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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 Engineering

To be implemented from

Academic Year 2026-27

SHIVAJI UNIVERSITY, KOLHAPUR

NANE OF FACULTY: SCIENCE AND TECHNOLOGY

PROGRAMME NAME AND CODE: MECHANICAL ENGINEERING

PART: THREE

Preamble

The Third Year B. Tech. Mechanical Engineering Curriculum of Shivaji University is designed to equip students with strong theoretical knowledge, practical skills, and emerging technological competencies required in modern industries and research environments. The syllabus emphasizes the integration of core Mechanical Engineering principles with advanced technologies such as Artificial Intelligence (AI), Machine Learning (ML), Computational Fluid Dynamics (CFD), Additive Manufacturing, and Smart maintenance systems to meet the demands of Industry 4.0.

The curriculum provides a balanced blend of design, manufacturing, thermal sciences, fluid mechanics, quality engineering, maintenance engineering, and system analysis. Courses such as Design of Machine Elements, Fluid Mechanics and Machinery, Metrology and Quality Control, Mechanical System Design, and Industrial Fluid Power strengthen the students' analytical and problem-solving abilities while developing a solid engineering foundation. The laboratory courses and project work encourage experiential learning, hands-on practice, innovation, teamwork, and industry-oriented skill development.

Special emphasis has been given to multidisciplinary learning and emerging domains through programme electives and minor courses including Computational Fluid Dynamics, Failure Analysis, Additive Manufacturing, Total Productive Maintenance, and Heat Power Engineering. These subjects prepare students to address real-world engineering challenges related to sustainability, automation, product reliability, smart manufacturing, energy efficiency, and predictive maintenance.

The inclusion of AI and ML applications across various subjects reflects the evolving needs of modern engineering industries. Students are introduced to data-driven approaches, intelligent monitoring systems, optimization techniques, and predictive analysis tools that enhance engineering decision-making and operational efficiency.

The curriculum also focuses on Outcome-Based Education (OBE), promoting critical thinking, creativity, communication skills, ethical values, and lifelong learning. Through laboratory work, industrial visits, assignments, mini-projects, students gain exposure to industrial practices and develop professional competencies required for higher studies, entrepreneurship, research, and employment in diverse sectors.

Overall, this syllabus aims to develop competent, innovative, and socially responsible mechanical engineers capable of contributing effectively to technological advancement, industrial growth, and sustainable development at national and global levels.

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 Career Growth**
   Graduates will apply fundamental knowledge of mechanical engineering to solve real-world engineering problems and establish successful careers through professional employment, higher education, research, or entrepreneurship in core and allied fields.

2. **Lifelong Learning and Technological Adaptability**
   Graduates will engage in continuous learning and adapt to emerging technologies such as automation, artificial intelligence, and advanced manufacturing to meet evolving industrial and societal needs.

3. **Ethics, Leadership, and Social Responsibility**
   Graduates will demonstrate ethical practices, environmental awareness, leadership qualities, teamwork, and effective communication skills while contributing to sustainable development in multidisciplinary environments.

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)**

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

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

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

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 Engineering
(Robotics and Industrial Automation)
to be implemented from Academic Year 2026-27
(As per GR NEP-2022(67/23) / Tanshi -2, Dated 04th July 2023)

Shivaji University, Kolhapur

Second Year (Sem- III) B.Tech. Mechanical Engineering

Collaborative Robotics (Emerging Minor)

Teaching Scheme			**Examination Scheme**	
Lectures	--		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

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

Course Objectives:

1	To introduce fundamentals of collaborative robotics and human–robot interaction.
2	To understand force-limited and vision-based collaborative robots.
3	To study safety standards and deployment strategies in SMEs.
4	To learn hand-guiding and intuitive robot programming methods.
5	To understand flexible manufacturing using cobots.
6	To analyse real industrial applications of collaborative robots.

Course Outcomes: At the end of this course, student will be able to

CO1	Understand fundamentals of collaborative robots and applications
CO2	Explain safe human–robot interaction principles
CO3	Analyze force-limited and vision-based cobots
CO4	Deploy cobots in SMEs and flexible manufacturing systems
CO5	Demonstrate hand-guiding and no-code programming
CO6	Evaluate collaborative robotics industrial case studies

	Course Contents	COs	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	CO1	**(06)**
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	CO2	**(08)**
Unit 3	**Force-Limited Collaborative Robots** Concept of force-limited robots ,Force and torque sensing principles ,Joint	CO3	**(06)**

	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		
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.	CO4	**(06)**
Unit 5	**Deployment in SMEs and Flexible Manufacturing** Cobots for small and medium enterprises , Flexible automation concepts , Reconfigurable manufacturing systems , Workcell layout design for cobots , End effectors and grippers , Tool changers and accessories , Integration with CNC and conveyor systems , Productivity improvement using cobots , ROI and cost justification , Case studies in SMEs	CO5	**(06)**
Unit 6	**Hand-Guiding and No-Code Programming** 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	CO6	**(06)**
Text Books			
01	Mikell P. Groover - Industrial Robotics: Technology, Programming and Applications - McGraw Hill		
02	Peter Corke - Robotics, Vision and Control: Fundamental Algorithms in MATLAB – Springer		
03	Saeed B. Niku - Introduction to Robotics: Analysis, Control and Applications – Wiley		
04	Frank Lamb - Collaborative Robots - Apress		
Reference Books			
01	Bruno Siciliano and Oussama Khatib - Springer Handbook of Robotics – Springer		
02	Rajiv Dubey - Introduction to Robotics - Tata McGraw Hill		
03	K.S. Fu, R.C. Gonzalez and C.S.G. Lee - Robotics: Control, Sensing, Vision and Intelligence - McGraw Hill		
04	Yoram Koren - Robotics for Engineers - McGraw Hill		
05	05 ISO/TS 15066 - Robots and Robotic Devices Collaborative Robot Safety Requirements - ISO Standard		

Shivaji University, Kolhapur

Second Year (Sem- IV) B.Tech. Mechanical Engineering

AI-Driven Robotics (Emerging Minor)

Teaching Scheme			**Examination Scheme**	
Lectures	--		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Engineering Mathematics (Linear Algebra, Probability and Statistics) ,Basic Electrical and Electronics Engineering ,Programming in C / Python ,Engineering Mechanics ,Basics of Mechatronics , Fundamentals of Artificial Intelligence / Data Science (Introductory level)

Course Objectives:

1	To introduce artificial intelligence techniques used in robotics.
2	To understand machine learning for robot perception and decision making.
3	To study vision-based object detection and manipulation.
4	To learn reinforcement learning for robot motion planning.
5	To analyse adaptive robotic behaviour in unstructured environments.
6	To explore industrial applications of AI-driven robotic systems.

Course Outcomes: At the end of this course, student will be able to

CO1	Understand fundamentals of AI-driven robotics systems
CO2	Apply machine learning for robot perception and decision-making
CO3	Analyze vision-based object detection and manipulation techniques
CO4	Implement reinforcement learning for motion planning
CO5	Evaluate adaptive robotic behaviour in unstructured environments
CO6	Analyze industrial applications of AI-based robotics

	Course Contents	**CO**	**Hours**
Unit 1	**Introduction to AI-Driven Robotics** Introduction to Artificial Intelligence in Robotics , Intelligent robotic system architecture: sensing, perception, planning and actuation , Conventional robots vs AI-driven robots , Data-driven robotics and learning-based control , Overview of machine learning and deep learning for robotics , Sensors used in AI robots: Camera, LiDAR, IMU, Ultrasonic sensors ,Robot perception pipeline: Sensing, Pre-processing and feature extraction , Autonomous robots and Intelligent decision-making , Applications of AI-driven robotics in manufacturing and service sectors , Challenges and future trends in AI-driven robotics	CO1	**(06)**
Unit 2	**Machine Learning for Robot Perception and Decision-Making** Machine learning fundamentals for robotics , Supervised learning, unsupervised learning and reinforcement learning , Feature extraction techniques for robot perception , Classification and regression methods , Artificial neural networks for robotic applications , Deep learning and convolutional neural networks for robot vision , Sensor fusion techniques for robot perception, Probabilistic decision-making methods , Bayesian inference for robotic decision-making Task planning using machine learning , Real-time	CO2	**(07)**

	perception in autonomous robots, Applications in mobile robots and pick-and-place robots		
Unit 3	**Vision-Based Object Detection and Manipulation** Machine vision fundamentals , Image acquisition systems for robotics , Image pre-processing techniques , Filtering and thresholding methods , Image segmentation techniques ,Feature extraction methods , Object detection algorithms , Deep learning-based object detection , Pose estimation for robotic manipulation , Object localization techniques , Vision-guided pick-and-place operations , Grasp planning using vision , Camera calibration for robotic systems , Robot and camera coordinate transformation ,Applications in sorting, assembly and inspection .	CO3	**(07)**
Unit 4	**Reinforcement Learning for Motion Planning** Fundamentals of reinforcement learning ,Agent, Environment and reward function ,Policy and value function concepts ,Markov decision process , Q-learning algorithm ,Policy-based reinforcement learning ,Motion planning using reinforcement learning ,Learning-based trajectory generation ,Robot navigation in dynamic environments ,Exploration and exploitation strategies , Obstacle avoidance using reinforcement learning , Adaptive motion planning for robotic manipulators Comparison with classical motion planning	CO4	**(06)**
Unit 5	**Adaptive Robotic Behaviour in Unstructured Environments** Robotics in unstructured environments, Environment perception techniques ,Mapping and localization methods, Simultaneous Localization and Mapping (SLAM) basics ,Handling uncertainty in robotics , Probabilistic robotics concepts , Adaptive control for robots , Self-learning robotic systems , Learning from demonstration , Imitation learning techniques, Human-aware robot navigation ,Multi-sensor fusion for adaptive behaviour , Autonomous navigation in unknown environments ,Applications in warehouse and agricultural robots	CO5	**(06)**
Unit 6	**Applications of AI-Driven Robotics** AI-driven robotics in Industry 4.0 , Intelligent robotic assembly systems , AI-based robotic inspection systems , Autonomous mobile robots for logistics , Vision-based robotic manipulation , AI-enabled collaborative robots , Healthcare robotic applications , Surgical and rehabilitation robots , Agricultural robots and field automation , Warehouse automation robots ,AI-driven service robots , Case studies of industrial AI robots ,Cloud robotics and edge AI , Future trends in autonomous intelligent robots	CO6	**(06)**

Text Books

01	Markus Vincze and Franziska U. Fleischer - AI-Based Robotics – Springer
02	Peter Corke - Robotics, Vision and Control – Springer
03	Saeed B. Niku - Introduction to Robotics: Analysis, Control and Applications – Wiley
04	Ian Goodfellow, Yoshua Bengio and Aaron Courville - Deep Learning - MIT Press

Reference Books

01	Stuart Russell and Peter Norvig - Artificial Intelligence: A Modern Approach – Pearson
02	Bruno Siciliano and Oussama Khatib - Springer Handbook of Robotics – Springer
03	Richard S. Sutton and Andrew G. Barto - Reinforcement Learning: An Introduction - MIT Press
04	Kevin P. Murphy - Machine Learning: A Probabilistic Perspective - MIT Press
05	Dietrich Fox, Wolfram Burgard and Sebastian Thrun - Probabilistic Robotics - MIT Press

Shivaji University, Kolhapur

Third Year (Sem- V) B.Tech. Mechanical Engineering

Autonomous Mobile Robots (AMRs) & AGVs (Emerging Minor)

Teaching Scheme			**Examination Scheme**	
Lectures	--		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Basics of Robotics, Sensors and Actuators, Control Systems, Mechatronics, Basics of Automation.

Course Objectives:

1	To introduce fundamentals of Autonomous Mobile Robots and AGVs
2	To understand navigation and localization techniques
3	To study sensors used in AMRs and AGVs
4	To learn path planning and obstacle avoidance methods
5	To understand industrial applications of AMRs and AGVs
6	To analyse safety and fleet management of mobile robots

Course Outcomes: At the end of this course, student will be able to

CO1	Understand AMR and AGV fundamentals and architecture
CO2	Explain navigation and localization techniques
CO3	Select sensors for mobile robot applications
CO4	Apply path planning and obstacle avoidance methods
CO5	Analyze industrial deployment of AMRs and AGVs
CO6	Evaluate safety and fleet management systems

	Course Contents	**CO**	**Hours**
Unit 1	**Introduction to AMRs and AGVs** Introduction to mobile robots , Definition of Autonomous Mobile Robots (AMRs) , Definition of Automated Guided Vehicles (AGVs) , AMRs vs AGVs comparison , Types of AGVs , Types of AMRs , Mobile robot architecture , Components of AMRs and AGVs , Drive mechanisms, Applications in manufacturing, warehouse and logistics , Advantages and limitations of AMRs and AGVs	CO1	**(06)**
Unit 2	**Navigation and Localization Techniques** Navigation fundamentals of mobile robots , Localization problem in mobile robotics , Dead reckoning method , Odometry based localization , Map-based localization , Landmark-based navigation , Laser-based navigation , Vision-based navigation , Magnetic tape and line following navigation (AGV) , QR code and marker-based navigation , GPS based navigation , SLAM (Simultaneous Localization and Mapping) basics , Indoor vs outdoor navigation techniques	CO2	**(07)**
Unit 3	**Sensors for AMRs and AGV** Sensors used in mobile robots , Proximity sensors , Ultrasonic sensors , Infrared sensors , LiDAR sensors, Vision cameras ,IMU (Inertial Measurement Unit) , Encoders for position measurement ,Bumper and safety sensors , Sensor fusion techniques , Obstacle detection sensors , Environmental sensing for navigation , Sensor selection criteria for AMRs and AGVs	CO3	**(07)**

Unit 4	**Path Planning and Obstacle Avoidance** Path planning fundamentals , Global path planning , Local path planning , Grid-based path planning , Graph-based planning methods , A* algorithm basics , Dijkstra algorithm basics , Potential field method , Dynamic obstacle avoidance , Real-time path planning , Motion planning for mobile robots, Trajectory generation , Collision avoidance techniques	CO4	**(06)**
Unit 5	**Industrial Applications of AMRs and AGVs** AMRs and AGVs in manufacturing , Warehouse automation using AMRs Material handling applications , Logistics and distribution centers , Assembly line automation , Hospital delivery robots , E-commerce warehouse robots , Fleet of AMRs in smart factories , Integration with conveyors and machines , Industry 4.0 and smart logistics , Case studies of AMRs and AGVs , Productivity improvement using mobile robots	CO5	**(06)**
Unit 6	**Safety, Control and Fleet Management** Safety requirements for mobile robots , Collision detection and avoidance, Emergency stop systems , Safety sensors and scanners , Traffic management for multiple robots , Fleet management systems , Task allocation methods , Communication systems, Battery management and charging systems. Autonomous docking and charging ,Monitoring and control software , Performance evaluation of AMRs and AGVs, Future trends in autonomous mobile robotics	CO6	**(06)**
Text Books			
01	Roland Siegwart, III[rd] Nourbakhsh and Davide Scaramuzza - Introduction to Autonomous Mobile Robots – 2[nd] Edition - MIT Press		
02	Saeed B. Niku - Introduction to Robotics: Analysis, Control and Applications - Wiley		
03	Alonzo Kelly - Mobile Robotics: Mathematics, Models and Methods - Cambridge University Press		
04	Mikell P. Groover - Automation, Production Systems and Computer Integrated Manufacturing – Pearson		
Reference Books			
01	Bruno Siciliano and Oussama Khatib - Springer Handbook of Robotics - Springer		
02	ebastian Thrun, Wolfram Burgard and Dietrich Fox - Probabilistic Robotics - MIT Press		
03	Gregory Dudek and Michael Jenkin - Computational Principles of Mobile Robotics - Cambridge University Press		
04	Howie Choset - Principles of Robot Motion - MIT Press		

Shivaji University, Kolhapur

Third Year (Sem- VI) B.Tech. Mechanical Engineering

Digital Twin of Robotic Systems (Emerging Minor)

Teaching Scheme			**Examination Scheme**	
Lectures	--		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Robotics Engineering, Mechatronics Systems ,Sensors and Actuators ,Basics of Automation and Control Systems ,Fundamentals of CAD/CAM

Course Objectives:

1	To understand the concept and architecture of digital twin technology.
2	To develop knowledge of virtual commissioning in robotic systems.
3	To study real-time data integration between physical and virtual systems.
4	To apply predictive maintenance techniques using digital twin data.
5	To analyze system performance and optimize robotic operations.
6	To understand fault diagnosis using digital twin models.

Course Outcomes: At the end of this course, student will be able to

CO1	Explain the fundamentals and architecture of digital twin systems.
CO2	Develop virtual models for robotic systems and production lines.
CO3	Implement real-time synchronization between physical and digital systems.
CO4	Apply predictive maintenance strategies using digital twin data.
CO5	Analyze system performance for optimization of robotic processes.
CO6	Diagnose faults and improve system reliability using digital twin approaches.

	Course Contents	**CO**	**Hours**
Unit 1	Introduction to Digital Twin: Concept, evolution, architecture, applications in robotics and manufacturing	**CO1**	**(06)**
Unit 2	Virtual Commissioning: Modeling of robotic systems, simulation tools, digital validation of production lines	**CO2**	**(08)**
Unit 3	Real-time Synchronization: Data acquisition, IoT integration, communication protocols, cyber-physical systems	**CO3**	**(06)**
Unit 4	Predictive Maintenance: Data analytics, machine learning basics, condition monitoring using twin data	**CO4**	**(06)**
Unit 5	Performance Optimization: System analysis, optimization techniques, efficiency improvement of robotic systems	**CO5**	**(06)**
Unit 6	Fault Diagnosis: Fault detection methods, diagnostics using digital twin, case studies in robotics	**CO6**	**(06)**

Text Books

01	Grieves, M., Digital Twin: Manufacturing Excellence through Virtual Factory Replication, White Paper.
02	Stark, J., Product Lifecycle Management (PLM): Digital Twin Concepts, Springer.
03	Qi, Q. and Tao, F., Digital Twin and Big Data Towards Smart Manufacturing, Elsevier.
04	Negri, E., Fumagalli, L.and Macchi, M., Digital Twin for Smart Manufacturing, Academic Press.

Reference Books	
01	Tao, F., Zhang, H., Liu, A., Nee, A.Y.C., Digital Twin Driven Smart Manufacturing, Elsevier.
02	Kritzinger, W. et al., Digital Twin in Manufacturing: A Review, CIRP Annals.
03	Bolton, W., Mechatronics: Electronic Control Systems in Mechanical Engineering, Pearson.
04	Groover, M.P., Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson.
05	Lee, J., Bagheri, B., Kao, H.A., Cyber-Physical Systems and Digital Twins, Springer.

Shivaji University, Kolhapur

Final Year (Sem- VII) B.Tech. Mechanical Engineering

Smart Sensors & Machine Vision (Emerging Minor)

Teaching Scheme			**Examination Scheme**	
Lectures	--		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Sensors and Actuators ,Mechatronics Engineering ,Robotics Engineering, Basics of Image Processing ,Control Systems

Course Objectives:

1	To understand the fundamentals of smart sensors and their applications.
2	To study 2D and 3D machine vision systems.
3	To learn working principles of force-torque and tactile sensors.
4	To explore integration of vision systems with robotic systems.
5	To analyze quality inspection techniques using machine vision.
6	To understand defect detection and industrial applications.

Course Outcomes: At the end of this course, student will be able to

CO1	Explain concepts of smart sensors and their industrial applications.
CO2	Understand and analyze 2D and 3D vision systems.
CO3	Describe working of force-torque and tactile sensing systems.
CO4	Implement vision-guided robotic systems.
CO5	Apply machine vision for quality inspection processes.
CO6	Detect defects and evaluate product quality using vision techniques.

