

# **COEP Technological University Pune**

**(A Unitary Public University of Govt. of Maharashtra)**

## **Mechanical Engineering Department Curriculum Structure**

### **B. Tech Mechanical Engineering**

**(As Per NEP 2020- NCrF Level 4.5- 6 )**

**(Effective from: A.Y. 2025-26)**

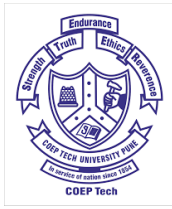


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**Mechanical Engineering Department**

## List of Abbreviations

	Abbreviation	Type of Course
1	BSC	Basic Science Course
2	ESC	Engineering Science Course
3	PCC	Programme Core Course
4	PEC	Programme Elective Course
5	MDM	Multidisciplinary Minor
6	OE	Open Elective
7	VSEC	Vocational and Skill Enhancement Course
8	HSMC	Humanities Social Science and Management
9	IKS	Indian Knowledge System
10	VEC	Value Education Course
11	RM	Research Methodology
12	IT	Internship / On job training
13	PW	Project
14	CEA	Community Engagement Activity (CEA)/Field Project
15	CCA	Co-curricular & Extracurricular Activities
16	AEC	Ability Enhancement course



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### **Vision of the Department:**

To be a leader amongst engineering institutions in India, offering value-based world class education and constantly pursuing excellence

### **Mission of the Department:**

**M1:** To offer state-of-the-art undergraduate, postgraduate, and doctoral programs.

**M2:** To develop employable and skilled undergraduates to accept the global and societal challenges, while imparting quality education at postgraduate and research level.

**M3:** To Foster the passion of life-long learning in all facets of employability.

### **Program Educational Objectives (PEOs)**

**PEO1.** Cater to the needs of Indian as well as multinational industries.

**PEO2.** Be competent with a strong technological background to analyze data, formulate and undertake industrial problems and obtain viable solutions.

**PEO3.** Make successful career in industry / research / higher Studies.

**PEO4.** Be life-long learning and should be able to work on multi-disciplinary projects.

**PEO5.** Be Competent for effective communication, in management and in professional skills and ethics

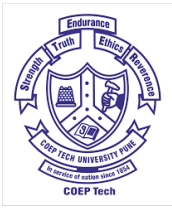
### **Program Outcomes**

Program Outcomes of Engineering program as per norms (common to all UG/ PG Programme)

**PO1. Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.

**PO2. Problem analysis:** Identify, formulate, research literature, and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

**PO3. Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.



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**PO4. Conduct investigations of complex problems:**

The problems:

- that cannot be solved by straightforward application of knowledge, theories and techniques applicable to the engineering discipline.
- that may not have a unique solution. For example, a design problem can be solved in many ways and lead to multiple possible solutions.
- that require consideration of appropriate constraints/requirements not explicitly given in the problem statement. (like cost, power requirement, durability, product life, etc.).
- which needs to be defined (modeled) within appropriate mathematical framework.
- that often require use of modern computational concepts and tools.

**PO5. Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling to complex engineering activities, with an understanding of the limitations.

**PO6. The engineer and society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to professional engineering practice.

**PO7. Environment and sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

**PO8. Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

**PO9. Individual and teamwork:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

**PO10. Communication:** Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

**PO11. Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

**PO12. Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.



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### Program Specific Objectives (PSOs)

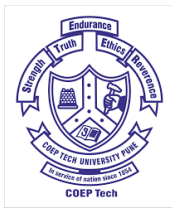
**PSO1. Design and Development:** The ability to design and develop the products as per the need of the customers in the field of Mechanical and Allied Engineering Industries.

**PSO2. Engineering Analysis and optimization:** The ability to analyze and optimize the Mechanical systems/processes using various computational tools.

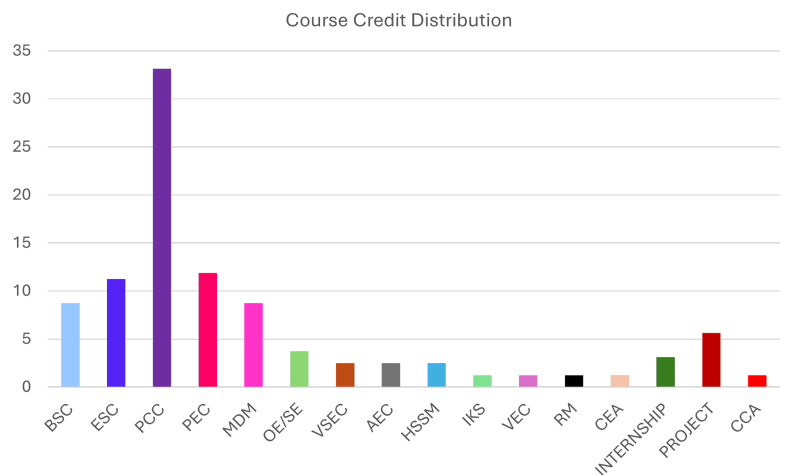
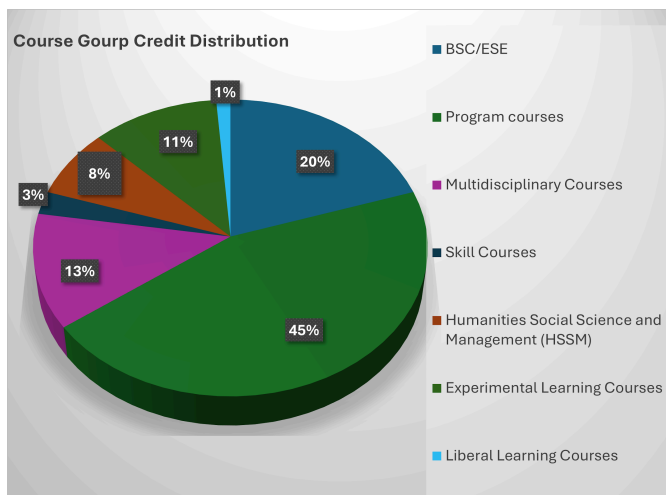
**PSO3. Society:** To strengthen Mechanical Engineering graduates who would value professional and ethical responsibilities while solving societal problems.

### Course Group-wise and Semester-Wise Credit Distribution

Course Group	Credits	% Credits	Course type	Sem 1	Sem 2	Sem 3	Sem 4	Sem 5	Sem 6	Sem 7	Sem 8	Total	% Credits
BSC/ESE	32	20	BSC	6	8							14	8.75
			ESC	10	8								18
Program courses	72	45	PCC			11	11	11	12	8		53	33.12
			PEC					3	4	3	9	19	11.87
Multidisciplinary Courses	20	12.5	MDM				3	4	4	3		14	8.75
			OE/SE			2	2	0		2		6	3.75
Skill Courses	4	2.5	VSEC	1	1		2					4	2.5
Humanities Social Science and Management (HSSM)	12	7.5	AEC	2		2						4	2.5
			HSSM			2	2					4	2.5
			IKS		2							2	1.25
			VEC			1	1					2	1.25
Experimental Learning Courses	18	11.25	RM					2				2	1.25
			CEA			2						2	1.25
			INTERNSHIP					1		1	3	5	3.12
			PROJECT					2	2	5		9	5.62
Liberal Learning Courses	2	1.25	CCA	1	1						2	1.25	
<b>Total</b>	<b>160</b>	<b>100</b>		<b>20</b>	<b>20</b>	<b>20</b>	<b>21</b>	<b>23</b>	<b>22</b>	<b>22</b>	<b>12</b>	<b>160</b>	<b>100</b>



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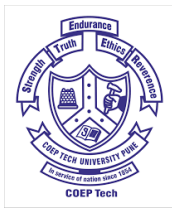


### Key Features of Curriculum

- Multiple entry and exit options are available after every academic year, allowing students to leave with a certificate, diploma, or degree. Each exit level is supported by 8-credit skill-based courses to ensure industry readiness.

NCrF Level	Year/Semester	Exit Option	Credits	Additional credits for exit students	Total Credits
4.5	Semester I & II	Diploma	40	8	48
5.0	Semester III & IV	UG Diploma	81	8	89
5.5	Semester V & VI	B.VOC	126	8	134
6.0	Semester VII & VIII	Double Minors	160	18	178
		Honors -Design	160	18	178
		Honors-Thermal	160	18	178
		Honors Research	160	18	178

- The curriculum includes various types of courses beyond the core, such as Open Electives (OE), Vocational and Skill Enhancement Courses (VSE), Ability Enhancement Courses (AE), Indian Knowledge System (IKS), Value Education Courses (VE), and Co-Curricular Courses (CC).
- A mandatory internship is required during every summer vacation, lasting at least one month and up to two months. The internship is evaluated at the start of the next semester.
  - 1st Year Summer Social Internship:** Focuses on community engagement and social awareness. Students participate in social service activities to develop empathy, communication skills, and an understanding of societal challenges.
  - 2nd Year Summer Internship:** Early exposure focused on observational learning. Students are introduced to basic engineering tools, processes, and industrial operations, building a foundational understanding of mechanical engineering.



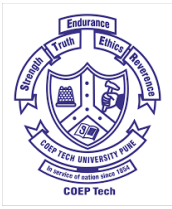
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- **3rd Year Summer Internship:** Application-oriented experience with hands-on tasks. Students begin to apply classroom knowledge in real-world settings, develop core technical skills, and engage more deeply with industry processes.
  - **8th Semester Final Internship:** Capstone industry experience involving advanced problem-solving and project execution. Students contribute to real projects, demonstrate leadership, and often receive pre-placement offers (PPOs). This internship can be completed in industry, research organizations, premier institutes, or through in-house university research projects. It provides excellent opportunities for securing employment before graduation and prepares students for full-time roles or higher studies.
4. Academic credits are awarded for Value Education, Ability Enhancement, and Co-Curricular Activities, recognizing the importance of holistic student development.
  5. Interdisciplinary and multidisciplinary education is promoted through options like single and double minors as well as open electives, encouraging students to explore beyond their primary field of study.
  6. The curriculum supports online learning through national platforms like SWAYAM and NPTEL, and the credits earned through these platforms can be counted toward the degree.
  7. A provision is available for students to pursue a B.Tech. Honours with Research degree by completing a research project, fostering innovation and academic depth.
  8. Students have the flexibility to choose courses from a wide range of disciplines, giving them the freedom to align their learning with their personal interests and career aspirations.
  9. Skill-based courses, fieldwork, internships, and mini-projects are integrated at each level of exit to ensure that students acquire practical and job-relevant skills.
  10. The curriculum is designed to be flexible for all types of learners—whether high achievers, average students, or those opting to exit early—ensuring that every student can benefit from a personalized and inclusive education system.

Good Students	Normal Students	Exit
B.Tech. Major with Multidisciplinary minor	B.Tech. Major with Multidisciplinary minor	Additional 8 credits in the form of skill-based courses/labs, internship, mini project shall be offered in 8 weeks
B. Tech Honors with Design Engineering	--	
B. Tech Honors with Thermal Engineering	--	
B. Tech Honors with Research	--	
B.Tech with Double Minor	--	

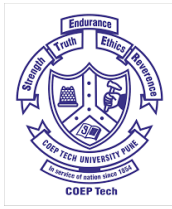
11. There is a provision for **progressive project work in the 5th, 6th, and 7th semesters**, allowing students to gradually develop and implement larger, application-based projects leading up to their final year. This enhances their design thinking, problem-solving, and practical engineering skills



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## Open MOOCs & Online Courses for Mechanical Engineering

1. **NPTEL (National Programme on Technology Enhanced Learning)**  
Indian government platform offering extensive Mechanical Engineering courses.  
<https://nptel.ac.in/course.html?disciplineId=37>
2. **MIT OpenCourseWare (OCW) – Mechanical Engineering**  
Explore free course materials on core Mechanical Engineering topics.  
<https://ocw.mit.edu/courses/mechanical-engineering/>
3. **Coursera – Mechanical Engineering Courses**  
Courses from top universities, free to audit.  
<https://www.coursera.org/browse/physical-science-and-engineering/mechanical-engineering>
4. **edX – Mechanical Engineering Courses**  
Free to audit with certificate options.  
<https://www.edx.org/learn/mechanical-engineering>
5. **Udemy – Mechanical Engineering Courses**  
Affordable paid and some free courses on CAD, SolidWorks, MATLAB, etc.  
<https://www.udemy.com/topic/mechanical-engineering/>
6. **Khan Academy – Physics and Engineering Basics**  
Great for fundamental concepts.  
<https://www.khanacademy.org/science/physics>
7. **FutureLearn**  
Offers mechanical engineering and manufacturing courses from universities worldwide.  
Example: *Introduction to Engineering Mechanics, Renewable Energy and Heat Transfer*  
<https://www.futurelearn.com/subjects/engineering-courses>
8. **LinkedIn Learning**  
Practical courses on CAD software (SolidWorks, AutoCAD), MATLAB, project management, and more.  
Great for upskilling with professional certificates.  
<https://www.linkedin.com/learning/topics/mechanical-engineering>
9. **Skillshare**  
Project-based courses on design tools, 3D modeling, and prototyping.  
Suitable for learners looking to enhance creative and technical skills.  
<https://www.skillshare.com/browse/mechanical-engineering>
10. **Alison**  
Free courses on mechanical engineering fundamentals and CAD software.  
Includes certification options.  
<https://alison.com/courses/engineering>
11. **OpenLearn by The Open University**  
Free engineering courses including mechanical topics and design fundamentals.  
<https://www.open.edu/openlearn/science-maths-technology/engineering-technology>
12. **Canvas Network**  
Offers courses from various universities, including mechanical engineering topics.  
<https://www.canvas.net/browse?subject=engineering>



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**F. Y. B. Tech: Mechanical Engineering**  
**[Level 4.5, UG Certificate] Semester -I**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	BSC		Mathematics I	2	1	0	1	1.5					
02	BSC		Mathematics II	2	1	0	1	1.5					
03	BSC		Applied Science I	2	0	2	1	1.5					
04	BSC		Applied Science II	1	0	4	1	1.5					
05	BSC		Applied Science III	1	0	0	1	1					
06	ESC		Engineering Sciences	3	0	0	1	3					
07	ESC		Engineering Sciences	2	0	2	1	3					
08	ESC		Engineering Sciences	2	0	2	1	3					
09	VSEC		Vocational Skills Enhancement courses	1	0	2	2	2					
10	AEC		Ability Enhancement courses	0	0	2	2	1					
11	CCA/LC		Co-curricular activities/ Liberal learning courses	0	0	2	2	1					
<b>Total Credit</b>								<b>19/20</b>					



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**F. Y. B. Tech: Mechanical Engineering**  
**[Level 4.5, UG Certificate] Semester -II**

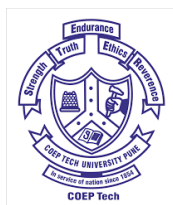
Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	BSC		Mathematics III	2	1	0	1	1.5					
02	BSC		Mathematics IV	2	1	0	1	1.5					
03	BSC		Applied Science III	2	0	2	1	1.5					
04	BSC		Applied Science IV	1	0	4	1	1.5					
05	BSC		Applied Science	1	0	0	1	1					
06	ESC		Engineering Sciences	3	0	0	1	3					
07	PCC		Program core course	3	0	2	1	4					
08	VSEC		Vocational Skills Enhancement courses	1	0	2	2	2					
09	ASEC		Ability Enhancements Courses	0	0	2	3	1					
10	IKS		Indian Knowledge System	2	0	0	1	2					
11	CCA/LLC		Co-curricular Activities/ Liberal Learning Course	0	0	2	2	1					
<b>Total Credit</b>								<b>20/ 21</b>					

# combined lab for Applied Chemistry and Material science

Legends: L-Lecture, T-Tutorial, P-Practical, S-Self Study, Cr-Credits

ISE-In-Semester-Evaluation, ESE-End-Semester-Evaluation, MSE-Mid-Semester-Evaluation,

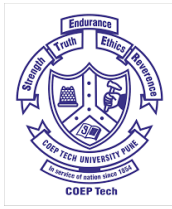
TA-Teachers' Assessment, CIE-Continuous-Internal-Evaluation



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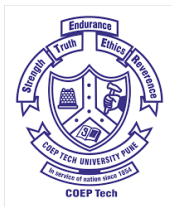
Sr. No.	Course Type	Course Title/ Collection	Semester I	Semester II	
1	BS	Mathematics (select any 1 subject 3 credits in I semester and 4 credits in II semester)	3	4	1. Matrix algebra and calculus (MAC) (3 credits) and Vector Calculus and Differential Equations (VCDE) (4 credits) Or 2. Linear Algebra (3 credits) and Probability and Statistics (PS) (4 credits)
02	BS	Applied Sciences (select any 1 subject 3 credits in I semester and 3 credits in II semester)	3	3	1. Engineering Physics (3 credits) and Engineering Chemistry (3 credits) 2. Engineering Chemistry (3 credits) and Engineering Physics (3 credits) 3. Engineering Physics (3 credits) and Quantum Physics (3 credits) 4. Engineering Physics (3 credits) and Semiconductor Physics (3 credits) 5. Engineering Chemistry (3 credits) and Semiconductor Physics (3 credits)
03	BS	Applied Sciences (select any 1 subject 1 credit in I or II semester)	1	-	1. Electromagnetism 2. Solid State Physics 3. Statistical Thermodynamics 4. Biology for Engineers 5. Emerging Technologies in Energy Storage 6. Nanomaterials in Emerging Technologies 7. Polymeric Materials in Engineering 8. Fundamental of Quantum physics



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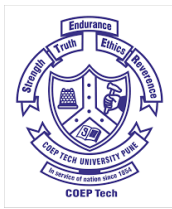
04	ESC	Engineering Sciences (select any 2 subject 3 credit for I Semester and II semester)	3+3		<ol style="list-style-type: none"> <li>1. Basics of Civil Engineering (Civil)</li> <li>2. Fundamentals of Physical Infrastructure (Civil - Planning)</li> <li>3. AI for Multidisciplinary Applications (Computer)</li> <li>4. Applied Electronics and IOT (Electronics)</li> <li>5. Electrical Energy Utilization (Electrical)</li> <li>6. Fundamentals of Measurement and Sensors (Instrumentation)</li> <li>7. Foundations in Mechanical Engineering (Mechanical)</li> <li>8. Nanomaterials (Metallurgy)</li> <li>9. Basics of Manufacturing Technology (Manufacturing Science)</li> </ol>
05	ESC	Engineering Sciences (select any 1 subjects 3 credits for I Semester and II semester)			<ol style="list-style-type: none"> <li>1. Applied Mechanics (Civil)</li> <li>2. Fundamentals of Cyber Security (Computer)</li> <li>3. Basic Electrical Engineering (Electrical)</li> <li>4. Digital logic design (Electronics)</li> <li>5. Engineering Graphics (Mechanical)</li> <li>6. Fundamentals of Corrosion Engineering (Metallurgy)</li> <li>7. Product prototyping practices (Manufacturing Science)</li> <li>8. Fundamentals of Electrical Engineering (Electrical)</li> </ol>



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06	VSEC	Vocational and Skill Enhancement Courses (select any 1 subject 2 credits for I semester and 1 subject 2 credits for II semester)	2	2	<ol style="list-style-type: none"> <li>1. Geomatic Engineering (Civil)</li> <li>2. Fundamentals of Construction Practices (Civil)</li> <li>3. Programming for problem solving (Computer)</li> <li>4. Web design (Computer)</li> <li>5. Python Programming (computer)</li> <li>6. Electrical Maintenance and Safety (Electrical)</li> <li>7. Electrical Workshop (Electrical)</li> <li>8. Digital public infrastructure (Electronics)</li> <li>9. Data preprocessing and visualization (Electronics)</li> <li>10. Fundamentals of PLC (Instrumentation)</li> <li>11. Computer-aided drafting (Mechanical)</li> <li>12. EV Architecture (Mechanical)</li> <li>13. Introduction to Materials Modelling (Metallurgy)</li> <li>14. Modern chemical Analysis (Metallurgy)</li> <li>15. Manufacturing practices and Fab Lab (Manufacturing Science)</li> <li>16. Robotics and Drone Operation and Safety (Manufacturing Science)</li> </ol>
07	AEC-01	Ability Enhancement Courses (select any 1 subject 1 credit for I semester and 1 subject 1 credit for II)	1	1	<ol style="list-style-type: none"> <li>1. Personality Development (Management)</li> <li>2. Communication Skills</li> </ol>



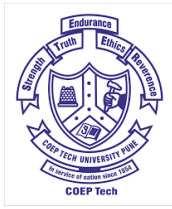
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		semester)			
08	CCA/ LLC-0 1	Co-curricular Activities/ Liberal Learning Course	1	1	

Mandatory subject as per programme

Sr no.		Credits	Computer	AIML	Electrical	Electronics	Instrumental	Civil	Mechanical	Metalurgy	Manufacturing science
1	Engineering science	3	Fundamentals of AI	Fundamentals of AI	Fundamentals of Electrical Engineering	Elements of Electronics Engineering	Fundamentals of MATLAB and Simulink	Essentials of Civil Engineering	Systems in Mechanical Engg	Structure & Properties of Materials	Design Thinking and Idea Lab
2	Programme Core Courses	4	Discrete structure	Discrete structure	Electrical and Electronic Measurements and Instrumentation	Foundation of Electronics and Emerging Technologies	Basics of Measurement and Sensor	Engineering Mechanics	Computer-Aided Engineering Drawing	Fuel furnaces and Refractories	Essentials of Production Systems and Smart Factories For SEM-II
3	Indian Knowledge System	1	Common for all								



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**Exit option to qualify for Diploma: Any two skill-based Courses:**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	VSEC	<td>	Computer Aided Geometric Modeling	0	0	8	0	4	---			CIE 100	
02	VSEC	<td>	Basics of CNC Programming	0	0	8	0	4	---			CIE 100	
03	VSEC	<td>	<a href="#">Additive Manufacturing</a>	0	0	8	0	4	---			CIE 100	



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**S. Y. B. Tech: Mechanical Engineering**  
**[Level 5, UG Regular] Semester -III**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	ME-24001	Engineering Thermodynamics	3	1	0	0	4	30	20	50	--	--
02	PCC	ME-24002	Solid Mechanics	2	0	0	1	2	30	20	50	--	--
03	PCC	ME-24003	Machine Drawing & Geometric Modeling	1	0	2	1	2	30	20	50	50	50
04	PCC	ME-24004	Manufacturing Technology	2	0	2	1	3	30	20	50	50	50
05	OE		Open Elective – I	2	0	0	0	2	30	20	50	—	—
06	AEC-II	HS-24003	Indian Language: Sanskrit/Pali	2	0	0	0	2	30	20	50	--	--
07	VEC-I	AS-24003	Constitution of India and Universal Human Values	1	0	0	0	1	—	—	—	--	--
08	HSSM	HS-24004	Principles of Economics	2	0	0	2	2	30	20	50	--	--
09	CEA	AS-24004	Community Engagement Activity/ Field Project *	0	0	0	0	2	-	-	-	CIE 100	
<b>Total</b>				<b>15</b>	<b>1</b>	<b>08</b>	<b>5</b>	<b>20</b>					

**\*After SEM II during summer vacation and evaluation will be done in the start of SEM III with a duration minimum One and a maximum Two months.**



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**Mechanical Engineering Department**

**S. Y. B. Tech: Mechanical Engineering**  
**[Level 5, UG Regular] Semester -IV**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	ME-24006	Fluid Mechanics	3	0	2	1	4	30	20	50	50	50
02	PCC	ME-24007	Design of Machine Elements	2	1	0	1	3	30	20	50	--	--
03	PCC	ME-24008	Kinematics of Machines	3	0	2	1	4	30	20	50	50	50
04	OE		Open Elective - II	2	0	0	0	2	30	20	50	--	
05	MDM-I		Multidisciplinary Minor I	3	0	0	1	3	30	20	50	--	
06	VSEC	ME-24009	Numerical Methods and Programming Language	1	0	2	1	2	30	20	50	50	50
07	HSMC	HS-24001	Entrepreneurship	2	0	0	1	2	30	20	50	--	--
08	VEC-II	AS-24001	Environmental Studies	1	0	0	1	1	30	20	50	--	--
<b>Total</b>				<b>17</b>	<b>1</b>	<b>6</b>	<b>7</b>	<b>21</b>					

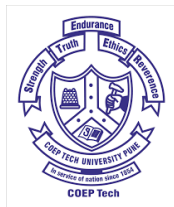


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**Mechanical Engineering Department**

**S. Y. B. Tech : Mechanical Engineering**  
**[Level 5, UG Diploma] Semester -III**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	ME-24001	Engineering Thermodynamics	3	1	0	0	4	30	20	50	-	-
02	PCC	ME-24002	Solid Mechanics	2	0	0	1	2	30	20	50	-	-
03	PCC	ME-24003	Machine Drawing & Geometric Modeling	1	0	2	1	2	30	20	50	50	50
04	PCC	ME-24004	Manufacturing Technology	2	0	2	1	3	30	20	50	50	50
05	OE		Open Elective – I	2	0	0	0	2	30	20	50	---	----
06	AEC-II	HS-24003	Indian language Sanskrit/Pali	2	0	0	0	2	30	20	50	-	-
07	VEC-I	AS-24003	Constitution of India and Universal Human Value	1	0	0	0	1	-	-	-	-	-
08	BSC		Mathematics	3	0	0	1	3	30	20	50	-	-
09	HSMC	HS-24001	Principles of Entrepreneurship	2	0	0	1	2	30	20	50	-	-
<b>Total Credit</b>								<b>21</b>					



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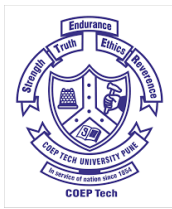
**S. Y. B. Tech : Mechanical Engineering**  
**[Level 5, UG Diploma] Semester –IV**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	ME-24006	Fluid Mechanics	3	0	2	1	4	30	20	50	50	50
02	PCC	ME-24007	Design of Machine Elements	2	1	0	1	3	30	20	50	--	--
03	PCC	ME-24008	Kinematics of Machines	3	0	2	1	4	30	20	50	50	50
04	OE		Open Elective - II	2	0	0	1	2	30	20	50	--	--
05	MDM-I		Multidisciplinary Minor-I	3	0	0	1	3	30	20	50	--	--
06	VSEC	ME-24009	Numerical Methods and Programming Language	1	0	2	1	2	30	20	50	50	50
07	HSMC	HS-24004	Principles of Economics	2	0	0	1	2	30	20	50	--	--
08	VEC-II	AS-24001	Environmental Studies	1	0	0	1	1	30	20	50	--	--
09	HSMC	HS-24007	Communication Skills	1	0	2	0	2	30	20	50	CIE 100	
<b>Total Credit</b>								<b>23</b>					

Legends: L-Lecture, T-Tutorial, P-Practical, S-Self Study, Cr-Credits  
 ISE-In-Semester-Evaluation, ESE-End-Semester-Evaluation, MSE-Mid-Semester-Evaluation, TA-Teachers' Assessment, CIE-Continuous-Internal-Evaluation

**Exit option to qualify for UG Diploma:**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC	<td>	Computer Aided Manufacturing (CAM)	0	0	8	0	4	-----			CIE 100	



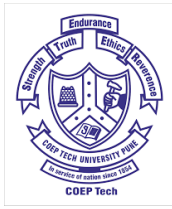
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**T. Y. B. Tech: Mechanical Engineering**  
**[Level 5.5, UG] Semester -V**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MS E	T A	ES E	ISE	ESE
01	PCC	ME-25001	Heat Transfer	3	0	2	1	4	30	20	50	50	50
02	PCC	ME-25002	Dynamics of Machine	3	0	2	0	4	30	20	50	50	50
03	PCC	ME-25003	Metrology & Measurement	2	0	2	1	3	30	20	50	50	50
04	PEC		Program Elective Course -I (Specify List)*	3	0	0	1	3	30	20	50	-	-
05	MDM		Multidisciplinary Minor II	3	1	0	0	4	30	20	50	-	-
06	RM		Open Elective Course III	2	0	0	2	2	30	20	50	-	-
07	ELC		Internship 1#	0	0	0	0	1	-	-	-	CIE-100	
08	ELC		Project-I	0	0	4	0	2	-	-	-	CIE-100	
<b>Total Credit</b>								<b>23</b>					

# Summer Internship (Industry /R&D / Academic Institute) after IV semester during summer vacation and evaluation will be done at the start of V semester. Duration minimum One and a maximum Two months.

