Thermal Engineering, Material and Manufacturing Processes, Basic Knowledge of Heat Transfer.

Course Objectives: The objectives of the course are to

1. Introduce the concept of experimental stress analysis
2. Prepare mechanical engineering students for advanced graduate studies in various experimental stress analysis techniques like photo elasticity, strain gauge etc.
3. Supply qualified personnel to meet the requirement in experimental stress analysis

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	**Explain** the principles of Experimental Mechanics and various methods of stress analysis along with their advantages and limitations	II
CO2	**Apply** the concepts of two-dimensional photo elasticity including stress-optic law, fringe formation, and material calibration.	III
CO3	**Analyze** photoelastic data to determine principal stresses and directions using methods such as shear difference and oblique incidence.	IV
CO4	**Apply and evaluate** strain measurement techniques using electrical resistance strain gauges and appropriate mounting and selection criteria.	III,V
CO5	**Analyze** Wheatstone bridge circuits and strain gauge rosette configurations to determine principal stresses and strains.	IV
CO6	**Explain and compare** advanced experimental techniques such as brittle coating, birefringent coating, and moiré fringe methods for stress analysis.	II,IV

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Principles of Experimental Approach-**		
	Introduction to Experimental Mechanics, advantages scope of Experimental Mechanics in design, various experimental methods of stress analysis and their relative merits and demerits	**CO1**	**04 Hrs**
Unit 2	**Two Dimensional Photo elasticity-**		
	Stress optics law, material fringe value in terms of stress and strain, significance of material fringe value, Nature of light, Wave theory of light – optical interference, Photo elastic Materials - Criteria for selection, common photo elastic materials and their properties, Photo elastic sheet casting and model making, calibration of photo elastic material, calibration methods using circular disc, polariscope, its scope in photo elasticity, various configurations of polariscope, effect of stressed model in plane and circular polariscope, isoclinics, isochromatics, their significance in photoelastic stress analysis. Properties of 2D photoelastic model materials, Materials for 2D photoelasticity Methods for fractional fringe measurement, Tardy's method of compensation (Derivation)	**CO2**	**12 Hrs**
Unit 3	**Analysis of Photo elastic Data**		
	Principle of photoelasticity, methods of photoelastic stress analysis, temporary and permanent double refraction, Determination of direction of principal stresses at a given point, shear difference method, oblique incidence method and electrical analogy method.	**CO3**	**06 Hrs**
Unit 4	**Strain Measurement Using Strain Gauges**		
	Concept, meaning of strain gauges, desirable properties of strain gauges, types of strain gauges, Strain measurement using electrical resistance strain gauge, Selection and mounting of strain gauge, criteria for selection, mounting of gauge and checking its installation	**CO4**	**07 Hrs**
Unit 5	**Strain Gauge Circuitry**		
	Wheatstone bridge circuit, its role in measurement of resistance change, condition for bridge balance, different configurations of Wheatstone bridge, output voltage of Wheatstone bridge, relationship between output voltage and strain, commercial strain indicators, potentiometer circuit. Introduction to strain gauge rosettes, two, three and four element rosettes, different configurations of rosettes and their comparison, determination of magnitudes and direction of principal stresses when principal stress directions are specified and not specified.	**CO5**	**07 Hrs**
	Coating Methods and Moire Fringe method–		
Unit 6	Introduction, Brittle coating, coating stresses, crack patterns, crack detection techniques, selection of brittle coating, advantages, Birefringent coating:- Limitations and applications, Introduction to Birefringent coating, Birefringence coating stresses, Effects of coating thickness: Reinforcing effects, Poisson's effect , Reflection polariscope Introduction to Moiré fringe method of stress analysis – Mechanism of fringe formation, approaches to moiré fringe analysis, advantages, limitations and applications	**CO6**	**06 Hrs**

Note - The ISE/CA is carried out through any eight Assignments from the following:

1. Bonding of strain gauge and checking its installation.
2. Determination of gauge factor for one arm sensitive and two arm sensitive configuration.
3. Determination of gauge factor for four arm sensitive and four arm sensitive two linear and two lateral configuration.
4. Transducer applications of strain gauge- determination of unknown weight using load cell.
5. Study of photo elastic stress analysis – use of diffused light transmission Polariscope.
6. Determination of fractional fringe order using Tardy‘s method.
7. Calibration of Photo elastic materials - determination of material fringe value.
8. Study of Moiré Fringe Technique.
9. Study of Brittle Coating Method.
10. Study of photo elastic materials.