	Course Contents	**COs**	**Hours**
Unit 1	Smart Sensors: Definition, characteristics, types, signal conditioning, intelligent sensing systems	**CO1**	**(06)**
Unit 2	2D and 3D Vision Systems: Image formation, cameras, lenses, illumination, depth sensing techniques	**CO2**	**(08)**
Unit 3	Force–Torque and Tactile Sensors: Principles, types, calibration, applications in robotics	**CO3**	**(06)**
Unit 4	Vision-Guided Robotics: Integration of sensors and vision systems, robot guidance, applications	**CO4**	**(06)**
Unit 5	Quality Inspection: Machine vision for dimensional inspection, surface inspection, measurement techniques	**CO5**	**(06)**
Unit 6	Defect Detection: Pattern recognition, image processing techniques, AI-based inspection systems, case studies	**CO6**	**(06)**

Text Books

01	Davies, E. R., Machine Vision: Theory, Algorithms, Practicalities, Elsevier.
02	Szeliski, R., Computer Vision: Algorithms and Applications, Springer.
03	Bolton, W., Mechatronics: Electronic Control Systems in Mechanical Engineering, Pearson.

04	Wilson, J. S., Sensor Technology Handbook, Elsevier.
Reference Books	
01	Jain, A. K., Fundamentals of Digital Image Processing, Prentice Hall.
02	Sonka, M., Hlavac, V., Boyle, R., Image Processing, Analysis, and Machine Vision, Cengage.
03	Corke, P., Robotics, Vision and Control, Springer.
04	Bishop, C. M., Pattern Recognition and Machine Learning, Springer.

Shivaji University, Kolhapur

Final Year (Sem- VIII) B.Tech. Mechanical Engineering

Autonomous Inspection & Maintenance Robots (Emerging Minor)

Teaching Scheme			**Examination Scheme**	
Lectures	--		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100rks

Prerequisites: Robotics Engineering ,Mechatronics Systems ,Sensors and Actuators ,Machine Vision , Basics of Artificial Intelligence

Course Objectives:

1	To understand the design and applications of autonomous inspection robots.
2	To study robotic systems used in hazardous and confined environments.
3	To explore drones and climbing robots for industrial inspection.
4	To learn AI-based techniques for defect identification.
5	To understand predictive and prescriptive maintenance strategies.
6	To analyze real-world applications of autonomous maintenance systems.

Course Outcomes: At the end of this course, student will be able to

CO1	Explain concepts of autonomous inspection and maintenance robots.
CO2	Analyze robots designed for hazardous and confined environments.
CO3	Understand working of drones and climbing robots for inspection.
CO4	Apply AI techniques for defect detection and identification.
CO5	Implement predictive maintenance strategies using data-driven methods.
CO6	Evaluate prescriptive maintenance and optimize maintenance decisions.

	Course Contents	**COs**	**Hours**
Unit 1	Introduction to Autonomous Inspection Robots: Concepts, need, classification, applications in industries	**CO1**	**(06)**
Unit 2	Robots for Hazardous Environments: Design considerations, explosion-proof robots, confined space robots, safety standards	**CO2**	**(08)**
Unit 3	Drones and Climbing Robots: UAV types, navigation, wall-climbing robots, inspection of pipelines, tanks, and structures	**CO3**	**(06)**
Unit 4	AI-Based Defect Identification: Image processing, machine learning techniques, pattern recognition for defect detection	**CO4**	**(06)**
Unit 5	Predictive Maintenance: Condition monitoring, data analytics, IoT-based maintenance, failure prediction models	**CO5**	**(06)**
Unit 6	Prescriptive Maintenance: Decision-making models, optimization techniques, maintenance scheduling, industrial case studies	**CO6**	**(06)**

Text Books

01	Siciliano, B. and Khatib, O., Springer Handbook of Robotics, Springer.
02	Murphy, R. R., Introduction to AI Robotics, MIT Press.
03	Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson.

04	Lee, J., Bagheri, B., Kao, H. A., Industrial AI and Smart Maintenance Systems, Springer.
Reference Books	
01	Corke, P., Robotics, Vision and Control, Springer.
02	Bishop, C. M., Pattern Recognition and Machine Learning, Springer.
03	Bolton, W., Mechatronics: Electronic Control Systems in Mechanical Engineering, Pearson.
04	Jardine, A. K. S., Lin, D., Banjevic, D., Maintenance, Replacement, and Reliability, CRC Press.

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 3Mr 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

Name of Programme: Mechanical Engineering

Scheme of Instructions: Third Year B. Tech. Mechanical Engineering

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	ME0251	Design of Machine Elements	3	--	--	3	3	30	10	60	100
2	PCC	ME0252	Fluid Mechanics and Machinery	3	--	--	3	3	30	10	60	100
3	PCC	ME0253	Metrology and Quality Control	3	--	--	3	3	30	10	60	100
4	PEC	ME0254	Programme Elective- 01	3	--	--	3	3	30	10	60	100
5	MDM	ME0255	Multi-disciplinary Minor–03	3	--	--	3	3	30	10	60	100
6	OE	ME0256	Open Elective-03	2	--	--	2	2	30	10	60	100
7	PCC	ME0257	Fluid Mechanics and Machinery Lab	--	--	2	2	1	--	25	25	50
8	PCC	ME0258	Metrology and Quality Control Lab	--	--	2	2	1	--	25	25	50
9	PEC	ME0259	Programme Elective– 01 Lab	--	--	2	2	1	--	25	--	25
10	MDM	ME02510	Multi-disciplinary Minor–03Lab	--	--	2	2	1	--	50	--	50
11	EL	ME02511	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 Programme (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**	**22**	--	**10**	**08**	**13**	**01**	**02**
Semester Credits	--	--	**11**	**04**	**06**	--	--	**01**	--
Cumulative Sum	**16**	**16**	**33**	**04**	**16**	**08**	**13**	**02**	**02**

PROGRESSIVE TOTAL CREDITS: 88 + 22 = 110

Programme Elective -01 Courses List

Sr. No	Name of Programme Elective Course -1 (PEC-1)
01	Failure Analysis
02	Computational Fluid Dynamics
03	Additive Manufacturing
04	Total Productive Maintenance

Programme Elective Lab -01 Courses List

Sr. No	Name of Programme Elective Course Lab -1 (PEC Lab-1)
01	Failure Analysis Lab
02	Computational Fluid Dynamics Lab
03	Additive Manufacturing Lab
04	Total Productive Maintenance Lab

THIRD YEAR (B. Tech) SEM. V

Shivaji University, Kolhapur

Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0251: Design of Machine Elements (Programme Core Course)

Teaching Scheme			**Examination Scheme**	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Analysis of Mechanical Elements (Mechanics of Materials)

Course Objectives:

1	To study basic principles of machine design.
2	To understand principles for sizing components to ensure function and strength.
3	To study machine elements subjected to fluctuating loading.
4	To study and select rolling contact bearings used for mechanical systems.
5	To design various types of gears using strength and wear considerations.
6	To use of design data books and standard practices.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Understand machine design fundamentals and determine safe component dimensions under various loading conditions to meet strength and functional requirements
CO2	Design machine elements subjected to fluctuating loading
CO3	Analyse and design of shafts, keys and springs
CO4	Design of various joints for given load to be transmitted
CO5	Select rolling contact bearings from manufacturer catalogues and design sliding contact bearings for mechanical systems
CO6	Design various types of gears such as spur, helical, bevel and worm and worm wheel

	Course Contents	**COs**	**Hours**
Unit 1	**Fundamentals of Machine Design and Design against Static Load** Concept of Machine design, Types of loads, Factor of safety- its selection and significance, phases in machine design, Role of AI in modern product design and manufacturing. Theories of failure, Selection and Use of Failure Theories, Numerical.	**CO1**	**(06)**
Unit 2	**Design against Fluctuating Load** 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	**CO2**	**(08)**
Unit 3	**Design of Shafts, Keys and Springs** Design of solid and hollow shafts, ASME code for shaft design, Types Keys, Design of Flat Key. Types of springs and their applications, Styles of end, Design of Helical Compression Spring subjected to static loading.	**CO3**	**(06)**

Unit 4	**Design of Joints and Couplings** Design of machine elements under static loading- Knuckle joint, Types of Couplings, Rigid Coupling. Design of bolted joints subjected to following conditions- 1) Joints in shear 2) Joints subjected to load perpendicular to the axis of bolt. Design of welded joints- 1) Strength of transverse and parallel fillet welds 2) Eccentric load in the plane of weld 3) Welded joint subjected to bending moment. (Numerical on bolted and welded joints only)	**CO4**	**(06)**
Unit 5	**Design of bearings** **Rolling Contact Bearing:** Classification of bearings, static and dynamic load capacities, Stribeck's equation (No derivation), equivalent bearing load, load-life relationship, Bearing life, Selection of bearing from manufactures catalogue. Ball and Roller bearing, Design for variable load and speed, Lubrication and mountings, dismounting and preloading of bearings. **Sliding Contact Bearing:** Introduction. Hydro-Dynamic Lubrication: Basic theory, Design consideration in hydrodynamic bearings, Reynolds equation (No derivation), Raimondi and Boyd method relating bearing variables, Bearing Design- Selection of parameters. (Numerical on Rolling Contact Bearing only)	**CO5**	**(06)**
Unit 6	**Design of gears** Introduction to Gears, Types of gear failure. **Spur Gear:** Force analysis, No. of teeth, Face width, Strength of gear teeth, Static beam strength (Lewis's equation) Barth equation, Dynamic tooth load (spot's equation and Buckingham equation), Wear strength (Buckingham's equation) [No derivation]. **Helical Gear & Bevel Gear:** Formative number of teeth in helical gears& bevel Gear, Force analysis, Beam and wear strength of helical gears& bevel Gear (No derivation), Effective load of helical gears & bevel Gear **Design of Worm and worm wheel**: Gear Terminology and geometrical relations. Standard dimensions and recommendation of worm gearing, Force analysis, Design of worm drive as per IS 7443-1974 based on beam strength and wear strength rating. (Numerical on Spur gears only)	**CO6**	**(06)**

Text Books	
01	V. B. Bhandari- Design of Machine Elements- 4th edition- McGraw Hill
02	R. G. Budynas & J. Keith Nisbett- Shigley's Mechanical Engineering Design- 9th edition- McGraw Hill
03	M. F. Spotts- Design of Machine Elements- 6th edition- Pearson
04	R.S. Khurmi and J.K.Gupta - A Text Book of Machine Design- S. Chand
Reference Books	
01	R. L. Norton- Machine Design- 4th edition- Pearson
02	Robert Juvinall- Fundamentals of Machine Component Design- Wiley
03	S. G. Kulkarni- Machine Design-2008- McGraw Hill (Sigma series)
04	U.C. Jindal- Machine Design- Pearson
05	Mohamed Arezki Mellal- Artificial Intelligence in Material Science: Advances- CRC
Design Data Books	
01	V. B. Bhandari- Machine Design Data Book- McGraw Hill
02	PSG- Design Data Book
03	Balaveera K. Reddy and K. Mahadevan- Design Data Handbook- CBS

Shivaji University, Kolhapur

Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0252: Fluid Mechanics And Machinery (Programme Core Course)

Teaching Scheme			**Examination Scheme**	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Thermodynamics, Strength of Materials

Course Objectives:

1	To identify various properties of fluids and their SI units.
2	To state and illustrate fundamentals of Fluid Statics, Kinematics and Dynamics.
3	To study the use of Continuity Equation, Bernoulli's Equation and Momentum Equation For various applications and study of fluid flow through the pipe and its application.
4	To learn the working principles of Impulse and Reaction water turbines and also to study its velocity triangles. To study design parameters related to Turbines
5	To understand the concept of Centrifugal pumps and its construction. To understand NPSH terms related to centrifugal pumps
6	To learn the implementation of AI in Fluid mechanics

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Understand properties of fluids, classification of fluid flows and identify the fluid flow problem and theoretical concepts of fluid statics.
CO2	Identify theoretical concepts of fluid kinematics and fluid dynamics.
CO3	Understand the application of momentum equation and to Calculate different losses in flow of fluid through different arrangements of pipes.
CO4	Remember Euler's equation of rotodynamic machines and evaluate the performance of Impulse and reaction water turbines.
CO5	To estimate the performance parameters of centrifugal pump.
CO6	Understand the basics of Artificial Intelligence and Computational Fluid Dynamics (CFD) and identify their applications in fluid mechanics and fluid machinery for analysis, prediction, and optimization.

Course Contents		**COs**	**Hours**
Unit 1	**Fluid Properties and Fluid Statics:** Definition of fluid, Properties of fluid Mass Density, Weight Density, Specific Volume, Specific Gravity, Dynamic Viscosity, Kinematic Viscosity, Surface Tension, Capillarity and Compressibility, Types of fluid (Simple Numerical Treatment) Statement of Pascal's law, Hydrostatic law of pressure, Definition of Total Pressure, Centre of Pressure, Buoyancy, Metacenter, Condition of Equilibrium of floating and submerged bodies (No Numerical Treatment on fluid Statics)	**CO1**	**(07)**
Unit 2	**Fluid Kinematics and Dynamics** Eulerian and Langragian approach of fluid flow, Flow visualization, Types of flow, Stream lines, Path lines, streak lines, Stream tube, Continuity Equation in Cartesian coordinates in three dimensional fluid flows. Euler's Equation of motion, Integration of Euler's equation as energy equation. Kinetic Energy correction factor, Applications of Bernoulli's equation Venturimeter, Orifice meter and Pitot tube	**CO2**	**(07)**

Unit 3	**Momentum Equation and Flow through Pipes** Derivation of momentum equation, Applications of momentum equation, momentum correction factor, Different energy losses in flow through pipe, Losses due to friction: Darcy's Weisbach equation and Chezy's equation, Minor Losses due to expansion, contraction, pipe fittings, at entrance, at exit, due to obstruction etc.	**CO3**	**(06)**
Unit 4	**Impulse and Reaction Water Turbines** Euler's equation for work done in Rotodynamic Machines classification of water turbines, Pelton wheel, its construction and working, Pelton wheel design (bucket dimensions, Number of buckets, Jet diameter, Wheel diameter, Jet ratio, Speed ratio, Number of jets,) Calculation of efficiency, Power, Discharge etc., Principle of operation of reaction turbine, Construction and working of Francis and Kaplan Turbine, Draft tube, Cavitation calculation of various efficiencies, Power, Discharge.	**CO4**	**(07)**
Unit 5	**Centrifugal Pumps** Working principles, Construction, Types, Various heads, Multistage pumps, Cavitation, Net positive suction head (NPSH). Efficiencies, Discharge, Head, and Power required	**CO5**	**(05)**
Unit 6	**Recent Trends in Fluid Mechanics and Machinery** Definition of Artificial Intelligence, Evolution of AI in engineering applications Importance of AI in Mechanical and Fluid Engineering, AI-based performance prediction of Centrifugal pumps Pelton, Francis, and Kaplan turbines, Optimization of Pump efficiency, Turbine blade angles, Discharge and power output Fault detection and predictive maintenance using AI [Theoretical Treatment Only]	**CO6**	**(05)**

Text Books

01	—Fluid Mechanics‖, K. L. Kumar, S. Chand Publication. New Delhi, 2nd edition, 2000
02	—Fluid Mechanics –Fundamentals and Application‖, Y. A. Cengel, J. M. Cimbala, TMI,
03	—Fluid Mechanics‖, R. K. Bansal, Laxmi publications. New Delhi, 1998
04	—Fluid Mechanics‖, Frank M. White, McGraw Hill, 2011 7th edition
05	—Fluid Mechanics and Hydraulic Machines‖, Ramamrutham
06	—Fluid mechanics and Hydraulic Machines‖, Modi and Seth.
07	—Fluid mechanics and Hydraulic Machinery‖, R. K Rajput, Laxmi publishers.
08	—Fluid mechanics and Hydraulic Machines‖, Modi and Seth, Standard Book House, 2004
09	—Fluid Mechanics and Hydraulic Machines‖, S.C. Gupta, Pearson Education, 1st edition
10	—Fluid Mechanics and Hydraulic Machines‖, R. K. Bansal, L.P. Pub. House

Reference Books

01	—Fluid Mechanics‖, V.L. Streeter and E.B. Wylie, Tata McGraw Hill Pvt. Ltd., New Delhi, 2nd Edition, 1997
02	—Mechanics of Fluid‖, Merle C. Potter, Prentis Hall of India, New Delhi, 2nd Edition
03	—Fluid Mechanics‖, Fox and McDonald, John Wiley and Sons, New York, 8th Edition.
04	—Fluid Mechanics –Fundamentals and Application‖, Y. A. Cengel, J. M. Cimbala, TMI,
05	—Fundamentals of Fluid Mechanics‖, B. R. Munson, D.F. Young, T. H. Okiishi Wiley India Pvt. Ltd.
06	—Fluid Mechanics and Machinery‖, C.S. Ojha, Oxford University Press.

Shivaji University, Kolhapur

Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0253: Metrology & Quality Control (Programme Core Course)

Teaching Scheme			Examination Scheme	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Machine Drawing.

Course Objectives:

1	To understand basic measurement systems, errors, limits, fits, and tolerances.
2	To study comparators and angular measuring instruments used in metrology.
3	To learn advanced metrology techniques and surface roughness evaluation.
4	To understand measurement of screw threads and gears.
5	To apply statistical quality control tools and sampling techniques.
6	To introduce AI applications in metrology and quality control.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Identify and use various measuring instruments and select appropriate instrument for particular feature measurement.
CO2	Distinguish and understand quality assurance and quality control.
CO3	Distinguish and understand quality assurance and quality control, and use control charts and sampling plans to manufacturing and service sector problems.
CO4	Learn advanced techniques of metrology in various industrial applications.
CO5	Learn AI Technology in metrology

	Course Contents	COs	Hours
Unit 1	**Linear measurement and Limits fits and tolerances** Need of measurement, International standards of length, line and end measurement, errors in measurement, slip gauges. Importance of limits system in mass production, IS specifications of limits, Unilateral and bilateral tolerances, Types of Fits	**CO1**	**(06)**
Unit 2	**Study of comparators** Dial indicator, Sigma and Johansson mikrokator. Pneumatic comparator (Solex and differential), Bevel protractor, Sine bar, Sine center, Clinometers. Application of angle dekkor & autocollimator	**CO2**	**(08)**
Unit 3	**Advancements in Metrology and surface roughness** Introduction & applications of: Coordinate Measuring Machine, Laser in metrology, Principle of interferometry, Application. Surface roughness terminology, Direction of lay, textures, symbols.	**CO3**	**(06)**
Unit 4	**Metrology of Screw Threads and Gears** Different errors in screw threads, Measurement of forms of thread with profile projector, Measurement of thread diameters with standard wire, Screw thread micrometer Profile checking, Backlash checking, Tooth thickness measurement	**CO4**	**(06)**
Unit 5	**Quality Control** Concept of Quality, Quality control and quality assurance, Seven QC tools. Importance of statistical method in quality control, ND curve, Different types of control charts (Numerical treatment on X Bar, R, P and C charts), their constructions and applications Basic concept of sampling inspection, Single and double sampling plans, Operating characteristic curves	**CO5**	**(06)**

Unit 6	**AI in Metrology and Quality Control** Scope of AI, real time monitoring, predictive maintenance, generative AI For calibration, Data analytics, Vision system, AI Applications in metrology & quality control (descriptive treatment)	**CO5**	**(06)**
	Text Books		
01	Engineering Metrology‖, I.C. Gupta, Dhanpat Rai Publications.		
02	—Engineering Metrology‖, R.K.Jain, Khanna Publisher.		
03	—Engineering Metrology‖, M. Mahajan, Dhanpat Rai and Sons.		
04	Engineering Metrology and Measurements‖, N.V.Raghvendra and L. Krishnamurthy Oxford University Press		
	Reference Books		
01	—Practical Engineering Metrology‖, Sharp K.W.B. Pitman, London		
02	—Statistical Quality Control‖, A.L. Grant, Tata McGraw Hill International, New York. 6th edition.		
03	—Metrology, Quality Control & Reliability‖ – Rohit Manglik		
04	The Quality of Measurements – A. E. Fridman, Publisher: Springer		

Shivaji University, Kolhapur

Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0254: Programme Elective -01 -Failure Analysis (Programme Elective Course)

Teaching Scheme			Examination Scheme	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Metallurgy, Analysis of Mechanical Engineering, Machine Tools and Processes.