<b>*Program Elective Course I – Discipline-wise List</b>			
<b>Design Engineering</b>	<b>Thermal Engineering/Fluid Science</b>	<b>Manufacturing Science and Engineering</b>	<b>Interdisciplinary</b>
Finite Element Methods (FEM)	Fluid Dynamics	Advanced Manufacturing Technology	Fundamentals of Green Hydrogen Technology
Experimental Stress Analysis	Modern IC Engines	Operations Research	Machine Learning
Innovative Design and Optimization	Steam and Gas Turbine	Design of Polymer composites	Renewable Energy Resources



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**T. Y. B. Tech: Mechanical Engineering**  
**[Level 5.5, UG] Semester -VI**

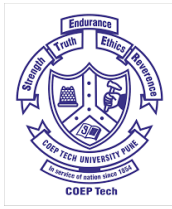
Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MS E	TA	ESE	ISE	ESE
01	PCC	<td>	Mechanical System Design	3	0	2	1	4	30	20	50	50	50
02	PCC	<td>	Computer Aided Design and Manufacturing	3	0	2	1	4	30	20	50	50	50
03	PCC	<td>	Fluid Machinery	3	0	2	0	4	30	20	50	50	50
04	PEC	<td>	Program Elective Course -II (Specify List) *	3	1	0	0	4	30	20	50	--	--
05	MDM	<td>	Multidisciplinary Minor III	3	1	0	1	4	30	20	50	--	--
06	ELC	<td>	Project-II	0	0	4	2	2				CIE-100	
<b>Total Credit</b>								<b>22</b>					

**Exit Option to B VOC:**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PCC		Finite Element Analysis	3	1	0	1	4	30	20	50		
02	PCC		Generative design	3	1	0	1	4	30	20	50		

**\*Program Elective Course II – Discipline-wise List**

Design Engineering	Thermal Engineering/Fluid Science	Manufacturing Science and Engineering	Other Disciplines
Advanced Finite Element Method (FEM)	Industrial Hydraulics and Pneumatics	Micro & Nano Machining	Biomass Energy Conversion
Design for Fatigue and Fracture	Computational Fluid Dynamics	Digital Manufacturing	Automotive Energy Conversion
Piping Design	Heat Exchangers: Fundamentals and Design Analysis	MicroFluidics	Deep Learning
		Additive Manufacturing	Sci. and Tech. Nanomaterials



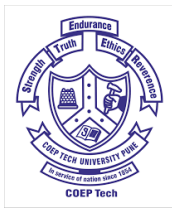
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**B. Tech: Mechanical Engineering**  
**[Level 6, UG] Semester -VII**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	T A	ES E	ISE	ESE
01	PCC	<td>	Energy Conversion	2	0	0	1	2	30	10	60		
02	PCC	<td>	Refrigeration and Air Conditioning	2	0	2*	1	3	30	20	50	50	50
03	PCC	<td>	Vibration and Acoustics	2	0	2	1	3	30	20	50	50	50
04	PEC	<td>	Program Elective Course -III (Specify List) *	3	0	0	0	3	30	20	50	--	--
06	ELC	<td>	Internship 2 #	0	0	0	0	1	30	20	50	50	50
07	OE	<td>	Research Methodology and IPR	2	0	0	1	2	30	20	50	--	--
08	MDM	<td>	Multidisciplinary Minor IV	3	0	0	1	3	30	20	50	--	--
	ELC		Project-III	0	0	10	2	5				50	50
<b>Total Credits</b>								<b>22</b>					

# Summer Internship (Industry /R&D / Academic Institute) after VI semester during summer vacation and evaluation will be done at the start of VII semester. Duration minimum One and a maximum Two months.

<b>*Program Elective Course III – Discipline-wise List</b>			
<b>Design Engineering</b>	<b>Thermal Engineering/Fluid Science</b>	<b>Manufacturing Science and Engineering</b>	<b>Other Disciplines</b>
Advanced CAD/CAM	Advanced Computational Fluid Dynamics	Industrial Engineering	Hybrid and Electric Vehicles
Mechanics of Composite Materials	Design of Thermal Systems	Reverse Engineering	Aerospace Engineering
Condition Monitoring	Mathematical Modelling & Analysis Thermal System	Production and Operations Management	Design of Defense Equipment
Automatic control systems		AI and ML for Mech. Engineers	Automotive control systems



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**B. Tech: Mechanical Engineering**  
**[Level 6, UG] Semester -VIII**

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	PEC	<td>	Program Elective Course -IV (Specify List) **	3	0	0	0	3	30	20	50		
02	PEC	<td>	Program Specific Elective- V (Specify List) **	3	0	0	3	3	30	20	50		
03	PEC	<td>	Program Specific Elective- VI (Specify List) **	3	0	0	3	3	30	20	50	--	--
04	ELC	<td>	Internship #3	0	0	0	0	3				50	50
<b>Total Credits</b>								<b>12</b>					

\*\* MOOCS / Online Courses



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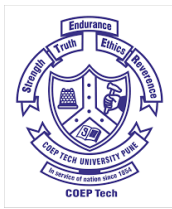
**Mechanical Engineering Department**

**Open Electives- Mechanical Engineering**

Sr. No.	Semester	Course Code	Course Name	L	T	P	Hrs	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	III	<tbd>	Computer Aided 3D Geometric Modelling	1	-	2	3	2	30	20	50		
2	IV	<tbd>	Engineering Thermodynamics and heat Transfer	2	-	-	2	2	30	20	50		
3	V	<tbd>	Introduction to aircraft system	2	-	-	2	2	30	20	50		
4	V	<tbd>	Automotive Technology	2	-	-	2	2	30	20	50		
<b>Total Credits</b>								<b>8</b>					

**MDM Courses: Agricultural Science and Smart Farming**

Sr. No.	Semester	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
01	IV	MDM I	Agriculture Fundamentals	3	0	0	1	3	30	20	50	-	
02	V	MDM II	Biomass Processing Technologies	3	1	0	1	4	30	20	50	-	
03	VI	MDM III	Farm machinery and Food processing	3	1	0	0	4	30	20	50	-	
04	VII	MDM IV	Advances in agriculture and smart farming	3	0	0	1	3	30	20	50	--	
<b>Total</b>				<b>12</b>	<b>2</b>	<b>0</b>	<b>3</b>	<b>14</b>					



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**Mechanical Engineering Department**

**Multiple Exit Options**

Option	NCrF Level	Qualification Title	Additional Credit Requirement	Bridge Course
Exit-1	4.5	One Yr. UG certificate course in Engg. / Tech.	8	2 months internship <b>OR</b> Online two skill courses at ITI level from NSQF/ESSC/Any other agency that provides certification/ Evaluation in ( <b>Drafting with AUTOCAD &amp; Microsoft Office</b> ) <b>OR</b> Technical Project
Exit-2	5.0	Two Yr. UG Diploma in Engg. / Tech.	8	2 months internship <b>OR</b> Online two skill courses at Diploma level from NSQF/ESSC/Any other agency that provides certification/ Evaluation in ( <b>Solar course &amp; 3D modeling course</b> ) <b>OR</b> Technical Project
Exit-3	5.5	Three Yr. Bacheor Degree in Vocation. (B VoC.) or BSc (Engg. / Tech.)	8	2 months internship <b>OR</b> Online two skill courses at Degree level from NSQF/ESSC/Any other agency that provides certification/ Evaluation in ( <b>CNC course &amp; CAE course</b> ) <b>OR</b> Technical Project



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**Mechanical Engineering Department**

**Double Minors and Honors (Additional 18 Credits)**

**Double minors – Mechanical Engineering for other Branches**

Sem .	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MS E	TA	ESE	ISE	ESE
IV		<td>	Energy Storage System for EV	3	-	-	-	3	30	20	50	-	-
V		<td>	IOT for Electric Vehicle	3	-	-	-	3	30	20	50	-	-
VI		<td>	Optimization Techniques in Design	4	-	-	-	4	30	20	50	-	-
VII		<td>	Introduction to hydrogen technology	4	-	-	-	4	30	20	50	-	-
				4	-	-	-	4	30	20	50	-	-
<b>Total</b>				<b>18</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>18</b>	<b>-</b>				

**Honors- Mechanical Engineering - Design Engineering**

Sem.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
III		<td>	MATLAB Programming and Simulink Modeling	3	1	-	1	4	30	20	50	-	-
IV		<td>	Design for Manufacturing and Assembly	3	-	-	3	3	30	20	50	-	-
V		<td>	Stress Analysis	3	1	-	3	4	30	20	50	-	-
VI		<td>	Optimization Techniques in Design	2	1	-	3	3	30	20	50	-	-
VII		<td>	Advanced Vibration and Acoustics	2	1	-	3	4	30	20	50	-	-
<b>Total</b>				<b>13</b>	<b>3</b>	<b>-</b>	<b>15</b>	<b>18</b>	<b>-</b>				



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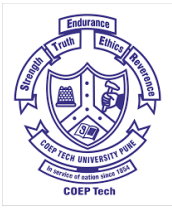
Note: The Courses selected for Honors degree from the pool of electives by a particular student should not be part of Mandatory 160 regular credits.

**Honors- Mechanical Engineering - Thermal Engineering**

Sem.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
III		<td>	MATLAB Programming and Simulink Modeling	3	1	-	1	4	30	20	50		
IV		<td>	Renewable energy systems	3	-	-	1	3	30	20	50		-
V		<td>	Electronic cooling systems	3	1	-	3	3	30	20	50		-
VI		<td>	Computational Fluid Dynamics	3	-	2	1	4	30	20	50		-
VII		<td>	Introduction to modeling and simulation of hydrogen technology	3	-	-	1	4	30	20	50		-
<b>Total</b>				<b>15</b>	<b>5</b>	<b>-</b>	<b>15</b>	<b>18</b>	<b>-</b>				

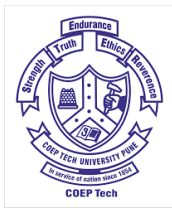
**Honors- Mechanical Engineering - Hybrid and Electrical Vehicle**

Sem.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightage in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
III		<td>	MATLAB Programming and Simulink Modeling	3	1	-	1	4	30	20	50		
IV		<td>	Automotive Engineering systems	3	-	-	1	3	30	20	50		-
V		<td>	Automotive Mechatronics	3	1	-	3	3	30	20	50		-
VI		<td>	Hybrid and Electrical vehicle	3	-	2	1	4	30	20	50		-
VII		<td>	Automotive transmission and control	3	-	-	1	4	30	20	50		-
<b>Total</b>				<b>15</b>	<b>5</b>	<b>-</b>	<b>15</b>	<b>18</b>	<b>-</b>				



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**Syllabus for Second Year B.Tech in  
Mechanical Engineering**



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**III-1 Engineering Thermodynamics**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-24001	Engineering Thermodynamics	3	1	0	0	4	30	20	50	--	--

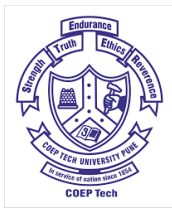
**Course Outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Apply basic laws of thermodynamics in analysis and design of thermodynamic cycles including vapor and gas power cycles, refrigeration cycles, and heat-pump.
2. Use thermodynamic relations in evaluation of thermodynamic properties.
3. Apply the fundamentals of conservation of mass and energy, and properties of ideal gas mixtures in design and analysis.
4. Evaluate performance of air standard cycles.
5. Evaluate performance of steam power cycles.
6. Gain design skills in thermal systems and enhance written communication.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Basic concepts and properties:</b> Introduction, thermodynamic system, control volume, macroscopic and microscopic approaches, properties and state of a system, point and path functions, thermodynamic equilibrium, processes and cycles, quasi-static process, properties such as specific volume, pressure, temperature, zeroth law of thermodynamics, temperature scales	6
2	<b>Ideal gases and vapors:</b> Difference between gases and vapors, ideal gases, gas laws, equation of state, gas constant, universal gas constant, work and heat, definition of work, thermodynamic work, work in compressible system, work-a path function, work done during various processes, p-v diagram, definition of heat, heat transfer a path function, comparison of heat and work, Phase change process of a pure substance: specific heats, sensible heat and latent heat, triple point, critical point, superheat and total heat of steam.	6
3	<b>First law of thermodynamics:</b> Energy of systems, classification of energy, law of conservation of energy, first law applied to closed system undergoing a cycle, Joule experiment, energy-a property of system, internal energy: a function of temperature, enthalpy, specific heat at constant volume and constant pressure, change in internal energy and heat transfer during various non-flow processes. First law applied to flow processes: steady-state steady flow process, mass balance and energy balance in steady flow process, steady flow energy equation and its application to nozzles and diffusers, throttling valve, turbines and compressors, pumps, heat exchangers etc. Work done and heat transfer during steady flow processes.	6



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4	<p><b>Second law of thermodynamics:</b> Limitations of first law, heat engines, refrigerators and heat pumps, Kelvin-plank and Clausius statements, their equivalence, reversible and irreversible processes, factors that render processes irreversible, Carnot cycle, two propositions regarding the efficiency of Carnot cycles, the thermodynamic temperature scale, reversed Carnot cycle, COP of heat pump and refrigeration. Thermodynamic processes – constant volume, isothermal, adiabatic, polytropic processes, throttling and free expansion- p-v and T-s diagrams-work done, heat exchanged, and change in internal energy.</p>	6
5	<p><b>Entropy:</b> Inequality of Clausius, entropy: a property of system, entropy change for ideal gases, entropy change of a system during irreversible process, lost work, principle of increase of entropy. Availability and irreversibility: available energy referred to cycle, decrease in available energy with heat transfer through a finite temperature difference. Tds equations, Availability in a steady flow system, irreversibility and effectiveness.</p>	6
6	<p><b>Powercycles:</b>  <b>Gas power cycles:</b> Otto cycle, Diesel cycle, semi-Diesel, Sterling cycles, and their efficiency and mean effective pressure calculations.  <b>Vapors power cycles:</b> Properties of steam, specific volume and entropy of steam, dryness fraction of steam, throttling of steam, determination of dryness fraction, steam tables and their use, T-s and H-s diagram, Rankine and modified Rankine cycle, work done and efficiency, specific steam consumption, comparison of Rankine and Carnot cycle, representation on P-v, T-s and h-s diagram.</p>	6

**Suggested learning resources:**

**Textbooks:**

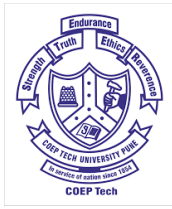
1. Thermodynamics: An Engineering Approach, 3rd Edition, Yunus Çengel and Michael, Boles, Tata McGraw Hill.
2. Basic and Applied Thermodynamics, 2nd Edition, Nag P. K., Tata McGraw-Hill.

**Reference Books:**

1. Fundamentals of Thermodynamics, 5th Edition, Richard E. Sonntag, Claus Borgnakke and Gordon J. Van Wylen, John Wiley and Sons, Inc.
2. Thermodynamics, 4th Edition, J.P. Holman, McGraw-Hill.
3. Engineering Thermodynamics, 2nd Edition, Jones J.B. and Hawkins G.A., John Wiley and Sons.
4. Fundamentals of Engineering Thermodynamics, Moran M.S. and Shapiro H.N., John Wiley and Sons, 1988.
5. Thermodynamics, 5th Edition, K. Wark, McGraw-Hill.

**Weblinks:**

- <https://nptel.ac.in/courses/101104063>
- <https://nptel.ac.in/courses/112106310>
- <https://www.coursera.org/learn/thermodynamics-intro#modules>



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### III-02 SOLID MECHANICS

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
Me-24002	Solid Mechanics	2	0	0	1	2	30	20	50	-	-

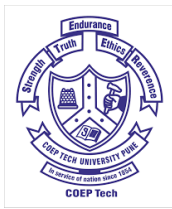
**Course outcomes:**

Upon completion of the course, students will be able to:

1. Understand the concepts of stress and strain at a point as well as the stress-strain relationships for homogenous, isotropic materials.
2. Calculate the stresses and strains in axially loaded members, circular torsion members, and members subject to flexural loadings.
3. Calculate the stresses and strains associated with thin-wall spherical and cylindrical pressure vessels.
4. Determine the stresses and strains in members subjected to combined loading and apply the theories of failure for static loading.
5. Determine and illustrate principal stresses, maximum shearing stress, and the stresses acting on a structural member.
6. Determine the deflections and rotations produced by the three fundamental types of loads: axial, torsional, and flexural.
7. Analyze slender, long columns subjected to axial loads.
8. Design simple bars, beams, and circular shafts for allowable stress and loads.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Simple stress and strain</b> Simple stress and strain- introduction to types of loads (static, dynamic and impact loading), various type of stresses with applications, Hook's law, Poisson's ratio, modulus of elasticity, modulus of rigidity, bulk modulus, interrelationship between elastic constants, stress-strain diagram for ductile and brittle materials, factor of safety, stresses and strains in determinate and indeterminate beams, homogenous and composite bars under concentrated loads and self-weight, thermal stresses in plane and composite members.	05
2	<b>Shear force and bending moment diagram</b> Shear force and bending moment diagram (SFD & BMD)- introduction to SFD, BMD with application SFD & BMD for statically determinate beam due to concentrated load, uniformly distributed load, uniformly varying load, couple and combined loading, relationship between rate of loading, shear force and bending moment, concept of zero shear force, maximum bending moment, point of contraflexure.	05
3	Stresses, slope and deflection on beams Bending stresses on a beam- introduction to bending stresses on a beam with application, theory of simple bending, assumptions in pure bending, derivation of	08



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	flexural formula, moment of inertia of common cross section (circular, hollow circular, rectangular – I and T), bending stress distribution along the same cross section. Shear stresses on beam- introduction to transverse shear stresses on a beam with application, shear stress distribution diagram along the circular, hollow circular, rectangular I and T cross section Slope and deflection on a beam- introduction to slope and deflection on a beam with application slope, deflection and radius of curvature, Macaulay's method.	
<b>4</b>	<b>Torsion of circular shafts, Buckling of columns and strain energy</b> Introduction to torsion on a shaft with application, basic torsion formulae and assumption in torsion theory, torque transmission on strength and rigidity basis. Buckling of columns- Introduction to buckling of columns with its applications, different column conditions, critical and safe load, determination by Euler's theory, limitations of Euler's theory. Strain energy and impact loading- concept of strain energy, derivation, and use of expressions for deformation of axially loaded members under gradual, sudden and impact loads.	<b>06</b>
<b>5</b>	<b>Principal stresses and Theories of failure</b> Principal stresses- introduction to principal stresses with applications, transformation of plane stress, principal stresses and planes (analytical methods and Mohr's circle), stresses due to combined normal and shear stresses. Theories of elastic failure- introduction to theories of failure with application, Maximum Principal stress theory, Maximum shear stress theory, Maximum distortion energy theory, Maximum principal strain theory, Maximum strain energy theory. Thin cylinders and spheres- Introduction, thin cylindrical vessel subjected to internal pressure, stresses in a thin cylindrical vessel subjected to internal pressure, effect on internal pressure on dimensions of a thin cylindrical shell, thin spherical shell, effect on internal pressure on dimensions of a thin spherical shell.	<b>06</b>

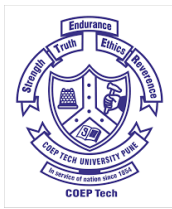
**Suggested learning resources:**

**Textbooks**

1. R K Bansal, "Strength of materials", Laxmi Publication
2. S. Ramamurtham, "Strength of materials", Dhanpatrai Publication
3. S S Ratan, "Strength of materials", Tata McGraw Hill Publication Co. Ltd.
4. S K Sarkar, "Strength of materials", McGraw Hill New Delhi
5. Singer and Pytel, "Strength of materials", Harper and row Publication
6. R C Hibbeler, "Mechanics of materials", Prentice Hall Publication

**Reference Books**

1. Egor P Popov, "Introduction to mechanics of solids", Prentice Hall Publication
2. G H Ryder, "Strength of materials", McMillan Publication
3. Beer and Johnston, "Strength of materials", CBS Publication
4. James M. Gere, "Mechanics of materials", CL Engineering
5. Timoshenko and Young, "Strength of materials", CBS Publication



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### III-03 MACHINE DRAWING AND GEOMETRIC MODELLING

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
Me-24002	Machine Drawing & Geometric Modeling	1	0	2	1	2	30	20	50	50	50

**Course outcomes:**

Upon completion of the course, students will be able to:

1. Comprehend various types of drawings, including production drawings, assembly drawings, and part drawings and apply standardization principles for creation of drawings.
2. Evaluate the application of fits, limits, geometric tolerances, and surface finish, and apply them using appropriate nomenclature, symbols, and rules.
3. Evaluate positional and orientation tolerances, understand material modifiers, and apply surface profiles and runout controls effectively in production drawings, ensuring quality and precision in manufacturing processes.

**Syllabus:**

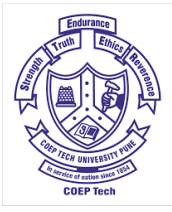
Unit	Content	Hrs	Self study
1	<b>Introduction to Machine Drawing</b> Types of Drawings, Standardization, Production Drawing, Assembly and part drawings, Blueprint reading, Study, and preparation of bill of materials. Design considerations – Limits, fits, and standardization; Friction and lubrication.	2	3
2	<b>Limits, Fits and Tolerances</b> ISO system of tolerance, Tolerance charts, Hole - base and shaft -base system of tolerance, Types of fits, symbols and applications, values related to various manufacturing processes, Application of fits.	4	3
3	<b>Geometric Tolerances</b> Introduction, Nomenclature, Rules, Symbols, datums and applications of Geometric Tolerances, Max & Min Material principles, Positional, Orientation tolerance (axis, midplane and surface), Material modifiers (MMC, LMC, RFS), Surface profiles, Surface form tolerance, Runout controls	4	3
4	<b>Surface Roughness &amp; Production Drawing</b> Surface Textures, Roughness values and Roughness Grades, Machining symbols Conventional Representation on part drawings.	2	3

**Suggested learning resources:**

**Text Books:**

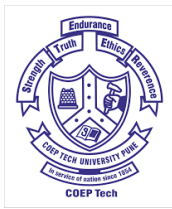
1. Machine Drawing, K. L. Narayana, P. Kanniah, & K.V. Reddy, SciTech Publications
2. Production Drawing, K. L. Narayana, P. Kanniah, & K.V. Reddy, New Age International Pvt Ltd

**Reference Books:**



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1. IS Code: SP 46 – 1988, Standard Drawing Practices for Engineering Institutes
2. Machine Drawing, PS Gill, Katsons
3. Machine Drawing, O.P Jahkar, Amit Mathur, Khanna Publishing House
4. Machine Drawing, ND Bhat, Charotar Publishing House
5. Manual of Engineering Drawing, Colin H Simmons, and Neil Phelps and Dennis Maguire, Elsevier Newnes.
6. Machine Design, Sadhu Singh, Khanna Book Publishing, 2021.
7. Fundamentals of Machine Component Design, Juvinal, R.C., John Wiley, 1994.
8. R. L. Norton, “Mechanical Design – An Integrated Approach,” Prentice Hall, 2009.
9. Sadhu Singh, “Machine Design Data Book”, Khanna Book Publishing, 2022.
10. Computer Aided Engineering Drawing, S. Trymbaka Murthy, I.K. International Publishing House Pvt. Ltd, Pune
11. Engineering Drawing and Computer Graphics, Shah, Pearson



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**III-03 Machine Drawing and Geometric Modeling Lab**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-24003	Machine Drawing and Geometric Modeling lab	0	0	2	1	1	--			CIE:100	

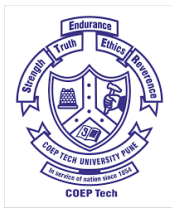
**Course outcomes:**

Students will be able to:

1. Comprehend the various machine elements such as keys, gears, shafts, and joints and apply the knowledge of various ISO and BIS standards conventions and guidelines, symbols, tolerances, limits and fits during drafting and part modelling of machine elements.
2. Create 3D geometric model of parts, their orthographic and production drawings using CAD software, considering manufacturing processes and incorporating technical details and symbols.
3. Collaborate effectively to create complex assembly drawings, demonstrating their ability to apply standards and conventions while working in a team.

**Syllabus:**

Unit	Content	Practical
1	<p><b>Lab learning: Studies and demonstration of standard components</b>            Machine elements such as keys, Joint between links, springs, gears, cams, shafts, rack and pinions, belt and chains drives, sprockets, pulleys, flywheels, bearings, couplings, clutches and breaks. Threaded parts and Locking Arrangements. Bolted, Riveted, Welded and Adhesive Joints. Conventional representation of piping layouts, pipe fittings, valves, joints. Stuffing box &amp; glands, Expansion joints etc.</p> <p><b>Lab work: Component and assembly study</b>            Observe all machine elements in a machine. Describe their relative position, sequence of assembly, relation with other mating components, classify fits, surface finish, mention feature details, requirement of lubrication etc.</p> <p><i>Self-Study: Observation and studies of different assemblies and their parts such as vehicles, IC engines, machine tools, manufacturing and any mechanical equipment.</i></p>	1
2	<p><b>Lab learning: Standards and conventions:</b>            Dimensioning Techniques, Sections and other conventions.</p> <p><b>Lab learning: Orthographic CAD:</b>            Orthographic representation of machine drawing, Draw, Modify, and Edit features/commands in drafting software.</p> <p><b>Lab work: Orthographic drawing:</b></p>	3



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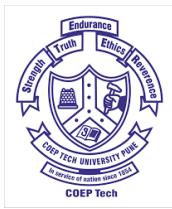
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	<p>Orthographic drawing of machine elements using 2D drafting software. Complete 3 views along with required sectional views, select machine element with more features along with few internal features which requires use of technical notes, and symbols on machine drawing.</p> <ul style="list-style-type: none"> <li>● Orthographic drawing No.1</li> <li>● Orthographic drawing No.2</li> </ul> <p><i>Self-Study: Use of any AutoCAD software for drafting and 3D part modelling.</i></p>	
3	<p><b>Lab learning: Solid Modelling using CAD:</b>          Part Modeling &amp; Assembly Modeling, editing of solids, Sheet metal modeling, Surface modelling, 3-D operations such as shading and rendering etc.          Introduction to CAD customization.</p> <p><b>Lab work: Production drawing:</b>          Production drawing of a machine part using part modelling (3D) CAD software. Complete 3 views along with sectional views, select machine element with more features along with few internal features which requires use of technical notes, and symbols, limits, and surface finish on machine drawing.</p> <ul style="list-style-type: none"> <li>● Production drawing No.1 assuming that the part is manufactured using machining/forging/casting and surface treatment.</li> <li>● Production drawing No.2 assuming the part is made using sheet metal operations and welding/riveting.</li> </ul> <p><i>Self-Study: Use of any AutoCAD software for drafting and 3D part modelling.</i></p>	3
4	<p><b>Lab learning: Assembly and part drawings</b>          Blueprint reading, Study, and preparation of bill of materials. Use of Limits, fits, tolerances, surface finish and production requirements on part drawing.</p> <p><b>Lab work: Assembly and details using Manual and CAD tools:</b>          Select an Assembly and detail drawing example having at least 6-12 different components. Complete 3 views along with sectional views of assembly and parts. Include required details for production drawing such as limits, fits and tolerances (Size, form, orientation etc.), all symbols, methods and conventions. Also include isometric and exploded views for assembly.</p> <ul style="list-style-type: none"> <li>● Complete the assembly and detail drawing on an A1 drawing sheet using manual tools.</li> <li>● Complete the assembly and detail drawing using Part/solid (3D) modelling software.</li> </ul> <p><i>Self-Study: Use of any AutoCAD software for drafting and 3D part modelling.</i></p>	3
5	<p><b>Lab learning: Collaborative teamwork:</b></p>	2



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	<p>Use of online tools and features in CAD software for concurrent engineering.</p> <p><b>Lab work: Assembly and detail drawing using CAD as group assignment in collaborative online CAD environment:</b> Select an Assembly and detail drawing example having at least 10-15 different components. Select assembly with at least 4 times the number of students. The minimum size of a group should not be less than 2 or more than 4. Complete the assembly and detail drawing using Part/solid (3D) modelling software. Complete 3 views along with sectional views of assembly and parts. Include required details for production drawing such as limits, fits and tolerances (Size, form, orientation etc.), all symbols, methods and conventions. Also include isometric and exploded views for assembly.</p> <p><b>Self-Study:</b> Use of any AutoCAD software for drafting and 3D part modelling.</p>	
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**III-04 MANUFACTURING TECHNOLOGY**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
Me-24004	Manufacturing Technology	2	0	2	1	3	30	20	50	50	50

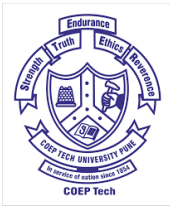
**Course outcomes:**

Upon completion of the course, students will be able to:

1. Analyze various manufacturing & finishing processes and select the particular process for a given job.
2. Estimate the indexing movements related to various types of indexing used in milling related processes.
3. Apply knowledge of manufacturing processes to solve the related problems.
4. Identify and explain the function of the basic components of machine tools and its accessories.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Hot and cold working of metals</b> Principles of rolling, forging, drop, press, upset, roll forging, extrusion, drawing, spinning, and effect of hot working. Cold working processes, Cold rolling, swaging, forging, extrusion- forward, backward and impact roll forming, tube drawing, wire drawing, spinning, shot penning, high energy rate forming, sheet metal working, types of presses, drives, different operations and types of dies, Forging design.	08
2	<b>Joining processes</b> Arc welding- Theory, SMAW, GTAW, GMAW, FCAW, Submerged arc welding, Stud welding Resistance welding- Theory, spot and seam projection welding processes Gas welding Friction welding, Ultrasonic welding, Thermit welding, EBW and LASER welding Use of adhesive for joining, classification of adhesives, types of adhesive and their application, surface preparation and various joints welding defects and quality.	06
3	<b>Foundry- Pattern making, moulding and casting</b> Sand casting, types of pattern material, pattern making allowances, core print moulding, sand properties and testing, hand and machine moulding, core boxes, core making, melting and pouring, melting furnaces- Cupola, electric arc and induction furnaces. Cleaning, finishing and heat treatment of casting, defects in casting, shell moulding and investment casting. Permanent mould dies casting- Die-casting, low-pressure permanent mould casting, hot and cold chamber processing, centrifugal casting, semi centrifugal casting and continuous casting.	08
4	<b>Machining processes-Turning, drilling, reaming and milling</b> Turning and boring, lathe construction, accessories and operations. Fundamentals of drilling processes, drill geometry, types of drilling machines, operations performed on drilling machines, type of drill. Reaming processes and reamer types. Fundamental	08



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	aspects, cutter types and geometry, Operations performed on milling machine, dividing head method of indexing. Fundamentals of CNC Machining- Lathe & milling.	
<b>5</b>	<b>Grinding and Finishing Processes</b> Grinding wheels, wheel marking, wheel selection, wheel mounting, and types of grinding machines. Honing, lapping, super finishing, buffing and burnishing processes.	<b>05</b>

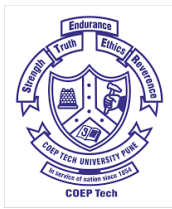
**Suggested learning resources:**

**Textbooks**

1. Chapman W.A.-“Workshop Technology, Vol. II, III, & I”, Edward Arnold Pub.Ltd. London
2. Hajra Chaudhary S.K.- Elements of Workshop Technology, Vol. I& II, Media Prom & Pub, Mumbai.