Text Books	
1	—Experimental Stress Analysis‖, J.W. Dally and W.F.Riley, Tata McGraw Hill Book Company, 3rd edition
2	—Experimental Stress Analysis‖, Dr. Sadhu Singh; Khanna Publishers, 5th edition.
3	—Experimental Stress Analysis‖, L.S.Srinath., Tata McGrawHill.
4	—Experimental Stress Analysis‖, U.C. Jindal, Pearson Publications, 1st edition.
Reference Books	
1	—Experimental Stress Analysis‖, Abdul Muben; Dhanpat Rai and Co., 1st edition.
2	—Principles of Experimental Stress Analysis‖,by American Society for Metals, 6th edition.
3	"Experimental Stress Analysis: Principles and Methods" – G.S. Holister (Cambridge University Press)1st edition
4	. "Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture, and Fatigue" – Norman E. Dowling 4th edition
5	"Modern Experimental Stress Analysis" – James F. Doyle (Wiley) 1st edition

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course -3 (PEC-3)			Course Code:MME0265		
Course Title :**Cryogenics**				Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Analysis of Mechanical Elements, Material & Manufacturing Processes, Electrical Machines, Engineering Mathematics, Basic Knowledge of Engineering Physics (Optics).

Course Objectives: The objectives of the course are to

1. Enable the students to analyze and solve cryogenic related problems by applying principles of mathematics, science and engineering.
2. Prepare students to use modern tools, techniques and skills to fulfill industrial needs related to low temperature systems.
3. Effective communication skill to demonstrate cryogenic theories.
4. Develop skills in the analysis of cryogenic systems in research or design.
5. Develop a professional approach to life long learning in the cryogenics to include the awareness of social and environment issues associated with engineering practices.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	**Explain** the fundamentals of cryogenics, properties of cryogenic fluids, and their applications in space, medical, and industrial fields.	II
CO2	**Analyze** the behavior of structural materials at cryogenic temperatures in terms of mechanical and thermal properties.	III,IV
CO3	**Evaluate** different gas liquefaction methods and systems such as Linde-Hampson, Claude, and Cascade systems based on performance parameters.	IV,V
CO4	**Analyze and compare** liquefaction systems for gases like hydrogen and helium, and **select appropriate heat exchangers** for cryogenic applications.	IV,V
CO5	**Explain and differentiate** various cryogenic refrigeration systems such as Gifford-McMahon, Pulse Tube, and Philips systems.	II,IV
CO6	**Apply** principles of gas separation, insulation, and vacuum technology in the design of cryogenic storage and processing systems.	III,IV

SYLLABUS

Unit No.	Content	COs	Hours
Unit 1	**Introduction:**		
	Cryogenics, Cryogenic Temperature scale, Historical Development of Cryogenics, Properties of cryogenic Fluids, Applications of cryogenics in different areas such as Space, Medical and Biological, Manufacturing processes. Behavior of Structural Materials at Cryogenic Temperature: Mechanical properties, Thermal properties.	**CO1**	**04 Hrs**
Unit 2	**Liquefaction of Cryogenic Gases:**		
	Ideal cycle, System performance parameters, Production of low temperature methods in Cryogenics (Joule Thomson effect, Adiabatic expansion), Liquefaction systems; Simple Linde- Hampson system, Pre-cooled Linde-Hampson system, Cascade system, Claude system, Comparison of above systems.	**CO2**	**12 Hrs**
Unit 3	**Liquefaction Systems for Neon, Hydrogen, Helium and Heat Exchanger:**		
	Maximum Inversion temperature, Limitations of Linde -Hampson System for liquefaction of Neon, Hydrogen and Helium, Precooled Linde-Hampson system for Neon and Hydrogen, Claude system for Hydrogen, Collins Helium Liquefaction system, Heat exchanger used in Liquefaction systems	**CO3**	**06 Hrs**
Unit 4	**Cryogenic Refrigeration Systems:**		
	Ideal refrigeration systems, Philips refrigerator ,Vuilleumier refrigerator, Solvay refrigerator, Gifford-McMohan refrigerator, Pulse tube refrigerator.	**CO4**	**07 Hrs**
Unit 5	**Gas Separation and Purification:**		
	Thermodynamic Ideal separation system, Temperature composition diagram, Principles of Gas separation, Principles of Rectifiers Column, Air Separation Systems (Linde Single Column system, Linde double Column system).	**CO5**	**07 Hrs**
Unit 6	**Insulation & Vacuum Technology**		
	Insulation: Cryogenic fluid storage, Vacuum insulation, Fibrous materials, Solid foams, Gas filled powder, Comparison. **Vacuum Technology:** Importance, Pump down time, Flow regimes, Components of vacuum systems, Mechanical Vacuum pumps, and Ion pumps	**CO6**	**06 Hrs**