Course Objectives:

01	To introduce fundamental concepts and importance of failure analysis in engineering applications.
02	To enable understanding of different failure modes and mechanisms in materials and components.
03	To develop capability to analyse engineering failures using scientific and systematic approaches
04	To familiarize students with fracture behaviour, fatigue, creep, and corrosion-related failures.
05	To train students to recommend preventive measures and design improvements based on failure analysis.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain basic concepts, terminology, and significance of failure analysis in engineering practice.
CO2	Identify and classify different types of material and component failures.
CO3	Analyse fracture, fatigue, creep, and corrosion failures using engineering principles.
CO4	Interpret failure evidence such as fracture features and material degradation.
CO5	Determine root causes of failures and suggest preventive and corrective measures
CO6	Prepare systematic failure analysis reports following standard procedures.

	Course Contents	COs	Hours
Unit 1	**Introduction to Failure Analysis** Definition and scope of failure analysis; Types of failures in engineering components; Causes of failures: design, material, manufacturing, service, and maintenance; Role of failure analysis in safety, reliability, and quality improvement; Economic, legal, and ethical aspects of engineering failures.	**CO1**	**(06)**
Unit 2	**Fracture and Mechanical Failures** Ductile fracture: mechanism, characteristics, cup-and-cone fracture; Brittle fracture: cleavage, intergranular fracture, ductile-to-brittle transition; Basics of fracture mechanics: Griffith theory, stress intensity factor, fracture toughness; Modes of crack propagation (Mode I, II, III); Stress concentration and notch sensitivity; Overload failures; Impact and sudden load failures.	**CO2**	**(07)**
Unit 3	**Fatigue Failure** Introduction to fatigue and cyclic loading; High-cycle and low-cycle fatigue; S–N curve and endurance limit; Factors affecting fatigue life; Fatigue crack initiation and propagation; Fatigue failure case studies.	**CO3**	**(07)**
Unit 4	**Creep and High-Temperature Failures** Creep mechanism and stages; Creep deformation and creep rupture; Stress rupture testing; High-temperature material degradation; Engineering applications and case studies	**CO4**	**(06)**
Unit 5	**Corrosion and Environment-Assisted Failures** Fundamentals of corrosion; Types of corrosion and corrosion mechanisms; Stress corrosion cracking; Hydrogen embrittlement; Corrosion fatigue; Prevention and control of corrosion failures	**CO5**	**(07)**

Unit 6	**Artificial Intelligence in Failure Analysis** Introduction to Artificial Intelligence (AI) and Machine Learning (ML) concepts; Role of AI in engineering failure analysis; Data acquisition and pre-processing for failure analysis; Machine learning techniques for failure prediction (regression, classification, clustering); AI-based condition monitoring and predictive maintenance; Applications of AI in fracture, fatigue, and corrosion failure assessment	**CO6**	**(07)**
	Text Books		
01	Prashant Kumar, Failure Analysis and Prevention, McGraw Hill Education India.		
02	B. S. Raghuwanshi, Engineering Failure Analysis, Dhanpat Rai Publications.		
03	V. Raghavan, Materials Science and Engineering, Prentice Hall India.		
	Reference Books		
01	ASM Handbook, Volume 11: Failure Analysis and Prevention.		
02	G. E. Dieter, Mechanical Metallurgy (Indian Reprint), McGraw Hill Education India.		
03	William D. Callister, *Materials* Science and Engineering (Indian Edition), Wiley India.		

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Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0254: Programme Elective -01-Computational Fluid Dynamics (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Fluid Mechanics, Heat and Mass Transfer, Applied Numerical Methods

Course Objectives:

01	To provide Fundamental fluid dynamic principles and their applications.
02	To carry out research in the area of Computational Fluid Dynamics.
03	To provide students with the necessary skills to use commercial Computational Fluid Dynamics packages
04	To introduce the student to widely used techniques in the numerical solution of fluid equations, issues that arise in the solution of such equations, and modern trends in CFD.
05	To understand the fundamental concepts of Artificial Intelligence (AI**)** and its scope in engineering and scientific applications.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Understand of the basic theory of Computational Fluid Dynamics, including discretization, accuracy and stability.
CO2	Capable of writing a simple solver and using a sophisticated commercial CFD package.
CO3	Develop programming skills to solve some specific CFD problems.
CO4	Ability to assess fluid mechanics problems commonly encountered in industrial and environmental settings, construct and apply computational models, determine critical control parameters and relate them to desired outcomes and write reports.
CO5	Define and explain turbulence, and distinguish between laminar, transitional, and turbulent flows using appropriate flow parameters.
CO6	Understand the role of AI and ML in modern CFD.

	Course Contents	**COs**	**Hours**
Unit 1	**Introduction to Computational Fluid Dynamics and Principles of Conservation** Computational Fluid Dynamics: What, When, and Why? CFD Applications, Numerical vs. Analytical vs. Experimental, Modeling vs. Experimentation, typical problems, Problem Solving with CFD — Methodology, The Governing Equations of Fluid Dynamics and Heat transfer	**CO1**	**(06)**
Unit 2	**Basic of Discretization and Grid Generation** Basic aspects of discretization - Discretization techniques Finite difference - Finite volume and Finite element method Comparison of discretization by the three methods, Transformation of non-uniform grids to uniform grids - General transformation of the equations -Form of the governing equations suitable for CFD - Compressed grids - Boundary fitted co-ordinate systems Elliptic grid generation - Adaptive grids - Modern developments in grid generation.	**CO2**	**(06)**
Unit 3	**Finite Difference Method and Finite Volume Method** Finite Difference Method:- Finite Difference Formulations: Introductory remarks, Taylor Series Expansions, Finite difference equations, Central Forward, Backward Numerical error, Explicit, Implicit, Semi- implicit (Crank- Nicholson method), Solution methods	**CO3**	**(06)**

	Direct, Iterative. Finite Volume Method: - **i. For Diffusion** Introduction, FVM for 1D steady state Diffusion, FVM for 2 D Diffusion **ii. For Convection Diffusion** Introduction, Steady 1-D Convection and Diffusion, Central Differencing, Upwind Differencing, Hybrid Differencing, Power Law Scheme, QUICK scheme.		
Unit 4	**Introduction to Solution Algorithms** Introduction, Pressure Velocity Coupling in Steady Flows and Turbulence and Multiphase Modeling (Introductory Treatment), staggered grid, introduction to SIMPLE, SIMLEC, SIMPLER, PISO algorithms, Modeling of multiphase problems.	**CO4**	**(06)**
Unit 5	**Introduction to Turbulence and its Modelling** What is turbulence?; Transition from laminar to turbulent flow; Effect of turbulence on time averaged Navier -Stokes equations; Characteristics of simple turbulent flows; Introduction to Turbulent Models like Mixing length Model, k-epsilon model.	**CO5**	**(06)**
Unit 6	**Role of Artificial Intelligence in Computational Fluid Dynamics** Application, Limitations of traditional CFD approaches including high computational cost, long simulation time, and grid dependency. Motivation for AI-based CFD modeling. Comparison between AI-assisted and physics-based CFD approaches. Introduction to hybrid CFD–AI frameworks.	**CO6**	**(06)**

Text Books

01	—Computational Fluid Mechanics the Basics with Applications‖, Anderson J. D. Jr, Tata McGraw Hill Education Pvt. Ltd.
02	—An Introduction to Computational Fluid Dynamics the Finite Volume Method‖ H. K.Versteeg and W. Malalasekera, Pearson Publication.
03	—Numerical Heat Transfer Fluid Flow‖,Suhas V. Patankar ,Taylor andFrancis.
04	—Introduction to Computational Fluid Dynamics‖, PradipNiyogi, S. K. Chakrabarthy,M.
05	"Introduction to Computational Fluid Dynamics: Development, Application and Analysis", Atul Sharma, Wiley
06	—Artificial Intelligence: A Modern Approach‖, Stuart Russell & Peter Norvig, Pearson Education

Reference Books

01	—Computational Fluid Dynamics: A Practical Approach‖,JiyuanTu, Guan HengYeoh, Chaoqun Liu, Butterworth –Heinemann.
02	—Computational Fluid Dynamics‖, T. J. Chung, Cambridge UniversityPress.
03	—Introduction to Computational Fluid Dynamics‖,AnilW. Date, Cambridge University Press.
04	—Convective Heat and Mass Transfer‖,S. MostafaGhiaasiaan, Cambridge University Press.
05	—Machine Learning for Fluid Mechanics‖, Karthik Duraisamy, Gianluca Iaccarino, Wang, Cambridge University Press

Shivaji University, Kolhapur

Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0254: Programme Elective -01-Additive Manufacturing (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Machine Tools and Processes, CAD

Course Objectives:

01	To introduce fundamentals and classifications of additive manufacturing processes.
02	To explain design principles and materials used in additive manufacturing.
03	To familiarize students with major additive manufacturing technologies and rapid tooling methods.
04	To develop understanding of post-processing, quality control, and industrial applications of AM.
05	To expose students to the role of artificial intelligence in additive manufacturing for process monitoring and optimization.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain fundamental concepts, classification, and benefits of additive manufacturing
CO2	Apply design for additive manufacturing principles in part design.
CO3	Describe working principles and applications of major AM processes.
CO4	Analyze rapid tooling techniques for suitable manufacturing applications.
CO5	Evaluate post-processing methods, quality issues, and industrial applications of AM parts
CO6	Apply basic AI techniques for defect detection and smart additive manufacturing systems.

	Course Contents	**COs**	**Hours**
Unit 1	**Introduction to Additive Manufacturing** Additive Manufacturing (AM) - Distinction Between AM and Conventional Manufacturing Processes - Benefits of AM - Generic AM Process - Eight Steps in AM - Classification of AM Processes - Liquid Polymer Systems - Discrete Particle Systems - Solid Sheet Systems. Design for AM - Part Orientation - Removal of Supports - Hollowing Out Parts - Inclusion of Undercuts - Interlocking Features - Reduction of Part Count - Identification Markings/Numbers.	**CO1**	**(07)**
Unit 2	**VAT Polymerization** Stereo Lithography Apparatus (SLA): process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages. Solid Ground Curing (SGC): process, working principle, applications, advantages and disadvantages, case studies. Powder Bed Fusion – Materials - Powder Fusion Mechanisms - Selective Laser Sintering (SLS): process, working principle, applications, advantages and disadvantages, case studies. Three Dimensional Printing (3DP): process, working principle, applications, advantages and disadvantages, case studies.	**CO2**	**(07)**
Unit 3	**Materials for Additive Manufacturing** Material Extrusion - Basic Principles - Fused Deposition Modeling (FDM) - process, working principle, applications, advantages and disadvantages, case studies. Material Jetting - Materials for Material Jetting - Technical Challenges of MJT - Droplet Formation Technologies - Process Parameters in Material Jetting - Process Benefits and Drawbacks. Sheet Lamination - Laminated Object Manufacturing (LOM) – process, working principle, applications, advantages and disadvantages, case studies	**CO3**	**(06)**

Unit 4	**Rapid Tooling** Introduction to Rapid Tooling (RT), Conventional Tooling Vs RT, Need for RT. RT classification: Indirect Rapid tooling methods: spray metal deposition, RTV epoxy tools, Ceramic tools, investment casting, spin casting, die casting, sand casting, 3D Keltool process. Direct Rapid Tooling: LOM Tools, DTM Rapid Tool Process, EOS Direct Tool Process and Direct Metal Tooling using 3DP.	**CO4**	**(07)**
Unit 5	**Post-Processing, Quality & Applications** Post-processing techniques: heat treatment, machining, surface finishing, Defects, tolerances, and quality control, Inspection and testing of AM parts, Applications in aerospace, automotive, medical implants, tooling, Future trends: Hybrid manufacturing, 4D printing	**CO5**	**(07)**
Unit 6	**Artificial Intelligence in Additive Manufacturing** Overview of AI in Manufacturing, Fundamentals of AI, Machine Learning, and Deep Learning, Data generation in Additive Manufacturing processes, Sensors and in-situ monitoring in AM, AI-based defect detection and quality prediction, Predictive maintenance and smart AM systems, Case studies and future trends in AI-enabled AM	**CO6**	**(06)**
	Text Books		
01	Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker Mahyar Khorasani, Springer ISBN 978-3-030-56126-0, ISBN 978-3-030-56127-7 (eBook) https://doi.org/10.1007/978-3-030-56127-7		
02	3D Printing and Additive Manufacturing: Principles and Applications – Chee Kai Chua, Kah Fai Leong – Publisher: World Scientific Publishing / BSP Books, Latest Ed. 2019/2023		
03	Rapid Prototyping: Principles and Applications in Manufacturing – Chua C.K., Leong K.F. – Publisher: John Wiley & Sons		
04	Additive Manufacturing of Metals: The Technology, Materials, Design and Production – Li Yang et al. – Publisher: Springer Cham, 2017		
05	A Guide to Additive Manufacturing – Edited by Damir Godec et al. – Publisher: Springer Cham, 2022		
	Reference Books		
01	3D Printing and Additive Manufacturing Technologies – L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny – Publisher**:** Springer Nature, 2019		
02	Additive Manufacturing – Developments in Training and Education – Edited by Eujin Pei et al. – Publisher: Springer Cham, 2018/2019		
03	Handbook of Sustainability in Additive Manufacturing – Subramanian Senthilkannan Muthu – Publisher: Springer, 2016		
04	Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development – Frank W. Liou – Publisher: CRC Press		
05	Rapid Tooling: Technologies and Industrial Applications – Peter D. Hilton, Paul F. Jacobs – Publisher: CRC Press		

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Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0254: PEC- Programme Elective -01-Total Productive Maintenance
(Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Basic knowledge of Maintenance Engineering and Management.

Course Objectives:

1	To understand TPM concepts, pillars, and reliability-based maintenance
2	To study TPM implementation, preventive maintenance, and scheduling methods.
3	To improve equipment effectiveness using OEE, three-zero concepts, and TPM organization.
4	To learn TPM tools, human factors, condition monitoring, and CMMS applications.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain the objectives of Total Productive Maintenance (TPM).
CO2	Determine the Overall Equipment Effectiveness (OEE).
CO3	Explain the 12 steps of TPM implementation.
CO4	Explain the Pillars of TPM.
CO5	Describe Computerized Maintenance Management System (CMMS).
CO6	Explain tools in TPM.

	Course Contents	COs	Hours
Unit 1	**Basics of TPM** Introduction to TPM concept, objectives and functions, Reliability Centered Maintenance (RCM), maintainability prediction, availability and system effectiveness, maintenance cost, pillers of TPM.	**CO1**	**(06)**
Unit 2	**Implementation of TPM** Developing the TPM implementation plan, types of abnormalities in TPM, primary types of preventive maintenance, essential elements of effective preventive maintenance plans, preventive maintenance scheduling, floating preventive maintenance scheduling.	**CO2**	**(06)**
Unit 3	**Organization of TPM** Three zeros, strategies to improve overall equipment effectiveness, TPM small group activities., TPM Organization, TPM Implementation, Maintenance Inventory Control, Maintenance Efficiency.	**CO3**	**(06)**
Unit 4	**Components of TPM** Human factors in maintenance, maintenance manuals, maintenance staffing methods, spare parts management, maintenance planning and scheduling, condition monitoring	**CO4**	**(06)**
Unit 5	**Maintenance Management Information Systems** Maintenance Management Information Systems, Computerized Maintenance Management Information Systems, CMMS functionality, Applications of CMMS maintenance, engineering production, inventory control, purchasing.	**CO5**	**(06)**

Unit 6	**Tools in TPM** TPM initial cleaning, problems caused by insufficient cleaning, fungai, F-tagging, golden rules of TPM, the Sagen principle, TPM‘s Three Principle Theory, ownership with TPM: Preventing, troubles, success of TPM.	**CO5**	**(06)**
	Text Books		
01	Seiichi Nakajima, Introduction to TPM, productivity press, Chennai.		
02	Gopala Krishnan, P and Benerji A. K., Maintenance and Spair Parts Management, Prentice Hall of India Pvt. Ltd		
03	**Total Productivity Maintenance (TPM)** – Peter Willmott, Dennis McCarthy – **Publisher:** Butterworth-Heinemann (Elsevier), 2nd edition, 2001		
	Reference Books		
01	Introduction to TPM by Seichi Nakajima		
02	TPM in Process Industries (Step-By-Step Approach to TPM Implementation) Tokutaro Suzuki		
03	Total Productive Maintenance (Lean Manufacturing Series) **– Tina Kanti Agustiady** – Publisher: **CRC Press, 2016**		

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Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0255: (Multi-Disciplinary Minor-03): Heat Power Engineering (Multi-Disciplinary Minor)

Teaching Scheme			**Examination Scheme**	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	03		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Fluid Mechanics, Basic Thermodynamics, Engineering Mathematics

Course Objectives:

01	To understand the fundamental concepts of thermodynamics, fluid properties, and heat and mass transfer mechanisms, enabling analysis of energy interactions in engineering systems.
02	To study the working principles, components, combustion processes, and performance parameters of Internal Combustion engines, including conventional and alternative fuels used for power generation.
03	To analyse gas and vapour power cycles such as Brayton, Rankine, and their modified versions, and to evaluate their efficiency improvement techniques used in modern power plants.
04	To explore renewable energy systems and recent AI–ML applications in heat power engineering, focusing on energy efficiency, system optimization, fault diagnosis, emission reduction, and sustainable power generation.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain and apply fundamental thermodynamic and fluid properties such as pressure, temperature, viscosity, energy, enthalpy, and entropy for basic engineering problem analysis.
CO2	Analyze heat and mass transfer mechanisms including conduction, convection, radiation, diffusion, boiling, condensation, and heat exchanger operations using fundamental laws.
CO3	Describe the working principles, components, fuel systems, and combustion processes of IC engines, and compare conventional and alternative fuels based on performance and energy content.
CO4	Analyze gas and vapor power cycles such as Brayton and Rankine cycles, including their modified versions, to evaluate efficiency improvement techniques in power generation systems.
CO5	Assess renewable energy technologies and their environmental impacts, emphasizing energy conservation and sustainable power generation practices.
CO6	Identify and explain AI and ML applications in heat power engineering, including predictive control, system optimization, fault diagnosis, thermal load forecasting, and emission reduction.

Course Contents		**COs**	**Hours**
Unit 1	**Introduction and basic concepts** Pressure, Temperature, volume, density, specific weight, specific gravity, viscosity (Newtonian vs. Non-Newtonian fluids), surface tension, capillarity, vapor pressure, compressibility, energy, work, force, power, heat, Specific heat, enthalpy and entropy.	**CO1**	**(06)**
Unit 2	**Heat and mass transfer** Definitions, modes of heat transfer, **conduction**, and **radiation** along with fundamental laws (Fourier's, Newton's, Stefan-Boltzmann), Mass Transfer basics -Diffusion, convection, Heat Exchanger classification and types, Boiling and its types, film wise and drop wise condensation.	**CO2**	**(06)**
Unit 3	**I C Engine** Engine cycles (Otto, Diesel), components (cylinders, pistons, cooling, lubrication, ignition), fuel systems (carburetion, fuel injection), combustion processes (SI & CI), Types of fuels, Calorific value of fuels, Alternative Fuels	**CO3**	**(06)**

Unit 4	**Gas and Vapor Power Cycles** a) Gas Power Cycle: Working Principle, Applications, Open and Closed cycle and their comparison, Gas turbine cycle (Brayton cycle, Cycles modified to Regeneration, reheat, intercooling, types of fuels for Gas Turbine b) Vapor Power cycle: Introduction, Carnot Cycle, Rankine Cycle, working principle, components, modified versions of the basic cycle to increase efficiency like superheat, reheat, regeneration, Organic Rankine Cycle (ORC) and its uses	**CO4**	**(08)**
Unit 5	**Renewable Energy and Environment** Use of Solar, Geothermal, Biomass, ocean, wind energy in power generation, Strengths and limitations of it in relation to human aspects of the environment, importance of energy conservation and its impact on environment.	**CO5**	**(06)**
Unit 6	**Recent Trend in AI ML of Heat Power Engineering** Definition of Artificial Intelligence, Machine Learning (ML), Use of AI ML in heat power Engineering, Application such as: - Energy efficiency improvement using AI-based predictive control, AI-based optimization of heat exchanger design, Fault detection and performance monitoring of boilers, condensers and heat exchangers, Use of AI in thermal load forecasting and energy management systems, AI applications in combustion optimization and emission reduction. AI applications in combustion optimization and emission reduction.	**CO6**	**(05)**

Text Books

01	—Heat and Mass Transfer‖, R. K. Rajput, S. Chand and Company Ltd. New Delhi., 5th Edition
02	—Heat Transfer‖, J.P. Holman, Tata McGraw Hill Book Company, New York,2nd Edition
03	—Engineering Thermodynamics‖ , P. K. Nag, McGraw-Hill
04	—Internal Combustion Engines‖, V. Ganesan, McGraw-Hill
05	—Power Plant Engineering‖, P. K. Nag, McGraw-Hill
06	—Renewable Energy Sources‖, G. D. Rai
07	—Artificial Intelligence Applications in Power Systems‖, Kwang Y. Lee & Mohamed El-Sharkawi, IEEE / Wiley.