**Reference Books**

1. HMT Hand book- Production Technology
2. Roy A. & Linberg- “Processes and materials of manufacturing”, Prentice Hall of India, Delhi.
3. Campbell J.S.- Principles of manufacturing Materials and Processes, McGraw-Hill, New York.
4. Begeman - “Manufacturing processes”, Asia Publishing house Bombay.



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**III-04 Manufacturing Technology Lab**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-24004	Manufacturing Technology	2	0	2	1	3	--			50	50

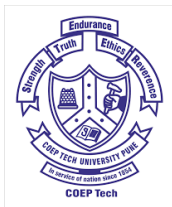
**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Get the knowledge of working of machine tools, mechanisms and accessories used in various manufacturing processes including CNC Machines.
2. Perform the job of turning, chamfering, taper turning and threading operation using conventional and CNC lathe by using CNC Programming.
3. Perform Welding using gas/arc/ resistance welding process.

**Syllabus:**

Unit	Content	Hrs.
1	<p><b>Term work:</b> Each candidate shall be required to complete and submit the following term work:</p> <p><b>Jobs:</b> Plain and Taper turning – one job (Conventional &amp; CNC Lathe), Thread cutting – one Job, Welding (gas or arc or resistance) – one job</p>	2
2	<p><b>Journal:</b> Assignments on machine tools will be in the form of a journal based on demonstrations on machine tools. This should include sketches and relevant descriptions as given below:</p> <ul style="list-style-type: none"> <li>● Machines (Any Two)</li> <li>● Lathe</li> <li>● Universal milling machine</li> <li>● Radial drilling machine</li> <li>● Cylindrical grinder.</li> <li>● Mechanisms (Any Two)</li> <li>● Spindle arbor (assembly) drive of milling machine</li> <li>● Half nut mechanism</li> <li>● Thread cutting mechanisms.</li> <li>● Accessories</li> <li>● Universal dividing head</li> <li>● Milling cutter</li> </ul>	2



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**Course:** Humanities & Social Sciences Course (Ability Enhancement Course)  
**S.Y. B.Tech. (Semester III) – Indian Language: Sanskrit**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
HS-24003	Sanskrit	2	0	0	0	2	30	20	50	--	--

**Course outcomes:**

On satisfying the requirements of this course, students will have the knowledge and skills to:

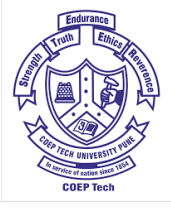
1. Familiarize themselves with the basic grammatical categories of Sanskrit.
2. Form simple sentences in Sanskrit.
3. Understand and extract the meaning of the prescribed Sanskrit scientific texts.
4. Co-relates the significance of scientific literature with modern knowledge.

**Syllabus:**

Unit	Contents	Hrs.
1	Introduction to the Sanskrit phonology, Sandhi- Guṇa, Vṛddhi, Yaṇ, Savarnaḍīrgha, Introduction to persons, numbers and the present tense. Introduction to Kāraka and Vibhaktis- 1. Prathamā - Dvītīyā 2. Tṛtīyā - Caturthī	7
2	Introduction to the past tense and the imperative and potential moods Introduction to Kāraka and Vibhaktis- 1. Pañcamī 2. Śaṣṭhī 3. Saptamī Introduction to Samāsa	7
3	Janapadaniveśa - Kauṭīliya Arthaśāstra + Rasaratnasamuccaya	7
4	Chapter 1 of the Līlāvātī (up to square roots)	7

**Suggested learning resources:**

- V. S. Apte, The student's Sanskrit to English dictionary, 2015. Motilal Banarasidass.
- A. Macdonell, A Sanskrit English dictionary, 1893, Oxford press.
- V. S. Apte, The student's English to Sanskrit dictionary, 2014. Motilal Banarasidass.
- Samskr̥t- Śabdadhātu- Rūpāvali, Navneet publications.
- R. D. Desai, Sanskrit pravesha, 2017, Continental prakashan.
- Madhav Deshpande, Samskr̥tsubodhinī, 2007, University of Michigan.
- Web Sanskrit Dictionary based on "The Practical Sanskrit-English Dictionary" by Vaman Shivaram Apte. - <http://www.aa.tufs.ac.jp/~tjun/sktdic/>



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- Shankar Lal Hari Shankar, RasaRatnaSamucchaya of Vagbhatacharya, 2019, Khemraj Shrikrushnadas Prakashan.
- Colebrook, English translation of the Līlāvātī, (with notes by Banerjee), 1893, Thacker spink and co.
- Līlāvātī, Khemraj Shrikrushnadas, 1908, Shri Venkateshvar steam press Mumbai.
- R. Shamasastri, Kautilya's Arthashastra, 1915, Bangalore: Government Press.
- R. Shamasastri, editor: Ashok Kumar Shukla - with Sanskrit Text, Kautilya's Arthashastra, 1915, Bangalore: Government Press.
- Read Kautilya's Arthashastra for free on:  
<https://www.wisdomlib.org/hinduism/book/kautilya-arthashastrasanskrit/d/doc905574.html>



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**Course: Humanities & Social Sciences Course (Ability Enhancement Course)**  
**S.Y. B.Tech. (Semester III) – Indian Language: Pali**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
HS-24003	Pali	2	0	0	0	2	30	20	50	--	--

**Course outcomes:**

On satisfying the requirements of this course, students will have the knowledge and skills to:

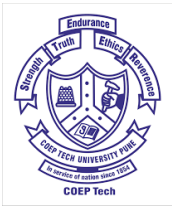
1. Students will become acquainted with some literary specimens of Pali literature in prose and poetry.
2. Through this literature they will learn ancient Indian moral, humanitarian and scientific values.
3. They will develop an interest in the Pali language and literature.
4. They will learn to appreciate the Indian literary heritage.

**Syllabus:**

Unit	Content	Hrs.
1	Introduction to Pali: What is Pali? Its origin and homeland; Pali Literature: Early Phase, Commentarial Phase and Post commentarial Phase	7
2	Introduction to Grammar: Alphabets, Pronunciation, Phonetic variation; Noun, Verb and Sentence formation	7
3	Selected Prose: Nakkhattajātaka, Vīmaṃsakasutta, Kālāmasutta, Vitakkasaṇṭhānasutta	7
4	Selected Poetry: Selected portion from Dhammapada, Puṇṇikātherī, Kumbhajātaka with pronunciation and recitation	7

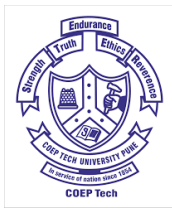
**Suggested learning resources:**

- B. Mahadevan, Bhat Vinayak and Nagendra Pavan R.N., 'Introduction to Indian Knowledge Systems: Concepts and Applications'
- Dharmapal 'Indian Science and Technology'
- Kapil Kapoor, Singh Avdhesh Kumar, 'Indian Knowledge Systems'
- Chattopadhyaya, Debiprasad, History of science and technology in ancient India: the beginnings, Firma KLM Pvt. Ltd. 1986.
- Irfan Habib (ed.), People's History of India – Vol 20: Technology in Medieval India, c. 650–1750, Aligarh Historians Society and Tulika Books, 2016.
- Jan Gonda, A History of Indian Literature, Otto Harrassowitz, Wiesbaden, 1975.
- L. Gopal and V. C. Shrivastava, History of Agriculture in India (Upto 1200 A. D.), Concept Publishing, New Delhi, 2008.



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- Pushkar Sohoni, Introduction to the History of Architecture in India, IISER, Pune, 2020.
- Surendranath Dasgupta, A History of Indian Philosophy, Cambridge University press, 1922.
- Radhavallabh Tripathi, Vāda in theory and practice: studies in debates, dialogues and discussions in Indian intellectual discourses, IAS, Shimla, 2016.
- Thanu Padmanabhan (ed.), Astronomy in India: A Historical Perspective, Indian National Science Academy, Springer, New Delhi. 2014.



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**Course: Value Education Course**  
**S.Y. B.Tech. (Semester III/IV) Constitution of India & Universal Human Values**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
AS-24003	Constitution of India & Universal Human Values	1	0	0	0	1	--			--	

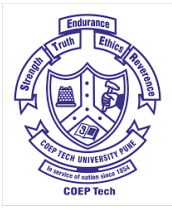
**Course Outcomes:**

Students will be able to

1. Understand the basis of Law, the concept 'Constitution' and the interpretation of the Preamble.
2. Define the basis of governance of the nation and the fundamental rights. Illustrate the functioning of the Union and the State Executive.
3. Outlines the aspects that allow the use of rights to fulfill one's duties as a responsible citizen.
4. Analyze the moral and ethical character needed for a professional engineer.

**Syllabus:**

Unit	Contents	Hrs.
1	Introduction to The Constitution of India, understanding its objects. Preamble to the constitution of India. Understanding the concept 'Rule of Law', Human Rights and Fundamental Rights.	3
2	Fundamental rights under Part-III, Exercise of the Rights, limitations, and important cases. Fundamental duties & their significance. Relevance of Directive principles of State Policy.	3
3	Legislative, Executive & Judiciary (Union and State Level) Prerogative Writs. Electoral procedure in India	3
4	Constitutional Provisions for Scheduled Castes, Scheduled Tribes, & Backward classes. Constitutional Provisions for Women & Children; Emergency Provisions. Amendment procedure and few important Constitutional Amendments	3
5	Relationship between Law and Ethics, Professional Ethics for Engineers Universal Human Values	2



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**Suggested Readings:**

- Introduction to the Constitution of India by Durga Das Basu (Students Edn.) Prentice – Hall EEE, 19th/20th Edn.
- Suresh, J. & Raghavan, B.S. (2016). Human Values and Professional Ethics. S. Chand & Company Pvt. Ltd. New Delhi.
- Engineering Ethics by Charles E.Haries, Michael. S.Pritchard and Michael J.Robins Thompson Asia,
- An Introduction to Constitution of India by M.V. Pylee, Vikas Publishing. Gogate, S. B. (2011). Human Values & Professional Ethics. Vikas Publishing House Pvt. Ltd. New Delhi.



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**Course: Humanities & Social Sciences Course**  
**S.Y. B.Tech. (Semester III/IV) – Principles of Economics**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
HS-24004	Principles of Economics	2	0	0	2	2	30	20	50	--	--

**Course Outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand and analyze fundamental economic theories and policies.
2. Identify and solve economic problems using knowledge, techniques, and available frameworks.
3. Compare and evaluate economic scenarios to draw logical conclusions.
4. Adapt to dynamic economic environments and propose viable alternative solutions.

**Syllabus:**

Unit	Content	Hrs.
1	<b>Introduction to Economics</b> Definitions, basic concepts of economics: Cost, efficiency and scarcity, Opportunity Cost, Types of economics: Microeconomics, Macroeconomics and Managerial Economics, Difference between microeconomics and macroeconomics, Application of Managerial economics	8
2	<b>Microeconomics Analysis</b> Demand Analysis, Supply Analysis, Theories of Utility and Consumers Choice, Cost analysis, Competition and Market Structures. Application of microeconomics theories	8
3	<b>Macro-Economic Analysis</b> Aggregate Demand and Supply, Economic Growth and Business Cycles, inflation, Fiscal Policy, National income, theory of Consumption, savings and investments, Commercial and Central banking. Use of macroeconomic theories.	8
4	<b>International Economics</b> Balance of Trade and Balance of Payments, Barriers to Trade, Benefits of Trade/Comparative Advantage, Foreign Currency Markets/Exchange Rates, Monetary, Fiscal and Exchange rate policies, Economic Development. Application of exchange rate policies	8

**Reference Books**

- N. Gregory Mankiw, Macroeconomics: 12th Edition, 2023.
- Paul Keat and Philip Young, Managerial Economics: Economic Tools for Today's Decision Makers: 10th Edition, 2020.



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- Misra and Puri, Principles of Macro Economics: 12th Edition, 2021, Himalaya Publishing House, New Delhi.
- A. Koutsoyiannis, Modern Microeconomics: 2nd Edition, 2003, Macmillan, London.
- Robert S. Pindyck and Daniel L. Rubinfeld, Microeconomics: 9th Edition, 2017, Pearson Education, New Delhi.
- K. N. Verma, Micro Economics: 3rd Edition, 2019.



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**Course: Mathematics**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Mathematics	3	0	0	1	3	30	20	50	--	--

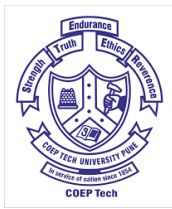
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Apply matrix algebra and eigenvalue-eigenvector concepts to solve systems of linear equations and other engineering problems.
2. Perform advanced calculus operations including partial derivatives, multiple integrals, and their applications to compute area, volume, and moments.
3. Analyze and compute vector calculus operations such as gradient, divergence, and curl, and apply integral theorems like Green's, Stokes', and Gauss' in engineering contexts.
4. Solve ordinary and partial differential equations (ODEs and PDEs) for various initial and boundary value problems, including applications to circuits and wave equations.
5. Employ probability theory and statistical distributions to analyze random events and their outcomes in engineering problems.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Matrix Algebra:</b> Properties of Matrices and Determinants, Solutions of Systems of linear equations using Gauss Elimination method, Eigen Values and Eigen Vectors. <i>Self-study: Properties of Matrices and Determinants</i>	6
2	<b>Calculus:</b> Functions of several variables (Domain and Range), Partial Derivatives, The Chain Rule, Double Integral, Triple Integral, Cartesian and polar coordinates. Applications to Area, Volume, Moments, and Center of Mass. <i>Self-study: Applications of Double and Triple Integral.</i>	8
3	<b>Vector Calculus:</b> Vector differentiation, gradient, divergence and curl, line integrals, surface integrals, statements, and illustrations of theorems of Green, Stokes and Gauss, applications. <i>Self-study: Area, Volume, Moments, and Center of</i>	10
4	<b>Ordinary Differential Equations:</b> First order Ordinary Differential Equations - Variable Separable, Homogeneous, Linear; Higher order linear equations with constant coefficients, non-homogeneous higher order linear differential equations with constant coefficients: method of variation of parameters; Applications to Initial value problems: Simple Electrical Circuits. <i>Self-study: First order Ordinary Differential Equations - Variable Separable, Homogeneous ODEs (Ordinary Differential Equations)</i>	8



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5	<b>Partial Differential Equations:</b> Fourier Series; Partial differential equations. Initial and Boundary value problems by separation of variables method, boundary value problems: Vibration of string: one dimensional wave equation. <i>Self-study:</i> Types of PDEs (Partial Differential Equations)	8
<b>OR</b>		
6	<b>Probability:</b> Mean, median, mode, standard deviation, combinatorial probability, joint and conditional probability. Probability distributions, Binomial distribution, Poisson distribution, Normal distribution.	8

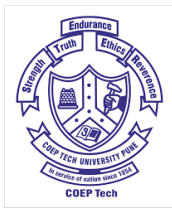
**Suggested learning resources:**

**Textbooks:**

1. Advanced Engineering Mathematics (10<sup>th</sup> edition) by Erwin Kreyszig, Wiley Eastern Ltd.
2. Thomas' Calculus (14<sup>th</sup> edition) by Maurice D. Weir, Joel Hass, Frank R. Giordano, Pearson Education.

**Reference Books:**

1. Calculus for Scientists and Engineers by K.D Joshi, CRC Press.
2. A course in Calculus and Real Analysis (1<sup>st</sup> edition) by Sudhir Ghorpade and Balmohan Limaye, Springer-Verlag, New York.
3. Applied Mathematics Vol.1 (Reprint July 2014) by P.N. Wartikar and J.N. Wartikar, Pune Vidhyarthi Griha Prakashan Pune.



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**IV-01 Fluid Mechanics**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-24006	Fluid Mechanics	3	0	2	1	4	30	20	50	50	50

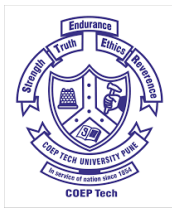
**Course outcomes:**

Students who successfully complete this course will have an ability to:

1. Understand and apply the basic concepts of Fluid Mechanics for solving problems involving fluid properties: Static and kinematic.
2. Derive and apply the governing equations of Fluid Dynamics.
3. Apply energy equations for various Fluid systems and measuring devices.
4. Apply and understand various dimensionless numbers for problems in fluid mechanics.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Basics with fluid statics:</b> Definition of fluid, fluid properties such as viscosity, vapor pressure, compressibility, surface tension, capillarity, Mach number etc., pressure at a point in the static mass of fluid, variation of pressure, Pascal's law, pressure measurement by simple and differential manometers using manometric expression. Introduction to Hydrostatic forces and Centre of pressure, Buoyancy, Centre of buoyancy, stability of floating bodies, metacenter and metacentric height and its application in shipping.	6
2	<b>Fluid Kinematics:</b> Velocity of fluid particle, types of fluid flow, description of flow, acceleration of fluid particle, rotational & irrotational flow, path line, streamline and streak line, Laplace's equation in velocity potential and Poisson's equation in stream function, flow net, Vorticity and Circulation.	4
3	<b>Governing equations in Fluid Dynamics</b> Continuity equation (Cartesian, polar and cylindrical coordinates). Derivation of Momentum equations using differential approach, Reynolds transport theorem, Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's theorem, Application of Bernoulli's theorem such as Venturi meter, Orifice meter, pitot tube (static, dynamic and stagnation pressure) and orifices etc. Introduction to Navier Stokes Equation.	6
4	<b>Laminar flow:</b> Hagen-Poiseuille equation, flow through parallel plates, Couette flow. <b>Introduction to boundary layer:</b> Thickness, over a plate, Equations of boundary layer, Laminar and turbulent boundary layer, introduction to flow separation of layer, and methods for control. Introduction to External flow: Drag, lift, Drag on cylinder, Development of lift in Cylinder	6



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<b>5</b>	<b>Turbulent flow:</b> Introduction to RANS (Models). Development in pipes, Velocity distribution in pipes, hydrodynamic smooth and rough pipe. Introduction to compressible flow.	<b>6</b>
<b>6</b>	<b>Flow through pipes:</b> Reynolds's experiment, frictional loss in pipe flow, major and minor losses, HGL and TEL, flow through series and parallel pipes, Equivalent Pipe, Loss of head due to friction in a pipe with side tapping's, siphon, Power Transmission, Pipe networks. Dimensional homogeneity, Rayleigh's method, Buckingham's theorem. Similitude and Model analysis: similarity laws and dimensionless numbers.	<b>8</b>

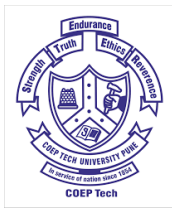
**Suggested learning resources:**

**Textbooks:**

1. Hydraulics and Fluid Mechanics including Hydraulic Machines, Dr. P. N. Modi and Dr. S. M. Seth, Standard Book House S. Ramamurtham, "Strength of materials", Dhanpatrai Publication.
2. Textbook of Fluid Mechanics and Hydraulic Machine, Dr. R. K. Bansal, Laxmi Publications, New Delhi S K Sarkar, "Strength of materials", McGraw Hill New Delhi.
3. Fluid Mechanics – Fundamentals and application. Yunus Cengel and John Cimbala.
4. Introduction to Fluid Mechanics and Fluid Machines. S. K. Som, Gautam Biswas and Suman Charaborty. Mc-Graw Hill Publication.

**Reference Books:**

1. Introduction to Fluid Mechanics, Fox R W, Pritchard P J, A T Mc Donald. John Wiley and Sons Publication G H Ryder, "Strength of materials", McMillan Publication
2. Fluid Mechanics, Frank M. White. McGraw Hill Publications
3. Engineering Fluid Mechanics, Prof K L Kumar, Chand Publication
4. Fluid Mechanics, P. K. Kundu, I. M. Kohen and David Dowling Fifth Edition Elsevier Publication.



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**IV-01 FLUID MECHANICS LAB**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-24006	Fluid Mechanics	3	0	2	1	4	30	20	50	50	50

**Course outcomes:**

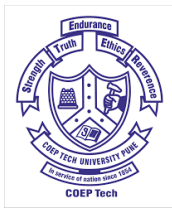
Students will be able to

1. Measure the pressure using manometers
2. carry out the velocity/discharge measurement using various devices
3. determine the coefficient of discharge using Bernoulli's equation
4. determine the friction factor for flow
5. Determination of Reynolds number and flow visualization.

**Lab work Term-work:**

The candidates must carry out the experiments and the analysis of the fluid flow phenomenon through at least 7 experiments from (sr. no. 1 to 11) and Sr. no 12.

1. Measurement of viscosity using Red Wood viscometer/Falling sphere viscometer.
2. Study and demonstration of pressure measurement using manometers.
3. Determination of the metacentric height of a floating body and its stability.
4. Verification of Bernoulli's Principle and Total energy.
5. Calibration Venturi meter for flow measurement
6. Calibration Orifice meter for flow measurement
7. Demonstration of Pitot tube for velocity measurement
8. Demonstration and flow visualization of laminar and turbulent flow using Reynolds apparatus.
9. Determination of the frictional losses and friction factor in pipes.
10. Determination of pressure variation around a circular body/surface when it is submerged in a flow.
11. Small application-oriented assignment based on concepts in fluid mechanics.
12. Flow through pipe using CFD software



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**IV-02 Design of Machine Elements**

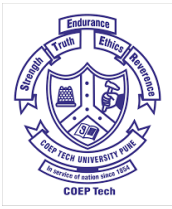
Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-24007	Design of Machine Elements	2	1	0	1	3	30	20	50	--	--

**Course Outcomes:**

1. Apply fundamentals of machine design to identify the type of design to formulate the design problem statement and apply the design procedure.
2. Evaluate the different types of modes of failures/stresses induced in a component due to different types of static loading conditions and design the elements/simple joints like cotter or knuckle joint against the most critical mode of failure.
3. Apply the shaft design codes to design various shafts, design of keys and couplings, springs like, helical compression, helical torsion and leaf spring.
4. Design various types of bolted joints and power screws and welded joints subjected to static loads and bending moments.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Fundamental aspects of design:</b> The meaning of design, engineering design, phases of design, design considerations, stress and strain considerations, factor of safety, standardization, preferred series.	6
2	<b>Design against static load:</b> Modes of failure, Critical mode of failure, stresses due to bending and torsional load, eccentric loading, Design for biaxial loading through theories of failure, design of cotter and knuckle joints.	6
3	<b>Design of shafts, keys, and couplings:</b> Shaft, Types of Shafts, Shaft subjected to bending and torsion, Shaft design on strength basis and rigidity deflection basis, A.S.M.E code for shaft design, types of keys and their design, design of rigid and flexible couplings.	6
4	<b>Design of threaded Joints and Power screws:</b> Threaded Joints, I.S.O Metric screw threads profile, Coarse and fine threads, designation of metric threads, Bolts of uniform strength, Design of bolted and threaded joints, eccentrically loaded bolted joints, Design of power screws.	6
5	<b>Design of welded joints:</b> Types of welded joints, stresses in welded joints, strength of welded joints, eccentrically loaded welded joints, and welded joints subjected to bending moment.	6
6	<b>Design of Mechanical Springs</b>	6



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	Mechanical Spring, Types of springs, Terminology of helical spring, Design of mechanical springs, helical torsion spring, design of multi leaf spring, nipping and shot peening of spring.	
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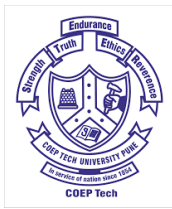
**Suggested learning resources:**

**Textbooks:**

1. Shigley I.E. and Mischke C.R., "Mechanical Engineering Design", McGraw Hill Education (India) Ltd.
2. Bhandari V.B., "Design of Machine Elements", McGraw Hill Education (India) Ltd.
3. Khurmi and Gupta, "A textbook of Machine Design" S Chand Publication.

**Reference Books:**

1. Spotts M. F., "Design of Machine Elements", Prentice Hall International.
2. Black P.H. and Eugene Adams, "Machine Design", McGraw Hill Book Co. Ltd.
3. P.S.G. College of Technology, "Design Data, Coimbatore.
4. Hall A.S., Holowenko A.R. and Laughlin H., "Theory and Practice of Machine Design", Schaumis outline series, McGraw Hill Publication.



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**IV-03 Kinematics of Machines**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-24008	Kinematics of Machines	3	0	2	1	4	30	20	50	50	50

**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand the concepts of motion transmission.
2. Determine the displacement, velocity, acceleration of points in given mechanisms analytically and graphically.
3. Calculate the torque and power transmitted by different types of gears.
4. Determine and illustrate the motion, acceleration of different types of cams and followers and illustrate the various types of governors.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Fundamentals of kinematics:</b> Kinematic link, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Degree of freedom (Mobility), Kutzbach criterion, Grubler's criterion, Grashoff's law for four bar kinematic chain. Inversions of Four bar chain, Slider crank chain and Double slider crank chain, Hooke's joint, Introduction to Compliant mechanism.	8
2	<b>Velocity and acceleration analysis:</b> Graphical methods - Relative velocity and acceleration methods, Corioli's component of acceleration, instantaneous centre of Rotation method,	10
3	<b>Kinetics of slider crank mechanism:</b> Static and dynamic force analysis of slider crank mechanism, dynamically equivalent system, correction couple, Klein's construction, graphical and analytical method for determination of torque on crankshaft for IC engine.	8
4	<b>Kinematics of Gears</b> Classification of gears, Types of gears, Spur gears - terminology, fundamental law of toothed gearing, involute and cycloidal profile, conjugate action, contact ratio, minimum number of teeth, interference and under cutting. Helical gears: Nomenclatures, center distance, force analysis.	8
5	<b>Kinematics of cams and followers and governors</b> Types of cams and followers, types of follower motion, velocity and acceleration diagrams, profile of cam cams for various follower motions. Governor of different types, Sleeve displacement and speed relation of the governor.	8



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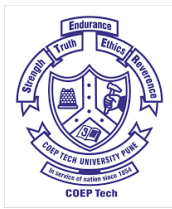
**Suggested learning resources:**

**Textbooks:**

1. John Hannah and Stephens, R. C., “Mechanics of Machines: Advanced Theory and Examples”, 1970, Hodder; Student international edition ISBN 0713132329 Edward Arnold London
2. Ballaney, P., “Theory of Machines and Mechanisms”, 2005, ISBN 9788174091222 Khanna Publications
3. S S Ratan, “Theory of Machines”, Fifth edition, Tata McGraw Hill Publication Co. Ltd.
4. Bansal, R. K., “Theory of machines”, Laxmi Publications Pvt. Ltd, New Delhi

**Reference Books:**

1. Bevan Thomas, “The Theory of Machines”, 3<sup>rd</sup> edition, CBS publishing
2. Uicker Jr, J. J., Penock G. R. and Shigley, J. E., “Theory of Machines and Mechanisms’ 2003, Tata McGraw Hill
3. Ramamurthy, V., “Mechanisms of Machines”, 3<sup>rd</sup> edition, ISBN 978-1842654569, Narosa Publishing House



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**IV-03 Kinematics of Machines Lab**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-24008	Kinematics of Machines	3	0	2	1	4	--			50	50

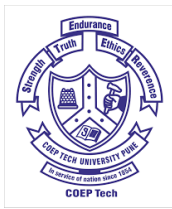
**Course Objectives:**

At the end of the course, students will demonstrate the ability to:

1. Students will demonstrate ability towards graphically estimating velocity and acceleration.
2. Students will exhibit skills towards application of principles of static and dynamics force analysis.
3. Students will demonstrate knowledge of various mechanisms to design and analyse mechanisms essential in mechanical engineering.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>List of Experiments:</b> 1. Determination of moment of inertia of rigid bodies by bifilar/trifilar suspension methods. 2. Compound pendulum. 3. Experimental verification of displacement relation for different shaft angles for single Hooke's joint. 4. To generate gear tooth profile and to study the effect of under cutting and rack shift using model. 5. To determine the characteristics curve of any two types of centrifugal governor and to find its coefficient of in-sensitiveness and stability.	2 each
2	<b>List of Assignments:</b> 1. Analytical determination of inertia forces in engine mechanisms. 2. Problem on Hooke's joint.	
3	<b>List of Drawing Sheets:</b> 1. Graphical solution to problems on velocity acceleration in mechanism by relative velocity and acceleration method including problem with Corioli's component of acceleration. 2. Velocity by instantaneous centre method. 3. Klein's construction and inertia force analysis for slider cranks mechanisms. 4. To draw cam profile for various types of followers' motion.	
4	Kinematics study of mechanism using CAD software	



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**Course: Numerical Methods and Programming Language**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-2400 9	Numerical Methods and Programming Language	1	0	2	1	2	CIE:100			50	50

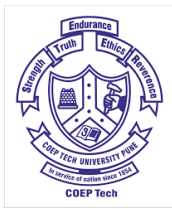
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Use numerical methods in modern scientific computing.
2. Determine numerical solutions of nonlinear equations in a single variable.
3. Use numerical interpolation and obtain numerical solution to engineering problems using programming.
4. Estimate solution to problems using numerical integration and differentiation.