Note - The ISE/CA is carried out through any six experiments/ tutorial based on above syllabus

Text Books	
1	—Cryogenic Systems‖, Barron F. Randall, Oxford University Press, New York.
2	"Cryogenic Engineering‖, Thomas M. Flynn, Marcel Dekker. Inc, NewYork.
3	Fundamentals of Cryogenic Engineering – by Mamata Mukhopadhyay PHI Learning Private Limited, New Delhi
4	Cryogenics: A Textbook – S. S. Thipse, published by Narosa Book Distributors Pvt Ltd
Reference Books	
1	"Cryogenic Process Engineering,Klaus D. Timmerhaus, Thomas M.Flynn, Plenum Publishing
2	—Experimental Techniques in low Temperature Physics‖,Guy, K White, Claredon Press,
3	—Cryogenic Research and Applications", Marshall Sitting and Stephen Kidd, D. Van Nostrand, Inc USA,(1963).
4	—Cryogenic Research and Applications", Marshall Sitting and Stephen Kidd, D. Van
5	Handbook of Cryogenic Engineering – *J. G. Weisend II* (Taylor & Francis)

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course -3 (PEC-3)			Course Code:MME0265		
Title of Course: **Production Management**				Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Material and Manufacturing Processes, Economics for Engineers, Strategic Management

Course Objectives: The objectives of the course are to

1. Understand the basics of production management, types of production, production system & role of production manager.
2 Understand the principles of product design and factors affecting manufacturability.
3 Understand the basic concepts and techniques of material management, including MRP, inventory control methods, stores management, purchasing, and JIT and Lean manufacturing,
4 Understand the basic concepts and functions of Production Planning and Control (PPC) including routing, scheduling, loading, dispatching, follow-up, and basics of aggregate and capacity planning.
5, Understand the basic concepts and importance of quality management, including SQC, control charts, process capability, TQM, Six Sigma, and quality standards.
6. Understand the concepts of maintenance management and modern production trends, including automation, CIM, lean, Kaizen, agile manufacturing,.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain simple ideas about production types, systems, and the manager‘s role.	II
CO2	Explain principles of product design to improve manufacturability.	III
CO3	Apply basic inventory and material management techniques such as EOQ, ABC, and VED analysis for effective control of materials.	III
CO4	Explain and apply basic PPC activities such as routing, scheduling, loading, dispatching, follow-up, and simple aggregate and capacity planning in production systems.	III
CO5	Explain and apply basic quality management tools and concepts such as SQC, TQM, Six Sigma, and quality standards in organizations.	III
CO6	Explain and apply basic maintenance strategies and modern production practices such as automation, lean, Kaizen, agile manufacturing.	III

SYLLABUS

Unit No	Content	CO's	Hours
Unit 1	**Introduction to Production Management**		
	Basics of Production Management- Definition, objectives, scope, and functions of production management Types of Production- Job production, batch production, mass production Production Systems- Continuous, intermittent, assembly line, cellular manufacturing Role of Production Manager- Responsibilities, decision-making, coordination with other functions	**CO1**	**08 Hrs**
Unit 2	**Product Design and Process Planning**		
	Product design: Steps, factors affecting design, design for manufacturability Process planning: Process selection, routing, sequencing, and scheduling Work study: Method study and work measurement Time study and standard time calculations	**CO2**	**06 Hrs**
Unit 3	**Material Management**		
	Material requirement planning (MRP)Inventory control techniques: EOQ, ABC analysis, VED analysis, Stores management and purchasing, Just-in-Time (JIT) and lean manufacturing concepts	**CO3**	**08 Hrs**
Unit 4	**Production Planning and Control (PPC)**		
	Objectives and importance of PPC, Routing, scheduling, and loading, Dispatching, follow-up, and production control techniques, Aggregate planning and capacity planning	**CO4**	**06 Hrs**
Unit 5	**Quality Management**		
	Definition and importance of quality management, Statistical Quality Control (SQC): Control charts, Process Capability, Total Quality Management (TQM) and Six Sigma Concepts, Quality Certifications and Standards (ISO, BIS)	**CO5**	**08 Hrs**
Unit 6	**Maintenance and Modern Trends in Production**		
	Maintenance management: Preventive, predictive, and breakdown maintenance, Automation in production and role of Computer-Integrated Manufacturing (CIM), Lean Manufacturing, Kaizen, and Agile Manufacturing,	**CO6**	**06 Hrs**

Note - The ISE/CA is carried out through the Assignments/Case study on each unit.