Reference Books

01	—Heat Transfer– A Practical approach‖,Yunus. A .Cengel, Tata McGraw Hill
02	—Heat Transfer‖ Chapman A.J., Tata McGraw Hill Book Company, New York
03	—Fundamentals of Heatand Mass Transfer‖, Frank P. Incropera, David P. Dewitt, Wisley India. 5th Edition
04	—A Text Book on Heat Transfer‖, Dr. S. P. Sukhatme, Orient Longman Publication Hyderabad
05	—Heat and Mass Transfer‖, S. C. Arora and S. Domkundwar, Dhanpat Rai and Sons, Delhi
06	—Renewable Energy Sources", G. D. Rai, Khanna Publishers, New Delhi.
07	"Thermal Engineering", R. K. Rajput, Laxmi Publications, New Delhi.

Shivaji University, Kolhapur

Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0257: Fluid Mechanics and Machinery Lab (Programme Core Course)

Teaching Scheme			**Examination Scheme**	
Practicals	2Hrs/Week		MSE	-
Tutorials	-		ISE/CA	25 Marks
Total Credits	01		ESE	25 Marks
			Total Marks	50 Marks

Prerequisites: Applied Physics, Applied Thermodynamics

Course Objectives:

01	To Understand the working principles and applications of fluid flow measuring devices, pressure measuring instruments, and hydraulic machines through laboratory experiments.
02	To Apply fundamental fluid mechanics concepts such as Reynolds number, Bernoulli's theorem, and flow measurement techniques for experimental investigations.
03	To Analyse fluid flow characteristics, major and minor losses in pipes and fittings, and performance parameters of hydraulic systems using experimental data.
04	To Evaluate the performance characteristics and efficiencies of hydraulic turbines, centrifugal pumps, and centrifugal blowers under different operating conditions.
05	To Develop problem-solving and technical reporting skills through experimentation, performance assessment, and industrial exposure related to fluid machinery systems.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Understand various pressure measuring devices and understand the Reynolds experiment.
CO2	Verify the Bernoulli's equation and Calibration of Venturimeter.
CO3	Understand the losses in pipes and fittings
CO4	Study the Performance Characteristics of Hydraulic Turbines
CO5	Study the performance parameters of Centrifugal Pump.
CO6	Study the performance parameters of Centrifugal Blower.

List of Experiments

Exp. No.	**Name of Experiment**	**COs**
Expt. 1	Study and demonstration of Pressure Measuring Devices (Compulsory)	CO1
Expt. 2	Reynolds experiment.	CO1
Expt. 3	Verification of Bernoulli's equation.	CO2
Expt. 4	Calibration of Venturimeter.	CO2
Expt. 5	Determination of major and minor losses in pips-fittings.	CO3
Expt. 6	Trial on Impulse / Reaction Turbine with characteristics curve.	CO4
Expt. 7	Trial on Centrifugal Pump with characteristics curve.	CO5
Expt. 8	Industrial visit to Pump/Turbine Manufacturing Industry or Hydro Power Plant.	CO4,CO5,CO6

Text Books	
01	—Fluid Mechanics‖, K. L. Kumar, S. Chand Publication. New Delhi, 2nd edition, 2000
02	—Fluid Mechanics –Fundamentals and Application‖, Y. A. Cengel, J. M. Cimbala, TMI,
03	—Fluid Mechanics‖, R. K. Bansal, Laxmi publications. New Delhi, 1998
04	—Fluid Mechanics‖, Frank M. White, McGraw Hill, 2011 7th edition
05	—Fluid Mechanics and Hydraulic Machines‖, Ramamrutham
06	—Fluid mechanics and Hydraulic Machines‖, Modi and Seth.
07	—Fluid mechanics and Hydraulic Machinery‖, R. K Rajput, Laxmi publishers.
08	—Fluid mechanics and Hydraulic Machines‖, Modi and Seth, Standard Book House, 2004
09	—Fluid Mechanics and Hydraulic Machines‖, S.C. Gupta, Pearson Education, 1st edition
10	—Fluid Mechanics and Hydraulic Machines‖, R. K. Bansal, L.P. Pub. House
Reference Books	
01	—Fluid Mechanics‖, V.L. Streeter and E.B. Wylie, Tata McGraw Hill Pvt. Ltd., New Delhi, 2nd Edition, 1997
02	—Mechanics of Fluid‖, Merle C. Potter, Prentis Hall of India, New Delhi, 2nd Edition
03	—Fluid Mechanics‖, Fox and McDonald, John Wiley and Sons, New York, 8th Edition.
04	—Fluid Mechanics –Fundamentals and Application‖, Y. A. Cengel, J. M. Cimbala, TMI,
05	—Fundamentals of Fluid Mechanics‖, B. R. Munson, D.F. Young, T. H. Okiishi Wiley India Pvt. Ltd.
06	—Fluid Mechanics and Machinery‖, C.S. Ojha, Oxford University Press.

Shivaji University, Kolhapur

Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0258: Metrology and Quality Control Lab (Programme Core Course)

Teaching Scheme			**Examination Scheme**	
Practicals	2Hrs/Week		MSE	-
Tutorials	-		ISE/CA	25 Marks
Total Credits	01		ESE	25 Marks
			Total Marks	50 Marks

Prerequisites: Machine Drawing

Course Objectives:

01	**To Understand** the principles of engineering metrology, measurement systems, limits, fits, tolerances,and quality control practices through laboratory experiments.
02	**To Apply** linear, angular, optical, and comparative measuring instruments for dimensional inspection and precision measurement of engineering components.
03	**To Analyze** measurement data, measurement errors, and surface characteristics using advanced metrology instruments and techniques.
04	**To Evaluate** manufacturing quality using statistical quality control tools, control charts, and sampling techniques for industrial applications.
05	**To Investigate** the applications of modern metrology systems and Artificial Intelligence techniques for inspection, measurement automation, and quality improvement.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Identify and use various measuring instruments and select appropriate instrument for particular feature measurement.
CO2	Distinguish and understand quality assurance and quality control. They can use control charts and sampling plans to manufacturing and service sector problems.
CO3	Learn advanced techniques of metrology in various industrial applications
CO4	Learn AI Technology in Metrology.

	List of Experiments	
Exp. No	**Name of Experiment**	**COs**
Expt. 1	Study and use of Linear Measuring Instruments.	CO1
Expt. 2	Study and Use of Comparators (practical use of pneumatic/Mechanical comparator).	CO1
Expt. 3	Study and Use of Angle Measuring Instruments.	CO1
Expt. 4	Screw Thread Measurement.	CO1
Expt. 5	Study and use of Optical Flat.	CO1
Expt. 6	Use of Tool Makers Microscope.	CO3
Expt. 7	Use of Optical Profile Projector.	CO3
Expt. 8	Assignment on Control Charts.	CO2
Expt. 9	Assignment on application of AI in Metrology.	CO4
Expt. 10	Industrial Visit.	CO1,CO2, CO3,CO4

NOTE- ESE (OE) Only Oral Exam based on Experiments

Text Books	
01	Engineering Metrology‖, I.C. Gupta, Dhanpat Rai Publications.
02	—Engineering Metrology‖, R.K.Jain, Khanna Publisher.
03	—Engineering Metrology‖, M. Mahajan, Dhanpat Rai and Sons.
04	Engineering Metrology and Measurements‖, N.V.Raghvendra and L. Krishnamurthy Oxford University Press
Reference Books	
01	—Practical Engineering Metrology‖, Sharp K.W.B. Pitman, London
02	—Statistical Quality Control‖, A.L. Grant, Tata McGraw Hill International, New York. 6th Edition.
03	—Metrology, Quality Control & Reliability‖ – Rohit Manglik
04	The Quality of Measurements – A. E. Fridman, Publisher: Springer

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Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0259: Programme Elective– 01 Lab (Failure Analysis Lab) (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Practicals	2Hrs/Week		MSE	
Tutorials	-		ISE/CA	25 Marks
Total Credits	01		ESE	-
			Total Marks	25 Marks

Prerequisites: Metallurgy, Analysis of Mechanical Engineering, Machine Tools and Process.

Course Objectives:

01	To Understand the fundamental concepts of material and component failure mechanisms through laboratory investigations.
02	To Apply mechanical testing and metallurgical techniques for identification of various failure modes.
03	To Analyze fracture surfaces, fatigue behaviour, creep, wear, and corrosion-related failures using experimental data.
04	To Evaluate the root causes of engineering component failures and recommend corrective measures.
05	To Develop technical reporting skills for systematic failure analysis of engineering components.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Identify ductile, brittle, fatigue, and creep failures using mechanical testing methods.
CO2	Examine fracture surfaces and material properties using hardness testing and SEM fractography.
CO3	Analyze the effects of corrosion, wear, temperature, and cyclic loading on material failure.
CO4	Apply failure analysis techniques to real engineering components and suggest preventive measures.

List of Experiments (Any 08)

Exp. No.	**Name of Experiment**	**COs**
Expt. 1	Tensile Failure Analysis: Study of ductile and brittle fracture using tensile test.	CO1
Expt. 2	Impact Failure (Charpy/Izod Test): Identification of brittle vs ductile fracture based on fracture mechanics	CO1
Expt. 3	Fatigue Failure Analysis: Analysis of crack initiation and propagation under cyclic loading.	CO1
Expt. 4	Creep Failure Analysis: Study of time dependent failure at high temperature and constant stress	CO1
Expt. 5	Scanning Electron Microscope (SEM) Fractography: Detailed micro level analysis of fracture surface	CO2
Expt. 6	Creep Failure Analysis: Creep test at elevated temperature	CO3
Expt. 7	Hardness Testing: Brinell / Rockwell / Vickers hardness	CO2
Expt. 8	Corrosion Failure Analysis: Uniform corrosion, pitting, galvanic corrosion	CO3
Expt. 9	Wear Failure Analysis: Adhesive, abrasive, erosive, fretting wear	CO3
Expt. 10	Case Study-Based Failure Analysis (Any one from following) • Real-life component failures, Shafts, Gears, Pressure vessels, Welded joints, Bolts and fasteners	CO4

Text Books	
01	Prashant Kumar, Failure Analysis and Prevention, McGraw Hill Education India.
02	B. S. Raghuwanshi, Engineering Failure Analysis, Dhanpat Rai Publications.
03	V. Raghavan, Materials Science and Engineering, Prentice Hall India.
Reference Books	
01	ASM Handbook, Volume 11: Failure Analysis and Prevention.
02	G. E. Dieter, Mechanical Metallurgy (Indian Reprint), McGraw Hill Education India.
03	William D. Callister, *Materials* Science and Engineering (Indian Edition), Wiley India.

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Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0259: Programme Elective– 01 Lab (Computational Fluid Dynamics Lab)
(Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Practical	2Hrs/Week		MSE	-
Tutorials	-		ISE/CA	25 Marks
Total Credits	01		ESE	-
			Total Marks	25 Marks

Prerequisites: Fluid Mechanics, Heat and Mass Transfer, Applied Numerical Methods

Course Objectives:

01	To Understand the workflow and capabilities of commercial/open-source CFD software for engineering analysis.
02	To Apply mesh generation, boundary condition specification, and solver selection techniques for fluid flow simulations.
03	To Develop numerical models and simple CFD codes for solving one-dimensional and two-dimensional flow problems.
04	To Analyze flow behaviour through visualization and interpretation of CFD results.
05	To Validate and evaluate numerical solutions by comparing them with analytical and benchmark solutions.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Apply commercial or open-source CFD software to simulate 2-D and 3-D steady and unsteady flow problems.
CO2	Generate appropriate computational grids and select suitable physical models for accurate CFD simulations.
CO3	Develop numerical codes for 1-D and 2-D steady flow problems using C, C++, or SciLab.
CO4	Post-process and validate numerical and CFD results by comparison with analytical or benchmark solutions.

List of Experiments

Expt. No.	**Name of Experiment**	**COs**
Expt. 1	Introduction to a commercial or open-source CFD package (ANSYS Fluent / CFX / STAR-CCM+ / Open FOAM / FLUIDYNE) Geometry creation, mesh generation, boundary condition specification, solver selection, and post-processing.	CO1,CO2
Expt. 2	Simulation of a 2-D steady incompressible flow problem (e.g., laminar flow through a channel or flow over a flat plate) Analysis of velocity and Pressure distribution.	CO1,CO4
Expt. 3	Simulation of a 2-D unsteady flow problem *(e.g., flow past a circular cylinder or transient flow in a channel)* Study of time-dependent flow behaviour.	CO1
Expt. 4	Simulation of a 3-D steady flow problem (e.g., flow through a pipe bend or diffuser)Evaluation of pressure drop and velocity contours.	CO1,CO2
Expt. 5	Simulation of a 3-D unsteady flow problem *(e.g., transient flow in a pipe or vortex shedding behind a bluff body)*Analysis of transient solution and flow structures.	CO1
Expt. 6	Development of a CFD code using C / C++ / SciLab for a 1-D steady flow	CO3,CO4

	problem (e.g., 1-D heat conduction or fully developed pipe flow) Validation of numerical results with analytical solution.	
Expt. 7	Development of a CFD code using C / C++ / SciLab for a 2-D steady flow problem (e.g., 2-D Laplace equation or lid-driven cavity flow). Post-processing and comparison with analytical or benchmark results.	CO3,CO4
Expt. 8	Visualization of CFD results: contours, vectors, streamlines, and plots. Comparison of numerical results from software and coded solutions with analytical/benchmark solutions.	CO4

Text Books	
01	—Computational Fluid Mechanics the Basics with Applications‖, Anderson J. D. Jr, Tata McGraw Hill Education Pvt. Ltd.
02	—An Introduction to Computational Fluid Dynamics the Finite Volume Method‖ H. K.Versteeg and W. Malalasekera, Pearson Publication.
03	—Numerical Heat Transfer Fluid Flow‖,Suhas V. Patankar ,Taylor andFrancis.
04	—Introduction to Computational Fluid Dynamics‖, Pradip Niyogi, S. K. Chakrabarthy,M.
05	"Introduction to Computational Fluid Dynamics: Development, Application and Analysis", Atul Sharma, Wiley
06	—Artificial Intelligence: A Modern Approach‖, Stuart Russell and Peter Norvig, Pearson Education
Reference Books	
01	—Computational Fluid Dynamics: A Practical Approach‖,JiyuanTu, Guan HengYeoh, Chaoqun Liu, Butterworth –Heinemann.
02	—Computational Fluid Dynamics‖, T. J. Chung, Cambridge University Press.
03	—Introduction to Computational Fluid Dynamics‖,AnilW. Date, Cambridge University Press.
04	—Convective Heat and Mass Transfer‖,S. Mostafa Ghiaasiaan, Cambridge University Press.
05	—Machine Learning for Fluid Mechanics‖, Karthik Duraisamy, Gianluca Iaccarino, Wang, Cambridge University Press

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Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0259: Programme Elective– 01 Lab (Additive Manufacturing Lab)
(Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Practicals	2Hrs/Week		MSE	-
Tutorials	-		ISE/CA	25 Marks
Total Credits	01		ESE	-
			Total Marks	25 Marks

Prerequisites: Machine Tools and Processes, Computer Aided Design (CAD)

Course Objectives:

01	To Understand the principles, processes, materials, and applications of additive manufacturing technologies.
02	To Apply Design for Additive Manufacturing (DFAM) concepts using CAD modeling tools.
03	To Generate and optimize STL files, slicing parameters, and build settings for AM processes.
04	To Fabricate components using additive manufacturing equipment and analyze process parameters affecting part quality.
05	To Evaluate dimensional accuracy, mechanical properties, and post-processing requirements of additively manufactured parts.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain additive manufacturing processes, materials, advantages, limitations, and applications.
CO2	Design components for additive manufacturing using CAD tools and apply DFAM principles.
CO3	Generate, slice, and fabricate AM parts by selecting appropriate process parameters and build settings.
CO4	Evaluate additively manufactured parts through dimensional inspection, mechanical testing, and post-processing analysis.

List of Experiments

Expt. No.	**Name of Experiment**	**COs**
Expt. 1	Introduction to Additive Manufacturing • Study of AM processes: FDM, SLA, SLS, DMLS, EBM Materials, advantages, limitations, and applications	CO1
Expt. 2	3D CAD Modeling for AM • Design of components suitable for additive manufacturing • Design for AM (DFAM) considerations	CO2
Expt. 3	STL File Generation and Error Analysis • Conversion of CAD model to STL • Checking and repairing STL errors	CO2
Expt. 4	Slicing and Build Preparation • Selection of layer thickness, infill density, build orientation, and supports • Toolpath generation using slicing software	CO3
Expt. 5	Fabrication Using FDM / Available AM Machine • Printing of a component • Observation of build time and material usage	CO3
Expt. 6	Effect of Process Parameters on Part Quality • Study of layer thickness, infill pattern, and orientation	CO3,CO4

	• Evaluation of surface finish and strength	
Expt. 7	Post-Processing of AM Parts • Support removal and surface finishing • Heat treatment (if applicable)	CO4
Expt. 8	Dimensional Accuracy and Mechanical Testing • Measurement of printed parts • Tensile / compression testing and comparison with design values	CO4

	Text Books
01	Additive Manufacturing Technologies, Ian Gibson, David Rosen, Brent Stucker Mahyar Khorasani, Springer ISBN 978-3-030-56126-0, ISBN 978-3-030-56127-7 (eBook) https://doi.org/10.1007/978-3-030-56127-7
02	3D Printing and Additive Manufacturing: Principles and Applications – Chee Kai Chua, Kah Fai Leong – Publisher: World Scientific Publishing / BSP Books, Latest Ed. 2019/2023
03	Rapid Prototyping: Principles and Applications in Manufacturing – Chua C.K., Leong K.F. – Publisher: John Wiley & Sons
04	Additive Manufacturing of Metals: The Technology, Materials, Design and Production – Li Yang et al. – Publisher: Springer Cham, 2017
05	A Guide to Additive Manufacturing – Edited by Damir Godec et al. – Publisher: Springer Cham, 2022
	Reference Books
01	3D Printing and Additive Manufacturing Technologies – L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny – Publisher**:** Springer Nature, 2019
02	Additive Manufacturing – Developments in Training and Education – Edited by Eujin Pei et al. – Publisher: Springer Cham, 2018/2019
03	Handbook of Sustainability in Additive Manufacturing – Subramanian Senthilkannan Muthu – Publisher: Springer, 2016
04	Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development – Frank W. Liou – Publisher: CRC Press
05	Rapid Tooling: Technologies and Industrial Applications – Peter D. Hilton, Paul F. Jacobs – Publisher: CRC Press

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Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0259: Programme Elective– 01 (Total Productive Maintenance Lab)
(Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Practicals	2Hrs/Week		MSE	-
Tutorials	-		ISE/CA	25 Marks
Total Credits	01		ESE	-
			Total Marks	25 Marks

Prerequisites: Basic knowledge of Maintenance Engineering and Management.

Course Objectives:

01	To Understand TPM concepts, pillars, and maintenance strategies used in industrial systems.
02	To Apply reliability-centered maintenance (RCM) and preventive maintenance techniques for equipment management.
03	To Analyze equipment effectiveness using OEE, availability, maintainability, and maintenance cost parameters.
04	To Evaluate TPM implementation plans and maintenance improvement strategies for industrial applications.
05	To Develop practical skills in condition monitoring, maintenance scheduling, and inventory management.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain TPM concepts, objectives, pillars, and compare TPM with conventional maintenance systems.
CO2	Analyze equipment reliability using RCM, failure mode identification, maintainability, availability, and maintenance cost evaluation.
CO3	Evaluate and improve equipment performance through OEE measurement, preventive maintenance planning, and TPM implementation strategies.
CO4	Apply TPM tools such as autonomous maintenance, condition monitoring, inventory control, and human-factor considerations to enhance maintenance efficiency.