**Syllabus:**

Unit	Contents	Hrs.
1	<p><b>Numerical methods I:</b></p> <p><b>Introduction to Numerical Methods:</b> Difference between analytical and numerical approaches.</p> <p><b>Error Approximations:</b> Types of Errors: Absolute, Relative, Algorithmic, Truncation, Round-off Error, Error Propagation, Concept of convergence and relevance to numerical methods.</p> <p><b>Roots of Equations:</b> Bracketing and Open Methods.</p> <p><b>Simultaneous Equations:</b> Gauss-Elimination (with partial pivoting), Gauss-Seidel, Gauss-Jordan, Gauss-Jacobi, Thomas algorithm for Tri-diagonal Matrix.</p>	6
2	<p><b>Numerical methods II:</b></p> <p><b>Numerical Integration:</b> Trapezoidal rule, Simpson's 1/3rd Rule, Simpson's 3/8th Rule, Gauss Quadrature (2-point and 3-point method).</p> <p><b>Double Integration:</b> Using Trapezoidal rule and Simpson's 1/3rd Rule.</p> <p><b>Ordinary Differential Equations (ODE):</b> Taylor series method, Euler Method, Runge-Kutta fourth order, Simultaneous equations using Runge-Kutta second-order method.</p> <p><b>Partial Differential Equations (PDE):</b> Finite Difference Methods - Introduction to finite difference method, Simple Laplace method, Parabolic explicit solution, Elliptic explicit solution.</p>	6
3	<p><b>Curve fitting and Regression analysis:</b></p> <p><b>Interpolation:</b> Approximation by Forward, Backward, Central, and Divided Difference Formulae, Interpolation using Newton's Formulae, Lagrange's Method, Spline Interpolation, Hermite and Stirling Formulae.</p> <p><b>Curve Fitting:</b> Least Square Technique (Straight line, Power equation, Exponential equation, Quadratic equation).</p>	6



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<p><b>Regression using Machine Learning Algorithms:</b> Linear Regression, Logistic Regression, Polynomial Regression, Support Vector Regression, Regression Trees (Decision tree, Random Forest), Ridge Regression, Lasso Regression. <b>Clustering and Neural Networks:</b> K-Means, K-Nearest Neighbor (KNN), Artificial Neural Networks.</p>
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**Suggested learning resources:**

**Textbooks:**

1. Steven C. Chapra, Raymond P. Canale, Numerical Methods for Engineers, 7th Edition, McGraw-Hill Education, 2015.
2. Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, 4th Edition, McGraw-Hill Education, 2018.
3. S. S. Sastry, Introductory Methods of Numerical Analysis, 5th Edition, PHI Learning, 2012.
4. Rajaraman, Computer Oriented Numerical Methods, Revised Edition, PHI Learning.
5. T. Veerarajan, T. Ramachandran, Theory and Problems in Numerical Methods, Revised Edition, McGraw-Hill Education.

**Reference Books:**

1. William H. Press, Saul A. Tenkolsky, William T. Vetterling, Brian P. Flannery, *Numerical Recipes: The Art of Scientific Computing*, 3rd Edition, Cambridge University Press, 2007.
2. Aurélien Géron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems*, 2nd Edition, O'Reilly Media, 2019.
3. Alex Smola, S.V.N. Vishwanathan, *Introduction to Machine Learning*, 2nd Edition, Cambridge University Press, 2020.
4. Rudolph Russell, *Machine Learning: Step-by-Step Guide to Implement Machine Learning Algorithms with Python*, Open-source publication.
5. E. Balagurusamy, *Numerical Methods*, 2nd Edition, McGraw-Hill Education, 2020.



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**Course: Humanities & Social Sciences Course**  
**S.Y. B.Tech. (Semester III/IV) – Principles of Entrepreneurship**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Principles of Entrepreneurship	2	0	0	1	2	30	20	50	--	--

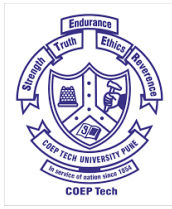
**Course Outcomes:**

On completion of syllabus students will understand the basic concepts of entrepreneurship and business opportunities to familiarize themselves with knowledge about business and project reports for starting a new venture on team based.

1. To enable the students to understand the concept of Entrepreneurship and to learn the professional behavior expected of an entrepreneur.
2. To identify significant changes and trends which create business opportunities and to analyze the environment for potential business opportunities.
3. To provide conceptual exposure on converting idea to a successful entrepreneurial firm.

**Syllabus:**

Unit	Contents	Hrs
1	Entrepreneurship: Meaning of entrepreneurship – Types of Entrepreneurships – Traits of entrepreneurship – Factors promoting entrepreneurship- Barriers to entrepreneurship- the entrepreneurial culture- Stages in entrepreneurial process – Women entrepreneurship and economic development- SHG.	3
2	Developing Successful Business Ideas: Recognizing opportunities – trend analysis – generating ideas – Brainstorming, Focus Groups, Surveys, Customer advisory boards, Day in the life research – Encouraging focal point for ideas and creativity at a firm level-Protecting ideas from being lost or stolen – Patents and IPR.	4
3	Opportunity Identification and Evaluation Opportunity identification and product/service selection – Generation and screening the project ideas – Market analysis, technical analysis, Cost benefit analysis and network analysis- Project formulation – Assessment of project feasibility- Dealing with basic and initial problems of setting up of Enterprises.	3
4	Business Planning Process Meaning of business plan- Business plan process- Advantages of business planning preparing a model project report for starting a new venture (Team-based project work)	2
5	Funding Sources of Finance- Venture capital- Venture capital process- Business angles Commercial banks- Government Grants and Schemes.	2



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**Suggested Readings:**

**Text Books:**

1. Reddy, Entrepreneurship: Text & Cases - Cengage, New Delhi.
2. Kuratko/rao, Entrepreneurship: a south asian perspective.- Cengage, New Delhi.
3. Leach/Melicher, Entrepreneurial Finance – Cengage., New Delhi.
4. K.Sundar – Entrepreneurship Development – Vijay Nicole Imprints private Limited
5. Khanka S.S., Entrepreneurial Development, S.Chand & Co. Ltd., New Delhi, 2001.
6. Sangeeta Sharma, Entrepreneurship Development, PHI Learning Pvt. Ltd., 2016.
7. P. Khanna, “Industrial Engineering and Management”, Dhanpatrai publications Ltd, New Delhi.

**Reference Books:**

1. Barringer, B., Entrepreneurship: Successfully Launching New Ventures, 3rd Edition, Pearson, 2011.
2. Bessant, J., and Tidd, J., Innovation and Entrepreneurship, 2nd Edition, John Wiley & Sons, 2011.
3. Desai, V., Small Scale Industries and Entrepreneurship, Himalaya Publishing House, 2011.
4. Donald, F.K., Entrepreneurship- Theory, Process and Practice, 9th Edition, Cengage Learning, 2014.



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Course: Value Education Course  
**S.Y. B.Tech. (Semester III/IV) - Environmental Studies**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Environmental Studies	1	0	0	1	1	CIE: 100			--	

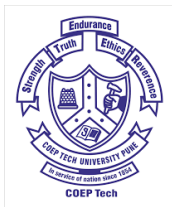
**Course outcomes:**

Students completing this course will:

1. Develop an understanding of sustainable techniques for conservation and management of natural resources, the importance of Sustainable Development Goals (SDGs), and critically analyze environmental issues on local, regional, and global scales.
2. Understand the sources and types of pollution, adverse health impacts, and the prevention and management techniques for pollution.
3. Recognize the factors affecting biodiversity loss, ecosystem degradation, and major conservation strategies in India and globally, with a focus on climate change, its impacts, and adaptation strategies.
4. Learn about environmental management systems, laws, policies, and international treaties, along with India's responses to global agreements and the role of international institutions in environmental preservation.

**Syllabus:**

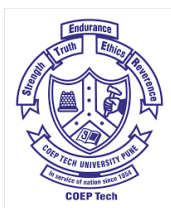
Unit	Contents	Hrs.
1	<b>Humans and the Environment:</b> The man-environment interaction: Humans as hunter-gatherers; Mastery of fire; Origin of agriculture; Emergence of city-states; Great ancient civilizations and the environment; Middle Ages and Renaissance; Industrial revolution and its impact on the environment; Population growth and natural resource exploitation; Global environmental change. The emergence of environmentalism: Anthropocentric and eco-centric perspectives (Major thinkers); The Club of Rome- Limits to Growth; UN Conference on Human Environment 1972; World Commission on Environment and Development and the concept of sustainable development; Rio Summit and subsequent international efforts.	1
2	<b>Natural Resources and Sustainable Development:</b> Overview of natural resources: Definition of resource; Classification of natural resources- biotic and abiotic, renewable and non-renewable. Biotic resources: Major type of biotic resources- forests, grasslands, wetlands, wildlife and aquatic (fresh water and marine); Microbes as a resource; Status and challenges. Water resources: Types of water resources- fresh water and marine resources; Availability and use of water resources; Environmental impact of over-exploitation, issues and challenges; Water scarcity and stress; Conflicts over water. Soil and mineral resources: Important	2



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	minerals; Mineral exploitation; Environmental problems due to extraction of minerals and use; Soil as a resource and its degradation. Energy resources: Sources of energy and their classification, renewable and non-renewable sources of energy; Conventional energy sources- coal, oil, natural gas, nuclear energy; non-conventional energy sources- solar, wind, tidal, hydro, wave, ocean thermal, geothermal, biomass, hydrogen and fuel cells; Implications of energy use on the environment. Introduction to sustainable development: Sustainable Development Goals (SDGs)- targets and indicators, challenges and strategies for SDGs.	
<b>3</b>	<b>Environmental Issues: Local, Regional and Global:</b> Environmental issues and scales: Concepts of micro-, meso-, synoptic and planetary scales; Temporal and spatial extents of local, regional, and global phenomena. Pollution: Impact of sectoral processes on Environment, Types of Pollution- air, noise, water, soil, municipal solid waste, hazardous waste; Transboundary air pollution; Acid rain; Smog. Land use and Land cover change: land degradation, deforestation, desertification, urbanization. Biodiversity loss: past and current trends, impact. Global change: Ozone layer depletion; Climate change.	<b>2</b>
<b>4</b>	<b>Conservation of Biodiversity and Ecosystems:</b> Biodiversity and its distribution: Biodiversity as a natural resource; Levels and types of biodiversity; Biodiversity in India and the world; Biodiversity hotspots; Species and ecosystem threat categories. Ecosystems and ecosystem services: Major ecosystem types in India and their basic characteristics forests, wetlands, grasslands, agriculture, coastal and marine; Ecosystem services- classification and their significance. Threats to biodiversity and ecosystems: Land use and land cover change; Commercial exploitation of species; Invasive species; Fire, disasters and climate change.	<b>2</b>
<b>5</b>	<b>Environmental Pollution and Health:</b> Understanding pollution: Production processes and generation of wastes; Assimilative capacity of the environment; Definition of pollution; Point sources and non-point sources of pollution. Air pollution: Sources of air pollution; Primary and secondary pollutants; Criteria pollutants- carbon monoxide, lead, nitrogen oxides, ground-level ozone, particulate matter and Sulphur dioxide; Other important air pollutants- Volatile Organic compounds (VOCs), Peroxyacetyl Nitrate (PAN), Polycyclic aromatic hydrocarbons (PAHs) and Persistent organic pollutants (POPs); Indoor air pollution; Adverse health impacts of air pollutants; National Ambient Air Quality Standards. Water pollution: Sources of water pollution; River, lake and marine pollution, groundwater pollution; water quality Water quality parameters and standards; adverse health impacts of water pollution on human and aquatic life. Soil pollution and solid waste: Soil pollutants and their sources; Solid and hazardous waste; Impact on human health. Noise pollution: Definition of noise; Unit of measurement of noise pollution; Sources of noise pollution; Noise standards; adverse impacts of noise on human health. Thermal and radioactive pollution: Sources and impacts on human health and ecosystems.	<b>2</b>
<b>6</b>	<b>Climate Change: Impacts, Adaptation and Mitigation:</b>	<b>2</b>



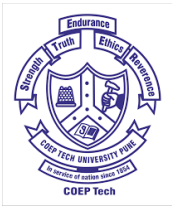
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	<p>Understanding climate change: Natural variations in climate; Structure of atmosphere; Anthropogenic climate change from greenhouse gas emissions– past, present and future; Projections of global climate change with special reference to temperature, rainfall, climate variability and extreme events; Importance of 1.5 °C and 2.0 °C limits to global warming; Climate change projections for the Indian sub-continent. Impacts, vulnerability and adaptation to climate change: Observed impacts of climate change on ocean and land systems; Sea level rise, changes in marine and coastal ecosystems; Impacts on forests and natural ecosystems; Impacts on animal species, agriculture, health, urban infrastructure; the concept of vulnerability and its assessment; Adaptation vs. resilience; Climate-resilient development; Indigenous knowledge for adaptation to climate change. Mitigation of climate change: Synergies between adaptation and mitigation measures; Green House Gas (GHG) reduction vs. sink enhancement; Concept of carbon intensity, energy intensity and carbon neutrality; National and international policy instruments for mitigation, decarbonizing pathways and net zero targets for the future; Energy efficiency measures; Renewable energy sources; Carbon capture and storage, National climate action plan and Intended Nationally Determined Contributions (INDCs); Climate justice.</p>	
7	<p><b>Environmental Management:</b>          Introduction to environmental laws and regulation: Constitutional provisions- Article 48A, Article 51A (g) and other derived environmental rights; Introduction to environmental legislations on the forest, wildlife and pollution control.          Environmental management system: ISO 14001, Life cycle analysis; Cost-benefit analysis, Environmental audit and impact assessment; Environmental risk assessment, Pollution control and management; Waste Management- Concept of 3R (Reduce, Recycle and Reuse) and sustainability; Ecolabeling /Eco mark scheme</p>	2
8	<p><b>Environmental Treaties and Legislation:</b>          Major International organizations and initiatives: United Nations Environment Programme (UNEP), International Union for Conservation of Nature (IUCN), World Commission on Environment and Development (WCED), United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Panel on Climate Change (IPCC), and Man and the Biosphere (MAB) programme.</p>	2
9	<p><b>Case Studies and Field Work:</b>          Discussion on one national and one international case study related to the environment and sustainable development.          Field visits to identify local/regional environmental issues, make observations including data collection and prepare a brief report.          Documentation of campus biodiversity, Campus environmental management activities such as solid waste disposal, water management and sewage treatment</p>	1

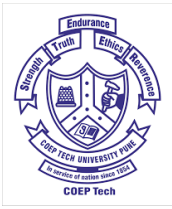
**Suggested Readings:**

- **J. Donald Hughes**, *An Environmental History of the World: Humankind's Changing Role in the Community of Life*, 2nd Edition, Routledge, 2009.
- **Gilbert M. Masters**, *Introduction to Environmental Engineering and Science*, 3rd Edition, Pearson, 2015.



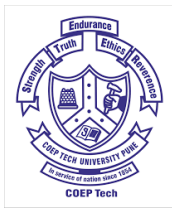
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- **Rajagopalan, R.**, *Environmental Studies: From Crisis to Cure*, 3rd Edition, Oxford University Press, 2021.
- **Krishnamurthy, K.V.**, *Textbook of Biodiversity*, 3rd Edition, Science Publishers, 2020.
- **Pittock, Barrie**, *Climate Change: Science, Impacts and Solutions*, 2nd Edition, Routledge, 2014.
- **Jackson, A.R.W. and Jackson, J.M.**, *Environmental Science: The Natural Environment and Human Impact*, 3rd Edition, Pearson, 2020.
- **United Nations**, *Transforming Our World: The 2030 Agenda for Sustainable Development* (Open Access).
- **IPCC**, *Climate Change 2023: Synthesis Report of the Sixth Assessment Report (AR6)*, Intergovernmental Panel on Climate Change, March 2023.



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# **Syllabus for Third Year B.Tech in Mechanical Engineering**



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**V-01 Heat Transfer**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-25001	Heat Transfer	3	0	2	1	4	30	20	50	50	50

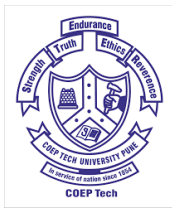
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Analyze the various modes of heat transfer and implement the basic heat conduction equations for steady one-dimensional thermal systems.
2. Quantify heat transfer through extended surfaces and unsteady-state conduction.
3. Obtain analytical solution for two-dimensional steady-state heat conduction.
4. Estimate forced and free convection heat transfer coefficients using appropriate correlations.
5. Develop solutions for radiation heat exchange between two or more surfaces.
6. Analyze heat exchanger performance using the LMTD method and the effectiveness-NTU method

**Syllabus:**

Unit	Contents	Hrs.
1	<b>One-dimensional steady-state heat conduction:</b> Introduction; derivation of generalized heat conduction equation in Cartesian coordinates; Fourier, Laplace and Poisson equations; equations in cylindrical and spherical coordinates (no derivation); conduction through composite slab, cylinder, sphere; variable thermal conductivity; critical radius of insulation; thermal contact resistance; conduction with internal heat generation for plane wall, cylinder, sphere.	8
2	<b>Extended surfaces and unsteady-state conduction:</b> Types and applications of fins; temperature distribution and heat transfer for constant-area fins; fin effectiveness, efficiency, overall efficiency of fin arrays; thermowell measurement errors; Biot and Fourier numbers; lumped capacitance method; Heisler charts.	8
3	<b>Two-dimensional steady-state conduction:</b> Analytical solutions in rectangular plates and semi-infinite plates; numerical methods; conduction shape factors for common geometries.	6
4	<b>Convective heat transfer:</b> Local and average convective coefficients; hydrodynamic and thermal boundary layers; laminar and turbulent flow over flat plates and in ducts; friction factor, drag coefficient; dimensionless numbers; empirical correlations for free and forced convection;	7



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	introduction to condensation and boiling (pool boiling, critical heat flux, burnout, forced boiling); film and drop-wise condensation (no numerical treatment).	
<b>5</b>	<b>Radiation:</b> Blackbody concepts; Planck's distribution; Wien's displacement; Stefan-Boltzmann law; surface properties (transmissivity, absorptivity, reflectivity); grey and real surfaces; radiation shape factors; Kirchhoff's and Lambert's cosine laws; exchange between non-black bodies; parallel planes and cylinders; shields; gas radiation (elementary); solar radiation; network method.	<b>7</b>
<b>6</b>	<b>Heat exchangers:</b> Classifications; overall heat transfer coefficient; LMTD method for parallel and counterflow; correction and fouling factors; effectiveness-NTU method; design considerations.	<b>6</b>

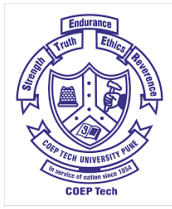
**Suggested learning resources:**

**Textbooks:**

- S.C. Arora, V.M. Domkundwar, A.V. Domkundwar, "A Course in Heat and Mass Transfer," Dhanpat Rai & Co., New Delhi.
- S.P. Sukhatme, "A Text Book of Heat Transfer," University Press, 4th Ed., 2005.
- R.K. Rajput, "Heat and Mass Transfer," S. Chand & Co., New Delhi.

**Reference Books:**

- F.P. Incropera and D.P. DeWitt, "Fundamentals of Heat and Mass Transfer," John Wiley & Sons.
- P.K. Nag, "Heat and Mass Transfer," Tata McGraw-Hill, 2011.
- Yunus A. Çengel, "Heat Transfer: A Practical Approach," McGraw-Hill Higher Education, 2002.
- J.P. Holman, "Heat Transfer," McGraw-Hill, 1996.
- C.P. Kothandaraman and S. Subramanyam, "Heat and Mass Transfer Data Book," New Age International, Mumbai.



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**V-01 Heat Transfer Lab**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-25001	Heat Transfer Lab	0	0	2	0	1	--			50	50

**Course Objectives:**

At the end of the course, students will demonstrate the ability to:

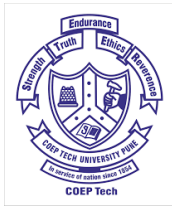
1. Apply theoretical principles of heat transfer to practical experimental setups.
2. Measure and determine key thermal properties like conductivity, heat transfer coefficient, and emissivity.
3. Analyze the performance of heat exchange equipment and interpret experimental data.

**Syllabus:**

Unit	Contents	Hrs.
1	Determination of thermal conductivity of a metal rod.	2 each
2	Determination of thermal conductivity of insulating powder.	2 each
3	Determination of thermal conductivity of a given liquid.	2 each
4	Determination of thermal resistance of composite slab.	2 each
5	Determination of time required to heat/cool a body (Unsteady State).	2 each
6	Determination of heat transfer coefficient in natural convection.	2 each
7	Determination of heat transfer coefficient in forced convection for flow through cylinder.	2 each
8	Determination of critical heat flux.	2 each
9	Determination of emissivity of a given surface.	2 each
10	Determination of Stefan-Boltzmann constant.	2 each

**Suggested Learning Resources**

- S.C. Arora, V.M. Domkundwar, A.V. Domkundwar – A Course in Heat and Mass Transfer, Dhanpat Rai & Co.
- S.P. Sukhatme – A Text Book of Heat Transfer, University Press, 4th Ed.
- R.K. Rajput – Heat and Mass Transfer, S. Chand & Co.
- Incropera & Dewitt – Fundamentals of Heat and Mass Transfer, Wiley
- P.K. Nag – Heat and Mass Transfer, Tata McGraw-Hill
- Yunus A. Cengel – Heat Transfer: A Practical Approach, McGraw-Hill
- J.P. Holman – Heat Transfer, McGraw-Hill



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**V-02: Dynamics of Machines**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-25002	Dynamics of Machine	3	0	2		4	30	20	50	--	--

**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Choose appropriate gear drives (spur, helical, bevel, worm) and analyze speed and torque in gear trains for specific applications.
2. Apply design principles to select appropriate belt for specific applications based on power transmission requirements, speed ratios, and other factors. Apply principles of friction, design, and operation of various clutch and brake systems
3. Understand and apply balancing techniques for static and dynamic balancing of various machines and components, including reciprocating and rotating masses.
4. Understand the principles of gyroscopes and their applications in various engineering fields.
5. Analyze single and multi-degree-of-freedom systems subjected to free, damped, and forced vibrations. This includes understanding natural frequencies, damping, and response to various excitations.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Gears II:</b> Helical gear, spiral gear, bevel gear and worm gear. Gear trains	7
2	<b>Belt Drives:</b> Introduction, Velocity ratio, Belt length, limiting ratio, power transmitted, centrifugal tensions, condition for maximum power transmission.	5
	<b>Clutches and Brakes:</b> Clutches and Brakes: types, power and torque transmission, and absorption derivations.	8
3	<b>Balancing:</b> Static and dynamic balance, balancing of revolving several masses on several planes, balancing of reciprocating masses in single and multi-cylinder engines, balancing machines.	8
4	<b>Gyroscope:</b> Introduction, Gyroscopic couple, Gyroscopic effects, Gyroscopic ship stabilization.	6
5	<b>Mechanical vibrations:</b>	8



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	Fundamentals, undamped and damped free vibrations of single degree freedom system, forced vibration of single degree of freedom system, critical speed of shafts.	
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**Suggested learning resources:**

**Textbooks:**

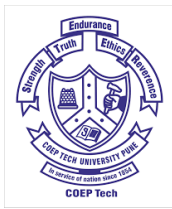
- John Hannah and Stephens, R. C., “Mechanics of Machines: Advanced Theory and Examples”, 1970, Hodder; Student international edition ISBN 0713132329 Edward Arnold London
- Ballaney, P., “Theory of Machines and Mechanisms”, 2005, ISBN 9788174091222 Khanna Publications
- Bansal, R. K., “Theory of machines”, Laxmi Publications Pvt. Ltd, New Delhi

**Reference Books:**

- Bevan Thomas, “The Theory of Machines”, 3rd edition, CBS publishing
- Uicker Jr, J. J., Penock G. R. and Shigley, J. E., “Theory of Machines and Mechanisms” 2003, Tata McGraw Hill
- Ramamurthy, V., “Mechanisms of Machines”, 3rd edition, ISBN 978-1842654569, Narosa Publishing House

**Weblinks:**

- <https://archive.nptel.ac.in/courses/112/105/112105125/>
- <https://archive.nptel.ac.in/courses/112/106/112106137/>



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**V-3: Metrology and Measurements**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME 25003	Metrology and Measurement	2	0	2	1	3	30	20	50	50	50

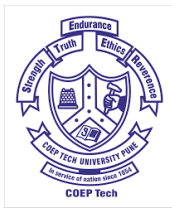
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Determine geometry and dimensions of components in engineering applications using various measuring instruments.
2. Design gauges to meet desired needs within realistic constraints.
3. Select the sensor/transducer for practical applications.
4. Understand methods of measurement for various quantities like force, torque, strain, flow, displacement, velocity/speed and acceleration.

**Syllabus:**

Unit	Contents	Hrs.
1	<p><b>Linear and Angular Measurements, Interferometry, Measurement System:</b>  <b>Introduction:</b> Meaning of Metrology, Precision, Accuracy, Methods and Errors in Measurement, Calibration.  <b>Linear Measurement:</b> Standards, Line Standards, End Standard, Wavelength Standard, Classification of Standards, Precision and Non -Precision Measuring instruments and their characteristics, Slip Gauges.  <b>Interferometry:</b> Introduction, Flatness testing by interferometry, NPL Flatness Interferometer. Study of Measuring Machines, Recent Trends in Engineering Metrology, use of interferometers for length, angle and surface roughness measurement  <b>Angle Measurement:</b> Sine bars, Sine Centers, Uses of sine bars, angle gauges, Autocollimator Angle Dekkor, Constant deviation prism.  <b>Measurement System Analysis:</b> Introduction, Influence of temperature, operator skills and the instrument errors etc.</p>	6
2	<p><b>Design of gauges, Interferometers and Comparators, Measuring Machines:</b>  <b>Limits, Fits and Tolerances:</b> Meaning of Limit, Fits and Tolerance, Cost – Tolerance relationship, concept of Interchangeability, Indian Standard System.  <b>Design of limits Gauges:</b> Types, Uses, Taylor’s Principle, Design of Limit Gauges.  <b>Inspection of Geometric parameters:</b> Straightness, Flatness, Parallelism, Concentricity, Squareness, and Circularity.  <b>Comparators:</b> Uses, Types, Advantages and Disadvantages of various types of Comparators.  <b>Measuring Machines:</b> Theory of Coordinate Metrology, Universal Measuring Machines, Coordinate Measuring Machines (CMM), different configurations of CMM, Principle, Error involved, calibration, Probing system, automated inspection system.</p>	7



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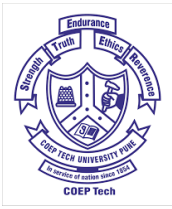
**Mechanical Engineering Department**

3	<p><b>Surface Finish Measurement, Screw Thread Metrology, Gear Metrology:</b></p> <p><b>Surface Finish Measurement:</b> Surface Texture, Meaning of RMS and CLA values, Roughness Measuring Instruments, Tactile and Non-tactile measuring instruments, difference between waviness and roughness, Grades of Roughness, Specifications, Assessment of surface roughness as per IS, Relationship between surface roughness and Manufacturing Processes.</p> <p><b>Screw Thread Metrology:</b> External Screw Thread Terminology, Floating Carriage Instruments, Pitch and flank Measurement of External Screw Thread, Application of Tool Maker's Microscope, Use of Profile Projector.</p> <p><b>Gear Metrology:</b> Spur Gear Parameters, Gear Tooth Thickness Measurement: Gear Tooth Vernier Caliper, Constant Chord Method.</p>	8
4	<p><b>Introduction to Mechanical Measurements:</b></p> <p>Importance of Measurements, Classification of measuring instruments, generalized measurement system, types of inputs for measurements. Concepts such as Linearity, Sensitivity, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span &amp; Range etc. Errors in Measurements, Classification of errors in measurements, First order instruments and its response to step, ramp, sinusoidal and impulse inputs.</p>	5
5	<p><b>Measurement Methods and Devices:</b></p> <p><b>Displacement Measurement:</b> Transducers for displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), Nozzle Flapper Transducer.</p> <p><b>Velocity Measurement:</b> Tachometers, Tacho generators, Digital tachometers and Stroboscope.</p> <p><b>Acceleration Measurement:</b> theory of accelerometer and vibrometers, strain gauge based and piezoelectric accelerometers.</p> <p><b>Strain Measurement:</b> Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors.</p>	5
6	<p><b>Measurement – Methods and Devices:</b></p> <p><b>Pressure Measurement:</b> Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge, Vacuum gauges viz. McLeod gauge, Ionization and Thermal Conductivity gauges.</p> <p><b>Temperature Measurement:</b> Thermocouple, Resistance thermometers, Thermistors, Pyrometers. Liquid in glass Thermometers, Bimetallic strip.</p> <p><b>Flow measurement:</b> Venturimeter, Orifice meter, Rotameter.</p>	5

**Suggested learning resources:**

**Textbooks:**

- R. K. Jain, A Text book of Engineering Metrology, Khanna Publications Pvt. Ltd. 18<sup>th</sup> Edition, 2002
- I.C. Gupta, A Text book of Engineering Metrology, Dhanpat Rai Publications Pvt. Ltd. 6<sup>th</sup> Edition, 2004

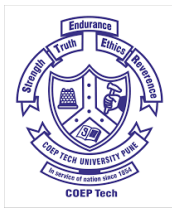


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- Anand Bewoor, Vinay Kulkarni, Metrology and Measurement, Tata McGraw-Hill, first edition 2009.
- N. V. Raghavendra, L. Krishnamurthy, Engineering Metrology and Measurements, Oxford University Press, 1st edition 2013
- R. K. Rajput, A textbook of measurement and metrology, S.K. Kataria & Sons, 2013.
- R. K. Jain, Mechanical and Industrial Measurements, Khanna Publishers, 1995
- A. K. Sawhney, Mechanical Measurement and Control, Dhanpat Rai & Co. (P) Limited, 2017

**Reference Books**

- G.M.S. De Silva, Basic Metrology for ISO 9000 Certification Elsevier Publications, 3rd Edition 2002.
- Ernest Doebelin and Dhanesh Manik, Measurement Systems, McGraw-Hill, 6<sup>th</sup> Edition, 2017.