Text Books	
1	—Production and Operations Management, Norman Gaither & Greg Frazier, Cengage Learning (India Edition)
2	—Production and Operations Management, K. C. Jain, Wiley India (Indian author).
3	—Production and Operations Management, R. B. Khanna, PHI Learning
4	Production and Operations Management – R. Panneerselvam
5	Production and Operations Management – K. C. Jain

Reference Books	
1	—Production and Operations Management, Norman Gaither & Greg Frazier, Cengage Learning (India Edition)
2	—Production and Materials Management, K. Shridhara Bhat, Himalaya Publishing House
3	—Production and Operations Managemen, R. Panneerselvam, Prentice Hall India
4	—Industrial Engineering and Production Management– Martand Telsang
5	—Production and Operations Management– S. N. Chary (Tata McGraw Hill)

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Program Elective Course -3 (PEC-3)			Course Code:MME0265		
Title of Course: **Work study and Ergonomics**				Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	03	--	--	03	03
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic understanding of human work, body movements, simple tools/machines, time and effort, and awareness of safety, comfort, and efficiency in daily activities.

Course Objectives: The objectives of the course are to

1. Introduce the basic concepts and importance of work study and ergonomics in engineering.
2. Understand systematic methods for improving work processes.
3. Introduce the basic ideas of work measurement for productivity improvement.
4. Understand human capabilities and limitations in work design.
5. Apply ergonomic principles in workplace and task design.
6. Understand human–machine interaction and safety aspects in modern industry.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain the importance of work study and ergonomics in engineering systems.	II
CO2	Describe method study steps for improving work methods.	II
CO3	Identify work measurement concepts used in industry.	III
CO4	Explain human physical factors affecting work performance.	II
CO5	Apply ergonomic principles to identify workplace problems.	III
CO6	Apply ergonomic concepts to improve safety and system performance.	III

SYLLABUS

Unit No.	Content	COs	Hours
Unit 1	**Introduction to Work Study and Ergonomics**		
	• Meaning and scope of work study • Objectives of productivity improvement • Meaning and importance of ergonomics • Man–machine–environment system • Role of work study and ergonomics in industry • Benefits: safety, comfort, efficiency	CO1	07 Hrs
Unit 2	**Method Study**		
	• Meaning and objectives of method study Basic steps in method study • Process charts and flow diagrams (conceptual) • Work simplification • Motion economy principles (conceptual) • Practical examples from manufacturing	CO2	07 Hrs
Unit 3	**Work Measurement (Conceptual)**		
	• Meaning and purpose of work measurement • Time study concept (no calculations) • Work sampling – basic idea • Standard time and performance rating (conceptual) • Allowances: relaxation, fatigue (concept only)	CO3	07 Hrs
Unit 4	**Ergonomics and Work Physiology**		
	• Anthropometry: concept and importance • Static and dynamic body dimensions • Working postures: sitting and standing • Work physiology and muscular work • Fatigue: causes and prevention • Work–rest cycles (conceptual)	CO4	07 Hrs
Unit 5	**Workplace Design and Manual Material Handling**		
	• Principles of workplace layout • Workstation design concepts • Manual material handling: lifting, pushing, pulling • Ergonomic tools and equipments • Musculo skeletal disorders (MSDs) • Ergonomics in machine operation.	CO5	07 Hrs

	Cognitive Ergonomics, Safety and Applications		
Unit 6	• Cognitive ergonomics: perception and attention • Human errors and prevention • Human–machine interface principles • Environmental ergonomics: lighting, noise, heat • Safety and accident prevention • Ergonomics in automation and Industry 4.0	**CO6**	**07 Hrs**