List of Experiments

Expt. No	Name of Experiment	COs
Expt. 1	• Study of TPM concept, objectives, functions, and pillars • Comparison of TPM with conventional maintenance systems	CO1
Expt. 2	• Identification of critical equipment • RCM analysis for selected machine/system • Failure modes and maintenance strategy selection	CO2
Expt. 3	• Prediction of maintainability parameters • Calculation of availability and system effectiveness • Analysis of maintenance cost	CO2
Expt. 4	• Measurement of availability, performance, and quality • Strategies to improve OEE • Concept of three zeros (zero breakdowns, zero defects, zero accidents)	CO3
Expt. 5	• Development of a TPM implementation plan • Identification and classification of abnormalities • Study of primary preventive maintenance types	CO3
Expt. 6	• Preparation of preventive maintenance schedules • Comparison of fixed and floating preventive maintenance scheduling	CO3

Expt. 7	• TPM initial cleaning procedure • Identification of problems caused by insufficient cleaning • Use of F-tagging and golden rules of TPM	CO4
Expt. 8	• Study of TPM organizational structure • Maintenance inventory control methods • Spare parts management and maintenance efficiency evaluation	CO4
Expt. 9	• Study of human factors affecting maintenance • Maintenance manuals and staffing methods	CO4
Expt. 10	• Study of condition monitoring tools • Selection of appropriate monitoring technique for equipment	CO4

Text Books

01	Seiichi Nakajima, Introduction to TPM, Productivity Press, Chennai.
02	Gopala Krishnan, P and Benerji A. K., Maintenance and Spare Parts Management, Prentice Hall of India Pvt. Ltd
03	**Total Productivity Maintenance (TPM)** – Peter Willmott, Dennis McCarthy – **Publisher:** Butterworth-Heinemann (Elsevier), 2nd Edition, 2001

Reference Books

01	Introduction to TPM by Seichi Nakajima
02	TPM in Process Industries (Step-By-Step Approach to TPM Implementation) Tokutaro Suzuki
03	Total Productive Maintenance (Lean Manufacturing Series) **– Tina Kanti Agustiady** – Publisher: **CRC Press, 2016**

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Third Year (Sem- V) B.Tech. Mechanical Engineering

ME02510: Multi-Disciplinary Minor-03 Lab: (Heat Power Engineering Lab)
(Multi-Disciplinary Minor)

Teaching Scheme			**Examination Scheme**	
Practicals	02Hrs/Week		MSE	--
Tutorials	--		ISE/CA	50 Marks
Total Credits	01		ESE	--
			Total Marks	50 Marks

Prerequisites: Fluid Mechanics, Basic Thermodynamics, Engineering Mathematics

Course Objectives:

01	To Understand the principles of heat transfer, thermodynamics, and power generation systems through experimentation.
02	To Apply standard experimental methods for determining thermal properties and heat transfer parameters.
03	To Analyze conduction, convection, radiation, and condensation phenomena in thermal systems.
04	To Evaluate the performance of heat exchangers, I.C. engines, and thermal energy devices using experimental data.
05	To Investigate renewable energy systems and power generation technologies through demonstrations and industrial visits.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Determine thermal properties (thermal conductivity, emissivity, Stefan–Boltzmann constant) of materials using standard experimental methods.
CO2	Analyze steady-state heat conduction, convection, and radiation in practical systems such as composite walls, lagged pipes, cylinders, and condensers.
CO3	Evaluate performance parameters of thermal systems including heat transfer coefficient, overall heat transfer coefficient, effectiveness of heat exchangers, and IC engine trials.
CO4	Understand working principles and applications of thermal devices and energy systems through demonstrations, power cycles, heat pipes, and renewable energy plant visits.

Term Work /List of Experiments/ List of Assignments

Any 8 Experiments based on following list

Expt. No	Name of Experiment	COs
01	Determination of thermal conductivity of insulating powder.	CO1
02	Determination of thermal resistance and temperature distribution in a Composite wall.	CO2
03	Determination of thermal conductivity of insulating material in Lagged pipe.	CO1
04	Determination of local and average heat transfer coefficient in Natural convection heat transfer from a vertical cylinder.	CO2
05	Determination of Heat Transfer Coefficient under forced convection to air through pipe.	CO3
06	Determination of emissivity of a Nonblack surface.	CO1
07	Determination of Stefan Boltzmann Constant.	CO1
08	Determination of overall heat transfer coefficient and effectiveness in a Parallel Flow and Counter Flow Heat Exchanger.	CO3
09	Study and Demonstration of Heat Pipe	CO4
10	Determination of heat transfer coefficient in drop-wise & film-wise condensation.	CO2
11	Trial on I. C Engine	CO3

12	Demonstration of any Power Cycle.	CO4
13	Industrial Visit on any Renewable Energy Power Plant.	CO4
14	Study and Demonstration of Solar Power Plant or Biomass Power Plant	CO4

Text Books	
01	—Heat and Mass Transfer‖, R. K. Rajput, S. Chand and Company Ltd. New Delhi., 5th Edition
02	—Heat Transfer‖, J.P. Holman, Tata McGraw Hill Book Company, New York,2nd Edition
03	—Engineering Thermodynamics‖ , P. K. Nag, McGraw-Hill
04	—Internal Combustion Engines‖, V. Ganesan, McGraw-Hill
05	—Power Plant Engineering‖, P. K. Nag, McGraw-Hill
06	—Renewable Energy Sources‖, G. D. Rai
07	—Artificial Intelligence Applications in Power Systems‖, Kwang Y. Lee & Mohamed El-Sharkawi, IEEE / Wiley.
Reference Books	
01	—Heat Transfer– A Practical approach‖,Yunus. A .Cengel, Tata McGraw Hill
02	—Heat Transfer‖ Chapman A.J., Tata McGraw Hill Book Company, New York
03	—Fundamentals of Heatand Mass Transfer‖, Frank P. Incropera, David P. Dewitt, Wisley India. 5th Edition
04	—A Text Book on Heat Transfer‖, Dr. S. P. Sukhatme, Orient Longman Publication Hyderabad
05	—Heat and Mass Transfer‖, S. C. Arora and S. Domkundwar, Dhanpat Rai and Sons, Delhi
06	—Renewable Energy Sources", G. D. Rai, Khanna Publishers, New Delhi.
07	"Thermal Engineering", R. K. Rajput, Laxmi Publications, New Delhi.

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Third Year (Sem- V) B.Tech. Mechanical Engineering

ME0259: Minor Project – I (Experiential Learning)

Teaching Scheme			**Examination Scheme**	
Practical	02Hrs/Week		MSE	-
Tutorials	-		ISE/CA	25 Marks
Total Credits	01		ESE	-
			Total Marks	25 Marks

Prerequisites: Workshop Technology / Workshop Practice

Course Objectives:

01	To train the students for team work to realize an engineering task.
02	To practice the steps involved for the selection, execution and reporting of the project.
03	To train the students to apply their engineering knowledge to real life problem solving.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Work in a group on specific assignment.
CO2	Think creatively to come out with feasible solution for engineering real life problem.

Project Group:

01	Maximum 4 students in one group are allowed.

Project Definition: Project work shall be based on any of the following:

Sr. No	Project Work	COs
01	Design of any equipment /test setup/product	CO2
02	Hardware/numerical or theoretical analysis /review of survey study/research and development work The subject content of the mini project shall be from emerging /thrust areas, topic of current relevance. The completion of work, the submission of the report and assessment should be done at the end of Part-I (First semester). • Term work will be assessed by the project guide along with one faculty appointed by the head of department.	CO1,CO2

Project Report Format: Project report should be of 15 to 20 pages (typed on A4 size sheets). For standardization of the project reports the following format should be strictly followed.

01	1. Page Size: Trimmed A4 2. Top Margin: 1.00 Inch 3. Bottom Margin: 1.32 Inches 4. Left Margin: 1.5 Inches 5. Right Margin: 1.0 Inch 6. Para Text: Times New Roman 12 Point Font 7. Line Spacing: 1.5 Lines 8. Page Numbers: Right Aligned at Footer. Font 12 Point. Times New Roman 9. Headings: Times New Roman, 14 Point Bold Face 10. Certificate: All students should attach standard format of Certificate as described by the department. *Certificate should be awarded to batch and not to individual student. *Certificate should have signatures of Guide, Head of Department and Principal.

	11. Index of Report: a. Title Sheet b. Certificate c. Acknowledgement d. Table of Contents. e. List of Figures f. List of Tables 12. References: References should have the following format For Books: —Title of Book‖, Authors, Publisher, Edition For Papers: —Title of Paper‖, Authors, Journal/Conference Details, Year

SCHEME OF INSTRUCTION & SYLLABI

Name of Programme: Mechanical Engineering

Scheme of Instructions: Third Year B. Tech. Mechanical Engineering

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	ME0261	Mechanical System Design	3	--	--	3	3	30	10	60	100
2	PCC	ME0262	Industrial Fluid Power	3	1	--	4	4	30	10	60	100
3	PCC	ME0263	Manufacturing Engineering	3	--	--	3	3	30	10	60	100
4	PEC	ME0264	Programme Elective- 02	3	--	--	3	3	30	10	60	100
5	PEC	ME0265	Programme Elective- 03	3	--	--	3	3	30	10	60	100
6	MDM	ME0266	Multi-disciplinary Minor–04	2	--	--	2	2	30	10	60	100
7	PCC	ME0267	Mechanical System Design Lab	--	--	2	2	1	--	50	25	75
8	PCC	ME0268	Manufacturing Engineering Lab	--	--	2	2	1	--	50	25	75
9	EL	ME0269	Minor Project 02	--	--	4	4	2	--	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 Programme (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**	**33**	**04**	**16**	**08**	**13**	**02**	**02**
Semester Credits	--	--	**12**	**06**	**02**	--	--	**02**	--
Cumulative Sum	**16**	**16**	**45**	**10**	**18**	**08**	**13**	**04**	**02**

PROGRESSIVE TOTAL CREDITS: 110 + 22 = 132

Programme Elective Course -02 List

Sr. No	Name of Programme Elective Course -2 (PEC-2)
01	Machine Tool Design
02	Design of Thermal Systems
03	Advance Manufacturing Processes
04	Product Lifecycle Management

Programme Elective Course -03 List

Sr. No	Name of Programme Elective Course -3 (PEC-3)
01	Experimental Mechanics
02	Cryogenic
03	Production Management
04	Entrepreneurship Development

THIRD YEAR (B. Tech) SEM. VI

Shivaji University, Kolhapur

Third Year (Sem- VI) B.Tech. Mechanical Engineering

ME0261: Mechanical System Design (Programme Core Course)

Teaching Scheme			**Examination Scheme**	
Lectures	03Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Engineering Mechanics, Strength of Materials, Theory of Machines, Machine Design

Course Objectives:

1	To understand aesthetic, ergonomic, and system-level design principles in mechanical products.
2	To analyse and design pressure vessels considering strength, safety, and IS codes.
3	To design effective brakes and clutch systems based on performance and thermal criteria.
4	To design machine tool gearboxes and I.C. engine components with fatigue and manufacturability considerations.
5	To apply AI and ML techniques for optimization, prediction, and maintenance of mechanical systems.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Apply ergonomic, aesthetic, and functional principles to analyse mechanical system design requirements.
CO2	Analyze and design pressure vessels and structural systems under static and dynamic loading conditions.
CO3	Design and evaluate braking and clutch systems for torque transmission and thermal performance.
CO4	Analyze and design machine tool gearboxes to achieve specified speed ratios and operational requirements.
CO5	Design and validate I.C. engine components considering fatigue, manufacturability, and safety criteria.
CO6	Develop and evaluate AI/ML-assisted models for optimization, performance prediction, and fault diagnosis in mechanical systems.

	Course Contents	**COs**	**Hours**
Unit 1	**Aesthetic, Ergonomic and System-Level Design Considerations** Product form and function, Design for appearance: shape, proportion, symmetry, contrast, surface finish, Colour codes and visual ergonomics, Human–machine interface, Design of displays and controls, Ergonomic considerations in mechanical systems, Creativity and innovation in mechanical design, Concepts of optimum design and adequate design, Case studies of industrial products.	**CO1**	**(06)**
Unit 2	**Design of Pressure Vessels** Thin and thick pressure vessels, Failure theories for pressure vessels, Lame‘s equation , Clavarino‘s and Birnie‘s equations, Compound cylinders and autofrettage, Classification of pressure vessels, Design considerations as per IS codes ,Shells, heads, openings, nozzles, and supports, Introduction to safety and reliability in pressure vessel design.	**CO2**	**(07)**

Unit 3	**Design of Brakes and Clutch Systems** **Brakes** Design considerations, Band brakes, Internal expanding shoe brakes, External contracting brakes, Thermal analysis and brake rating **Clutches** Design requirements of friction clutches, Single plate and multi-plate clutches, Cone and centrifugal clutches, Torque transmission capacity and material selection	**CO3**	**(07)**
Unit 4	**Design of Machine Tool Gearboxes** Speed regulation and speed range, Graphical representation of speeds, Structure diagram, Deviation diagram, Ray diagram, Selection of optimum ray diagram, Tooth number progression, Analysis and design of multi-speed gearboxes, Design of machine tool gearboxes for industrial applications	**CO4**	**(06)**
Unit 5	**Design of I.C. Engine Components** Material selection for engine components, Design of cylinder and cylinder head, Cylinder liners, Piston and piston pin, Piston rings**,** Connecting rod design**,** Crankshaft and crank pin design, Fatigue and manufacturability considerations	**CO5**	**(06)**
Unit 6	**AI and ML Applications in Mechanical System Design** Need for AI/ML in modern mechanical design, Overview of data-driven design approaches, Introduction to Machine Learning concepts for engineers, AI-assisted design optimization, Regression and classification models for performance prediction, ML-based fault detection and condition monitoring, Surrogate modeling for design space exploration • Case studies: • AI-assisted gearbox optimization • ML-based fatigue life prediction • Predictive maintenance of mechanical systems	**CO6**	**(08)**

	Text Books
01	V. B. Bhandari- Design of Machine Elements- 4th edition- McGraw Hill
02	R. G. Budynas & J. Keith Nisbett- Shigley‘s Mechanical Engineering Design- 9th edition- McGraw Hill
03	M. F. Spotts- Design of Machine Elements- 6th edition- Pearson
04	R.S. Khurmi and J.K.Gupta - A Text Book of Machine Design- S. Chand
05	—Design Data Book‖,P.S.Gill (PSG) 3rdEdition.
06	I.S.:2825 Code for Unfired PressureVessels
07	—Machine Tools Design‖,N.K. Mehta, Tata Mc- Graw Hill Publication, 5th Edition.
	Reference Books
01	—Machine Design‖, Black P.H.and O.Eugene Adams, Tata Mc- Graw Hill Publication
02	Robert Juvinall- Fundamentals of Machine Component Design- Wiley
03	S. G. Kulkarni- Machine Design-2008- McGraw Hill (Sigma series)
04	U.C. Jindal- Machine Design- Pearson
05	—Handbook of Gear Design‖, Jitin Maitra, TataMc-Graw Hill Publication.
06	Machine Learning and Optimization for Engineering Design, *Shastri, A. S., Shaw, K., & Singh, M., Springer Nature Singapore, 2023.*

Shivaji University, Kolhapur

Third Year (Sem- VI) B.Tech. Mechanical Engineering

ME0262: Industrial Fluid Power (Programme Core Course)

Teaching Scheme			Examination Scheme	
Lectures	03Hrs/Week		MSE	30 Marks
Tutorials	01Hr/Week		ISE/CA	10 Marks
Total Credits	4		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Fluid Mechanics, Engineering Mechanics, Basic Mechanical Engineering

Course Objectives:

01	To classify and understand various hydraulic and pneumatic ISO/JIC symbols.
02	To discuss hydraulic and pneumatic system components.
03	To illustrate hydraulic and pneumatic circuits with its application.
04	To discuss maintenance and safety regulation in hydraulics and pneumatics.
05	To describe fluidics and its application.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain and draw different ISO/JIC symbols used in hydraulic and pneumatic circuits.
CO2	Demonstrate hydraulic and pneumatic system components.
CO3	Interpret the hydraulic and pneumatic circuits with their application.
CO4	Explain safety regulations and troubleshooting in hydraulic and pneumatic system.
CO5	Explain fluidics and their application.

	Course Contents	COs	Hours
Unit 1	**Introduction to Fluid Power** a) Classification, general features, applications in various fields of engineering, various Hydraulic and Pneumatic ISO/JIC Symbols, transmission of power at Static and Dynamic States, advantages and disadvantages. b) Principle of hydraulic system, Types of hydraulic fluids and their properties, selection of fluid, effect of temperature on fluids. c) Introduction and Application of pneumatics, Physical properties, Principles, basic requirement of pneumatic system, comparison with hydraulic system.	**CO1**	**(06)**
Unit 2	**Control of Fluid Power Elements** a) Requirements of Pressure control, Direction Control and Flow control valves. b) Principle of Pressure Control valves, directly operated and pilot operated pressure relief valve, pressure reducing valve, sequence valves, counter balance valve. c) Principles and Types of direction Control valves-2/2, 3/2, 4/2, 4/3, 5/2. Open center, Close Center, Tandem Center, Manual Operated, Mechanical Operated Solenoid, Pilot Operated Direction Control Valves, Check Valves. d) Principles of flow control valves, temperature compensated, pressure compensated, temperature and pressure compensated flow control valve.	**CO2**	**(07)**

Unit 3	**Elements of Hydraulic System** a) Classification, types of Seals, Sealing Material, Pipes, Hoses, Compatibility of Seal with Fluid, Sources of Contamination and its Control, Strainer, Filter, Heat-Exchanger, Reservoir. b) Pumps-Types, Selection of Pumps From Gear, Vane, Piston, Screw, Ball Pump etc. for various applications. c) Actuators-Linear and Rotary, Hydraulic Motors, Types of Hydraulic Cylinders and their Mountings. d) Accumulators, Intensifier and their applications.	**CO3**	**(07)**
Unit 4	**Elements of Pneumatic System** a) Air compressor- Types, selection criteria, Capacity Control, piping layout, fitting and connectors, Pneumatic controls, Direction Control Valves (two way, three way, four way), Check Valves, Flow Control Valves, Pressure Control Valves, Speed Regulators, Quick Exhaust Valves, Time Delay Valve, Shuttle Valve And Twin Pressure Valve. Solenoid Operated, Pilot Operated valves, Pneumatic Actuators, Rotary and Reciprocating Cylinders–types and their mountings, Air motor – types, Comparison with hydraulic and electric motor. b) Serving of compressed air – types of Filters, Regulators, Lubricators (FRL unit), Mufflers, Dryers.	**CO4**	**(07)**
Unit 5	**a) Hydraulic Circuits and its Application** i. Speed control circuits – Meter-in, Meter-out, Bleed off, Regenerative, Fast approach and slow traverse. ii. Sequence Circuits – Travel dependent and Pressure dependent iii. Synchronizing Circuit. iv. Regenerative Circuit. **b) Pneumatic Circuits and its Application**. Speed Control Circuits i. Impulse operation Circuit. ii. Sequence Circuits. iii. Time Delay Circuit	**CO5**	**(07)**
Unit 6	**Recent Trends in IFP** a) Hydraulic and Pneumatic servo system for linear and rotary motion. b) Maintenance, troubleshooting and safety of hydraulic and pneumatic systems.	**CO6**	**(06)**

Text Books	
01	—Oil hydraulics Systems‖, S. R. Mujumdar, Tata McGraw Hill Publication.
02	—Pneumatic Systems‖, S. R. Mujumdar- Tata McGraw Hill Publication.
03	—Industrial Fluid Power‖,D. S. Pawaskar, Nishant Prakashan.
04	—Hydraulics and Pneumatics‖, Shaikh and Khan, R.K. Publication.
05	—Fluid Power with Application‖, Esposito, Pearson Education , 7th Edition.
06	—Basic Hydraulic – Festo Manual‖
07	—Basic Pneumatic – Festo Manual‖
Reference Books	
01	—Industrial Fluid Power‖, S.S. Kuber, Nirali Prakashan, 3rd Edition.
02	—Hydraulic and Pneumatic‖,H.L.Stewart,Industrial Press.
03	—Industrial Hydraulic‖, J. J. Pipenger ,Tata McGraw Hill.
04	—Power Hydraulics‖, Goodwin 1st Edition.
05	—Introduction to Hydraulic and Pneumatics‖,S. Ilango and V Soundararajan, Prentice
06	—Hall of India, 2nd Edition.
07	—Pneumatic Control‖,Joji P.,Wiley. ,1st Edition.