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**V-3 Metrology and Measurement Lab**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME-25003	Metrology and Measurement Lab	3	0	2	1	4	--			50	50

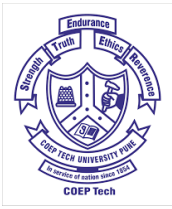
**Course Objectives:**

At the end of the course, students will demonstrate the ability to:

1. Demonstrate proficiency in selecting and using various linear, angular, circular, straightness, runout, total runout, and screw thread measurements for accurate dimensional inspection of components.
2. Demonstrate proficiency in selecting and using various linear, angular, circular, straightness, runout, total runout, and screw thread measurements for accurate dimensional inspection of components.
3. Apply surface and thread inspection techniques using tools like optical flats, interferometry, and profile projectors to evaluate surface flatness and thread parameters of mechanical components
4. Demonstration of the Pneumatic comparator, CMM, vision measurement machine, and surface finish measurement equipment
5. Exercise on the design of limit gauges, temperature measurement, and flow measurement

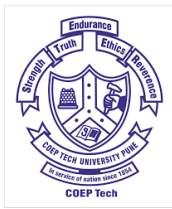
**Syllabus:**

Unit	Contents	Hrs.
1	<p><b>List of Experiments:</b></p> <ol style="list-style-type: none"> <li>1. Determination of Linear dimensions of a part using Precision and non-precision measuring Instruments.</li> <li>2. Precision angular measurement using a setup of Sine Bar and Slip Gauges</li> <li>3. Measurement of straightness, circularity, run out ,and total run out.</li> <li>4. Measurement of screw thread parameters using Floating Carriage Micrometer.</li> <li>5. Surface Finish measurement using a suitable instrument.</li> <li>6. Interferometry: Measurement of surface flatness using an optical flat.</li> <li>7. Study and Measurement of Parameters Using Profile Projector.</li> <li>8. Exercise on Design of Limit Gauges using Taylor's Principles.</li> <li>9. Demonstration of Digital Comparator and Pneumatic Comparator</li> <li>10. Demonstration of CMM and Vision Measurement Machine</li> <li>11. Measurement of temperature using RTD</li> <li>12. Measurement of flow using a flowmeter</li> </ol>	2 each
2	<p><b>List of Assignments:</b></p> <ol style="list-style-type: none"> <li>1. Exercise on Design of Limit Gauges using Taylor's Principles.</li> </ol>	



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	2. Develop a MATLAB-Simulink model for first-order instruments for various inputs.	
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**PEC -4.1 Finite Element Method**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME(PE)-250 01	Finite Element Method	3	0	0	1	3	30	20	50	--	--

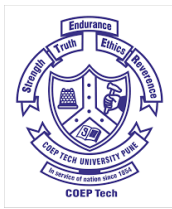
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand and formulate engineering problems using physical, mathematical, and numerical modeling concepts.
2. Apply variational methods and weighted residual approaches (Galerkin, Petrov-Galerkin) to derive finite element equations in 1D & 2D.
3. Formulate and simulate FEM models for trusses and beams, and analyze results for real-world applications.
4. Model and analyze single-variable 2D field problems using FEM with various elements and numerical integration techniques for real-world engineering applications.
5. Identify, analyze, and minimize sources of errors in finite element solutions.
6. Solve eigenvalue problems involving vibration analysis of spring-mass systems and beams using FEM techniques.

**Syllabus:**

Unit	Contents	Hrs.
<b>1</b>	<b>Introduction</b> Overview of engineering problems and solution methods, illustrated through an example: physical system - physical model - mathematical model (Governing differential equation) - solution methods - final solution. Emphasizes the need for numerical methods and types of engineering analysis. Concepts of shape functions, approximation functions, local and global coordinates. Initial Value Problems, Boundary value problems and solution methods, Direct approach – example, advantage and limitations. Introduction to steps of FEM for the generic problems.	4
<b>2</b>	<b>Variational Methods in FEM:</b> Elements of calculus of variation, Strong form and weak form, equivalence between strong and weak forms, Rayleigh-Ritz method, Principle of Minimum Potential Energy . Euler -Lagrange Equations from a Functional . Method of weighted residuals – Galerkin and Petrov-Galerkin approach;Least Squares . Examples - Axially loaded bar, Heat Conduction/Convection Pin-Fin for 1-D Problems, governing equations, discretization, derivation of element equation, assembly, imposition of boundary condition and solution, examples.	6
<b>3</b>	<b>Trusses &amp; Beams:</b>	5



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	Finite element formulation for plane trusses. Finite element formulation for Euler-Bernoulli beams (Governing differential equation, Characteristics of formulation for problems - FEM procedure - Computation of derived quantities like strains and stresses from the nodal values of the field variables, Result post-processing). Static and dynamic force analysis of slider crank mechanism, dynamically equivalent system, correction couple, Klein's construction, graphical and analytical method for determination of torque on crankshaft for IC engine.	
<b>4</b>	<b>2-D Problem from structural mechanics:</b> Introduction to 2-dimensional problem from structural mechanics static analysis, different elements (triangular, rectangular, quadrilateral, axis symmetric, etc.), shape functions. Basic concepts of Plain stress and Plain strain. Constant strain triangular element Stiffness Matrix and Equation. Finite element Solution of a plane stress Problem. Higher order elements, isoparametric elements. Need for numerical integration and co-ordinate transformation, Gauss- Legendre integration technique for numerical integration, linear elasticity problems & heat conduction. Application of FEM to Axisymmetric problems, Axisymmetric solids under rotation.	<b>7</b>
<b>5</b>	<b>Eigen-value problems:</b> Eigen value problems, Mass and stiffness matrices, 2 Dof and 3 Dof spring mass problems. Transverse vibration of beams. Methods to find Eigen values and Eigen vectors.	<b>3</b>
<b>6</b>	<b>Thermal Stresses and Errors in FEM:</b> Thermal Stresses – Formulation – Numericals (1D & 2D). Sources of errors, error analysis, remedies to minimize the errors.	<b>3</b>

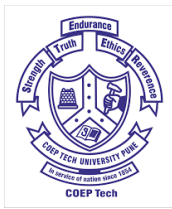
**Suggested learning resources:**

**Textbooks:**

- Daryl L Logan “A First Course in Finite Element Method” Sixth Edition.
- Introduction to Finite Element Method By J.N .Reddy.
- Cook R.D. “Concepts and applications of finite element analysis” Wiley, New York, 1981.
- Bathe K.J., Cliffs, N.J. “Finite element procedures in Engineering Analysis”, Englewood. Prentice Hall, 1981.

**Reference Books:**

- Jacob Fish and Ted Belytschko. 2007. A First Course in Finite Elements. John Wiley & Sons, Inc., Hoboken, NJ, USA.
- Desai C.S. and J.F. Abel “Introduction to the finite element method.” New York, Van Nostrand Reinhold, 1972.
- O. P. Gupta, “Finite and boundary element methods in Engineering”, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 2000.
- Chandrupatla and Belegundu “Introduction to finite elements in Engineering”, Prentice Hall of India Pvt. Ltd. New Delhi, 2001.



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**PEC -4.2 Fluid Dynamics**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME (PE)-25004	Fluid Dynamics	3	0	0	1	3	30	20	50	--	--

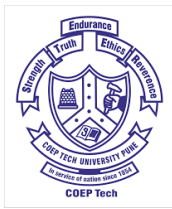
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

5. Understand and define the fluid flow problems along with range of governing parameters
6. Use the governing equations for different flow conditions for exact and approximate solutions.
7. Differentiate the different fluid flow patterns, flow regimes and its effects.
8. Devise the fluid flow problems of the industrial base.
9. Design and develop experimental procedures for internal and external fluid flow conditions.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Governing equations in Fluid Dynamics:</b> Reynolds Transport Theorem, Derivation of Continuity and Momentum equations using integral and differential approach, dimensionless form of governing equations, special forms of governing equations.	8
2	<b>Exact solutions of Navier-Stokes equations:</b> Fully developed flows, parallel flow in straight channel – Couette flow with and without applied pressure gradients, Fully Developed Flow in a Round Pipe— Poiseuille Flow, unconfined Flow over the horizontal and inclined plate, Creeping flow approximation	7
3	<b>Potential flow:</b> Irrotational flow approximations for continuity and momentum equations, Kelvin's theorem, Bernoulli Equation in Inviscid Regions of Flow, Two-Dimensional Irrotational Regions of Flow, Elementary Planar Irrotational Flows – uniform, source, sink, Irrotational Flows Formed by Superposition – doublet, flow past a half body, a Rankine Oval Body, a circular cylinder, lift and drag Forces on Submerged Bodies – stationary and rotating cylinder. Drag Force acting on a rotating cylinder	6
4	<b>Boundary Layer Approximation</b> Boundary layer equations, Laminar flat plate boundary layer exact solution, Turbulent flat plate boundary layer approximate solution, approximate solution methodology for boundary layer equations, Von-Karman integral Momentum equation for boundary layer, Pressure gradients in boundary layer flow, Separation of Boundary Layer, Control of Boundary Layer Separation.	7
5	<b>Turbulent flow:</b>	8



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	Characteristics of turbulent flow, laminar turbulent transition, time mean motion and fluctuations, Reynolds stresses, Prandtl's mixing length theory, derivation of governing equations for turbulent flow- Continuity, Reynolds Navier-Stokes equation, shear stress models, universal velocity distribution law and friction factor in duct flows for very large Reynolds number, Fully developed turbulent flow in a pipe for moderate Reynolds number.	
<b>6</b>	<b>Experimental techniques:</b> Introduction to measurements related to fluid flow, Analysis of experimental data-types of errors, sources of error, uncertainty analysis, Measurement of temperature-thermoelectric thermometry, resistance thermometry, pyrometry, bimetallic and liquid crystal thermometer, Measurement of pressure-U-tube manometer, pressure transducers, Measurement of volume flow rate- orifice plate meter, flow nozzle, venturi meter, rotameter, velocity measurement based on thermal effect - Hot wire Anemometry, Laser Doppler Velocimetry, Particle Image Velocimetry.	<b>6</b>

**Suggested learning resources:**

**Textbooks:**

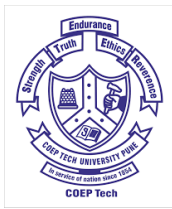
- Hydraulics and Fluid Mechanics including Hydraulic Machines, Dr. P. N. Modi and Dr. S. M. Seth, Standard Book House S. Ramamurtham, "Strength of materials", Dhanpatrai Publication.
- Textbook of Fluid Mechanics and Hydraulic Machine, Dr. R. K. Bansal, Laxmi Publications, New Delhi S K Sarkar, "Strength of materials", McGraw Hill New Delhi.
- Fluid Mechanics – Fundamentals and application. Yunus Cengel and John Cimbala.
- Introduction to Fluid Mechanics and Fluid Machines. S. K. Som, Gautam Biswas and Suman Charabarty. Mc-Graw Hill Publication.

**Reference Books:**

- Introduction to Fluid Mechanics, Fox R W, Pritchard P J, A T Mc Donald. John Wiley and Sons Publication G H Ryder, "Strength of materials", McMillan Publication
- Fluid Mechanics, Frank M. White. McGraw Hill Publications
- Engineering Fluid Mechanics, Prof K L Kumar, Chand Publication
- Fluid Mechanics, P. K. Kundu, I. M. Kohen and David Dowling Fifth Edition Elsevier Publication.

**NPTEL Course:**

<https://nptel.ac.in/courses/101103004>



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**PEC -4.3 Advanced Manufacturing Technology**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME(PE)-25 007	Advanced Manufacturing Technology	3	0	0	1	3	30	20	50	--	--

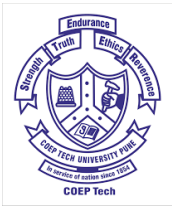
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand the fundamental principles of surface treatment.
2. Learn the principles and techniques used for non-traditional machining.
3. Understand the advanced technologies like ceramic processing

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Surface treatment:</b> Scope, Cleaners, Methods of cleaning, Surface coating types, and ceramic and organic methods of coating, economics of coating. Electro forming, Chemical vapour deposition, thermal spraying, Ion implantation, diffusion coating, Diamond coating and cladding.	6
2	<b>Non-Traditional Machining:</b> Introduction, need, AJM, Parametric Analysis, Process capabilities, USM –Mechanics of cutting, models, Parametric Analysis, WJM –principle, equipment, process characteristics, performance, EDM – principles, equipment, generators, analysis of R-C circuits, MRR, Surface finish, WEDM.	6
3	<b>Laser Beam Machining:</b> Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Plasma Arc Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Electron Beam Machining - Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Electro Chemical Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications.	6
4	<b>Processing of ceramics:</b> Applications, characteristics, classification. Processing of particulate ceramics, Powder preparations, consolidation, Drying, sintering, Hot compaction, Area of application, finishing of ceramics. Processing of Composites: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, MMC, CMC, Polymer matrix composites.	6



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<b>5</b>	<b>Fabrication of Microelectronic devices:</b> Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, computer aided design in microelectronics, surface mount technology, Integrated circuit economics. E-Manufacturing, nanotechnology, micromachining and High-speed Machining, basic principles, working, applications, advantages.	<b>6</b>
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**Suggested learning resources:**

**Textbooks:**

1. Manufacturing Engineering and Technology by Kalpakjian, Addison Wesley, 1995.
2. Foundation of MEMS by Chang Liu, Pearson, 2012.
3. Advanced Machining Processes by V. K. Jain, Allied Publications.

**NPTEL Course:**

[https://onlinecourses.nptel.ac.in/noc24\\_me154/preview](https://onlinecourses.nptel.ac.in/noc24_me154/preview)



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**PEC-4.4 Fundamentals of Green Hydrogen Technology**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME(PE)-250 09	Fundamentals of Green Hydrogen Technology	3	0	0	1	3	30	20	50	-	-

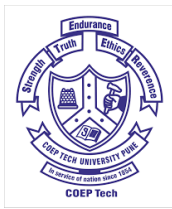
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Explain the concept of the hydrogen economy and classify various hydrogen production pathways, with a focus on green hydrogen.
2. Analyze and compare different hydrogen production technologies, particularly electrolysis methods, and evaluate their efficiency and suitability for renewable energy integration.
3. Design and evaluate hydrogen storage and transportation systems considering technical, safety, and economic aspects.
4. Assess hydrogen utilization technologies including fuel cells and internal combustion systems, and explore their integration in industrial and transportation sectors.
5. Investigate emerging trends, policies, and case studies related to the global and national green hydrogen ecosystem, and propose solutions to current challenges.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to Hydrogen Economy and Green Hydrogen:</b> Overview of hydrogen as an energy carrier, Hydrogen economy: concepts, evolution, and need, Classification of hydrogen: grey, blue, green, turquoise, Role of green hydrogen in decarbonization, Current global and Indian scenario: policies, initiatives, and projects, Challenges and opportunities in green hydrogen deployment.	4
2	<b>Hydrogen Production Technologies:</b> <b>Electrolysis Techniques:</b> Alkaline Electrolyzers, Proton Exchange Membrane (PEM) Electrolyzers, Solid Oxide Electrolyser (SOE), Solar and wind energy integration for green hydrogen, Water purification and resource management for electrolysis, Biomass gasification and thermochemical routes, Techno-economic analysis and efficiency comparisons.	6
3	<b>Hydrogen Storage and Transportation:</b> <b>Physical storage:</b> Compressed gas, Liquid hydrogen, <b>Material-based storage:</b> Metal hydrides, Chemical carriers (ammonia, LOHCs), Storage system design considerations, Transportation methods: Pipelines, Cryogenic tankers, Hydrogen blending in NG pipelines, Safety standards, codes, and regulations.	5
4	<b>Hydrogen Utilization and Applications:</b>	7



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	<p><b>Fuel cells:</b> PEMFC, SOFC, applications and integration, Hydrogen in internal combustion engines (H<sub>2</sub>-ICE), Industrial applications: Steel, Fertilizer, Refineries.</p> <p><b>Mobility and transportation:</b> Fuel cell electric vehicles (FCEVs), hybrid systems,</p> <p><b>Power-to-X technologies:</b> Synthetic fuels, Ammonia, Methanol</p>	
<b>5</b>	<p><b>Emerging Trends, Challenges, and Future Prospects:</b>          Techno-economic analysis of hydrogen value chain, Hydrogen hubs, microgrids, and sector coupling, Carbon footprint and life-cycle assessment (LCA), Policy framework, incentives, and public-private partnerships, Case studies: National Hydrogen Mission (India), EU Hydrogen Strategy, HyDeploy, etc., Research opportunities and startup ecosystem</p>	<b>6</b>

**Suggested learning resources:**

**Textbooks:**

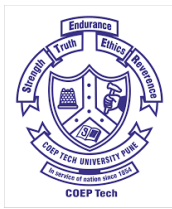
- "Hydrogen and Fuel Cells: Emerging Technologies and Applications"  
 Author: Bent Sørensen
- Hydrogen Economy: Supply Chain, Life Cycle Analysis and Energy Transition for Sustainability". Authors: Antonio Scipioni, Alessandra Manzardo, Javier G. Pérez  
 Publisher: Academic Press

**Reference Books:**

- "Fuel Cell Fundamentals"  
 Authors: Ryan O'Hayre, Suk-Won Cha, Whitney Colella, Fritz B. Prinz Publisher: Wiley
- "Hydrogen Energy and Vehicle Systems"  
 Author: Scott E. Grasman Publisher: CRC Press
- "Green Hydrogen: Renewable Energy for a Low Carbon Future"  
 Editors: V. Subramanian et al. Publisher: CRC Press (Recent publication)

**Supplementary Reading (Reports, White Papers & Journals)**

- IEA Global Hydrogen Review (International Energy Agency)
- IRENA Report on Green Hydrogen: A Guide to Policy Making
- NITI Aayog – India's Green Hydrogen Policy and Roadmap



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**PEC-4.5 Experimental Stress Analysis**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME(PE)-25 002	Experimental Stress Analysis	3	0	0	1	3	30	20	50	-	-

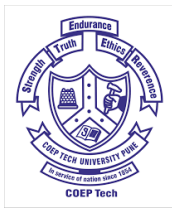
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand the fundamental concepts of stress, strain, and their relationship.
2. Learn the principles and techniques for experimental stress and strain measurement.
3. To analyze experimental data to validate theoretical models.
4. To gain hands-on experience with modern experimental tools and techniques.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to Experimental Stress Analysis:</b> Importance and Scope of Experimental Stress Analysis, Equilibrium equations in 3D, Shear force and bending moment diagrams, Concepts of Stress and Strain tensors. Mohr circle, transformation of stress and strain components in 3D, Principal Stresses and Strains.	6
2	<b>Constitutive relations, theories of yielding and composite materials:</b> Constitutive equations in 3D, isotropic materials, anisotropic material, fibre composite materials, theories of yielding, piezo-electric sensors. Overview of Experimental Methods.	4
3	<b>Measurement of strain through strain gages:</b> Electrical Resistance Strain Gauges: Working Principles, Types, and Applications. Wheatstone Bridge Circuits and Gauge Factor. Rosette strain gages: Measurement of strain in a thin elastic beam, compare it with theoretical prediction, and study geometrical nonlinearity; measure strain in a circular tube loaded with a torsional member using full bridge.	8
4	<b>Photoelasticity:</b> Principles of Photoelasticity: Stress-Optic Law, Plane and Circular Polariscope Techniques, Fringe Patterns: Isoclinics and Isochromatics, Determination of material fringe value, Pure bending moment through four-points bend specimen, study of Saint Venant's principle through photoelasticity	8
5	<b>Advanced Techniques in Stress Analysis:</b> Moire' interferometry, Principle, Types, and Applications; Digital Image Correlation (DIC): Principles, Equipment, and Applications; Thermoelastic Stress Analysis Using Infrared Thermography, Ultrasonic Stress Analysis Methods, Fiber Optic Strain Sensors.	6



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6	<b>Applications and Case Studies:</b> Fiber Optic Strain Sensors, its principle, applications, and its strength and limitations; case studies of applications of various measuring techniques in actual cases in industrial applications.	6
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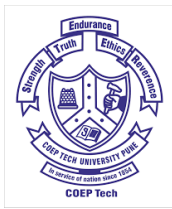
**Suggested learning resources:**

**Textbooks:**

- John Hannah and Stephens, R. C., “Mechanics of Machines: Advanced Theory and Examples”, 1970, Hodder; Student international edition ISBN 0713132329 Edward Arnold London
- Ballaney, P., “Theory of Machines and Mechanisms”, 2005, ISBN 9788174091222 Khanna Publications
- S S Ratan, “Theory of Machines”, Fifth edition, Tata McGraw Hill Publication Co. Ltd.
- Bansal, R. K., “Theory of machines”, Laxmi Publications Pvt. Ltd, New Delhi

**Reference Books:**

- Bevan Thomas, “The Theory of Machines”, 3<sup>rd</sup> edition, CBS publishing
- Uicker Jr, J. J., Penock G. R. and Shigley, J. E., “Theory of Machines and Mechanisms’ 2003, Tata McGraw Hill
- Ramamurthy, V., “Mechanisms of Machines”, 3<sup>rd</sup> edition, ISBN 978-1842654569, Narosa Publishing House



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**PEC-4.6: Modern IC Engine**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME(PE)-25 005	Modern IC Engine	3	0	0	1	3	30	20	50	---	---

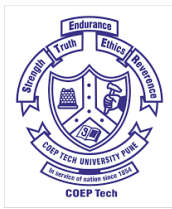
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Construction and operation of IC engine
2. Fuels and combustion of fuels in SI and CI engine
3. Conduct performance test and carry out calculations
4. Formation of exhaust emissions and their controlling measures.

**Syllabus:**

Unit	Contents	Hrs.
<b>1</b>	<b>Overview of thermodynamics of fuel-air cycles and real cycles</b> Otto cycle, Diesel cycle, Atkinson cycle, Stirling cycle, Brayton cycle. Assumptions in fuel air cycle and its analysis, Composition of cylinder gases <b>Engine construction and operation</b> Construction and working principle of SI, CI engines and gas turbines, Major engine components, four stroke and two stroke engines	<b>6</b>
<b>2</b>	<b>Engine fuels</b> Basic requirements of engine fuels: Chemical structure of petroleum, Heat value of fuels, Rating of SI Engine fuels, Rating of CI engine fuels, Combustion equation for hydrocarbon fuels, Properties and ratings of petrol and diesel fuels, Fuel supply systems of SI and CI engines, non-conventional fuels for IC engines; LPG, CNG, Methanol, Ethanol, Non-edible vegetable oils, Hydrogen.	<b>5</b>
<b>3</b>	<b>Carburetor &amp; Fuel Injection systems</b> Construction and working of carburettor, Inlet and exhaust valve timings, Fuel feed and fuel injection pumps, Petrol injection, Electronic Fuel Injection systems (EFI), Multi-point fuel injection system (MPFI)	<b>5</b>
<b>4</b>	<b>Combustion in SI and CI Engines:</b> Ignition systems, Stages of combustion in engines, Flame propagation and factors affecting it, Knocking and pre-ignition, Factors affecting knocking and Control of knocking, Combustion chamber requirements, Turbo charging and super charging, Engine emissions, Engine emissions and emission standards	<b>5</b>



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<b>5</b>	<p><b>Engine lubrication systems</b> Engine lubrication systems, Hydrodynamic theory of lubrication, Properties of lubricants, Types of lubricants and additives Grading of lubricating oils,</p> <p><b>Engine cooling</b> Air- and water-cooling systems, Working principles of air- and water-cooling systems, Variation of gas temperatures, Components of water-cooling system</p>	<b>6</b>
<b>6</b>	<p><b>Engine performance and testing of engines</b> Performance parameters, Engine power, BHP, Fuel consumption, Air consumption, Engine heat balance sheet, Mechanical efficiency, Engine efficiencies, Testing of engines and related numerical problems</p>	<b>6</b>

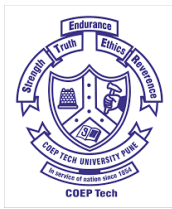
**Suggested learning resources:**

**Practicals:**

1. Engine dismantling and engine assembly: SI and CI engines.
2. Identification of engine components and checking them for defects.
3. Performance testing of SI/CI engine
4. Tailpipe emission testing of given engine

**References:**

1. Heywood, J. B, , *Internal Combustion Engine Fundamentals*, McGraw Hill Publishing Co., New York, 1990.
2. Sharma, S. P, Chandramohan, *Fuels and Combustion*, Tata McGraw Hill Publishing Co, 1987.
3. Mathur and Sharma, *A course on Internal combustion Engines*, Dhanpat Rai & Sons, 1998.
4. Pulkrabek, W. W., *Engineering Fundamentals of the Internal Combustion Engine*, Prentice-Hall of India Private Limited, 2002.
5. Prof. P.L. Ballaney, *Internal Combustion Engines*, Khanna Publications, Delhi, India
6. R.K. Mohanty, *A Text Book of Internal Combustion Engines*, Standard Book House, Delhi, India



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**V-4.7 Operations Research**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME(PEC)-2 5008	Operations Research	3	0	0	1	3	30	20	50	--	--

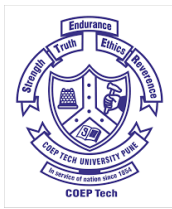
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Illustrate the need to optimally utilize the resources in various types of industries.
2. Apply and analyse mathematical optimization techniques to various applications.
3. Demonstrate cost effective strategies in various applications in industry.
4. Demonstrate the use of quantitative techniques in project management.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to operations research and linear programming problem:</b> Scope, phases, and applications of operations research, advantages and limitations of operations research. Linear Programming Problem (LPP)- formulation and graphical solution to LPP, simplex method, artificial variable technique- Big M method and two-phase method, duality and sensitivity analysis.	8
2	<b>Transportation, assignment and sequencing problem:</b> Mathematical formulation of transportation problem (TP), methods to obtain initial basic feasible solution, TP with and without degeneracy. Assignment problem (AP)- Mathematical formulation, variations of AP, Travelling Salesman Problem. Sequencing Problem-Assumptions in sequencing problem, processing of n jobs through two machines, processing of n jobs through three machines.	8
3	<b>Replacement model and waiting line theory:</b> Replacement of items whose maintenance and repair cost increases with time ignoring money value and considering money value, replacement of items that fails suddenly-group replacement. Waiting line theory- Kendall's notation, waiting line with single channel Poisson arrivals with exponential service times, infinite population.	8
4	<b>Games theory and simulation:</b>	8



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	Minimax criteria for optimality, characteristics of game, dominance principles, 2X2 game- arithmetic and algebraic method, 2Xn and mX2 game- graphical and method of subgames, 3X3 game- method of matrices Simulation- Monte Carlo simulation, advantages and limitations of simulation, applications of simulation	
<b>5</b>	<b>Network analysis:</b> Network construction, identification of critical path, float calculations, Programme Evaluation and Review Technique (PERT) time calculations, crashing of network, resource scheduling, network updating	<b>8</b>

**Suggested learning resources:**

**Textbooks:**

- Operations Research- theory, methods & applications, eighteenth revised edition 2017, S. D. Sharma, Kedar Nath Ram Nath
- Operations Research, Revised and enlarged edition 2012 Prem Kumar Gupta and D S Hira, S Chand & Company Ltd.

**Reference Books:**

- Operations Research-An Introduction, Ninth edition 2014, Hamdy A Taha, Pearson Education India
- Operations Research: Methods and Problems, Maurice Saseini, Arthur Yaspan and Lawrence Friedman, John Wiley and Sons., New York.



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**PEC-4.8 Machine Learning**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME(PE)-2 5010	Machine Learning	3	0	0	1	3	30	20	50	-	-

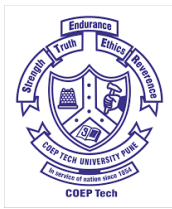
**Course Outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand Fundamental Concepts of Machine learning.
2. Apply Data Preprocessing Techniques
3. Implement Supervised Learning Algorithms
4. Utilize Unsupervised Learning Methods
5. Develop Deep Learning Models
6. Explore Advanced ML Applications

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to AI &amp; Machine Learning in Mechanical Engineering:</b> History and evolution of AI and ML, Differences between AI, ML, and Data Science. Importance of ML in engineering, Overview of ML approaches: Supervised, Unsupervised, Reinforcement Learning Basic concepts: Reasoning, problem-solving, knowledge representation, planning, perception	6
2	<b>Feature Engineering and Data Preprocessing:</b> Importance of data quality and preprocessing, Techniques for feature extraction: Statistical features, Principal Component Analysis (PCA), Feature selection methods, Dimensionality reduction techniques	7
3	<b>Supervised Learning Algorithms:</b> Linear and logistic regression, Decision trees and random forests, Support Vector Machines (SVM), K-Nearest Neighbors (KNN), Model evaluation metrics: Accuracy, precision, recall, F1-score	6
4	<b>Unsupervised Learning and Clustering:</b> Clustering algorithms: K-Means, Hierarchical clustering, Dimensionality reduction: PCA, t-SNE, Anomaly detection techniques, Applications in mechanical systems: Fault detection, pattern recognition	7



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5	<b>Deep Learning and Neural Networks:</b> Introduction to neural networks and deep learning, Convolutional Neural Networks (CNNs) for image data, Recurrent Neural Networks (RNNs) for time-series data, Applications in mechanical engineering: Predictive maintenance, image-based inspections	8
6	<b>Advanced Topics and Applications in Mechanical Engineering:</b> Reinforcement learning and its applications, Physics-informed machine learning models, Integration of ML with Computer-Aided Engineering (CAE) tools, Case studies: Digital twins, smart manufacturing, structural health monitoring	7

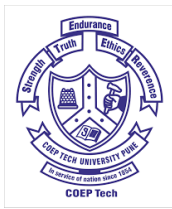
**Suggested learning resources:**

**Textbooks:**

- Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow Concepts, Tools, and Techniques to Build Intelligent Systems, O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.
- Introduction to Machine Learning with Python by Andreas C. Müller & Sarah Guido
- Machine Learning For Dummies by John Paul Mueller & Luca Massaron

**Reference Books:**

- Tom Mitchell "Machine Learning" McGraw Hill Publication, ISBN :0070428077 9780070428072
- Marc Peter Deisenroth (Author), A. Aldo Faisal (Author), Cheng Soon Ong (Author), MATHEMATICS FOR MACHINE LEARNING, Cambridge University Press (23 April 2020); Cambridge University Press.