Note - The ISE/CA is carried out through six Assignments based on six units

Text Books	
1	Ergonomics and Human Factors by R. S. Bridger Publication: CRC Press, 2018 ISBN: 978-1498760832
2	Introduction to Work Study by I. L. Mundel and D. L. Danner Publication: Pearson Education, 2012 ISBN: 978-8120330917
3	Work Study and Ergonomics by S. Dalela and S. Sourabh Publication: Standard Publishers, 2015 ISBN: 978-8180141501.
4	Ergonomics: How to Design for Ease and Efficiency by K. H. E. Kroemer and E. Grandjean Publication: Pearson Education, 2014 ISBN: 978-9332543514.
5	Ergonomics in Industry by Umesh Prasad Publication: Sonali Publications, 2011 ISBN: 978-8184113396

Reference Books	
1	Work Study and Ergonomics by K. K. Chitkara Publication: Tata McGraw Hill, 2010 ISBN: 978-0070700239
2	Work Study by K. B. Akhilesh Publication: PHI Learning, 2013 ISBN: 978-8120347649
3	Work Study and Ergonomics by P. C. Tewari Publication: Ane Books / Routledge India, 2017 ISBN: 978-9386761620
4	Introduction to Ergonomics by R. S. Bridger Publication: CRC Press, 2013 ISBN: 978-1439834920
5	Work Study and Ergonomics by K. C. Jain Publication: New Age International Publishers, 2019 ISBN: 978-9386649331

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Multi-disciplinary Minor (MDM-04)			Course Code:MME0266		
Title of Course: **Ergonomics and Human Factors**				Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	02	--	--	02	02
Examination Scheme	MSE	ISE/CA	ESE	Total	
	30 Marks	10 Marks	60 Marks	100 Marks	

Prerequisites: Basic knowledge of Ergonomics, basic understanding of human body functions, simple physics (force, work), workplace activities.

Course Objectives: The objectives of the course are to

1. Introduce the basic concepts and importance of ergonomics in engineering and daily life.
2. Understand human physical capabilities and limitations relevant to work design.
3. Introduce ergonomic principles in workplace and task design.
4. Understand human mental processes and their role in system design.
5. Study the effect of environmental factors on human performance and safety.
6. Understand practical applications and future scope of ergonomics.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Explain the importance of ergonomics in engineering systems	II
CO2	Understand human physical capabilities and limitations relevant to work design.	II
CO3	Identify ergonomic issues in workplace and material handling tasks.	III
CO4	Explain human interaction with machines and systems.	II
CO5	Identify environmental factors affecting safety and performance.	III
CO6	Apply ergonomic concepts to real-world engineering problems	III

SYLLABUS

Unit No.	Content	COs	Hours
Unit 1	**Introduction to Ergonomics and Human Factors**		
	• Meaning and definition of ergonomics and human factors • Evolution and scope of ergonomics • Man–machine–environment system • Importance of ergonomics in engineering, industry, and society • Benefits of ergonomics: safety, comfort, productivity • Applications of ergonomics in manufacturing. • Applications of ergonomics in service.	**CO1**	**05 Hrs**
Unit 2	**Human Body Dimensions and Work Physiology**		
	• Anthropometry: concept and importance • Static and dynamic body dimensions • Human posture: sitting, standing, and working postures • Work physiology: basic idea of muscular work • Fatigue: causes, types, and prevention • Work–rest cycles and energy expenditure (conceptual)	**CO2**	**05 Hrs**
Unit 3	**Workplace Design and Manual Material Handling**		
	• Principles of workplace layout and design • Design of workstations (conceptual) • Manual material handling: lifting, pushing, pulling • Ergonomic tools and equipment design • Prevention of musculoskeletal disorders (MSDs) • Ergonomics in machine operation	**CO3**	**05 Hrs**
Unit 4	**Cognitive Ergonomics and Human–Machine Interaction**		
	• Cognitive ergonomics: meaning and importance • Human perception, attention, and memory (basic idea) • Information processing in humans • Human errors: causes and prevention • Human–Machine Interface (HMI) principles • Display and control design (conceptual)	**CO4**	**05 Hrs**
Unit 5	**Environmental Ergonomics and Safety**		
	• Thermal comfort and heat stress • Lighting and illumination at workplace • Noise and vibration: effects and control • Workplace safety and ergonomics	**CO5**	**04 Hrs**

	• Ergonomic risk factors and hazards • Accident prevention through ergonomic design		
	Ergonomics Applications, Standards and Future Trends		
Unit 6	• Ergonomics in manufacturing, healthcare, and offices • Computer ergonomics and digital workspaces • Ergonomics standards and guidelines (ISO, OSHA – overview) • Ergonomics in automation and robotics • Human factors in Industry 4.0 • Emerging trends in ergonomics	**CO6**	**04 Hrs**

Note - The ISE/CA is carried out through six Assignments based on six units.