Shivaji University, Kolhapur

Third Year (Sem- VI) B.Tech. Mechanical Engineering

ME0263: Manufacturing Engineering (Programme Core Course)

Teaching Scheme			**Examination Scheme**	
Lectures	03Hrs/Week		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Machine Tools and Processes, Basic Mechanical Engineering

Course Objectives:

01	To provide fundamental knowledge of metal cutting theory, chip formation, and machining mechanics.
02	To develop understanding of cutting tool materials, tool geometry, wear, tool life, and machinability.
03	To enable students to apply principles of jigs, fixtures, and press tools in manufacturing applications.
04	To introduce CNC technology, tooling systems, and modern machining centers used in industry.
05	To familiarize students with recent trends in manufacturing engineering, including AI, smart manufacturing, and sustainable systems.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Understand fundamentals of metal cutting, chip formation, and cutting forces.
CO2	Analyze tool materials, wear, tool life, and machinability.
CO3	Apply jigs and fixtures principles for machining operations.
CO4	Analyze press tools, dies, and press capacity calculations.
CO5	Explain CNC systems, tooling, and machining centers.
CO6	AI-based trends in smart and sustainable manufacturing.

	Course Contents	**COs**	**Hours**
Unit 1	**Theory of Metal Cutting** Wedge action, Concept of speed, Feed and depth of cut, orthogonal and oblique cutting. Mechanics of metal cutting-Chip formation, Types of chips, cutting ratio, shear plane and shear angle, velocity relationships, force measurement by tool dynamometers.	**CO1**	**(06)**
Unit 2	**Tool Life and Tool Geometry** Cutting tool materials and their properties, Advanced cutting tools. Machinability of Metals- Factors affecting, improvement and machinability index. Tool life - Types of wear, relationship with cutting parameters, Taylor‘s equation, improvement measures. Surface finish- Factors affecting, effect of cutting parameters, improvements. Heat generation in machining, its effect on cutting force, tool life and surface finish, types and selection criteria of cutting fluids.	**CO2**	**(06)**
Unit 3	**Drilling Jigs and Milling Fixtures** Applications, basic elements, principles and types of locating, clamping and indexing elements, auxiliary elements like tenon, setting block etc. Type of Drilling jigs and Milling Fixtures-Design consideration of Jigs and fixtures with respect to different operations.	**CO3**	**(10)**

Unit 4	**Press Tools** Dies, punches, types of presses, clearances, types of dies, strip layout, calculation of press capacity, center of pressure, Design consideration for die elements (Theoretical treatment only).	**CO4**	**(06)**
Unit 5	**CNC Technology and Tooling** CNC Technology and CNC tooling: Introduction, Construction and working of CNC, DNC and machining center. CNC axes and drives. Automatic Tool Changer (ATC) and Automatic pallet changer (APC) New trends in Tool Materials, Turning tool geometry, Tool inserts (coated and uncoated), Modular tooling system for Turning	**CO5**	**(06)**
Unit 6	**Recent trends in Manufacturing Engineering** Introduction to AI in manufacturing; machine learning basics for manufacturing data; smart manufacturing and Industry 4.0/5.0; AI-based process monitoring and optimization; predictive maintenance; computer vision for quality inspection; intelligent robotics and human–robot collaboration; digital twins and simulation; AI-enabled production planning and supply chain management; sustainable and autonomous manufacturing systems.	**CO6**	**(06)**

Text Books

01	—Elements of Workshop Technology Vol. II‖, S. K Hajra Choudhury, Media Promoters and Publishers, Mumbai.
02	—Text Book of Production Engineering‖, P.C. Sharma, S. Chand Publication, 11th Edition.
03	—Machine Tool Engineering‖ G.R. Nagarpal, Khanna Publication.
04	—Principles of Modern Manufacturing‖, Groover, Wiley Publication., 5th Edition.

Reference Books

01	—Production Technology‖, HMT –Tata McGraw-Hill Publishing Ltd,. ISBN, 0070964432, 9780070964433., (2001).
02	Metal Cutting Theory and Tool design‖ Mr. Arshinnov, MIR Publication.
03	—Fundamentals of Tool Design‖ ASTME,Prentice-Hall of India Private Ltd., New Delhi Publication, (1976).
04	—Tool Design‖, Donaldson,THM Publication, 3rd Edition.
05	—Machine Tool Engineering‖, G.R. Nagarpal, Khanna Publication.
06	—Theory of Metal Cutting‖, Sen and Bhattacharya, New Central Book Agency, (1965).
07	—Production Engg. Design (Tool Design)‖, S. Chandar and K. Surendra, Satya Prakashan, Delhi.
08	—Jigs and Fixtures‖, Kempster, ELBS.
09	—Metal Cutting and Machine Tools‖, Thirupati Reddy, Scitech Publication, 1st Edition.

Shivaji University, Kolhapur

Third Year (Sem- VI) B.Tech. Mechanical Engineering

ME0264: Programme Elective-02 -Machine Tool Design (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	03Hrs/Week		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Manufacturing Processes / Production Technology

Course Objectives:

1	To understand basic principles, layout, motions, and drives of machine tools.
2	To design and analyze speed and feed regulation mechanisms of machine tools.
3	To design machine tool structures and components considering stiffness and materials.
4	To analyze guide-ways, power screws, spindles, bearings, and hoisting mechanisms.
5	To apply AI and machine learning techniques for smart machine tools and predictive maintenance.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Draw structural diagram of a speed gear box
CO2	Design a gear box.
CO3	Design machine tool with all geared headstock and Norton gear box.
CO4	Design machine tool slideways
CO5	Design machine tool housings, columns and tables
CO6	Design spindle of general purpose and high speed machine tools

	Course Contents	**COs**	**Hours**
Unit 1	**GENERAL PRINCIPLES OF MACHINE TOOL DESIGN:** Introduction to machine tool, General requirements of machine tool design, Specifications and layout of machine tools, Machining range diagram, Interference diagram, Parameter defining working motions of a machine tool. Working and auxiliary motion in machine, Machine tool drives, Hydraulic transmission, Mechanical transmission.	**CO1**	**(05)**
Unit 2	**REGULATION OF SPEED AND FEED RATES:** Aim of speed feed regulation, classification of speed and feed boxes, stepped regulation of speed, design of speed box, Design of feed box, Special cases of gear box design, regulation of speed and feed rates.	**CO2**	**(10)**
Unit 3	**DESIGN OF MACHINE TOOL STRUCTURE:** Fundamentals of machine tool structures and their requirements, Design criteria of machine tool structure, Materials for machine tool structure, Static and dynamic stiffness, Structure profiles, Design of beds and columns, Design of housing models, bases and tables, Design of saddle, carriages and rams.	**CO3**	**(07)**
Unit 4	**DESIGN OF GUIDE-WAYS AND POWER SCREWS:** Function and type of guide-ways, design of slide-ways, Protecting devices for slide-ways, Design of power screws.	**CO4**	**(07)**
Unit 5	**DESIGN OF SPINDLES AND SPINDLE SUPPORTS and HOISTS**: Materials for spindles, Design principles of spindles, Antifriction bearings, Sliding bearings. Drives for hoisting, components, and hoisting mechanisms; rail traveling components and mechanisms; hoisting gear operation during transient motion; selecting the motor rating and determining breaking torque for hoisting mechanisms.	**CO5**	**(07)**

Unit 6	**AI-ENABLED MACHINE TOOL DESIGN AND SMART MANUFACTURING**: Introduction to AI in Machine Tool Design Role of Artificial Intelligence in modern manufacturing systems, evolution from conventional machine tools to smart machine tools, relevance of AI in Industry 4.0 and Industry 5.0. Machine Learning Applications in Machine Tools Basics of machine learning (supervised, unsupervised and reinforcement learning) with relevance to machine tools, data acquisition from sensors, feature extraction from machining data, AI-based decision making. AI-Based Condition Monitoring and Predictive Maintenance Tool wear monitoring using AI, spindle health monitoring, vibration and acoustic emission analysis, fault diagnosis of bearings and guideways using machine learning models, concept of predictive maintenance for machine tools. Intelligent Control of Machining Processes Adaptive control of cutting parameters using AI, optimization of speed, feed and depth of cut, AI-based chatter detection and suppression, real-time process optimization.	**CO6**	**(05)**
	Text Book		
01	Machine Tool Design– N. K. Mehta – Publisher: Tata McGraw-Hill Education (India), 2012		
02	Machine Tool Design and Numerical Control– N. K. Mehta – Publisher: McGraw Hill Education (India) Pvt. Ltd., 2012		
03	Design of Machine Tools– Saroj Kumar Basu, D. K. Pal – Publisher: Oxford and IBH Publishing, 1995		
04	Machine Tool Design (Vol. I & II)– N. Acherkan, V. Vermakov – Publisher: University Press of the Pacific, 2000		
	Referance Book		
01	Advances in Machine Tool Design and Research– S. A. Tobias, F. Koenigsberger (Editors) – Publisher: Springer / Macmillan, 1973		
02	Machine Tool Design: Volume I– N. Acherkan et al. – Publisher: University Press of the Pacific, 2000		
03	Principles of Machine Tools– G. K. Lal – Publisher: Satya Prakashan (India)		
04	Production Engineering and Machine Tool Design– R. K. Jain – Publisher: Khanna Publishers (India)		

Shivaji University, Kolhapur

Third Year (Sem- VI) B.Tech. Mechanical Engineering

ME0264: Programme Elective-02 -Design of Thermal Systems (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	03Hrs/Week		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Applied Thermodynamics

Course Objectives:

1	To understand fundamentals of thermal system design and energy balance.
2	To design refrigeration, air-conditioning, and solar thermal systems.
3	To apply advanced cooling and exergy analysis for efficient thermal systems.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Apply knowledge of mathematics, science, and engineering for mathematical formulation of components as well as a whole thermal system.
CO2	Analyze the heat load calculations for refrigeration applications.
CO3	Design the thermal systems.

	Course Contents	**COs**	**Hours**
Unit 1	**Introduction to Thermal System Design** Thermal systems used in practice, Classification of design, Optimal and nearly optimal design, Methodology of design, Aspects of thermal system design, Assessment concept and creation, Mathematical formulation component level and system level by first law of thermodynamics [energy balance basis].	**CO1**	**(06)**
Unit 2	**Design of Refrigeration System** Types of components used in VCRC, Controls, Accessories, their functions, salient features, applications, heat load calculations and design of basic components of refrigeration systems, Design of refrigeration systems - Household refrigerator, Ice plant, Cold storage, refrigerated vehicle, Vapour absorption systems.	**CO1, CO2**	**(08)**
Unit 3	**Design Analysis of Air Conditioning System** Design of Air conditioning systems: Design considerations, Load calculations, Single unit room air-conditioner, Central air conditioning plant, Industrial drying systems, Component selection.	**CO2, CO3**	**(06)**
Unit 4	**Design of Solar System** Design of solar assisted water heating systems, Applications of solar energy, Types of solar collectors, Preliminary specifications, Concepts development, Component design.	**CO1, CO3**	**(06)**
Unit 5	**Heat Exchanger Networking & Advanced Cooling Systems** Design of advanced heat exchanger networks, Design of electronic miniature cooling systems, Utilization of Nano- Fluids for cooling systems, Design of waste heat recovery systems.	**CO3**	**(06)**
Unit 6	**Exergy Analysis** Concept of exergy, Physical exergy and Chemical exergy, Exergy analysis for control region, Exergy concepts for closed systems, Exergy efficiency, Grassmann diagram.	**CO1, CO3**	**(08)**

Text Books	
01	—Thermal Design and optimization‖, Adrian Bejan, George Tsatsaronis, Michael Moran, JOHN WILEY and SONS INC .
02	—The Exergy Method of Thermal Plant Analysis‖, T. J. Kotas, British Library Cataloguing in Publication Data.
03	—Exergy, Energy, Environment and Sustainable Development —, Ibrahim Dincer, Marc A. Rosen 4. —Handbook of Process Heat Transfer‖, Hewitt
Reference Books	
01	—HVAC System Design Handbook‖ ASHRAE.
02	—Design and Optimisation of Thermal Systems‖, Yogesh Jalurkar, CRC Press.
03	—Design and Simulation of Thermal Systems‖, N.V. Suryanarayana, Oner Arici, Tata Mc Graw Hill Inc.
04	—Thermal System Design‖,Stoecker, Tata McGrew Hill Publication, 3rd Edition.

Shivaji University, Kolhapur

Third Year (Sem- VI) B.Tech. Mechanical Engineering

ME0264: Programme Elective-02 Advance Manufacturing Processes
(Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	--		ISE	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites:

Course Objectives:

1	To understand limitations of conventional manufacturing processes.
2	To learn principles and applications of non-conventional machining processes.
3	To analyze working of thermal, electro-chemical, and mechanical machining processes.
4	To apply additive manufacturing for rapid product development.
5	To understand AI and machine learning applications in manufacturing.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Identify the limitation of conventional machining processes.
CO2	Understand the physics of non-conventional machining process.
CO3	Select advanced manufacturing process for product development.
CO4	Analyse advanced manufacturing machining processes.
CO5	Develop product using the advanced manufacturing processes.

	Course Contents	COs	Hours
Unit 1	**Conventional Manufacturing Processes-** Capability analysis of existing manufacturing processes, Demand of new product in terms of size, shape, material, properties in various sector, Challenges in manufacturing to fulfill the requirements of industries,	**CO1**	**(06)**
Unit 2	**Non-Conventional Machining Processes**: conventional metal cutting operation, Difference between conventional and non-conventional machining processes, Classification of Non-conventional machining processes, Requirement of non-conventional machining processes, Advantage and Disadvantage of non-conventional machining processes	**CO2**	**(06)**
Unit 3	**Non-Conventional Machining Processes-Part –I** (Thermal Processes) Construction & Working of Electro Discharge Machining (EDM): Electron Beam Machining (EBM): Ion Beam Machining (IBM) Laser Beam Machining (LBM):	**CO1, CO4**	**(06)**
Unit 4	**Non-Conventional Machining Processes- PART –II** (Electro-Chemical & Mechanical) Construction & Working of Electro Chemical Machining (ECM) Chemical Milling (CM): Abrasive Jet Machining (ABM): Water Jet Machining,Ultrasonic Machining (USM):	**CO4**	**(06)**
Unit 5	**Additive Manufacturing** Introduction: Introduction to Prototyping, Traditional Manufacturing Vs. Additive Manufacturing, Need for time compression in product development, Usage of Additive Manufacturing parts CAD Modeling and Data Processing for Additive Manufacturing:	**CO3, CO5**	**(06)**
Unit 6	**AI IN MANUFACTURING PROCESSES** Introduction to AI & Industry 4.0: Definitions, scope, components, and the	**CO3, CO5**	**(06)**

	transition from traditional manufacturing to intelligent manufacturing systems. Machine Learning (ML) & Deep Learning (DL): Fundamentals of supervised, unsupervised, and reinforcement learning, with a focus on neural networks and back propagation.		
Text Books			
01	Manufacturing Engineering and Technology by Kalpakijian, Addison Wesley, 1995		
02	Foundation of MEMS by Chang Liu, Pearson, 2012.		
03	Advanced Machining Processes by V. K. Jain, Allied Publications		
Reference Books			
01	Process and Materials of Manufacturing by R. A. Lindburg, 4^{th} edition, PHI 1990.		
02	Introduction to Manufacturing Processes by John A Schey, Mc Graw Hill.		
03	Micro Machining of Engineering Materials by J. Mc Geough, CRC Press.		
04	Non-Traditional Manufacturing Processes by Gary F Benedict, CRC Press.		
05	Advanced Methods of Machining by J. A Mc Geough, Springer.		

Shivaji University, Kolhapur

Third Year (Sem- VI) B.Tech. Mechanical Engineering

ME0264: Programme Elective-02 -Product Lifecycle Management (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	03Hrs/Week		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	03		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites:

Course Objectives:

01	To understand the complete life cycle of a product from concept to disposal.
02	To learn how PLM integrates people, processes, and technology.
03	To apply PLM concepts to real industrial products.
04	To gain awareness of digital tools used in PLM.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain the concept of Product Lifecycle Management (PLM).
CO2	Analyze customer needs and market requirements.
CO3	Demonstrate the use of product design tools and data management practices.
CO4	Integrate manufacturing and supply chain activities.
CO5	Evaluate product support and service strategies.
CO6	Identify modern PLM tools and emerging technologies.

	Course Contents	COs	Hours

Unit 1	**Introduction to PLM**
	• Definition and importance of PLM
	• Product life cycle phases:
	  ○ Concept
	  ○ Design
	  ○ Development
	  ○ Production
	  ○ Service
	  ○ Retirement
	• PLM vs SCM
	• Benefits of PLM in industry
	• Challenges in PLM implementation
		CO1	**(06)**

Unit 2	**Product Development Process**
	• Customer needs and market analysis
	• Product planning and requirement management
	• Concurrent engineering
	• Design for X (DFX):
	  ○ Design for Manufacturing
	  ○ Design for Assembly
	  ○ Design for Cost
	New Product Development (NPD) models
		CO2	**(06)**

Unit 3	**Product Design and Data Management** • CAD, CAE, and CAM overview • Engineering drawings and documentation • Product Data Management (PDM) • Bill of Materials (BOM) • Configuration and version control	**CO3**	**(06)**
Unit 4	**Manufacturing and Supply Chain Integration** • Process planning • Manufacturing systems • PLM integration with ERP and SCM • Supplier collaboration • Quality management and compliance • Lean and Agile manufacturing concepts	**CO4**	**(07)**
Unit 5	**Product Support and Service** • Product maintenance and service management • Reliability and failure analysis • Warranty and service lifecycle • Feedback and continuous improvement • End-of-Life (EOL) strategies • Recycling and sustainability	**CO5**	**(06)**

Unit 6	**PLM Tools and Technologies**
	• Overview of PLM software
	  ○ Siemens Teamcenter
	  ○ PTC Windchill
	  ○ Dassault ENOVIA
	• Digital twin concept
	• Cloud-based PLM
	• Industry 4.0 and PLM
	• Role of AI and IoT in PLM
		CO6	**(06)**

Text Books			
01	Grieves, M. Product Lifecycle Management.		
02	Stark, J. Product Lifecycle Management: 21st Century Paradigm.		
03	Saaksvuori and Immonen, Product Lifecycle Management.		
Reference Books			
01	La Rosa, Product Design for the environment-A life cycle approach, Taylor and Francis 2006.		
02	Robert J. Thomas, NPD: Managing and forecasting for strategic processes.		
03	Martins Joseph, Technological Forecasting for decision Making, 2nd edition, North Holland.		

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ME0265: Programme Elective-03 -Experimental Mechanics (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	03Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	03		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Analysis of Mechanical Elements

Course Objectives:

1	To introduce the concept of elementary elasticity and experimental stress analysis.
2	To prepare mechanical engineering students for advanced graduate studies in various experimental stress analysis techniques like photo elasticity, strain gauge.
3	To supply qualified personnel to meet the requirement of specialist in experimental stress analysis.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain the fundamentals, scope, and importance of Experimental Mechanics in engineering design and analysis.
CO2	Analyze two-dimensional stress fields in engineering components using photoelastic techniques
CO3	Analyze complex stress distributions in engineering components using three-dimensional photoelastic methods.
CO4	Apply calibration procedures and stress–optic constants for accurate photoelastic measurements.
CO5	Design and analyze strain gauge circuits such as quarter, half, and full Wheatstone bridge arrangements
CO6	Analyze displacement, strain, and stress fields using geometric and shadow moiré techniques.