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**PEC-4.9 Renewable Energy Resources**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME(PEC)-2 5003	Renewable Energy Resources	3	0	0	1	3	30	20	50	--	--

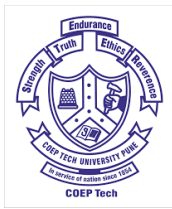
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand the effect of fossil fuels on global warming and their relative impact on the environment.
2. Comprehends the energy scenario of India and the scope of non-conventional energy sources.
3. Describe the difference between non-conventional energy and renewable.
4. Evaluate the performance of the various non-conventional and renewable energy sources.
5. Comprehend the recent advancements in energy generations.
6. Design skills in non-conventional energy systems and enhance written communication.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to energy:</b> Energy demand growth and supply, Historical perspectives, Fossil fuels: Consumption and Reserves, Environmental impacts of burning fossil fuels, Sustainable development and the role of renewable energy.	6
2	<b>Wind and Hydro power systems :</b> Atmospheric circulations, factors influencing the winds, wind turbines and types, coefficient of power, torque, Betz limit, Aerodynamic design principle for blades, Introduction to hydro power plant and types, overview of micro, mini and small hydropower plant, types and operational characteristics of hydro turbine	6
3	<b>Bio energy and bio-fuels:</b> Biomass source and characterization, direct combustion, pyrolysis, mechanism of bio-renewable energy, Gasifiers, updraft gasifier, downdraft gasifier, gasifier-based electricity-generating systems, application of biogas slurry in agriculture, bio ethanol for energy generation	6
4	<b>Fuel cells:</b> Working principle of fuel cells, fuel cell electrochemistry, types of fuel cells: Alkaline fuel, Fuel Cells, Phosphoric acid fuel cell, Solid oxide fuel cell, Molten carbonate fuel	6



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	cell, Direct methanol Fuel Cell, their applications, relative merits and demerits. Introduction to thermal heat storage.	
<b>5</b>	<p><b>Tidal energy:</b>          Tidal power plants: single basin &amp; two basin plants, variation in generation level, Ocean thermal electricity conversion, electricity generation from waves, shortline and floating wave systems.</p> <p><b>Geothermal energy:</b>          Introduction, Geothermal sites in India, high temperature and low temperature sites in India, Conversion technologies, Steam and binary systems, geothermal power plant, open loop and closed loop system</p>	<b>6</b>
<b>6</b>	<p><b>Solar energy:</b>          Principles of solar energy conversion: Photovoltaic (PV) cells and solar thermal systems, Efficiency of solar cells and factors affecting performance, Solar power plants: Concentrated solar power (CSP) vs. photovoltaic systems, Solar thermal collectors and applications, Energy storage for solar power systems</p>	<b>6</b>

**Suggested learning resources:**

**Textbooks:**

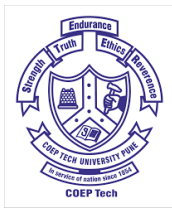
- Godfrey Boyle, Renewable energy, Oxford press, 2012
- Twidell J and Weir T., Renewable energy resources, Taylor and Francis, 2006
- Rai G.D., Non-conventional energy sources, Khanna Publication, 2009
- B.H. Khan, Non-conventional energy sources, Mcgrawhill education, 2006.
- "Solar energy" by S. P. Sukhatme, Fourth edition, McGraw Hill Education.

**Reference Books:**

- Wind Energy Systems by Johnson G. L., Prentice Hall, 1985
- Introduction to Hydro Energy Systems: Basics, Technology and Operation by Wagner H. and Mathur J, Springer, 2009.
- Bio-fuels: biotechnology, chemistry, and sustainable development by DM Mousdale, CRC Press, 2008.
- Fuel Cells: From Fundamentals to Applications by S Srinivasan, Springer, 2006

**NPTEL Course:**

<https://nptel.ac.in/courses/103103206>



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**PEC- 4.10: Steam and Gas Turbines**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
ME(PEC) -25006	Steam and Gas Turbines	3	0	0	1	3	30	20	50	-----	

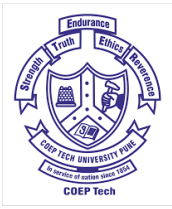
**Course outcomes:**

After learning the course, the students should be able to:

1. Analyze thermodynamic cycles of steam power plant and understand construction, working and significance of its various components.
2. Analyze thermodynamic cycles of gas turbine power plant and jet propulsion systems

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Steam Nozzles:</b> Types of nozzles, velocity of steam, discharge through nozzle, critical pressure ratio and condition for maximum discharge, physical significance of critical pressure ratio, nozzle efficiency	6
2	<b>Steam Turbine:</b> Principle of operation, types of steam turbines, compounding of steam turbines, impulse turbine - velocity diagram, calculation of work, power and efficiency, condition for maximum efficiency, Reaction turbines - velocity diagram, degree of reaction, reheat factor, governing of steam turbine - throttle, nozzle and bypass governing, Methods of attachment of blades to turbine rotor, Labyrinth packing, Losses in steam turbine, Special types of steam turbine- back pressure, pass out and mixed pressure turbine.	10
3	<b>Gas Turbine:</b> Classification, open and closed cycle, gas turbine, fuels, the actual Brayton cycle, optimum pressure ratio for maximum thermal efficiency, work ratio, air rate, effect of operating variables on the thermal efficiency and work ratio, and air rate, simple open cycle turbine with regeneration, reheating and Intercooling, Combined steam and gas turbine plant, requirements of combustion chamber, types of combustion chambers.	10
4	<b>Jet Propulsion:</b> Fundamentals of propulsion technology, Turbojet Engine, thrust, thrust power, propulsive efficiency, thermal efficiency, Turboprop, Ramjet and Pulsejet engines	8



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**Suggested learning resources:**

**Textbooks:**

1. Groover, M. P. - Automation, Production Systems, and Computer-Integrated Manufacturing (Pearson)
2. Tönshoff, H.K., & Denkena, B. - Digital Manufacturing (Springer)
3. Tao, F., Cheng, Y., & Zhang, M. - Digital Twin Driven Smart Manufacturing (Elsevier)
4. Alasdair Gilchrist - Industry 4.0: The Industrial Internet of Things

**Reference Books:**

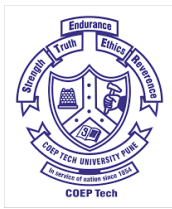
1. Power Plant Engineering, P.K. Nag, McGraw-Hill Education
2. Power Plant Engineering, R. K. Hegde, Pearson India Education
3. Gas Turbines, V. Ganeshan, McGraw Hill Education
4. Thermal Engineering, R.K.Rajput, Laxmi Publication
5. Steam Turbine Theory and Practice, William J. Kearton, CBS Publication

**List of Open-Source Software/learning websites:**

<http://nptel.ac.in/courses/112104117/18>

<http://nptel.ac.in/courses/112104117/4>

<http://nptel.ac.in/courses/112104117/17>



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**PEC- 4.11: Innovative Design and Optimization**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Innovative Design and Optimization	3	0	0	0	3	30	20	50	-----	

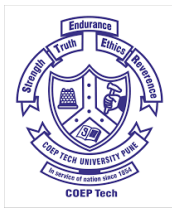
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Apply the concept of design for design and analyse the product design and development processes and value engineering in manufacturing industry
2. Define the components and their functions of innovate design and processes their relationships from concept to customer over whole product lifecycle.
3. Apply suitable design guidelines in developing a product based on strength and environmental issues.
4. Utilize the optimization techniques and analyze the methodologies for product design, development and management.
5. Analyze the economic factors and apply the concept human engineering in designing a new product.
6. Analyze value engineering through various strategies and models in product design for creative thinking skills and idea generation.

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Innovation and Design</b> History of design and innovation, Use of technology in day-to-day life, in agriculture, manufacturing, sanitation, medicine, transportation, information processing, and communications, Perception of gap and need in user experience. Concepts and ideas, Visualization of ideas through drawing. Computer generated design using auto CAD software.	<b>4</b>
<b>2</b>	<b>Design Model and Morphology</b> Asimow's model: Definition of product design, Design by Evolution, Design by Innovation, Essential Factors of Product design, Production-Consumption Cycle, Flow and Value Addition in the Production-Consumption Cycle. Morphology of Design (The seven phases), Primary Design Phases and Flowcharting, Role of Allowance, Process Capability and Tolerance in Detailed Design & Assembly.	<b>5</b>



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<b>3</b>	<p><b>Design Practice and Industry</b> Introduction - Product Strategies - Time to Market - Analysis of the product - The S's Standardization - Renard Series – Simplification - Role of Aesthetics in Product Design - Functional Design Practice.</p> <p><b>Strength Consideration in Product Design</b> Principal Stress Trajectories (Force-Flow Lines), Balanced Design, Criteria and Objectives of Design, Material Toughness: Resilience Designing for Uniform Strength, Tension vis-a-vis Compression</p>	<b>6</b>
<b>4</b>	<p><b>Optimization in Design and Management</b> Introduction, Siddal's Classification of Design Approaches, Optimization by Differential Calculus, Lagrange Multipliers, Linear Programming (Simplex Method), Geometric Programming, Johnson's Method of Optimum Design.</p> <p>Product by nature of demand, new product strategy, Product classification, Product Management, The product life cycle – Booz, Allen, Hamilton new product development process.</p>	<b>6</b>
<b>5</b>	<p><b>Economic and Human Engineering Consideration</b> Design for safety - Reliability and environmental considerations- Manufacturing operations in relation to Design - Economic analysis - Profit and Competitiveness - Break-Even analysis - Economic of a new product design.</p> <p>Introduction of human engineering in product design - Human being as applicator of forces - Anthropometry; Man as occupant of space - The design of controls - The design of displays - Man/Machine information exchange.</p>	<b>5</b>
<b>6</b>	<p><b>Value Engineering and Product Design</b> Introduction - Historical perspective - Nature and measurement of value - Normal degree of value - the value analysis job plan – creativity - Steps to problem-solving and value analysis - Value analysis test - Value engineering idea generation check-list cost reduction through value engineering case study on Tap switch control assembly. Material and Process Selection in Value Engineering Modern Approaches to Product Design: Concurrent Design and Quality Function Deployment (QFD).</p>	<b>6</b>

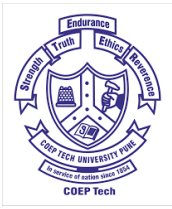
**Suggested learning resources:**

**Textbooks:**

4. A.C. Chitale and R.C. Gupta, "Product Design and Manufacturing, 6 th edition, PHI, 2011.
5. Karl T.Ulrich & Steven D, Epinger, "Product Design & Development", 4th edition, Tata Mc. Graw Hill, 2007.
6. John Kolko Exposing the Magic of Design, OXFORD.

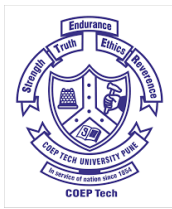
**Reference Books:**

5. Tim jones, Butterworth Heinmann, "New Product Development", Oxford, mc 1997.



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6. Roland EngeneKinetovicz, “New Product Development: Design & Analysis” John Wiley and Sosn Inc., N.Y.1990.
7. Geofferry Boothroyod, Peter Dew Hurst and Winston Knight - Product Design for Manufacture and Assembly -3rdEdition, Taylor & Francis Group,2011.
8. AK Chitale & RC Gupta Product Design & Manufacturing, PHI.



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**PEC- 4.12: Processing of Polymer Composites**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Processing of Polymer Composites	3	0	0	0	3	30	20	50	-----	

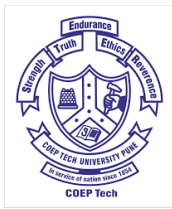
**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Explain the fundamental concepts, classification, and constituents of polymer composites, including matrix-reinforcement interactions and their influence on properties.
2. Select and apply appropriate processing techniques (such as compression molding, injection molding, filament winding, microwave processing etc.) based on material type, part geometry, and end-use requirements
3. Analyze the influence of processing parameters (temperature, pressure, curing time, fiber orientation, resin flow) on the structural and mechanical performance of polymer composite components.
4. Evaluate composite quality using analytical and experimental characterization methods (DMA, DSC, TGA, tensile testing, microscopy) and assess defects, failure modes, and process optimization strategies.
5. Design and develop a polymer composite product by integrating material selection, process planning, modeling, and performance requirements for real-life industrial applications

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction to Polymer Composites</b> Definition and classification of composites, classification of polymer matrices (thermoplastics and thermosets), classification of fibers (synthetic and natural fibers), advantages and limitations of polymer composites, applications in automotive, aerospace, marine, construction, sports, biomedical, consumer products. Concept of reinforcement and matrix; need for processing; interface and interphase; overview of manufacturing routes; sustainability aspect in composite processing.	5
2	<b>Raw Materials and Pre-processing</b> Polymer matrices: epoxy, polyester, vinyl ester, polypropylene, nylon, high-performance polymers; characteristics and selection criteria. Reinforcements: glass, carbon, aramid, natural fibers - properties, sizing, surface treatments, fibre architecture (unidirectional, woven, braided, stitched mats). Fillers and additives: coupling agents, catalysts, pigments, tougheners, flame retardants. Prepregs: concept, preparation methods, storage, handling.	5



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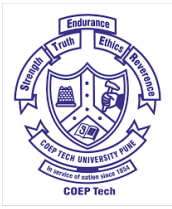
<b>3</b>	<p><b>Polymer Composite Manufacturing Processes</b></p> <p>Hand Lay-up and Spray Lay-up: tools, processing steps, curing, advantages/limitations.          Compression Moulding: sheet moulding compounds (SMC), bulk moulding compounds (BMC), thermal cycle, pressure cycle.          Injection Moulding for Composites: short fibre and long fibre thermoplastic composites, flow behaviour, defects, applications.          Resin Transfer Moulding (RTM) &amp; VARTM: mould design, resin flow modelling, vacuum infusion, curing behaviour.          Autoclave Moulding: vacuum bagging, process parameters, aerospace applications.          Filament Winding, Pultrusion, Sheet/Wet Winding: winding patterns, resin bath systems, applications (tanks, pressure vessels, profiles).          Extrusion and Thermoforming of Polymer Composites.          Discussion of process capabilities, cost, product quality, advantages and limitations of each process.</p>	<b>8</b>
<b>4</b>	<p><b>Design and Modelling for Composite Processing</b></p> <p>Basics of composite design; rule of mixtures; volume fraction calculations. Flow modelling for liquid composite moulding; permeability and Darcy's law; void formation mechanisms; fibre waviness, orientation control.          Cure kinetics modelling for thermoset composites; thermal effects during processing (heat transfer, exotherm).          Defect formation and mitigation: voids, delamination, dry spots, warpage, residual stresses.          Use of simulation tools (introductory): ANSYS, COMSOL Multiphysics for composite curing simulations.</p>	<b>8</b>
<b>5</b>	<p><b>Emerging trends in PMCs</b></p> <p>Emerging trends: automation, microwave-assisted composite processing, recyclable composites, secondary processing.          Industrial case studies: automotive composite panels, aircraft components, wind turbine blades, marine structures, sports goods, biomedical implants.</p>	<b>6</b>

**Suggested learning resources:**

**Textbooks:**

7. Kishore Debnath and Inderdeep Singh, Primary and Secondary Manufacturing of Polymer Matrix Composites, CRC Press, 2017.
8. Mallick, P.K., Fiber-Reinforced Composites: Materials, Manufacturing, and Design, CRC Press, 2007.
9. Chawla, K.K., Composite Materials: Science and Engineering, Springer, 2012.
10. Campbell, F.C., Manufacturing Processes for Advanced Composites, Elsevier, 2003.
11. Barbero, E.J., Introduction to Composite Materials Design, CRC Press, 2018.

**Reference Books:**



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- Kishore Debnath and Inderdeep Singh, Primary and Secondary Manufacturing of Polymer Matrix Composites, CRC Press, 2017.
- Thomas, S., Joseph, K., Malhotra, S.K., Goda, K. & Sreekala, M.S., Polymer Composites: Macro- and Microcomposites, Wiley-VCH, 2012.
- Lubin, G., Handbook of Composites, Springer, 1998.
- Ari-Gur, P., Processing of Polymer Matrix Composites, Momentum Press, 2014.
- Chung, D.D.L., Polymer Composites, Elsevier, 2012.



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**MDM II Biomass Processing Technologies**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<i>MDM II</i>	Biomass Processing Technologies	3	1	0	0	4	30	20	50	--	--

**Course outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Classify different types of biomasses, including lignocellulosic materials and bio-based wastes, and their roles in producing energy and chemicals.
2. Describe the principles of biorefineries and the economic aspects of process integration and product options.
3. Understand the processes for producing bioethanol and apply Monod kinetics to optimize fermentation.
4. Assess technologies like gasification and pyrolysis for energy production and resource recovery.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to Biomass Energy:</b> Global energy scenario and fossil fuel depletion. Biomass as a renewable energy source. Availability, abundance, and energy potential of biomass. Photosynthesis and energy production. Types of biomasses: virgin, waste (municipal, industrial, agricultural, forestry). Energy crops: maize, sorghum, sugarcane, perennial herbaceous crops, woody crops. Microalgae as biofuel feedstock. Challenges in improving biomass for biofuel conversion.	6
2	<b>Biorefinery Concepts and Feedstocks:</b> Introduction to biorefineries. Types of biorefineries and their feedstocks. Feedstock properties and selection. Economic aspects of biorefineries. Market demand, production costs, scalability. Case studies on successful biorefineries.	6
3	<b>Biomass Pretreatment and Conversion Processes:</b> Challenges in lignocellulosic biomass conversion. Pretreatment methods: acid, alkali, autohydrolysis, hybrid methods. Role of pretreatment in biomass processing. Physical and thermal conversion processes. Equipment, applications, and products. Thermal conversion products: syngas, biooil, biochar. Case studies on successful thermal conversion.	6
4	<b>Microbial Conversion and Biofuels:</b>	6



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	Microbial conversion processes. Biodiesel production from vegetable oils, microalgae, and syngas. Transesterification and biodiesel purification. Bioethanol and biobutanol production. Fermentation technologies and microorganisms. Biohydrogen and biogas production. Fuel cell integration. Biooil and biochar production and upgradation.	
<b>5</b>	<b>Organic Commodity Chemicals and Integrated Biorefineries:</b> Biomass as feedstock for organic chemicals. Production of lactic acid, succinic acid, acetic acid, PHA. Integrated biorefineries: corn, soybean, sugarcane, lignocellulosic, algal. Hybrid chemical and biological conversion processes. Techno-economic evaluation and life-cycle assessment of biorefineries.	<b>8</b>

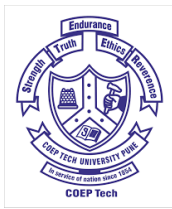
**Suggested learning resources:**

**Tutorials**

1. Overview of biomass energy, including global energy scenarios, biomass types, and their potential as a renewable resource.
2. Introduction to biorefinery concepts, types of feedstocks, economic aspects, and case studies of successful biorefineries.
3. Examination of biomass pretreatment methods, including acid and alkali processes, and their role in improving conversion efficiency.
4. Study of microbial conversion processes for biodiesel, bioethanol, biobutanol, and biohydrogen production, along with fermentation technologies.
5. Exploration of biomass as a feedstock for organic chemicals, including the production of lactic acid, succinic acid, and integrated bio refineries.

**Reference Books:**

1. "Biomass to Renewable Energy Processes" by Jay Cheng
2. "Biomass Processing Technologies" by Rajesh Kumar Sharma and Sandeep Kumar
3. "The Biorefinery: A Sustainable Approach to the Production of Fuels and Chemicals" by David S. Armenta
4. "Biofuels: Production and Utilization" by S. K. Singh and M. S. Ranjan
5. "Lignocellulosic Biomass for Bioenergy" by R. A. B. D. Bevan



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**VI-1: Mechanical System Design**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Mechanical System Design	3	0	2	1	4	30	20	50	50	50

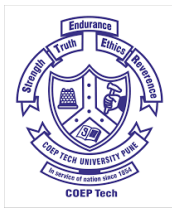
**Course Outcomes (COs):**

Students who successfully complete this course will have demonstrated an ability to:

1. Apply fundamental principles of fatigue and stress concentration while designing various components.
2. Design spur, helical, bevel and worm gears.
3. Select sliding and rolling contact bearings.
4. Explain and select different types of transmission drives.
5. Identify different types of vibrations and calculate the natural frequency of various systems.
6. Apply the balancing concept to various types of rotating and reciprocating machine elements.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Design against fluctuating load:</b> Stress concentration, fatigue failure, endurance limit, notch sensitivity, Goodman and Soderberg diagrams, and modified Goodman diagram.	6
2	<b>Bearings:</b> Working principle of hydrodynamic, hydrostatic bearing and rolling contact bearing. Classification of bearings. Selection of bearings from manufacturer's catalogue. Comparison of sliding contact and rolling contact bearings.	4
3	<b>Spur and helical Gears</b> Introduction to gears: Gear Selection, material selection, Basic modes of tooth failure, Gear Lubrication Methods. Spur Gears: Number of teeth and face width, Force analysis, Beam strength (Lewis) equation, Velocity factor, Service factor, Load concentration factor, Effective load on gear, Wear strength (Buckingham's) equation, Estimation of module based on beam and wear strength, Estimation of dynamic tooth load by velocity factor and Buckingham's equation. Types of helical , Terminology, Virtual number of teeth, and force analysis of Helical. Design of Helical based on Beam Strength, Wear strength	9



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4	<p><b>Bevel and Worm and worm Gears</b> Bevel gear, Terminology, Virtual number of teeth, and force analysis of the Bevel gear. Design of Straight Bevel Gear based on Beam Strength, Wear Strength . Worm and worm gear: Worm and worm gear terminology and proportions of worm and worm gears, Force analysis of worm gear drives, Friction in Worm gears, efficiency of worm gears, Worm and worm gear material, Strength and wear ratings of worm gears (Bending stress factor, speed factor, surface stress factor, zone factor) IS 1443-1974, Thermal consideration in worm gear drive, Types of failures in worm gear drives,</p>	9
5	<p><b>Design of Cylinders and Pressure Vessels</b> Design of Cylinders: Thin and thick cylinders, Lame's equation, Clavarino's and Bernie's equations, design of hydraulic and pneumatic cylinders, auto-frettage and compound cylinders,(No Derivation) gasketed joints in cylindrical vessels (No derivation). Design of Pressure vessel : Modes of failures in pressure vessels, unfired pressure vessels, classification of pressure vessels as per I. 2825 - categories and types of welded joints, weld joint efficiency, stresses induced in pressure vessels, materials for pressure vessel, thickness of cylindrical shells and design of end closures as per code, nozzles and openings in pressure vessels, reinforcement of openings in shell and end closures - area compensation method, types of vessel supports (theoretical treatment only).</p>	10

**Suggested learning resources:**

**Textbooks:**

1. Bhandari V.B. - "Design of Machine Elements", McGraw Hill Education (India) Ltd.
2. Shigley J.E. and Mischke C.R."Mechanical Engineering Design" McGraw Hill Publ. Co.Ltd.
3. IS 2825
4. M. V. Joshi and V. V. Mahajani, Process equipment design,
5. Brownell, L.E. and Young, E.H., Process Equipment Design, Wiley Eastern India Limited (1991).

**Reference Books:**

1. Spotts M.F. -"Design of Machine Elements", Prentice HallInternational.
2. Black P.H. and O. Eugene Adams - "Machine Design" - McGraw Hill BookCo.Ltd.
3. "Design Data" - P.S.G. College of Technology,Coimbatore.
4. Hannah and Stephens, "Mechanics of Machines: Advanced Theory and Examples", 1970, ISBN 0713132329 Edward Arnold London.
5. Hall A.S.; Holowenko A.R. and Laughlin H.G. - "Theory and Problems of Machine Design" - Schaum"s outline series.
6. ASME handbook on pressure vessels

**Weblinks:**

- <https://archive.nptel.ac.in/courses/112/105/112105125/>  
<https://archive.nptel.ac.in/courses/112/106/112106137/>



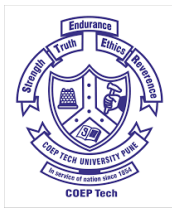
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**VI-1: Mechanical System Design Laboratory**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Mechanical System Design laboratory	3	0	2	0	4	-	-	-	50	50

Term work on:

1. A detail design report and working drawing of detail and assembly of the following
  - a. Spur with different profiles (involute and cycloid)
  - b. Machine tool gear box (three stage, 12 speed gear box)/ Automobile gear box/ differential gear box
  - c. Pressure vessel design



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**VI-2 : Computer Aided Design & Manufacturing**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Computer Aided Design and Manufacturing	3	0	2	1	4	30	20	50	50	50

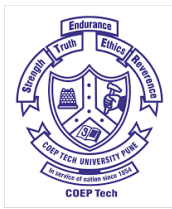
**Course Outcomes (COs):**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand the fundamentals of Geometric modelling.
2. Develop and manipulate the curves using algebraic, parametric equations.
3. Develop and manipulate the surfaces using parametric equations.
4. Develop and manipulate the solid models using different modelling approaches.
5. Apply various 2-D and 3-D geometric transformations.
6. Examine CNC program for production of components.

**Syllabus:**

Unit	Contents	Hrs.
1	Introduction: Definitions, Historical developments. Geometric Modelling, Nameable Un-nameable shapes, Affine and convex combination. Introduction to Equations - Implicit, explicit, parametric. Coordinate systems, Concepts of Torsion and Curvature, Osculating Plane, Binormal Vector. Concepts of Continuity.	4
2	Design of Curves: Cubic Hermite curves - Algebraic and geometric forms, Blending functions, Subdivision, Reparameterization, Truncating, Space curve, four point form, straight line and Composite Hermite curves ( $C^0$ & $G^0$ continuity). Spline curve, Bezier curves - Control polygons and Bernstein basis, De Casteljau algorithm, First and second derivatives at the ends, Continuity aspects. B-Spline Curves - periodic, open and non-uniform knot vectors and corresponding curves, Rational B-Splines, NURBS.	8
3	InDesign of surfaces: Hermite Surface - Algebraic and geometric form, tangent and twist vectors, blending functions, plane surface, cylindrical surface, ruled surface, surface of revolution. Bezier surface - Control net representation, Continuity aspects.	6



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<b>4</b>	Introduction to Solid Modelling - Topology, Generalized concept of boundary, set theory, Boolean operators (Union, Difference and Intersection). Set memberships classification, Euler and modified form of equations. Solid model construction: Boolean models, Instances and parameterised shapes, sweep, Boundary Representation (B-Rep), Constructive Solid Geometry (CSG), Generative design	<b>8</b>
<b>5</b>	Geometric versus coordinate transformations, 2D geometric transformations, Homogeneous coordinate Composite transformations, 3D transformations, Inverse transformations, geometric mapping, Examples of transformation applications in mechanical engineering	<b>5</b>
<b>6</b>	Introduction to NC/CNC/DNC machines, Classification of NC systems, Axis nomenclature, Interpolation, features of CNC controllers, Types of CNC machines, Construction features of CNC machines, Manual Part Programming, NC word format, Details of G and M codes, Canned cycles, subroutines and Do loops, Tool radius and length compensations. Exercises on CNC turning center and machining center programming	<b>6</b>

**Suggested learning resources:**

**Textbooks:**

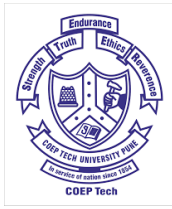
7. Michael E. Mortenson, Geometric Modeling, John Wiley & Sons; 2nd edition
8. Shigley J.E. and Mischke C.R. "Mechanical Engineering Design" McGraw Hill Publ. Co.Ltd.
9. Ibrahim Zeid, R Sivasubramanian, CAD CAM Theory And Practice, Ibrahim Zeid, McGraw Hill Education; 2nd edition
10. Marti Mantyla, Introduction to Solid Modelling, Computer Science Press.

**Reference Books:**

1. Gerald Farin, Curves and Surfaces for CAGD, Morgan Kaufmann Publishers In; 5th edition.
2. Les Piegl (Author), Wayne Tiller, The NURBS Book, Springer-Verlag.

**Weblinks:**

<https://archive.nptel.ac.in/courses/112/102/112102101/>



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**Computer Aided Design & Manufacturing Laboratory**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Computer Aided Design and Manufacturing	3	0	2	1	4	--	--	--	50	50

**Course Outcomes (COs):**

At the end of the course, students will demonstrate the ability to:

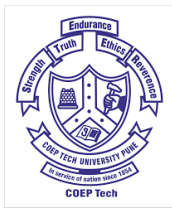
1. Develop 2D drawings and 3D solid/assembly models using CAD software.
2. Apply CAD tools for part and assembly design with parametric and feature-based modeling.
3. Generate CNC part programs for turning and milling using CAM software.
4. Simulate and validate tool paths for manufacturing processes.
5. Operate CNC machine tools for basic machining operations.
6. Integrate CAD and CAM tools for computer-aided process planning and manufacturing applications.