Text Books	
1	Work Study and Ergonomics by S. K. Sharma Publication: S. K. Kataria and Sons, 2003 ISBN: 978-9350144534
2	Industrial Ergonomics Publication: PHI Learning ISBN: Available online
3	Work Study and Ergonomics by S. K. Kataria and Sons Publication: Kataria Publications ISBN: Available online
4	Industrial Ergonomics by M. I. Khan Publication: PHI Learning Pvt. Ltd., 2017 ISBN: 978-8120340848
5	Industrial Ergonomics by B. S. Dhillon Publication: PHI Learning Pvt. Ltd. ISBN: 978-8120317261

Reference Books	
1	Ergonomics and Human Factors by R. S. Bridger Publication: CRC Press, 2018 ISBN: 978-1498760832
2	Work Study and Ergonomics by Dr. Suresh Dalela and Saurabh Dalela Publication: Standard Publishers ISBN: 978-8180141330
3	Work Study and Ergonomics by Lakhwinder Pal Singh Publication: Cambridge University Press India ISBN: 978-1107503366
4	Essential of Ergonomics by Umesh Prasad Publication: Sonali Publications, 2011 ISBN: 978-8184113396
5	Work Study and Ergonomics by K. C. Jain Publication: New Age International Publishers ISBN: 978-9386649331

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC) Lab			Course Code:MME0267		
Title of Course: **Robot Operating System Lab**				Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	50 Marks	25 Marks	75 Marks	

Prerequisites: Basic Mechanical Engineering, Basic Electrical Engineering and Signal Processing

Course Objectives: The objectives of the course are to

1. **Automation Basics:** Understand types and need of automation.
2. **Industrial Control:** Learn control systems and transfer line fundamentals.
3. **Assembly Automation:** Study parts feeding and assembly methods.
4. **Robot Fundamentals:** Learn robot types, motions and control systems.
5. **End Effectors & Sensors:** Understand grippers, tools and sensor types.
6. **Robot Programming:** Learn teaching methods and basic robot programming.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Identify types of automation and their applications.	II
CO2	Explain industrial control systems and transfer line operations.	II
CO3	Demonstrate assembly automation methods and parts feeding techniques.	III
CO4	Describe robot specifications, motions, and control systems.	II
CO5	Select appropriate sensors and end effectors for robotic tasks.	III
CO6	Program simple robot tasks using teaching methods and robot languages.	III

SYLLABUS

Unit No.	Content	COs	Hours
Unit 1	**Introduction to Automation:**		
	Types, need, and basic elements of automated systems.	**CO 1**	**02 Hrs**
Unit 2	**Industrial Control and Transfer Lines:**		
	Control systems, transfer line configurations, and applications.	**CO 2**	**02 Hrs**
Unit 3	**Assembly Automation:**		
	Parts feeding, orientation methods, and automated assembly techniques.	**CO 3**	**02 Hrs**
Unit 4	**Fundamentals of Industrial Robots:**		
	Robot types, motions, actuators, and control systems.	**CO 4**	**02 Hrs**
Unit 5	**Robot End Effectors and Sensors:**		
	Types of grippers, tools, and sensors used in robotics	**CO 5**	**02 Hrs**
Unit 6	**Robot Teaching and Programming:**		
	Teaching methods, task programming, and basic robot languages.	**CO 6**	**02 Hrs**

Term work:

1. Study of Automation Systems: Identify and classify types of automation in manufacturing.
2. Industrial Control System Analysis: Examine continuous and discrete control systems.
3. Assembly Automation Simulation: Demonstrate parts feeding and orientation mechanisms.
4. Robot Specifications and Motion Study: Explore robot types, motions, and control characteristics.
5. End Effectors and Sensor Study: Analyze different grippers, tools, and sensors used in robots.
6. Robot Programming Exercise: Write and simulate basic robot tasks using teaching methods and commands

Text Books	
1	**"Robotics and Industrial Automation** R. K. Rajput, S. Chand and Company Pvt. Ltd., 2nd Revised Edition.
2	**"Industrial Automatic Control and Robotics"** Chikesh Ranjan and Shahid J. Akhtar, Global Vision Publishing House, 1st Edition.
3	**"Introduction to Robotics: Mechanics and Control",** Craig, J.J., Pearson Education, 4th Edition (2018).
4	**"Robotics: Control, Sensing, Vision and Intelligence",** Fu, K.S.; Gonzalez, R.C.; Lee, C.S.G., McGraw Hill International Edition, 1st Edition (1987).
5	**"Principles of Industrial Robot Applications",** James G. Keramas, Delmar Cengage Learning, 1st Edition (1999).