	Course Contents	**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)**
Unit 2	**Two Dimensional Photoelasticity** Nature of light, wave theory of light, optical interference, polarized light. Temporary and permanent double refraction, principle of photoelasticity. Stress optic law, plane and circular polariscopes, isoclinics and isochromatics. Fringe order determination, fringe multiplication techniques. Calibration of photoelastic materials, model materials for 2D photoelasticity. Stress separation methods: shear difference method, analytical separation method. Model to prototype scaling laws.	**CO2**	**(07)**
Unit 3	**Three-Dimensional Photo elasticity** Three-dimensional stress analysis concepts. Stress freezing method, slicing technique and interpretation. Scattered light photoelasticity, scattered light as interior analyzer and polarizer. Scattered light polariscope and stress data analysis. Photoelastic (birefringent) coatings: principle, stress–optic relation. Effect of coating thickness, reinforcing effects, Poisson‘s ratio influence. Stress separation techniques: oblique incidence method, strip coatings	**CO3**	**(07)**

Unit 4	**Analysis of Photoelastic Data and Materials** Determination of principal stress directions. Determination of exact fringe order and difference of principal stresses. Shear difference method, oblique incidence method, electrical analogy method. **Photoelastic materials:** criteria for selection, properties of common materials. Photoelastic sheet casting, model making techniques. Calibration of photoelastic materials using circular disc and standard methods.	**CO4**	**(06)**
Unit 5	**Strain Measurement Using Strain Gauges and Circuitry-** Concept of strain and strain measurement. Strain gauges: desirable properties, types, metallic and semiconductor gauges. Electrical resistance strain gauge: construction, materials, gauge factor, sensitivity, cross sensitivity. Selection and mounting of strain gauges, installation and checking procedures. Wheatstone bridge circuit: balance condition, bridge configurations. Output voltage–strain relationship, commercial strain indicators. Strain gauge rosettes: two, three and four element rosettes. Determination of principal stresses when directions are known and unknown. Transducer applications of strain gauges.	**CO5**	**(07)**
Unit 6	**Brittle Coating and Moiré Fringe Methods** Brittle coating method: principle, coating materials, crack patterns, interpretation of results. Crack detection techniques and selection of brittle coatings. Birefringent coating: principle, reflection polariscope, applications, merits and limitations. Moiré fringe method: introduction, fringe formation mechanism. Geometric and displacement moiré techniques. Advantages, limitations, and engineering applications of moiré fringe methods.	**CO6**	**(07)**
Text Books			
01	—Experimental Stress Analysis‖, Dr. Sadhu Singh; Khanna Publishers, 5th Edition.		
02	—Experimental Stress Analysis‖, U.C. Jindal, Pearson Publications, 1st Edition.		
03	—Experimental Stress Analysis‖, Abdul Muben; Dhanpat Rai and Co., 1st Edition.		
04	—Experimental Stress Analysis‖, Vazirani, Khanna Publications.		
05	—Stress Analysis and Experimental Techniques an Introduction‖,J. Srinivas, Narosa Publications.		
Reference Books			
01	—Experimental Stress Analysis‖, J.W. Dally and W.F.Riley, Tata McGraw Hill Book Company, 3rd edition.		
02	—Principles of Experimental Stress Analysis‖, by American Society for Metals ,6th edition.		

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ME0265: Programme Elective-03 –Cryogenics (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	03Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Engineering Thermodynamic, Heat Transfer, Fluid Mechanics

Course Objectives:

01	To enable the students to analyze and solve cryogenics related problems by applying principles of mathematics, science and engineering.
02	To prepare students to use modern tools, techniques and skills to fulfill industrial needs related to low temperature systems.
03	To develop effective communication skills to demonstrate cryogenics theories.
04	To develop skills in the analysis of cryogenics systems in research or design.
05	To develop a professional approach to lifelong learning in the cryogenics to include the awareness of social and environment issues associated with engineering practices.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Describe different Cryogenic Systems.
CO2	Understand and interpret the analysis report in the field of Cryogenics.
CO3	Apply knowledge of mathematics, science, and engineering for the needs in Cryogenics.
CO4	Design systems as per the desired needs based on economical, social, and environmental issues associated with engineering practices.
CO5	Communicate required information to develop various ideas related to design/research in different Cryogenic systems.
CO6	Contribute knowledge to solve step by step problems for lifelong learning.

	Course Contents	**COs**	**Hours**
Unit 1	**Introduction:** Introduction**,** Industrial applications, Recent development, Properties of cryogenic Fluids, Applications of cryogenics in different areas such as Space, Medical, Manufacturing processes, Mechanical Design **Behavior of Structural Materials at Cryogenic Temperature:** Mechanical properties, Thermal properties, Thermoelectric properties.	**CO1**	**(06)**
Unit 2	**Liquefaction of Cryogenic Gases:** Ideal cycle, System performance parameters, Joule Thomson effect, Adiabatic expansion, Liquefaction systems; Simple Linde-Hampson system, Precooled Linde-Hampson system, Cascade system, Claude system, Comparison of above systems	**CO2**	**(07)**
Unit 3	**Liquefaction Systems for Neon, Hydrogen, Helium and Heat Exchanger:** Precooled Linde- Hampson system forneon and hydrogen, Claude system for hydrogen, Helium refrigerated hydrogen liquefaction system, Heat exchanger used in liquefaction systems	**CO3**	**(07)**
Unit 4	**Cryogenic Refrigeration Systems:** Ideal refrigeration systems, Philips refrigerator, Vuilleumier refrigerator, Solvay refrigerator, Gifford-McMohan refrigerator, Pulse tube refrigerator.	**CO4**	**(06)**

Unit 5	**Gas Separation and Purification:** Thermodynamic Ideal refrigeration system, Temperature composition diagram, Principles of Gas separation, Principles of Rectifiers column, Separation column design; Plate calculation, Types of rectification columns, Single column and double column air separation systems, Cryogenic air separation plants, Linde single Column separation system, Gas Purification methods	**CO5**	**(07)**
Unit 6	**Insulation:** Cryogenic fluid storage, Vacuum insulation, Fibrous materials, Solid foams, Gas filled power, Comparison, Critical thickness. **Vacuum Technology:** Importance, Pump down time, Flow regimes, Components of vacuum systems, Mechanical Vacuum pumps, and Ion pumps	**CO6**	**(07)**
	Text Books		
01	—Cryogenic Systems‖, Barron F. Randall, Oxford University Press, New York.		
02	"Cryogenic Engineering‖, Thomas M. Flynn, Marcel Dekkcr. Inc, New York.		
03	"Cryogenic Process Engineering‖,Klaus D. Timmerhaus, Thomas M. Flynn, Plenum Publishing Corporation (1989).		
04	"Applied Cryogenic Engineering‖,Vance, R. W, and Duke, Isted, W. M., John Wiley (1962).		
05	—Introduction to Cryogenics*"* B. S. Gawali, Mahalaxumi Publication.		
	Reference Books		
01	—Experimental Techniques in low Temperature Physics‖, Guy, K White, Claredon Press, Oxford, (1987).		
02	—Cryogenic Research and Applications*"*, Marshall Sitting and Stephen Kidd, D. Van Nostrand, Inc USA, (1963).		
03	—Cryo-Cooler: Fundamentals Part-I‖, G. Walker, Plenum Press, New York.		
04	—Cryo-Cooler: Fundamentals Part-II‖, G. Walker, Plenum Press New York.		
05	—International Journal of Cryogenics‖, Elsevier Publication.		
06	—Advanced Cryogenic Engineering‖, Proceedings of Cryogenic Engineering Conference, Vol. 1-145, Plenum Press, New York (1968).		

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ME0265: Programme Elective-03 -Production Management (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	03Hrs/Week		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	03		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Manufacturing Processes / Production Technology

Course Objectives:

1	To understand the fundamentals of production management, PPC, product, and process design.
2	To analyze capacity planning, scheduling, and operations management techniques.
3	To apply supply chain management, JIT, maintenance, and replacement strategies.
4	To evaluate production economics and investment decisions for manufacturing systems.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain concepts, objectives, and strategies of production management and PPC.
CO2	Apply product and process design principles for process selection and product development.
CO3	Analyze capacity requirements, aggregate planning, and scheduling of operations.
CO4	Explain supply chain management concepts, JIT philosophy, and performance measures.
CO5	Compute OEE and evaluate maintenance and replacement decisions.
CO6	Evaluate production economics and investment decisions using economic analysis tools.

	Course Contents	**COs**	**Hours**
Unit 1	**Introduction to Production Management** Production types, Objectives and scope of Production Management, Production Planning and Control (PPC)- Definition and elements, Strategy formulation process, Order qualifiers and order winners, Strategic options for Operations- Product – Process Matrix, Product portfolio, Process technology.	**CO1**	**(06)**
Unit 2	**Product and Process Design** Determinants of process characteristics- Volume, Variety, Flow, Types of processes, Choice of Process, Equipment selection, Use of BEP in selection process- Product matrix. Estimation of Demand- Time series Analysis, Role of Product Development in competitiveness, Product Life Cycle (PLC), Product Development Process.	**CO2**	**(06)**
Unit 3	**Capacity and Scheduling of Operations:** Capacity- Definition, Measure of Capacity, Capacity strategies, Estimation of number of machines, Overcapacity and under capacity factors, Aggregate Planning, Aggregate Planning Strategies, Use of transportation model approach to aggregate planning Loading, scheduling and sequencing,	**CO3**	**(06)**
Unit 4	**Supply Chain Management and Advanced Manufacturing Techniques** Concept of supply chain and supply chain management, Manufacturing supply chain, SCM activities, Supply chain strategies, Managing supply chain, Measuring supply chain performance, JIT Philosophy, Elements of JIT.	**CO4**	**(06)**
Unit 5	**Total Productive Maintenance and Replacement** Introduction, Definition, Six big losses, Stages of maintenance, Pillars stages of TPM Development, Overall Equipment Effectiveness (OEE) Computation Replacement - Need replacement of items whose maintenance cost increases	**CO5**	**(06)**

	with time (with and without considering time value of money).		
Unit 6	**Production Economics** Demand and supply, Demand curve and supply curve, Equilibrium of supply and demand, Elasticity of demand Production function, Factors of production, Isoquants, Review - Time value of money, Cash flows, Evaluation criteria for capital projects (investment) Payback period, IRR and BCR	**CO6**	**(06)**
Text Books			
01	—Industrial Engineering and Production Management‖, Martand Telsang, S Chand and Company New Delhi, (2009).		
02	—Productions and Operations Management‖, Kanishka Bedi, Oxford Higher Education., 3rd Edition		
03	—Production and Operation Management‖, Tripathi, , Scitech Publications.		
04	—Production and Operation Management‖, S. N. Chary, Tata McgGraw Hill, 5th Edition.		
Reference Books			
01	—Production and Operations Management‖, Buffa. Elwood modern Wiley India,8th Edition.		
02	—Operation Management, Process and Value Chain‖, Krajewski and Ritzman, Malhotra Pearson Education.		
03	—Production and Operations Management‖, Ashwathappa, Bhat , Himalaya Publishing		
04	—Techniques of Value Analysis and Engineering‖, Miles Lawrence.		
05	—Operation Management Theory and Practice‖, Mahadevan B Pearson Education,(2007)		
06	—Operations Management‖ Kaither and Frazer, Cengage Publication		
07	—Production and Operation Management‖, Everett E. Adam and Ebert, PHI Publication, ISBN No. 9788120308381.		

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ME0265: Programme Elective-03 -Entrepreneurship Development (Programme Elective Course)

Teaching Scheme			**Examination Scheme**	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	--		ISE/CA	10 Marks
Total Credits	3		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Communication Skills / Professional Communication

Course Objectives:

1	To understand the fundamentals of entrepreneurship, types of entrepreneurs, and their role in economic development.
2	To identify business opportunities, generate ideas, and evaluate feasibility using SWOT and other tools.
3	To develop business plans and models, including financial planning, funding, and investor pitching.
4	To apply marketing strategies, scaling techniques, and legal/ethical principles in entrepreneurial ventures.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Analyze entrepreneurship fundamentals, ecosystem dynamics, and challenges to evaluate opportunities for new ventures in diverse economic contexts
CO2	Design innovative business ideas using creativity tools and assess their viability through market, technical, and financial feasibility analysis.
CO3	Develop structured business plans and models (e.g., Business Model Canvas) to communicate value propositions
CO4	Apply ethical, legal, and sustainable practices to manage startup operations, funding strategies, marketing efforts, and scaling challenges

	Course Contents	**COs**	**Hours**
Unit 1	**Introduction to Entrepreneurship** Definition, stages, characteristics, and importance of entrepreneurship, Types of entrepreneurs, Entrepreneurial mindset and traits (creativity, risk-taking, resilience), Role of entrepreneurship 111 economic development, Key components of the entrepreneurship, Types of entrepreneurship, Challenges faced by entrepreneurs in developing and developed economies.	**CO1**	**(08)**
Unit 2	**Idea Generation and Opportunity Recognition** Sources of business ideas (market trends, customer needs, technological advancements), Creativity tools, Identifying gaps in the market, Difference between ideas and opportunities, Feasibility analysis (market, technical, financial), SWOT analysis for opportunity evaluation	**CO2**	**(06)**
Unit 3	**Business Planning and Model Development** Business plan, Importance and structure of a business plan, Key component, Pitching a business plan to stakeholders, Introduction to the Business Model Canvas (BMC), Nine building blocks of BMC, Case studies of successful business models.	**CO3**	**(06)**
Unit 4	**Funding and Financial Management** Bootstrapping, angel investors, venture capital, crowdfunding, and government schemes, Equity vs. debt financing, preparing for investor	**CO1, CO4**	**(07)**

	pitches, Basics of financial statements (income statement, balance sheet, cash flow statement), Break-even analysis and budgeting, managing cash flow and working capital.		
Unit 5	**Marketing and Scaling a Business** Understanding the target market and customer personas, Digital marketing tools (social media, SEO, content marketing), Building a brand and customer loyalty, Challenges of scaling a business, Franchising, partnerships, and global expansion, Leveraging technology for growth.	**CO3, CO4**	**(06)**
Unit 6	**Legal and Ethical Aspects of Entrepreneurship** Business registration and intellectual property rights, Compliance with taxation C04 and labour laws, Contracts and agreements, Ethical decision making in business, Corporate Social Responsibility (CSR) and sustainable entrepreneurship, Case studies of ethical dilemmas in entrepreneurship.	**CO2**	**(07)**
	Text Books		
1.	Entrepreneurship: Successfully Launching New Venture. Bruce R. Barringer and R.Duane Ireland, 7th edition, Pearson ,2024		
2.	Business Model Generation Alexander Osterwalder and Yves Pigneur, John Wi1y and amp; Sons, Edition 2010.		
3.	Venture Deals: Be Smarter Than Your Lawyer and Venture Capitalist and Brad Fld and Jason Mendelson, Wiley publication, 4th edition, 2019.		
	Reference Books		
1.	—Innovation and Entrepreneurship‖, Peter F. Drucker, Harper Business, 1st edition,2014.		
2.	The Lean Startup: How Today and Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Eric Ries, Crown Publishing Group, 1st edition,2011.		
3.	Business Model Generation: A Handbook/or Visionaries, Game Changers, and Challeners and Alexander Osterwalder and amp; Yves Pigneur, John Wiley and amp; Sons, 1st edition, 2010		

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ME0266: Multidisciplinary Minor 04 -Machine Design (Multi-Disciplinary Minor)

Teaching Scheme			**Examination Scheme**	
Lectures	3Hrs/Week		MSE	30 Marks
Tutorials	-		ISE/CA	10 Marks
Total Credits	2		ESE	60 Marks
			Total Marks	100 Marks

Prerequisites: Analysis of Mechanical Elements (Mechanics of Materials)

Course Objectives:

1	To study basic principles of machine design.
2	To understand principles for sizing components to ensure function and strength.
3	To study machine elements subjected to fluctuating loading.
4	To study and select rolling contact bearings used for mechanical systems.
5	To design various types of gears using strength considerations.
6	To use design data books and standard practices.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Understand machine design fundamentals and determine safe component dimensions under various loading conditions to meet strength and functional requirements.
CO2	Design machine elements subjected to fluctuating loading.
CO3	Analyze and design of shafts, keys and springs.
CO4	Design various joints for given load to be transmitted.
CO5	Select rolling contact bearings from manufacturer catalogs and design sliding contact bearings for mechanical systems.
CO6	Design various types of gears such as spur, helical, bevel and worm gear.

	Course Contents	**COs**	**Hours**
Unit 1	**Fundamentals of Machine Design and Design against Static Load** Concept of Machine design, Types of loads, Factor of safety- its selection and significance, phases in Machine design. Factors governing selection of Engineering materials. Theories of failure, Selection and use of Failure Theories. Design of machine elements under static loading- Knuckle joint	**CO1**	**(04)**
Unit 2	**Design against Fluctuating Load** 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, Goodman diagram, Modified Goodman diagram	**CO2**	**(05)**
Unit 3	**Design of Shafts, Keys and Springs** Design of solid and hollow shafts, Types Keys, Design of Flat key Types of springs and their applications, Styles of end, Design of Helical Compression Spring subjected to static loading.	**CO3**	**(05)**
Unit 4	**Design of Joints and Couplings** Design of bolted joints subjected to following conditions- 1) Joints in shear 2) Joints subjected to load perpendicular to the axis of bolt. Design of welded joints- 1) Strength of transverse and parallel fillet welds Types of Couplings. (Numerical on bolted joints only)	**CO4**	**(04)**

Unit 5	**Design of bearings** Rolling Contact Bearing: Classification of bearings, static and dynamic load capacities, Stribeck's equation (No derivation), equivalent bearing load, load- life relationship, bearing life, Selection of bearing from manufactures catalogue. Ball and Roller bearing. Introduction on Sliding contact bearing. Hydro-Dynamic Lubrication: Basic theory, Design consideration in hydrodynamic bearings (No numerical on sliding contact bearing)	**CO5**	**(05)**
Unit 6	**Design of gears** Introduction to Gears **Spur Gear:** Force analysis, No. of teeth, Face width, Strength of gear teeth, Static beam strength (Lewis's equation) Barth equation, Dynamic tooth load (spott's equation and Buckingham equation), Wear strength (Buckingham's equation) [No derivation]. **Design of Worm and worm wheel**: Gear Terminology and geometrical relations. Standard dimensions and recommendation of worm gearing. (Numerical on spur gears only)	**CO6**	**(05)**

	Text Books
01	V. B. Bhandari- Design of Machine Elements- 4th edition- McGraw Hill
02	R. G. Budynas & J. Keith Nisbett- Shigley's Mechanical Engineering Design- 9th edition- McGraw Hill
03	M. F. Spotts- Design of Machine Elements- 6th edition- Pearson
04	R.S. Khurmi and J.K.Gupta - A Text Book of Machine Design- S. Chand
	Reference Books
01	R. L. Norton- Machine Design- 4th edition- Pearson
02	Robert Juvinall- Fundamentals of Machine Component Design- Wiley
03	S. G. Kulkarni- Machine Design-2008- McGraw Hill (Sigma series)
04	U.C. Jindal- Machine Design- Pearson
	Design Data Books
01	V. B. Bhandari- Machine Design Data Book- McGraw Hill
02	PSG- Design Data Book

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ME0267: Mechanical System Design Lab (Programme Core Course)

Teaching Scheme			**Examination Scheme**	
Practical	02 Hrs/week		MSE	--
Tutorials	-		ISE/CA	50 Marks
Total Credits	01		ESE	25 Marks
			Total Marks	75 Marks

Prerequisites: Engineering Mechanics, Strength of Materials, Theory of Machines, Machine Design

Course Objectives:

1	To Apply mechanical design principles for the analysis and design of machine components and systems.
2	To Develop design solutions for pressure vessels, brakes, clutches, gearboxes, and I.C. engine components using standard design procedures.
3	To Analyze functional, ergonomic, safety, and manufacturability requirements in mechanical system design.
4	To Evaluate design alternatives using engineering calculations, standards, and performance criteria.
5	To Create optimized mechanical system designs and technical documentation using modern engineering tools.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Understand the fundamental concepts of aesthetics, ergonomics, and their influence on engineering design.
CO2	Apply standard design procedures to analyse and design components of an internal combustion (I.C.) engine and machine tool gearbox.
CO3	Analyze stresses, material selection, and safety factors to design pressure vessels, clutches, and braking systems using engineering principles.
CO4	Prepare a detailed design reports and generate accurate A2-size working drawings for mechanical components and assemblies.
CO5	Evaluate mechanical component performance using AI/ML models such as predictive analysis, fatigue life estimation, and gearbox optimization.
CO6	Interpret and analyze real-world case studies involving AI-assisted optimization, fatigue prediction, and predictive maintenance for mechanical systems.