**Practical Course Strategy:**

1. Students will be expected to work in teams of two or three.
2. Lab-work will be assigned each week. The lab-work will consist of study as well as designing curves & surfaces. Students are expected to complete the homework in teams. However, each student is required to submit his/her homework individually.
3. The team will be required to simulate their work on MATLAB or any other coding based platforms. A report showing the detailed calculations and results of representations must be performed for each assigned team.
4. Students will be expected to write simple codes (in MATLAB, JULIA, PYTHON, etc.) for specific problem in order to get a better grasp of the material covered in the course.
5. Students are expected to participate actively in the course. 5% of the final grade will be based on class participation.
6. Some typical design based assignments are provided for students can familiarize themselves with coding environment. The course instructor has the freedom to add on more design and CAM based lab-work as and when required\*\*.

**Syllabus:**

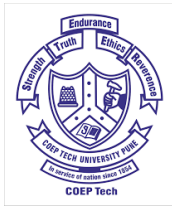
Sr. No.	Practical Lab Work List
1.	Formation of varying degree curves and studying their nature.
2.	Study of Known shapes of curves and modelling them by Algebraic Forms
3.	Study of Known shapes of curves and modelling them by Parametric Forms



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4.	Time Study of various parametric forms and algebraic of circle
5.	Formation of Hermite curves by – a. Varying Magnitude of a single tangent vector in a specified range. b. Varying Magnitude of a both tangent vectors in a specified range. c. Varying Direction Cosines which impact direction of tangent vectors.
6.	Study of Bezier Curve by – a. Reversal of control points defined b. Formation of close Bezier Curve with desired continuity $C^0$ , $C^1$ c. Repeating Certain control points – Multiplicity study
7.	Coding of B-Spline Curves a. Studying impact by Varying the control points b. Studying impact by Varying Degree of Curve
8.	Coding for formation of Surfaces a. Ruled Surfaces / Tabulated Surface b. Surface of Revolution (Sphere, Cylindrical, Arbitrary Curve rotated about and axis) c. Bezier Surface
9.	Construct a Boolean Tree Structure for a given 3d object with all the instances, scaling, rotation performed on the primitives utilized for the formation of object.
10.	Assignment to check for Affine transformation properties of curves. a. Translation of curves / Known Figure b. Rotation of curves / Known Figure c. Scaling of Curves / Known Figure
11.	Generative Design of Knuckle Joint, Bracket or any other component Under Realistic Load Conditions (Fusion 360 or other licensed software oncampus)
12.	Assignment on CNC Coding for few specific workpieces.



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**VI-3: Fluid Machinery**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Fluid Machinery	3	0	2	0	4	30	20	50	50	50

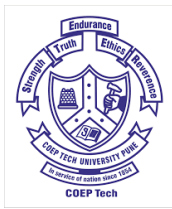
**Course Outcomes (COs):**

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

1. Design and evaluate performance of various Turbo Machines.
2. Apply laws of fluid mechanics and governing equations for Turbo Machinery.
3. Describe working of various components used for hydraulic & pneumatic systems.
4. Design various hydraulic and pneumatic systems for industrial applications.

**Syllabus :**

Unit	Contents	Hrs.
1	Impact of Jet: Force of fluid flow in nozzles, inclined plate, fixed and moving vanes, work done, efficiency. Calculation force exerted on series of moving vanes, velocity diagrams & their analysis.	05
2	Introduction and classification of hydrodynamic machines. Impulse Turbine: Principle and Construction, Working, velocity triangles, Power, efficiencies, Number of buckets & jets, Non-dimension parameters. Performance characteristics.	06
3	Reaction Turbine: Francis & Kaplan Turbines-construction and Working, draft tubes and its efficiency, Velocity diameter & analysis requirement of head & flow. cavitations . concept of unit speed, unit head , specific speed Governing, Performance & Selection . Governing of turbines	08
4	<b>Centrifugal pumps:</b> Working principles, Construction, Types, Various heads, multistage pumps, Velocity triangles, Minimum starting speed, cavitation, Maximum permissible suction head (MPSH) and Net positive suction head (NPSH). Methods of priming, calculations of efficiencies, Discharge, Blade angles, Head, Power required Impeller dimensions etc. Specific speed and performance characteristics of pumps.	08



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5	Reciprocating pumps: Working principle, types, Indicator diagram, effect of air vessel, multiple cylinder pumps. Introduction to Air lift pump, hydraulic ram, deep bore well pump, propeller pump submersible pump, Gear pump ( restricted to working principle and construction )	07
6	Introduction to Fluid power : constructional and working principle of hydraulic and pneumatic circuits. Basic nomenclature, function and symbols of various components used in hydraulic and pneumatic circuits.	06

**Suggested learning resources:**

**Textbooks:**

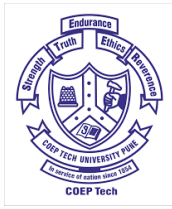
1. Modi & Seth, Fluid Mechanics & Fluid Machinery, Standard Book House, 2002.
2. R. K. Rajput, A Textbook of Fluid Mechanics and Hydraulic Machines, S. Chand Co. Ltd., 2002.
3. Jagdish Lal, Hydraulic Machines Including Fluidics, Metropolitan Book.
4. Esposito, *Fluid Power with Applications*, Prentice Hall International, 1998.
1. J. J. Pipenger, *Industrial Hydraulics*, McGraw Hill, New York, 1981.

**Reference Books:**

1. S. R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGraw-Hill, New Delhi, 2000.
2. S. R. Majumdar, Oil Hydraulic Systems and Maintenance, Tata McGraw-Hill, New Delhi, 2001.
3. ISO-1219:1988, Fluid Systems and Components.
4. Franklin Yeaple, Hydraulics and Pneumatics: Power and Control, McGraw Hill Book Co., New York, 1966.

**Weblinks:**

<https://archive.nptel.ac.in/courses/112/104/112104117/>



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**VI-3: Fluid Machinery Laboratory**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Fluid Machinery Laboratory	3	0	2	0	4	--	--	--	--	100

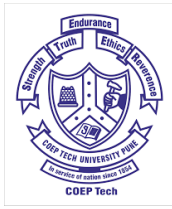
**Course Outcomes (COs):**

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

1. Evaluate performance of hydraulic turbines.
2. Evaluate performance of centrifugal pump.
3. Describe the construction, working and application of components used in hydraulic and pneumatic circuits.
4. Design various hydraulic and pneumatic circuits.

**Syllabus:**

Unit	Contents	Hrs.
<b>1</b>	<b>List of Experiments:</b> 1. Study and trial on Pelton Turbine for performance testing. 2. Study and trial on Francis Turbine for performance testing. 3. Study and trial on Kaplan Turbine for performance testing. 4. Study & trial on centrifugal pump for performance testing. 5. Study & trial on gear pump for performance testing. 6. Hydraulic and pneumatic circuits for some application 8. Demonstration of working of Hydraulic Press 9. Demonstration of cut sections of various Hydraulic Components.	2 each



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**PEC-6-1: Advanced Finite Element Method**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Advanced Finite Element Method	3	1	0	0	4	30	20	-	-	-

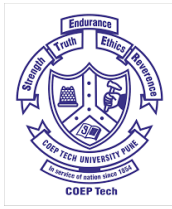
**Course Outcomes (COs):**

Students who successfully complete this course will have demonstrated an ability to:

1. Analyze 3D problems in heat transfer, elasticity, and fluid flow using FEM.
2. Solve transient and coupled field problems with proper time integration and FEM techniques.
3. Apply FEM to bending of plates and shells and validate results.
4. Classify and model various types of non-linearity in FEM.
5. Solve realistic non-linear FEM problems using robust numerical strategies.
6. Implement and validate non-linear simulations for real-world problems.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>3D Finite Element Analysis</b> Solid elements (tetrahedral, hexahedral), shape functions, numerical integration FEM formulations for physics of 3D heat conduction, elasticity, incompressible materials and viscous flow. Babuska- Brezzi Condition	6
2	<b>Transient and Coupled Field Problems</b> Time-dependent FEM (structural dynamics, conduction, convection, diffusion) Coupled thermo-mechanical and multi-physics problems	6
3	<b>Plate and Shell Bending</b> Need for a higher order theory, Kirchhoff and Mindlin plate theories, shell element modeling. Applications to aerospace, automotive, and civil systems	8
4	<b>Introduction to Non-Linear FEA</b> Geometric, material, and contact non-linearity, Various strain and stress measures for non-linearity analysis. Conversion of engineering stress -strain curve to True stress strain curve , Johnson-Cook plasticity model, Total and Updated Lagrangian formulations	6
5	<b>Solving Non-Linear Problems</b> Non-Linear Bending of Beams, Large deformation, plasticity, hyperelasticity, viscoelasticity, Frictional/contact problems and nonlinear solution algorithms	8



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<b>6</b>	<b>Applications and Case Studies</b> Simulations in Solvers (ANSYS, Abaqus, etc.): metal forming, crash, biomedical, NVH, Fatigue and Crash Solver settings, mesh convergence, interpretation	<b>8</b>
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**Suggested learning resources:**

**Textbooks:**

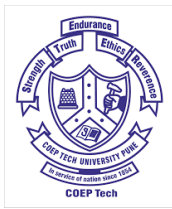
1. Introduction to Finite Element Method By J.N .Reddy.
2. Cook R.D. “Concepts and applications of finite element analysis” Wiley, New York, 1981.
3. “Practical Finite Element Analysis”, First Ed., N. Gokhale, S. S. Deshpande, S. V. Bedekar, A. N. Thite, Published By - Finite to Infinite, Pune, India.

**Reference Books:**

1. An Introduction to Nonlinear Finite Element Analysis by J. N. Reddy, Oxford University Press, 2004, ISBN 0198525
2. The Finite Element Method: Linear Static and Dynamic Finite Element Analysis by T. J. R. Hughes, Dover Publications, 2000.29X.
3. Desai C.S. and J.F. Abel “Introduction to the finite element method.” New York, Van Nostrand Reinhold, 1972.

**Weblinks:**

**<https://nptel.ac.in/courses/112106130>**



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**PEC-6-1: Advanced Finite Element Method Laboratory**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Advanced Finite Element Method Laboratory	3	1	0	0	4	-	-	-	100	

**Course Outcomes (COs):**

Students who successfully complete this course will have demonstrated an ability to:

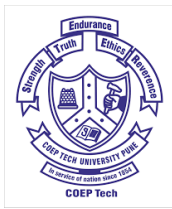
1. Formulate and implement FEM solutions for 1D structural and thermal problems using MATLAB/Python.
2. Develop and analyze FEM models using commercial software (ANSYS/ABAQUS).
3. Evaluate the effect of mesh density, element type, and boundary conditions on solution accuracy.
4. Apply FEM to 2D problems such as plane stress, plane strain, and axisymmetric structures.
5. Analyze modal, dynamic, and thermal problems using FEM software.
6. Validate FEM solutions with analytical or benchmark results and interpret discrepancies.

**Practical Course Strategy**

1. Students will be expected to work in teams of two or three.
2. Lab-work will be assigned each week. The Lab-work will consist of mathematical derivations and numerical simulations. Students are expected to complete the homework in teams. However, each student is required to submit his/her homework individually.
1. The team will be required to simulate their work on ANSYS or similar licensed solvers. A report showing the detailed calculations and results of simulations performed will be required for each assigned team.
2. Students are expected to participate actively in the course. 5% of the final grade will be based on class participation.
3. Some typical simulation based assignments are provided for students to get hold of licensed FE solvers. The course instructor has the freedom to add or change lab-work as and when required\*\*.

**Suggestive List of Practical / Lab Work\*\***

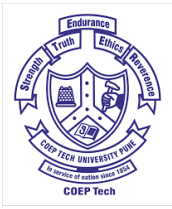
Practical No.	Title	Objective
1	3D Heat Conduction Analysis in a Cubic Block	Apply 3D FEM to solve a steady-state thermal conduction problem using brick elements.



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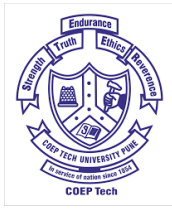
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Practical No.	Title	Objective
2	Structural Analysis of a 3D Bracket under Load	Analyze 3D elasticity problem with stress-strain evaluation using isoparametric elements.
3	Transient Thermal Response of a Heat Sink	Model and analyze transient heat conduction in a fin using time-stepping algorithms.
4	Coupled Thermo-Mechanical Analysis of a Bimetallic Strip	Simulate thermal expansion and stress in a bimetallic structure due to heating.
5	Bending of a Simply Supported Plate	Use Mindlin plate theory to analyze deflection and bending stresses in a square plate.
6	Bending of a cantilver beam into a circle	Understand small and large deformations and associated large rotations .
6	Large Deformation Analysis of a Rubber Seal	Demonstrate geometric and material non-linearity through hyperelastic modeling.
7	Elasto-Plastic Analysis of a Notched Specimen under Tension	Analyze non-linear stress-strain behavior and plastic deformation using iterative solvers.
8	Modal and Crash Simulation of a Car FUPD,RUPD System ( FUPD : Front Under-run Protection Device and Rear Under run Protection Device )	Perform NVH modal analysis and crash simulation for energy absorption and failure study.
9	Weld Joint Simulation under Static Loading	Model weld geometry, simulate stress concentration and plasticity at the weld zone.
10	Pre-Tensioned Bolt Assembly Analysis	Simulate bolt preload using contact and pretension elements, study clamping effects.
11	Rolling Element Bearing Load Distribution	Analyze contact forces and deformation in a ball or roller bearing under radial load.
12	Shrink Fit Simulation between Shaft and Hub	Model thermal expansion to simulate interference fit; evaluate stress distribution.



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<b>Practical No.</b>	<b>Title</b>	<b>Objective</b>
13	Low-Cycle Fatigue Analysis Using Strain-Life ( $\epsilon$ -N) Approach	Simulate cyclic loading on a notched component using the strain-life method; account for plastic strain.
14	High-Cycle Fatigue Using Non-Linear Stress-Life (S-N) Curves	Use non-linear S-N data to predict fatigue life in elastic regime under varying amplitude loading.
15	Weld Fatigue Analysis with Structural Hot Spot Method	Evaluate fatigue at weld toe/root using hot spot stress method; ideal for welded beam structures.
16	Multi-Axial Fatigue of a Shaft Under Combined Bending and Torsion	Apply critical plane-based multi-axial fatigue models to evaluate life under complex stress state.



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**PEC-6.2: Industrial Hydraulics and Pneumatics**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Industrial Hydraulics and Pneumatics	3	1	0	0	4	30	20	50	--	--

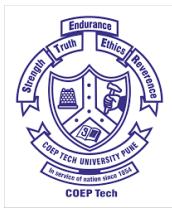
**Course Outcomes (COs):**

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

1. Working principle of various components used for hydraulic & pneumatic
2. Identify various components of hydraulic & pneumatic systems.
3. Ability to select appropriate components required for hydraulic and pneumatic systems.
4. Ability to design hydraulic and pneumatic system for industrial applications.
5. Ability to understand industrial applications of hydraulic and pneumatic system.
6. Troubleshooting of hydraulic & pneumatic circuits

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to Hydraulics and Pneumatics:</b> Introduction to oil hydraulics and pneumatics, their structure, advantages and limitations. Properties of fluids, Fluids for hydraulic systems, governing laws. Distribution of fluid power, ISO symbols, and energy losses in hydraulic systems.	8
2	<b>Pumps &amp; Power Units:</b> Types, classification, principle of working and constructional details of vane pumps, gear pumps, radial and axial plunger pumps, screw pumps, power and efficiency calculations, characteristics curves, selection of pumps for hydraulic Power transmission. <b>Power units and accessories:</b> Types of power units, reservoir assembly, constructional details, pressure switches, temperature switches. <b>Accumulators:</b> Types, selection/ design procedure, applications of accumulators. Types of Intensifiers, Pressure switches /sensors, Temperature switches/sensors, Level sensors.	8



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3	<p><b>Hydraulic Actuators:</b> (i) Linear and Rotary. (ii) Hydraulic motors - Types- Vane, Gear, Piston types, radial piston. (iii) Methods of control of acceleration, deceleration. (iv) Types of cylinders and mountings. (v) Calculation of piston velocity, thrust under static and dynamic applications, considering friction, inertia loads. (vi) Design considerations for cylinders. Cushioning of cylinder. (Numerical treatment).</p>	8
4	<p><b>Industrial Circuits:</b> Simple reciprocating, Regenerative, Speed control (Meter in, Meter out and bleed off), Sequencing, Synchronization, transverse and feed, circuit for riveting machine, automatic reciprocating, fail safe circuit, counter balance circuit, actuator locking, circuit for hydraulic press, unloading circuit (Numerical treatment), motor breaking circuit.</p>	8
5	<p><b>Pneumatics:</b> Principle of Pneumatics: (i) Laws of compression, types of compressors, selection of compressors. (ii) Comparison of Pneumatic with Hydraulic power transmissions. (iii) Types of filters, regulators, lubricators, mufflers, and dryers. (iv) Pressure regulating valves, (v) Direction control valves, two-way, three way, four-way valves. Solenoid operated valves, push button, lever control valves. (vi) Speed regulating Methods used in Pneumatics. (vii) Pneumatic actuators-rotary, reciprocating. (viii) Air motors- radial piston, vane, axial piston (ix) Basic pneumatic circuit, selection of components, (x) Application of pneumatics in low cost automation and in industrial automation. Introduction to vacuum and vacuum measurement, Vacuum pumps, types, introduction to vacuum sensors and valves. Industrial application of vacuum.</p>	6
6	<p><b>System Design:</b> Design of hydraulic/pneumatic circuit for practical application, Selection of different components such as reservoir, various valves, actuators, filters, pumps based on design.</p>	5

**Suggested learning resources:**

**Textbooks:**

1. Esposito, Fluid Power with application, Prentice Hall
2. Majumdar S.R, Oil Hydraulic system- Principle and maintenance , Tata McGraw Hill
3. Majumdar S.R, Pneumatics Systems Principles and Maintenance , Tata McGraw Hill
4. H.L. Stewart, Hydraulics and Pneumatics , Taraporewala Publication GMH1'

**Reference Books:**

1. J. J. Pipenger, Industrial Hydraulics, McGraw Hill
5. Pinches, Industrial Fluid Power, Prentice Hall
6. D. A. Pease, Basic Fluid Power, Prentice Hall

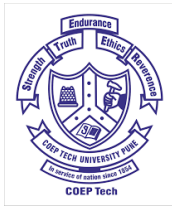


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7. B. Lall, Oil Hydraulics, International Literature Association
8. Yeaple, Fluid Power Design Handbook
9. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books.
10. ISO - 1219, Fluid Systems and components, Graphic Symbols
11. Michael J, Pinches and Ashby J. G, "Power Hydraulics", Prentice Hall.
12. Dr. R.K. Bansal, Fluid Mechanics, Laxmi Publication (P) Ltd.
13. Product Manuals and books from Vickers/ Eaton, FESTO, SMC pneumatics

**Weblinks:**

**<https://archive.nptel.ac.in/courses/112/105/112105047/>**



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**PEC-6.3 : Micro and Nano Machining**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Micro and Nano Machining	3	1	0	0	4	30	20	50	--	--

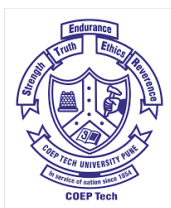
**Course outcomes:**

Upon completion of the course, students will be able to:

1. Understand the concept of micromachining and its applications
2. Understand difference between micro and macro machining and importance of non-traditional methods for micromachining
3. Understanding principles and processes of different non-traditional processes for micro machining
4. Understanding principles and processes of mechanical micro machining processes
5. Understanding fundamentals, tools and processes for nanotechnology.
6. Understanding the application of nanotechnology

**Syllabus:**

Unit	Contents	Hrs.
<b>1</b>	<p><b>Introduction to micro machining</b>            Miniaturization, Trend of miniaturization, basic concepts in machining, applications- Bio medical and BioMEMS, watchmaker and jewelry, automotive, aerospace, telecommunication and information technology, Classification of micromachining-Subtractive, additive, mass containing, Joining, MEMS Vs mechanical micromachining, mechanical micromachining Vs ultra precision machining, Operator's skill and sensing in micro machining, things to remember in micro machining  <b>Scaling laws</b>-Different types of scale reduction of a system, scaling laws, Types of scaling laws, scaling factor</p>	<b>8</b>



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<b>2</b>	<p><b>Difference between macro and micro machining</b></p> <p>Size effect in micro cutting- grain size to chip thickness, uncut chip thickness to cutting edge radius, material flow angle of four distinct mechanisms, metal behavior at micro scale machining, failure of ductile, brittle , alloys, anisotropic materials, burr formation-material properties, burr reduction strategies, burr reduction by supporting materials, deburring, Surface roughness- effect of material properties, tool wear, key aspects in micro machining, advantages micro mechanical machining</p> <p>Importance of non-traditional machining in micro machining domain, Classification of Non-traditional Micromachining, Thermal Micromachining, Chemical and Electrochemical Micromachining, Hybrid Micromachining</p>	<b>8</b>
<b>3</b>	<p>Introduction to Different Non-traditional Micromachining Processes- Micro Ultrasonic Machining (USM), Micro Electro-Discharge Machining (EDM), Micro Laser Beam Machining (LBM), Micro Ion Beam Machining (IBM), Micro Electron Beam Machining (EBM), Micro Chemical Machining (CM), Micro Electrochemical Machining (ECM), Introduction to Various Hybrid Micromachining- Electrochemical Grinding (ECG), Electrochemical Discharge Micromachining, Abrasive Assisted Micromachining, Ultrasonic Assisted Micromachining, Laser Assisted Micromachining</p> <p><b>Mechanical micromachining- Micro tools fabrication and Micro machines</b></p> <p>Micro cutting tools, required properties of tool, micro tool fabrication processes</p> <p><b>Diamond turning</b></p> <p>Need of diamond turning, applications of diamond turning process, classification of diamond turning process, difference with conventional machines, features of Diamond turning machines</p>	<b>8</b>
<b>4</b>	<p><b>Nanotechnology</b></p> <p>Fundamentals behind nanotechnology, tools of nanotechnology- tools for measuring nanostructures-scanning probe instruments, spectroscopy, electrochemistry, electron microscopy and tools to make nanostructures-nanoscale lithography, , dip pen lithography, E-beam lithography, molecular synthesis, nanoscale crystal growth, polymerization, nano bricks and building blocks</p>	<b>6</b>
<b>5</b>	<p><b>Applications for nanotechnology</b></p> <p>Smart materials-self healing structures, recognition, separation, catalysts, heterogeneous nanostructures and composites</p> <p>Sensors- natural nano scale sensors, electromagnetic sensors, biosensors</p> <p>Biomedical applications- drugs delivery, photodynamic therapy, molecular motors</p>	<b>6</b>



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**Suggested learning resources:**

**Textbooks:**

1. V K Jain, "Introduction to micromachining", Narosa Publication
2. Balasubramaniam et al, "Diamond turn machining: theory and practice (2017)", CRC Press USA
3. Charles P. Poole Jr and Frank J. Owens, "Introduction to Nanotechnology", Wiley-India

**Reference Books:**

1. Cheng & Huo, "Micro-cutting: Fundamentals and applications", Wiley
2. Dornfeld and Lee, "Precision Manufacturing", Springer
3. Mark Ratner and Daniel Ratner, "Nanotechnology", Pearson Education
4. Lynn E. Foster, "Nanotechnology-Science, Innovation and Opportunity", Pearson Education

**Weblinks:**

**<https://archive.nptel.ac.in/courses/117/108/102108078/>**



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**PEC-6.4: Biomass Energy Conversion**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Biomass Energy Conversion	3	1	0	0	4	30	20	50	--	--

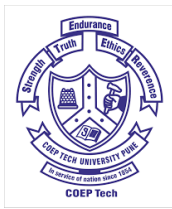
**Course Outcomes:**

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

1. Identify and classify various biomass sources and their energy potential.
2. Explain thermochemical and biochemical biomass conversion technologies.
3. Design and analyze biomass-based energy systems for thermal and power applications.
4. Evaluate the environmental impact and policy frameworks related to biomass energy.
5. Investigate real-world biomass utilization projects and propose improvements.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Biomass Resources and Classification:</b> Overview of biomass: Agricultural residues, forestry waste, energy crops, Properties: Calorific value, moisture content, ash composition, Biomass collection, transportation, preprocessing, densification (briquettes, pellets)	8
2	<b>Thermochemical Conversion Technologies:</b> Combustion systems and designs, Pyrolysis: Mechanisms, types (slow, fast, flash), Gasification: Fixed bed, fluidized bed, entrained flow Biochar, syngas and bio-oil analysis, Reactor design and efficiency calculations	7
3	<b>Biochemical Conversion Technologies:</b> Biomass cookstoves, boilers, and dryers, Combined Heat and Power (CHP) from biomass, Co-firing with coal in thermal power plants, Distributed power generation for rural areas	7
4	<b>Biomass Energy Systems and Applications:</b> Biomass cookstoves, boilers, and dryers, Combined Heat and Power (CHP) from biomass, Co-firing with coal in thermal power plants, Distributed power generation for rural areas	6



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<b>5</b>	<b>Environmental and Policy Aspects:</b> Emissions and pollution control, Carbon neutrality and LCA of biomass systems, Government policies (MNRE schemes, renewable obligations) , Case studies: Bagasse-based plants, rice husk gasifiers, biogas grids	<b>6</b>
<b>6</b>	<b>Integration and Deployment of Deep Learning Models:</b> Model Deployment Strategies: Edge Computing, Cloud Services, Tools: TensorFlow Lite, ONNX, Docker, Case Studies: Real-world Applications in Mechanical Engineering Ethical Considerations and Model Interpretability	<b>8</b>

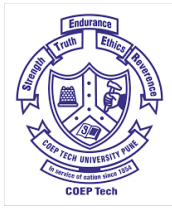
**Suggested learning resources:**

**Textbooks:**

1. "Biomass to Renewable Energy Processes" – Jay Cheng, CRC Press
2. "Biomass Conversion and Technology" – C. Y. Wereko-Brobby & E. B. Hagan, Wiley
3. "Biomass Gasification, Pyrolysis and Torrefaction: Practical Design and Theory" – Prabir Basu, Academic Press
1. "Bioenergy: Biomass to Biofuels" – Anju Dahiya, Academic Press
2. "Biomass Conversion: The Interface of Biotechnology, Chemistry and Materials Science" – S. M. Reddy, Springer.

**Reference Books:**

1. "Handbook of Biomass Downdraft Gasifier Engine Systems" – Thomas B. Reed, SERI
2. "Renewable Energy: Power for a Sustainable Future" – Godfrey Boyle, Oxford University Press
3. "Biomass for Energy and the Environment" – P. Chartier et al., Elsevier.
4. "Biofuels: Biotechnology, Chemistry, and Sustainable Development" – D. M. Mousdale, CRC Press



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**PEC-6.5: Design for Fatigue and Fracture**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Design for Fatigue and Fracture	3	1	0	0	4	30	20	50	--	--

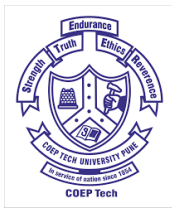
**Course Outcomes:**

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

1. Understand fatigue mechanisms and design principles under cyclic loads.
2. Apply fatigue failure theories for fluctuating load conditions.
3. Analyze crack formation and growth using fracture mechanics.
4. Estimate component life based on fatigue and crack growth models.
5. Utilize experimental and digital tools for fatigue and fracture analysis.
6. Interpret failures and optimize design using case studies and industrial standards.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Fundamentals of Fatigue</b> Stress-life (S-N) approach, High-cycle vs Low-cycle fatigue, Fatigue loading types: fully reversed, fluctuating, random, Stress concentration and notch sensitivity, Material fatigue behavior in AM (additive manufacturing) components.	5
2	<b>Design for Fatigue Strength</b> Mean stress correction theories: Goodman, Soderberg, Gerber Design of components under fluctuating loads, Cumulative damage and Miner's Rule, Influence of surface finish, size, and reliability, AI-based fatigue life prediction, load spectrum analysis	5
3	<b>Fracture Mechanics – Fundamentals:</b> Modes of fracture: brittle, ductile, Griffith theory of brittle fracture, Fracture toughness, KIC and critical crack length, Introduction to Linear Elastic Fracture Mechanics (LEFM), Fracture in composites and biomaterials	5



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4	<b>Crack Propagation and Fatigue Crack Growth</b> Fatigue crack initiation and growth stages, Paris' law and crack growth rate Threshold stress intensity factor, Life estimation from crack growth data Fracture analysis in layered materials and thin films	5
5	<b>Experimental Techniques and Digital Tools</b> Fatigue testing machines and methods (rotating beam, axial loading), Fractography (SEM analysis), Digital Image Correlation (DIC), Finite Element Analysis for fatigue and fracture simulation, Machine learning for failure prediction, digital twins in testing	5
6	<b>Case Studies and Modern Applications</b> Fatigue in gears, shafts, pressure vessels, aircraft structures, Fracture in welded joints and composite structures, Fatigue failure analysis (field failure case studies), Industry standards: ASTM, ISO, ASME, Design-for-durability in EVs, wind turbine blades, biomedical implants	5

**Suggested learning resources:**

**Textbooks:**

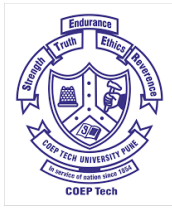
1. Mechanical Metallurgy – George E. Dieter, McGraw Hill
2. Metal Fatigue in Engineering – Ralph I. Stephens, Ali Fatemi, Robert R. Stephens, Henry O. Fuchs, Wiley
3. Fundamentals of Metal Fatigue Analysis – Julie A. Bannantine, Jess J. Comer, James L. Handrock, Prentice Hall
4. Elements of Fracture Mechanics – Prashant Kumar, Tata McGraw Hill
5. Fracture Mechanics: Fundamentals and Applications – T. L. Anderson, CRC Press

**Reference Books:**

1. “Handbook of Biomass Downdraft Gasifier Engine Systems” – Thomas B. Reed, SERI
5. Anderson, T.L., Fracture Mechanics: Fundamentals and Applications, CRC Press
6. Juvinall & Marshek, Fundamentals of Machine Component Design, Wiley
7. Dieter, G.E., Mechanical Metallurgy, McGraw-Hill
8. Bannantine, Comer & Handrock, Fundamentals of Metal Fatigue Analysis, Prentice Hall
9. Research papers on fatigue in AM materials, fracture in composites, AI in durability – IEEE, Elsevier

**Weblinks:**

[https://onlinecourses.nptel.ac.in/noc22\\_mm42/preview](https://onlinecourses.nptel.ac.in/noc22_mm42/preview)



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**PEC-6.6 : Computational Fluid Dynamics**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Computational Fluid Dynamics	3	1	0	0	4	30	20	50	--	--

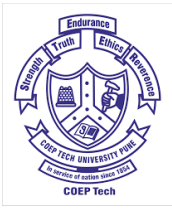
**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Understand the discretization procedure of the governing equations
2. Prepare the problem definition of a given fluid flow heat transfer problem
3. Decide the governing equations, boundary conditions, initial conditions etc for the given problem
4. To carry out the simulations and obtain the results in terms of dependent variables
5. Analyze the CFD results through post processing to obtain engineering parameters

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to CFD:</b> Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations.	6
2	<b>Governing Equations:</b> Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy.	7
3	<b>Finite Volume Method:</b> Domain discretizations, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach	6
4	<b>Geometry Modelling and Grid Generation:</b> Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance	7
5	<b>Methodology of CFDHT:</b> Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation	8
6	<b>Solution of N-S Equations for Incompressible Flows:</b> Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows	8



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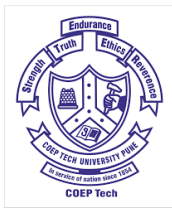
**Suggested learning resources:**

**Reference Books:**

1. John A. Anderson, Jr., Computational Fluid Dynamics, The Basic with applications by John A. Anderson, Jr., McGraw Hill International editions, Mechanical Engineering series.
2. Dr. Suhas Patankar, Numerical Heat Transfer and Fluid Flow, Crc Press.
3. H.K. Versteeg, W.Malalasekera, Introduction to Computational Fluid Dynamics, An: The Finite Volume Method, PHI; 2nd edition.
4. Ferziger and Peric, Computational Methods for Fluid Dynamics, Springer Publication.
5. Chuen-Yen Chow, An Introduction to Computational Fluid Mechanics, Seminole Pub Co.
6. Muralidhar K (Author), Sundararajan, Computational Fluid Flow & Heat Transfer, Narosa Publishing House.