Reference Books	
1	**"Robot Technology Fundamentals",** Keramas, James G, Thomson Learning–Delmar ISBN:981- 240-621-2,(1998).
2	**"Handbook of Robotics",** Noff, Shimon Y., John Wiley and Sons.
3	**"Introduction to Robotics: Mechanics and Control",** John J. Craig, Pearson Education, 4th Edition.
4	**"Industrial Robotics: Technology, Programming and Applications",** Mikell P. Groover, McGraw Hill Education, 1st Edition.
5	**"Robotics: Modelling, Planning and Control",** Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer, 1st Edition.

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Programme Core Course (PCC) Lab				Course Code:MME0268	
Title of Course: **Fabrication Lab**				Contact Hrs./Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	50 Marks	25 Marks	75 Marks	

Prerequisites: Engineering Graphics, Material and Manufacturing Processes, Workshop Practice.

Course Objectives: The objectives of the course are to

1. Provide advanced hands-on training in fabrication processes used in mechanical and mechatronic industries.
2. Develop skills in precision manufacturing, joining, and assembly techniques.
3. Expose students to modern welding and machining practices.
4. Enable fabrication of functional components and sub-assemblies.
5. Enhance understanding of manufacturability and design-for-fabrication concepts.
6. Support prototype development for mechatronic and automation systems.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Select and safely operate advanced fabrication tools, machines, and measuring instruments.	II
CO2	Perform precision fitting, drilling, tapping, and assembly operations within specified tolerances.	II
CO3	Execute advanced welding processes (MIG/TIG/Arc) and inspect welded joints for defects.	III
CO4	Fabricate sheet metal and machined components used in mechanical and mechatronic systems.	III
CO5	Design and fabricate simple jigs, fixtures, or structural frames for engineering applications.	II
CO6	Integrate fabricated components into functional mechanical or mechatronic sub-assemblies and evaluate their performance.	III

Unit No.	Content	COs	Hours
1	**Advanced Fitting and Machining** Precision measurement and tolerances Drilling, tapping, reaming Fabrication of mating components with tolerances	**CO1**	**02 Hrs**
2	**Advanced Welding Techniques** MIG / TIG welding (demonstration and practice) Multi-pass welding Inspection of welded joints and defect identification	**CO2**	**04 Hrs**
3	**CNC Machining (Introductory)** CNC lathe or milling machine overview Part programming basics (G & M codes) Fabrication of simple CNC components	**CO3**	**04 Hrs**
4	**Sheet Metal Fabrication (Advanced)** Press working operations Bending using press brake Fabrication of enclosures, panels, or brackets	**CO4**	**04 Hrs**
5	**Jigs, Fixtures, and Assembly** Design and fabrication of simple jigs or fixtures Assembly of fabricated components Alignment and fastening techniques	**CO4**	**04 Hrs**
6	**Surface Finishing and Inspection** Grinding and polishing Surface roughness measurement Dimensional inspection using gauges	**CO2**	**02 Hrs**
7	**Fabrication for Mechatronic Applications** Fabrication of frames for robots/automation setups Mounts for motors, sensors, and actuators	**CO5**	**04 Hrs**
8	**Mini Fabrication Project** Design and fabrication of a mechanical or mechatronic system Example: robotic frame, conveyor model, automated clamp, actuator mount	**CO6**	**04 Hrs**

Text Books	
1	**Manufacturing Engineering and Technology – Serope Kalpakjian**
2	**Workshop Technology – B.S. Raghuwanshi**
3	**P. N. Rao, "Manufacturing Technology", Vol. I and II.**
4	**Manufacturing Processes – P.N. Rao**
5	**Manufacturing Processes *4–5* by Lam Ngeun Virasak Publisher: Open Oregon Educational Resources Year: 2019**

Reference Books	
1	**"Course in Workshop Technology –Volume . I and II "** –B.S. Raghuwansh
2	**Production Technology – HMT Handbook**
3	**"Manufacturing Processes–II"**– HMT (Hindustan Machine Tools)
4	**"Workshop Technology –Part I and II"**–W.A.J. Chapman
5	***Manufacturing Engineering and Technology –** by Serope Kalpakjian and Steven Schmid