List of Experiments/Assignments

Expt. No	Name of Experiment	COs
Expt.1	Assignment on Aesthetic and Ergonomics	CO1
Expt.2	Assignment on Design of an I.C. Engine	CO2
Expt.3	Assignment on Design of Machine Tool Gearbox	CO2
Expt.4	Component Design and Modelling of a Pressure Vessel: A detail design report and A2 size sheet containing working drawing of detail and assembly	CO3,CO4

Expt.5	Design and Analysis of a Clutch or Braking System A detail design report and A2 size sheet containing working drawing of detail and assembly	CO3,CO4
Expt.6	Assignment on AIML-Based Prediction of Mechanical Component Performance	CO5
Expt.7	Case studies : (Any 02) • AI-assisted gearbox optimization • ML-based fatigue life prediction • Predictive maintenance of mechanical systems	CO6

	Text Books
01	V. B. Bhandari- *Design of Machine Elements*- 4th edition- McGraw Hill
02	R. G. Budynas & J. Keith Nisbett- *Shigley's Mechanical Engineering Design*- 9th edition- McGraw Hill
03	M. F. Spotts- *Design of Machine Elements*- 6th edition- Pearson
04	R.S. Khurmi and J.K.Gupta - *A Text Book of Machine Design*- S. Chand
05	—Design Data Book‖,P.S.Gill (PSG) 3rd Edition.
06	I.S.:2825 Code for Unfired PressureVessels
07	—Machine Tools Design‖,N.K. Mehta, Tata Mc- Graw Hill Publication, 5th Edition.
	Reference Books
01	—Machine Design‖, Black P.H.and O.Eugene Adams, Tata Mc- Graw Hill Publication
02	Robert Juvinall- Fundamentals of Machine Component Design- Wiley
03	S. G. Kulkarni- Machine Design-2008- McGraw Hill (Sigma series)
04	U.C. Jindal- *Machine Design*- Pearson

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ME0268: Manufacturing Engineering Lab (Programme Core Course)

Teaching Scheme			**Examination Scheme**	
Practical	2Hrs/Week		MSE	--
Tutorials	--		ISE	50 Marks
Total Credits	1		ESE	25 Marks
			Total Marks	75 Marks

Prerequisites: Machine Tools and Processes, Basic Mechanical Engineering

Course Objectives:

01	To develop understanding of metal cutting principles, cutting tools, tool materials, tool geometry, and tool life.
02	To enable design and drafting of drilling jigs and milling fixtures using standard engineering practices and CAD tools
03	To provide exposure to CNC machining systems and AI applications in manufacturing.
04	To enhance practical skills, analytical ability, and industrial awareness through laboratory work and industrial visits.

Course Outcomes (COs): At the end of this course, student will be able to

CO1	Explain and demonstrate the theory of metal cutting, including chip formation, cutting forces, and machining parameters.
CO2	Identify and analyze cutting tools, tool materials, tool geometry, and tool life for single-point and multi-point cutting tools.
CO3	Design and prepare engineering drawings of drilling jigs and milling fixtures using manual drafting and/or AutoCAD.
CO4	Demonstrate the working principles and applications of CNC machining tools and systems.
CO5	Explain the role of Artificial Intelligence in manufacturing and relate laboratory learning with industrial practices through industrial visits.

List of Experiments/Assignments

Expt. No.	Name of Experiment	COs
Expt.1	Study of Theory of metal Cutting	CO1
Expt.2	Study of cutting Tools (Tool Life, Tool Materials etc.)	CO2
Expt.3	Study of Tool Geometry (Single and Multipoint cutting Tools)	CO2
Expt.4	Design and drawing of any one Drilling jig (Sheet &/ Auto-CAD)	CO3
Expt.5	Design and drawing of any one Milling fixture jig (Sheet &/ Auto-CAD)	CO3
Expt.6	Study and Demonstration of tools used in CNC machining.	CO4
Expt.7	Case Study on AI in Manufacturing	CO5
Expt.8	Case Study on AI in Process Planning	CO5
Expt.9	Industrial visit to study jig and fixtures, sheet metal.	CO5

Note: Students shall perform **at least seven experiments** from the prescribed list.

Text Books	
01	—Elements of Workshop Technology Vol. II‖, S. K Hajra Choudhury, Media Promoters and Publishers, Mumbai.
02	—Text Book of Production Engineering‖, P.C. Sharma, S. Chand Publication, 11th Edition.
03	—Machine Tool Engineering‖ G.R. Nagarpal, Khanna Publication.
04	—Principles of Modern Manufacturing‖, Groover, Wiley Publication., 5th Edition.
Reference Books	
01	—Production Technology‖, HMT –Tata McGraw-Hill Publishing Ltd,. ISBN, 0070964432, 9780070964433., (2001).
02	Metal Cutting Theory and Tool design‖ Mr. Arshinnov, MIR Publication.
03	—Fundamentals of Tool Design‖ ASTME,Prentice-Hall of India Private Ltd., New Delhi Publication, (1976).
04	—Tool Design‖, Donaldson,THM Publication, 3rd Edition.
05	—Machine Tool Engineering‖, G.R. Nagarpal, Khanna Publication.
06	—Theory of Metal Cutting‖, Sen and Bhattacharya, New Central Book Agency, (1965).
07	—Production Engg. Design (Tool Design)‖, S. Chandar and K. Surendra, Satya Prakashan, Delhi.
08	—Jigs and Fixtures‖, Kempster, ELBS.
09	—Metal Cutting and Machine Tools‖, Thirupati Reddy, Scitech Publication, 1st Edition.

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Third Year (Sem- VI) B.Tech. Mechanical Engineering

ME0269: EL- Minor Project-02 (Experiential Learning)

Teaching Scheme			**Examination Scheme**	
Practical	4Hrs/Week		MSE	--
Tutorials	--		ISE/CA	50 Marks
Total Credits	2		ESE	--
			Total Marks	50 Marks

Prerequisites:

Course Objectives:

01	To provide an opportunity to students to work in a group on a topic/ problem/ experimentation selected by them and encourage them to think independently in a group on their own to bring out the conclusion under given circumstances and to expose them to industry.
02	To encourage creative thinking process to help them to get confidence by planning and carrying out the work plan of the project and to successfully complete the same, through observations discussions and decision making process.

Course Outcomes (CO's): At the end of this course, student will be able to

CO1	Work in a group on specific assignment.
CO2	Think creatively to come out with feasible solution for engineering real life problem.

Project Group: Maximum 4 students in one group are allowed.

Project Definition: Project work shall be based on any of the following:

Sr. No.	Project Work	CO
1	Fabrication of product/ testing setup of an experimentation unit/ apparatus/ small equipment, in a group.	CO1,CO2
2	Experimental verification of principles used in Mechanical Engineering Applications.	CO2
3	Critical analysis of any design or process for optimizing the same.	CO2
4	Software development for particular applications. The subject content of the mini project shall be from emerging/ thrust areas, topics of current relevance. The completion of work, the submission of the report and assessment should be done at the end of Part-II (Second Semester).	CO2

• Term work will be assessed by the project guide along with one colleague appointed by the Head of Department

Project Report Format: Project report should be of 15 to 20 pages (typed on A4 size sheets). For standardization of the project reports the following format should be strictly followed.

1. Page Size: Trimmed A4
2. Top Margin: 1.00 Inch
3. Bottom Margin: 1.32 Inches
4. Left Margin: 1.5 Inches
5. Right Margin: 1.0 Inch
6. Para Text: Times New Roman Font 12 Point.
7. Line Spacing: 1.5 Lines
8. Page Numbers: Right Aligned at Footer. Font 12 Point. Times New Roman
9. Headings: Times New Roman, 14 Point, Bold Face
10. Certificate: All students should attach standard format of Certificate as described by the department.

Certificate should be awarded to batch and not to individual student. Certificate should have signatures of Guide, Head of Department and Principal/Director

11. Index of Report:

a) Title Sheet, b) Certificate, c) Acknowledgement, d) Table of Contents, e) List of Figures, f) List of Tables

12. References: References should have the following format

For Books: —Title of Book‖, Authors, Publisher, Edition

For Papers: —Title of Paper, Authors, Journal/Conference Details, Year.

Exit Course for Mechanical Engineering **After 3rd Year**

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) 1. Introduction to ANSYS / SOLIDWORKS (03) 2. Advanced Modeling and Assemblies (03) 3. Certification Course 2 Week (02)	Online/offline certificationCourse or project of total 8credits	8
OR				
2	ME-EC-0206	CNC/VMC Machine Maintenance Lab 1. CNC/VMC Machine Maintenance Fundamentals (03) 2. CNC/VMC Maintenance Planning and Management (03) 3. CNC/VMC Practical Training– Industry (02)		8

Exit Course for Mechanical Engineering after 3rd Year

Exit option: Award of B. Vocational in Major with 132 credits and an additional 8 Credits from following Exit Course				
Sr. No.	**Course Code**	**Course Title**	**Mode**	**Credits**
1	ME-EC-0205	***Computer Aided Drafting Lab (ANSYS/SOLID WORKS)*** **1. Introduction to ANSYS/ SOLID WORKS (03)** • Introduction to CAE: Overview of CAD/CAE/FEA, Applications, Benefits in design and analysis, CAE workflow, Software introduction. • Pre-processing Concepts**:** Geometry creation, Import/export of CAD models, Material properties, Meshing basics, Boundary conditions • ANSYS Workbench Interface and Basic Analysis Setup: Project schematic, Analysis types, Units and coordinate systems, Setting up simple static structural problems. • Static Structural Analysis**:** Applying loads and constraints, Solving, reviewing stress, displacement, and strain results, Validating results. • Thermal Analysis**:** Heat transfer basics, Boundary conditions, Thermal loads, Temperature distribution, Heat flux analysis. • Modal Analysis**:** Vibration basics, Natural frequencies, Mode shapes, Setup and results interpretation. • Advanced Features**:** Parametric modeling, Design optimization, Contact and nonlinear analysis basics. • Case Studies: Import CAD models, Run simulations, Analyze results.	Online/Offline Certification Course or Project of total 8 Credits	08

Textbooks	
1	Finite Element Analysis with ANSYS Workbench (Tutorial Approach) — Prof. Sham Tickoo (covers fundamental FEA and simulation workflows using ANSYS Workbench).
2	Introduction to Finite Element Analysis Using SolidWorks Simulation — Randy H. Shih (step-by-step guide to FEA fundamentals and simulation practice).
3	Applied Finite Element Analysis with SolidWorks Simulation — Dr. Cyrus Raoufi (introductory FEA concepts with practical examples).
4	Solid Works Simulation: A Power Guide for Beginners and Intermediate Users — Sandeep Dogra and John Willis (practical CAE guide focused on FEA using SolidWorks)
Reference Books	
1	Finite Element Simulations with ANSYS Workbench — Huei-Huang Lee and Paul J. Schilling (comprehensive real-world FEA examples).
2	Engineering Analysis with Solid Works Simulation — Paul Kurowski (advanced FEA problems and case studies).
3	Computer-Aided Design, Engineering, and Manufacturing — Cornelius T. Leondes (foundation CAE concepts and integration with CAD/CAM)

1	ME-EC-0205	**2. Advanced Modeling and Assemblies (03)** • Introduction to Advanced Modeling: Review of basic CAD features, Parametric modeling, Design intent, Feature hierarchy, Sketch relations. • Advanced Part Modeling – Part I: Complex features (Loft, Sweep, Boundary), Multi-body parts, Shells, Draft and Rib features. • Advanced Part Modeling – Part II: Patterns (Linear, Circular, Sketch-driven), Mirror, Feature suppression, Configurations, Derived parts. • Surface Modeling Basics: Introduction to surface modeling, Surface creation (Extrude, Revolve, Sweep), Surface trimming, Knit and Thicken. • Assembly Modeling – Part I: Introduction to assemblies, Mates (Standard, Advanced), Sub-assemblies, exploded views, Interference checking. • Assembly Modeling – Part II: Top-down vs. Bottom-up assembly design, Assembly patterns, Assembly features (cuts, holes), Managing large assemblies. • Advanced Drawings and Detailing: Associative drawings, Section and detail views, Annotations, Bill of Materials (BOM), Drawing templates and standards. • Practical Applications: Design projects involving multi-part assemblies, Motion studies, Collision detection, Realistic rendering, Model validation.	Online/Offline Certification Course or Project of total 8 Credits	08

Textbooks	
1	Engineering Design with SolidWorks– David C. Planchard and Marie P. Planchard Comprehensive coverage of part modeling, assemblies, and detailed drawings using SolidWorks.
2	—Parametric Modeling with SolidWorks– Randy Shih Strong focus on parametric design, configurations, advanced features, and assembly modeling.
3	—Mastering SolidWorks – Ibrahim Zeid / Matt Lombard Covers advanced SolidWorks tools, surfacing, assemblies, motion, and design techniques.
4	—SolidWorks 3D CAD: Advanced Techniques – (various authors, e.g., Trish and David Planchard) Detailed content on advanced modeling, complex geometry, and assembly methods.
Reference Books	
1	CAD/CAM: Principles and Applications– P. N. Rao Good general reference for CAD fundamentals and advanced modeling concepts.
2	—Machine Drawing and Design – K. L. Narayana, P. Kannaiah, K. Venkata Reddy Useful for understanding assembly drawings, detailing, and drafting standards.

3	—Geometric Modeling – Michael E. Mortenson Theoretical foundation on geometric and surface modeling techniques used in CAD.			
4	—Computer Aided Design and Manufacturing – Andreasen and Nielsen / Chang Reference material on CAD systems, modeling			
1	ME-EC-0205	**3. Certification Course 2 Week (02)**	• Courses like NPTEL, Udemy etc	08

OR				
Sr. No.	**Course Code**	**Course Title**	**Mode**	**Credits**
2	ME-EC-0206	**CNC/VMC Machine Maintenance Lab** **1. CNC/VMC Machine Maintenance Fundamentals (03)** • **Unit 1: Introduction to CNC/VMC Machines (06)** Overview of CNC and VMC machines, machine configurations and axes, major machine components, CNC control systems, machine specifications, safety practices in CNC/VMC maintenance. • **Unit 2: Maintenance Concepts and Strategies (06)** Importance of maintenance, types of maintenance: breakdown, preventive, predictive, and condition-based maintenance, maintenance planning and scheduling, documentation and maintenance records, basics of TPM for CNC machines. • **Unit 3: Mechanical Systems Maintenance (6 Hours)** Spindle systems and bearings, guideways and linear motion systems, ball screws and backlash, lubrication systems, hydraulic and pneumatic systems, automatic tool changer (ATC), mechanical fault diagnosis. • **Unit 4: Electrical and Control Systems Maintenance (6 Hours)** Electrical power supply and protection, CNC control panels, servo motors and drives, encoders and feedback devices, sensors and limit switches, PLC basics, electrical troubleshooting and alarms. • **Unit 5: Preventive and Predictive Maintenance Techniques (6 Hours)** Preventive maintenance schedules and checklists, condition monitoring techniques, vibration and temperature monitoring, lubrication monitoring, predictive maintenance concepts, spindle health monitoring. • **Unit 6: Troubleshooting, Calibration, and Best Practices (6 Hours)** Systematic troubleshooting methods, common CNC/VMC faults and remedies, machine calibration and accuracy testing, backlash and positioning error measurement, maintenance best practices, industrial case studies.	Online/Offline Certification Course or Project of total 8 Credits	08

Textbooks				
1	CNC Machining Handbook: Building, Programming, and Implementation — Alan Overby (covers CNC components, setup, troubleshooting and maintenance aspects).			
2	CNC Trade Secrets: A Guide to CNC Machine Shop Practices — James Harvey (practical guide to shop practices including maintenance insights).			
3	Machine Tool Maintenance — various authors (covers maintenance of CNC machine tools, electrical and mechanical troubleshooting).			
4	Precision Machining Equipment Maintenance Handbook — (practical handbook focusing on maintenance of machine tools and equipment).			
Reference Books				
1	Machinery‘s Handbook — Industrial Press (classic mechanical reference; useful for understanding machine elements, tolerances, fits, and shop practices).			
2	Maintenance Planning and Scheduling Handbook — (detailed guide on planning, scheduling, and documentation in maintenance). (Often available in technical libraries)			
3	Industrial Maintenance and Mechatronics — (covers mechanical, electrical and control system maintenance relevant to CNC/VMC)			
4	OEM CNC/VMC Machine Manuals & Maintenance Guides — (manufacturer-specific manuals are highly valuable for real-world maintenance).			
2	ME-EC-0206	**2. CNC/VMC Maintenance Planning and Management (03)** • **Unit 1: Introduction to CNC/VMC Maintenance Management (6 Hours)** Role of maintenance in CNC/VMC productivity, maintenance objectives, reliability and availability concepts, maintenance organization and responsibilities, safety management in CNC maintenance, overview of maintenance standards and documentation. • **Maintenance Planning and Scheduling (6 Hours)** Maintenance planning principles, preventive maintenance planning for CNC/VMC machines, preparation of maintenance schedules, manpower planning, spare parts planning, shutdown planning, maintenance checklists and work orders. • **Maintenance Strategies and TPM for CNC Machines (6 Hours)** Maintenance strategies: breakdown, preventive, predictive, and condition-based maintenance, introduction to Total Productive Maintenance (TPM), pillars of TPM, OEE calculation for CNC/VMC machines, implementation of TPM in CNC workshops. • **Condition Monitoring and Predictive Maintenance (6 Hours)** Condition monitoring techniques for CNC/VMC machines, vibration monitoring, thermal	Online/Offline Certification Course or Project of total 8 Credits	08

		monitoring, lubrication analysis, spindle and bearing health monitoring, basics of predictive maintenance tools and software. • **Unit 5: Maintenance Costing and Performance Measurement (6 Hours)** Maintenance cost elements, cost control and budgeting, life cycle costing of CNC machines, maintenance performance indicators (MTBF, MTTR, availability), maintenance audits and continuous improvement. • **Unit 6: Maintenance Management Systems and Case Studies (6 Hours)** Computerized Maintenance Management Systems (CMMS), maintenance data management and reporting, spare parts inventory management, failure analysis and root cause analysis (RCA), industrial case studies on CNC/VMC maintenance management.		
Textbooks				
1	CNC Machining Handbook: Building, Programming, and Implementation – Alan Overby — a comprehensive guide covering CNC machine components, operation, troubleshooting, and maintenance fundamentals.			
2	CNC Trade Secrets: A Guide to CNC Machine Shop Practices – James A. Harvey — practical insights on CNC practices including setup, maintenance tips, and troubleshooting.			
3	CNC Control Setup for Milling and Turning – Peter Smid — detailed coverage of machine control systems and setup which supports maintenance understanding.			
4	Machinery‘s Handbook – Industrial Press — widely used reference for machine elements, shop practice, and fundamentals useful for maintenance engineers.			
5	CNC Machine Maintenance Training Manual – (training manual/resource) containing maintenance planning, checklists, inspection procedures and logs.			
Reference Books				
1	Maintenance Planning and Scheduling Handbook – (2nd Edition) — classic reference on systematic maintenance planning and work order management.			
2	Industrial Maintenance and Mechatronics – Shawn A. Ballee and Gary R. Shearer — covers industrial maintenance systems including mechanical, electrical, and control aspects relevant to CNC/VMC machines.			
3	Precision Machining Equipment Maintenance Handbook – handbook style reference for machine tool maintenance practices and procedures.			
2	ME-EC-0206	**3. CNC/VMC Practical Training-Industry (02)**	Online/Offline Certification Course or Project of total 8 Credits	08