Third Year B. Tech - Semester VI Mechanical and Mechatronics Engineering (Additive Manufacturing)					
Course Category: Experiential Learning (EL)			Course Code:MME0269		
Title of Course: **Minor Project 02 – Based on IAR**				Contact Hrs/Week	Credits
Teaching Scheme	L	T	P		
	--	--	02	02	01
Examination Scheme	MSE	ISE/CA	ESE	Total	
	--	50 Marks	--	50 Marks	

Prerequisites: Basic Mechanical Engineering, Industrial Automation Robotics and Signal Processing

Course Objectives: The objectives of the course are to

1. Introduce basic concepts of industrial automation robotics.
2. Help students identify simple industrial automation problems.
3. Understand the working of automation and robotic systems.
4. Explain basic control logic and sequence of operations.
5. Study the role of sensors, actuators, and controllers in automation.
6. Develop skills in technical documentation and presentation.

Course Outcomes:

COs	**At the end of successful completion of the course, the student will be able to**	**Blooms Taxonomy Level**
CO1	Identify simple industrial automation or robotics problems.	I
CO2	Explain working principles of automation and robotic systems.	II
CO3	Prepare basic block diagrams and system layouts.	II
CO4	Describe control logic and sequence of operations.	II
CO5	Select suitable sensors, actuators, and controllers conceptually.	II
CO6	Present a structured technical report on automation systems.	III

SYLLABUS

Unit No	Content	COs	Hours
Unit 1	**Problem Identification:**		
	• Selection of an industrial automation or robotics application • Objectives and expected outcomes	**CO 1**	**04 Hrs**
Unit 2	**Literature Survey:**		
	• Study of existing automation/robotic systems • Industrial relevance and applications	**CO 2**	**04 Hrs**
Unit 3	**System Description:**		
	• Block diagram of proposed system • Explanation of major components	**CO 3**	**06 Hrs**
Unit 4	**Control Logic and Operation:**		
	• Sequence of operations • Flowchart / ladder logic explanation (conceptual only)	**CO 4**	**06 Hrs**
Unit 5	**Component Selection (Conceptual):**		
	• Sensors, actuators, PLC/robot controller (no calculations) • Justification for selection	**CO 5**	**04 Hrs**
Unit 6	**Documentation and Presentation:**		
	• Project report preparation • Oral presentation and viva-voce	**CO 6**	**04 Hrs**

Term work:

1. Study of PLC-based Conveyor Automation System
2. Conceptual Design of Robotic Pick-and-Place System
3. Automation of Bottle Filling Process – System Study
4. Industrial Safety Automation using Sensors – Case Study
5. Automated Material Handling System – Conceptual Design

Text Books	
1	**"Industrial Automation and Robotics" R. A. Gupta**, Laxmi Publications, Latest Edition.
2	**"Industrial Automation" S. K. Singh**, McGraw-Hill Education, Latest Edition.
3	**"Introduction to Robotics: Mechanics and Control",** Craig, J.J., Pearson Education, 4th Edition (2018).
4	**"Robotics: Control, Sensing, Vision and Intelligence",** Fu, K.S.; Gonzalez, R.C.; Lee, C.S.G., McGraw Hill International Edition, 1st Edition (1987).
5	**"Principles of Industrial Robot Applications",** James G. Keramas, Delmar Cengage Learning, 1st Edition (1999).

Reference Books	
1	**"Robot Technology Fundamentals",** Keramas, James G, Thomson Learning–Delmar ISBN:981- 240-621-2,(1998).
2	**"Handbook of Robotics",** Noff, Shimon Y., John Wiley and Sons.
3	**"Introduction to Robotics: Mechanics and Control",** John J. Craig, Pearson Education, 4th Edition.
4	**"Industrial Robotics: Technology, Programming and Applications",** Mikell P. Groover, McGraw Hill Education, 1st Edition.
5	**"Robotics: Modelling, Planning and Control",** Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo, Springer, 1st Edition.

Exit option : Award of B. Vocational in Major with 132 credits and an additional 8 credits from following Exit Courses				
Sr. No	**Course Code**	**Course Title**	**Mode**	**Credits**
1	ME-EC-0205	Computer Aided Drafting Lab (ANSYS, SOLIDWORKS)	Online/offline certification Course or project of total 8 credits	8
OR				
2	ME-EC-0206	Machine Maintenance Lab		8