**Weblinks:**

**<https://nptel.ac.in/courses/112105045>**



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**PEC- 6.7: Digital Manufacturing**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Digital Manufacturing	3	1	0	0	4	30	20	50	--	--

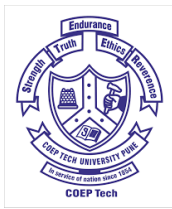
**Course Outcomes (COs):**

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

1. Explain the principles and components of digital manufacturing systems.
2. Utilize digital tools and technologies for manufacturing applications.
3. Analyze manufacturing data to improve processes and product quality.
4. Implement digital twins and simulation techniques to applications.
5. Understanding the smart manufacturing solutions in various industrial contexts.
6. Integrate digital manufacturing tools for manufacturing projects.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to Digital Manufacturing:</b> Definition and evolution of digital manufacturing, Key concepts and terminology, Differences between traditional and digital manufacturing, Overview of Industry 4.0	6
2	<b>Digital Manufacturing Technologies:</b> Additive Manufacturing (3D Printing), Computer Numerical Control (CNC) Machines, Robotics and Automation, Internet of Things (IoT) in Manufacturing, Cyber-Physical Systems	6
3	<b>Data Analytics in Manufacturing:</b> Importance of data in manufacturing, Data collection and management, Big Data Analytics, Predictive Maintenance, Case studies on data-driven manufacturing.	6
4	<b>Digital Twins and Simulation:</b> Concept of Digital Twins, Applications of Digital Twins in manufacturing, Simulation techniques and tools, Virtual commissioning of manufacturing systems	6
5	<b>Smart Manufacturing Systems:</b> Characteristics of smart manufacturing, Smart factories and their components, Real-time monitoring and control, Role of AI and Machine Learning in Smart Manufacturing	6



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6	<b>Integration and Implementation:</b> Integration of digital technologies in existing systems, Challenges and solutions in digital manufacturing implementation, Case studies of successful digital manufacturing projects, Future trends and developments.	6
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**Suggested learning resources:**

**Textbooks:**

1. Groover, M. P. - Automation, Production Systems, and Computer-Integrated Manufacturing (Pearson)
2. Tönshoff, H.K., & Denkena, B. - Digital Manufacturing (Springer)
6. Tao, F., Cheng, Y., & Zhang, M. - *Digital Twin Driven Smart Manufacturing* (Elsevier)
7. Alasdair Gilchrist - *Industry 4.0: The Industrial Internet of Things*

**Reference Books:**

1. Tien-Chien Chang - Digital Manufacturing: In Design and Production
10. Michael Grieves - Digital Twin: Manufacturing Excellence through Virtual Factory Replication
11. Jay Lee, Behrad Bagheri, & Hung-An Kao - A Cyber-Physical Systems Approach to Smart Manufacturing Dieter, G.E., Mechanical Metallurgy, McGraw-Hill
12. Sharma, R. & Kundra, T. K. - Introduction to Digital Manufacturing (McGraw-Hill)
13. Kuehn, W. - Digital Factory: Integration of Simulation & Virtual Reality (Springer)
14. Zhang, X. & Tao, F. - Smart Manufacturing: Concepts and Methods (Elsevier)

**ONLINE/E RESOURCES:**

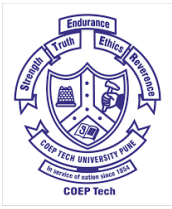
Related NPTEL/Swayam Courses:

1. Automation in Manufacturing (IIT Kanpur)
2. Computer Integrated Manufacturing (IIT Roorkee)

**List of Practicals:**

ANY EIGHT experiments to be conducted during the course.

1. 3D Printing Basics: Print simple geometric shapes to understand machine setup, material loading, and basic operation.
2. CNC Machining Introduction: Create a basic part using CNC milling or turning with simple tool paths.
3. Laser Cutting and Engraving: Design and cut/engrave basic shapes or patterns on various materials like wood or acrylic.
4. Basic Robotics Programming: Program a robotic arm to perform simple pick-and-place operations.
5. Simulation of Manufacturing Processes: Use simulation software (e.g., Arena or Simul8) to model a basic production line.
6. IoT in Manufacturing: Set up a simple IoT device to monitor environmental conditions (temperature, humidity) in a manufacturing setup.
7. Digital Twin Creation: Create a digital model of a simple physical object using CAD software and link it to real-time data.
8. Predictive Maintenance: Analyze sensor data to predict and schedule maintenance for a piece of equipment.

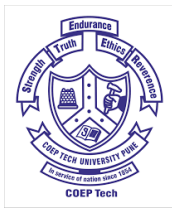


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9. Virtual Reality (VR) in Manufacturing: Explore a virtual factory setup using basic VR tools and software.
10. Data Analytics for Manufacturing: Use basic statistical tools to analyze production data and identify trends or anomalies.

**Weblinks:** [https://onlinecourses.nptel.ac.in/noc21\\_mg83/preview](https://onlinecourses.nptel.ac.in/noc21_mg83/preview)

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**PEC- 6-8: Automotive energy conversion**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Automotive Energy Conversion	3	1	0	0	4	30	20	50	--	--

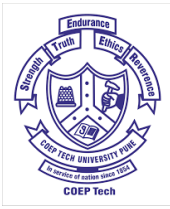
**Course Outcomes:**

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

1. Understand the fundamental principles of energy conversion in automotive systems.
2. Analyze various energy conversion devices and their applications in vehicles.
3. Evaluate the efficiency and environmental impact of different automotive energy systems.
4. Explore emerging technologies in automotive energy conversion, including hybrid and electric vehicles.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Internal Combustion Engines and Alternative Fuels:</b> Thermodynamics and Heat Engines: Principles of thermodynamic cycles, heat engine efficiency, and the conversion of heat into mechanical energy. Spark Ignition (SI) and Compression Ignition (CI) Engines: Comparison of combustion processes, fuel injection systems, and factors affecting efficiency.	6
2	<b>Hybrid and Electric Vehicle Technologies:</b> Principles of hybrid systems, electric motors, battery technology, and charging systems. Renewable Energy Sources: Exploring the potential of solar and other renewable energy sources for vehicle propulsion.	7
3	<b>Advanced Engine Technologies:</b> Exploring emerging engine technologies like direct injection, variable valve timing, and advanced combustion strategies. <b>Fuel Cell Vehicles (FCEVs):</b> Fuel cell technology, hydrogen storage, and the conversion of chemical energy into electrical energy.	6
4	<b>Fuel Cells and Advanced Energy Storage:</b> Principles of fuel cell operation and types used in vehicles, Integration of fuel cells into automotive powertrains, Advanced energy storage systems: supercapacitors and flywheels.	7



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<b>5</b>	<b>Energy Recovery and Waste Heat Utilization:</b> Regenerative braking systems: mechanisms and benefits, Waste heat recovery techniques: thermoelectric generators and Rankine cycles, Impact of energy recovery on overall vehicle efficiency.	<b>8</b>
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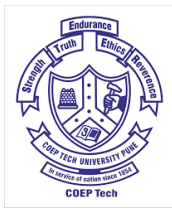
**Suggested learning resources:**

**Reference Book:**

1. "Fundamentals of Advanced Energy Conversion" by MIT open Course Ware.
2. Jack Erjavec and Rob Thompson, "Automotive Technology: A Systems Approach", Delmar Pub; 7th edition.
3. Mark Warner, The Electric Vehicle Conversion Handbook, HP Books.
4. D. Yogi Goswami, ENERGY CONVERSION 2ED, CRC Press; 2nd edition; TAYLOR & FRANCIS

**Weblinks:**

**<https://archive.nptel.ac.in/courses/108/103/108103009/>**



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**PEC- 6.9 : Course: Piping Design**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Piping Design	3	1	0	0	4	30	20	50	--	--

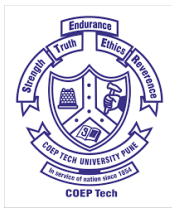
**Course Outcomes:**

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

1. Understand the safety and practical engineering aspects of piping
2. Understand the design and principles used in piping system.
3. Know the terminology, concepts, equipment, and process used piping network
4. Have an idea of pipe support with other accessories and P& I diagram

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Fundamentals of piping:</b> Classification of pipe, Codes and standards, Pipe Fabrication, vibration, its prevention and control in piping systems, Mechanical Properties of material, schedule number, Piping materials and selection	6
2	<b>Design calculations for piping</b> Determination of pipe size, Calculation of pressure drop in pipe, Equivalent length of pipe line for fittings and valves, Energy losses in pipe line, Different types of pumps and their selection criteria, NPSHA & NPSHR, Power required by pump, Calculation of flow measurement in pipe line.	7
3	<b>Piping component and Flow through pipe line</b> Types of Fitting, Different types of flange and gasket, their selection criteria and applications, Different types of valves, their selection criteria and applications, Determination of valve size, Steam separators and steam traps, Calculation of pressure drop for two phase flow through pipe line by using Lockhart and Martinelli correlations, Piping drainage and water hammer in process plant, Calculations for water hammer in pipeline.	6
4	<b>Mechanical design of piping:</b> Operating pressure and temperature, Design Pressure & Design Temperature for Piping Systems, Design equation for longitudinal, hoop and allowable stresses, Determinations of thickness required by steel pipe for withstanding internal and external pressure, Determinations of thickness required by jacketed steel pipe for withstanding external pressure.	7



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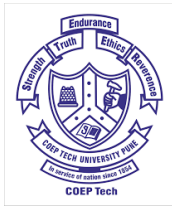
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<b>5</b>	<b>Pipe supports and P &amp; I diagram:</b> Functions of Supports and selection, Types of loads, Different types of piping support, Determination of support location, Maximum span between the supports suggested by ASME B 31.1, Thermal expansion in pipe line, Different types of expansion joints and their applications, Difference between a PFD and P&ID, Typical P&I diagrams for pumps, distillation column, Reactors and Shell and tube heat exchanger.	<b>8</b>
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**Suggested learning resources:**

**Reference Book:**

1. Perry R.H., "Chemical Engineers Handbook", McGraw-Hill, 2009
2. Coulson J. M, Richardson J. F. and Sinnott, R. K. "Coulson and Richardson's Chemical Engineering, Vol. 6, 4<sup>th</sup> Edition, Elsevier, New Delhi, 2006.
3. McCabe W.L, Smith J.C, Harriott P., "Unit Operations of Chemical Engineering", Mc Graw Hill Publication.



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**PEC- 6.10: Heat Exchangers: Fundamentals and Design Analysis**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Heat Exchangers: Fundamentals and Design Analysis	3	1	0	0	4	30	20	50	--	--

**Course Outcomes (Cos):**

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

1. Develop mathematical modeling of various heat exchanger.
2. Understand compact heat exchanger
3. Design the double pipe heat exchanger and shell & tube heat exchanger.

**Syllabus :**

Unit	Contents	Hrs.
1	<b>Basic design methodologies</b> Classification of heat exchanger, selection of heat exchanger, Thermal-Hydraulic fundamentals, Overall heat transfer coefficient, LMTD method for heat exchanger analysis for parallel, counter, multipass and cross flow heat exchanger, e-NTU method for heat exchanger analysis, Fouling, Rating and sizing problems, heat exchanger design methodology.	8
2	<b>Fouling of heat exchangers</b> Basic consideration, effect of fouling on heat transfer and pressure drop, cost of fouling, design of heat exchangers subject to fouling, fouling resistance, cleanliness factor, techniques to control fouling.	8
3	<b>Piping Design Documentation</b> Process Flow Diagrams (PFDs): Representation of process systems, symbols, and conventions, Piping and Instrumentation Diagrams (P&IDs): Detailed schematics showing piping, equipment, and instrumentation, Piping Isometrics: 3D representation of piping systems, dimensioning, and annotations, General Arrangement (GA) Drawings: Layout of equipment and piping in a plant, Line Lists and Material Take-Off (MTO): Compilation of piping components and materials required.	8
4	<b>Design of double pipe heat exchangers</b> Thermal and Hydraulic design of inner tube and annulus, hairpin heat exchanger with bare and finned inner tube, total pressure drop.	8

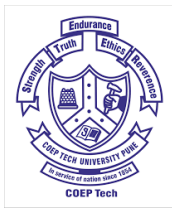


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<b>5</b>	<b>Design of shell and tube heat exchangers</b> Basic components, basic design procedure of heat exchanger, TEMA code, J-factors, conventional design methods, Bell-Delaware method.	<b>8</b>
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**Reference Books:**

1. Heat Exchanger Selection, Rating and Thermal Design by Sadik, Kakac, CRC Press
2. Fundamentals of Heat Exchanger Design by Ramesh K Shah, Wiley Publication
3. Compact Heat Exchangers by Kays, V.A. and London, A.L., McGraw Hill
4. Heat Exchanger Design Handbook by Kuppan, T, Macel Dekker, CRC Press
5. Heat Exchanger Design Handbook by Schunder E.U., Hemisphere Pub
6. Process Heat transfer by Donald Q Kern, McGraw Hill



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**PEC- 6.11 : Micro Fluidics**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Micro Fluidics	3	1	0	0	4	30	20	50	--	--

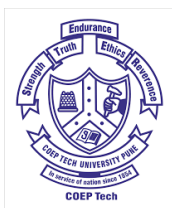
**Course Outcomes (COs):**

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

1. Summarize the fundamentals of the physics of flows at micro-scale level.
2. Apply a mathematical model for micro scale flow.
3. Understand the fundamentals of capillary flow.
4. Explain and apply fundamentals of electrokinetics to the flow problems.
5. Design components for applications of microfluidics systems.

**Syllabus :**

Unit	Contents	Hrs
1	Introduction: Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.	6
2	Microscale fluid mechanics: Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels.	8
3	Capillary flows: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Lucas- Washburn equation, Interfacial boundary conditions, Marangoni effect	6



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<b>4</b>	Electrokinetics: Electrohydrodynamics fundamentals, Electro-osmosis, Debye layer, Thin EDL limit, Boltzman ionic distribution, Stokes Einstein equation, Ideal electroosmotic flow, Ideal EOF with back pressure, Osmotic pressure, velocity scale in electroosmosis, Helmholtz-Smoluchowski velocity, Streaming potential, Lenz's Law, Ionic advection, and conduction current, Electroosmotic velocity profile, Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size, Huckel equation	<b>8</b>
<b>5</b>	Microfabrication techniques: Materials, Clean room, Silicon crystallography, Miller indices, Oxidation, photolithography-mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding, Polymer micro fabrication, PMMA/COC/PDMS substrates, micromolding, hot embossing, fluidic interconnections.	<b>6</b>
<b>6</b>	Microfluidics components: Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pump, EHD pump, MHD pumps, Microvalves, Pneumatic valves, Thermopneumatic valves, Thermomechanical valves, Piezoelectric valves, Microflow sensors, Differential pressure flow sensors, Drag force flow sensors, Lift force flow sensors, Thermal flow sensors, Droplet generators, Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction, Droplet formation, breakup and transport.	<b>6</b>

**Suggested learning resources:**

**Text Books**

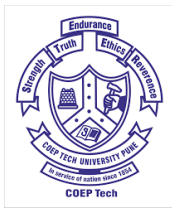
1. Nguyen, N. T., Wereley, S. T., Fundamentals and applications of Microfluidics, Artech House Inc., 2002.
2. Madou, M. J., Fundamentals of Microfabrication, CRC press, 2002.

**Reference Books**

1. Bruus, H., Theoretical Microfluidics, Oxford University Press Inc., 2008.
2. Tabeling, P., Introduction to microfluidics, Oxford University Press Inc., 2005.
3. Kirby, B.J., Micro- and Nanoscale Fluid Mechanics: Transport in Microfluidic Devices, Cambridge University Press, 2010.
4. Colin, S., Microfluidics, John Wiley & Sons, 2009.

**Weblinks:**

**<https://nptel.ac.in/courses/112105187>**



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**PEC- 6.12: Deep Learning**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Deep Learning	3	1	0	0	4	30	20	50	--	--

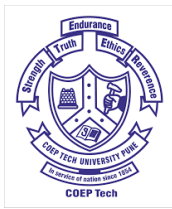
**Course Outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand the foundational concepts of deep learning.
2. Implement basic neural network architectures.
3. Design and train CNNs for image-based mechanical engineering problems.
4. Develop RNN models for sequential data in mechanical systems.
5. Apply RL algorithms to control problems in mechanical engineering.

**Syllabus :**

Unit	Contents	Hrs.
1	<b>Introduction to Deep Learning and Neural Networks:</b> Overview of Machine Learning and Deep Learning, Biological vs. Artificial Neural Networks, Activation Functions and Loss Functions, Optimization Techniques: Gradient Descent, Backpropagation, Overfitting, Underfitting, and Regularization Methods	8
2	<b>Convolutional Neural Networks (CNNs) for Mechanical Applications:</b> Convolution Operations and Pooling Layers, Architectures: LeNet, AlexNet, VGG, ResNet Transfer Learning and Fine-Tuning, Applications: Defect Detection, Thermal Imaging Analysis	7
3	<b>Recurrent Neural Networks (RNNs) and Time-Series Analysis:</b> RNN Architectures: Vanilla RNNs, LSTM, GRU, Sequence Modeling and Prediction, Applications: Vibration Analysis, Predictive Maintenance, Challenges: Vanishing/Exploding Gradients, Sequence Length Handling	7
4	<b>Autoencoders and Generative Models:</b> Autoencoders: Structure and Training, Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), Applications: Design Optimization, Anomaly Detection	6



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5	<b>Reinforcement Learning in Mechanical Systems:</b> Fundamentals of Reinforcement Learning (RL), Deep Q-Networks (DQN) and Policy Gradient Methods, Applications: Robotics Control, Adaptive Systems, Simulation Environments: OpenAI Gym, Custom Simulators	6
6	<b>Integration and Deployment of Deep Learning Models:</b> Model Deployment Strategies: Edge Computing, Cloud Services, Tools: TensorFlow Lite, ONNX, Docker, Case Studies: Real-world Applications in Mechanical Engineering Ethical Considerations and Model Interpretability	8

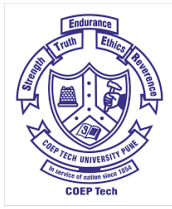
**Suggested learning resources:**

**Textbooks:**

1. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn and TensorFlow Concepts, Tools, and Techniques to Build Intelligent Systems, O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.
2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press
3. Charu C. Aggarwal, Neural Networks and Deep Learning, Springer Nature.
4. François Chollet, Deep Learning with Python, Manning; First Edition

**Weblinks:**

[https://onlinecourses.nptel.ac.in/noc20\\_cs62/preview](https://onlinecourses.nptel.ac.in/noc20_cs62/preview)



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**PEC- 6.13: Additive Manufacturing**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Additive Manufacturing	3	0	2	0	3	30	20	50	50	50

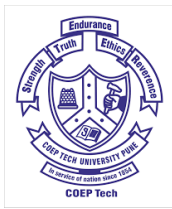
**Course Outcomes:**

Students who successfully complete this course will have demonstrated an ability to:

1. Understand the fundamentals of additive manufacturing technologies and explore opportunities and career for various applications.
2. Identify design constraints to create CAD models and apply engineering knowledge, techniques with modern tools to analyze problems in additive manufacturing.
3. Understand the methodology to manufacture the products using different methods and study their applications, advantages and case studies.
4. Develop mathematical models to represent synthetic curves and surfaces in designing mass customized products
5. Evaluate the process parameters of AM technologies to improve the quality of the parts produced and apply knowledge for various real-life applications

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction to Additive Manufacturing (AM)</b> Introduction to the Basic Principles of Additive Manufacturing, Historical Development, Additive v/s Conventional Manufacturing, Role of AM in Product development cycle, Rapid prototyping, Relevance of AM in Industry 4.0, Current industry and manufacturing trends driving AM, AM Process-Chain, Reverse engineering, Advantages.	5
2	<b>Design and Modelling:</b> CAD Modelling for 3D printing: 3D Scanning and digitization, data handling & reduction Methods, AM Software: data formats and standardization, Slicing algorithms: -uniform flat layer slicing, adaptive slicing, Process-path generation: Process-path algorithms, rasterization, part Orientation and support generation.	4



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<b>3</b>	<p><b>AM Classification and Processes:</b></p> <p>Classification of AM Processes (Process-based, material form based, application-based -direct and indirect processes and Micro- and Nano-additive processes). Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), Stereo Lithography (SLA), Selection Laser Melting (SLM), Jetting, 3D Printing, Laser Engineering Net Shaping (LENS), Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM). Capabilities, materials costs, advantages and limitations of different systems.</p>	<b>8</b>
<b>4</b>	<p><b>Design for Additive Manufacturing (DFAM):</b></p> <p>Introduction to geometric modelling, Modelling of Synthetic curves like Hermite, Bezier and B-spline, Parametric Representation of freeform surfaces, Design freedom with AM, Need for Design for Additive Manufacturing (DFAM), CAD tools vs. DFAM tools, Requirements of DFAM methods, General Guidelines for DFAM, The Economics of Additive Manufacturing, Design to Minimize Print Time, Design to Minimize Post-processing.</p>	<b>7</b>
<b>5</b>	<p><b>Process Parameters and Applications:</b></p> <p>Process Planning for Additive Manufacturing, Mechanisms of material consolidation-FDM, SLS, SLM, 3D printing and jetting technologies. Meso and macro structures, Process evaluation: process-structure relationships, structure property relationships, Applications: Prototyping, Industrial tooling, Aerospace, Automobile, Medical etc., Quality control and reliability: Defects in FDM, SLS and SLM, Critical process parameters: geometry, temperature, composition, phase transformation, Numerical and experimental evaluation, roles of process parameter combination, process optimization.</p>	<b>8</b>

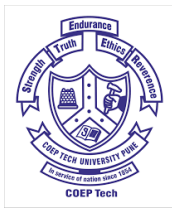
**Suggested learning resources:**

**Textbooks:**

- Gibson, I., Rosen, D.W. and Stucker, B., “Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2015.
- Chua, C.K., Leong K.F. and Lim C.S., “Rapid prototyping: Principles and applications”, Third edition, World Scientific Publishers, 2010.
- Amit Bandyopadhyay, Susmita Bose, “Additive manufacturing”, CRC Press, Taylor & Francis Group, 2016
- A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.

**Reference Books:**

- Design for Advanced Manufacturing: Technologies and Process, Laroux K, Gillespie, McGrawHill, 2017.
- Hopkinson, Hague, Dickens, Rapid Manufacturing: An Industrial Revolution for the Digital Age. Wiley, 2005.



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- Rupinder Singh J. Paulo Davim, “Additive Manufacturing - Applications and Innovations” CRC Press Taylor& Francis Group, 2019.
- Additive Manufacturing Technologies, Gibson, Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani, Springer, 2021.
- L. Jyothish Kumar, Pulak M. Pandey, David Ian Wimpenny, “3D Printing and Additive Manufacturing Technologies” Springer, 2019.
- Andreas Gebhardt and Jan-Steffen Hötter, "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing" Hanser Publishers, Munich, 2016.
- Ben Redwood, FilemonSchöffner& Brian Garret, "The 3D Printing Handbook: Technologies, design and applications", 3D Hubs B.V. 2017

**PEC- 6.13: Additive Manufacturing Lab**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Additive Manufacturing	3	0	2	1	3	--			50	50

**Laboratory Syllabus:**

CAD Modeling: Introduction to CAD environment, Sketching, Modeling and Editing features, Different file formats, Export/Import geometries, Part orientation, Layer slicing, Process path selection, Printing, Numerical and experimental evaluation.

Contents	Hrs.
<p><b><u>List of Experiments:</u></b></p> <ul style="list-style-type: none"> <li>● CAD/CAM Laboratory - 3</li> <li>● Polymer Printing Laboratory -2</li> <li>● Metal Printing Laboratory - 2</li> <li>● Materials and Part Characterization Laboratory - 2</li> </ul>	2 hours for each experiment



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**PEC- 6.14: Science and Technology of Nanomaterials**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Science and Technology of Nanomaterials	2	0	0	0	2	30	20	50	0	0

**Syllabus**

Unit	Contents	Hrs
1	<b>Introduction:</b> Definitions, Classification, Fundamental principles, Fullerenes, nanoparticles, nanoclusters, nanowires, nanotubes, nanolayers, nanopores, supramolecules.	4
2	<b>Synthesis:</b> Top-down and bottom-up approaches, Plasma arcing, Chemical vapor deposition, Electro-deposition, Sol-gel synthesis, High-energy ball milling, Nanolithography, Self-assembly, Langmuir-Blodgett films, Electrospinning.	5
3	<b>Characterization:</b> Particle size and surface area determination, IR and Raman Spectroscopy, X-ray photoelectron spectroscopy, scanning tunnelling Microscopy, and atomic force microscopy.	5
4	<b>Properties and applications:</b> Size dependence of properties, such as Electrical, Physical, Optical, and Chemical. Applications: Nanomachines and nanodevices, nanocomposites	4
5	Impact of nanomaterials in the areas of materials manufacturing, health care, data storage, clean energy, etc. Society and nanotechnology: Challenges and fears, Impact on health and environment.	4

**Suggested learning resources:**

**Textbooks and References:**

1. D. L. Schodek, P. Ferreira and M. F. Ashby, Nanomaterials, Nanotechnologies and Design, Butterworth-Heinemann, Oxford, 2009.



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2. M. Wilson, K. Kannangara, G. Smith, M. Simmons and B. Raguse, Nanotechnology: basic science and emerging technologies, CRC press, Boca Raton, 2002.
3. C. P. Poole, Jr., and F. J. Owens, Introduction to Nanotechnology, Wiley-Interscience, New Jersey, 2003.



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**VI-05- Advances in Farm Equipment and Food Technology**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Advances in Farm Equipment and Food Technology	3	1	0	0	4	30	20	50	--	--

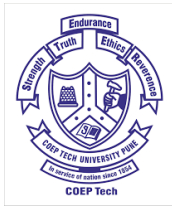
**Course Outcomes:**

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

1. Understand the importance of Farm Machinery and its implementation in context of India.
7. Study the need and implements of Ploughing and its implements.
8. Comprehend various Methods and Equipment of Seeding and Planting.
9. Learn about different methods of crop Protection and Harvesting.
10. Develop understanding of food processing and preservation techniques

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to farm machinery:</b> Modern trends, principles, procedures, fundamentals and economic considerations of Farm machinery, Importance of farm machinery in the contest of enhanced production, multiple cropping, labour scarcity	6
2	<b>Primary and Secondary Tillage implements:</b> Definition and Objectives of Tillage, Primary and Secondary Tillage, Physical, Chemical and Biological Influences of Tillage, Concept of ploughing, Tools used for ploughing, Disc Ploughs, Harrows, Seedbed preparation and irrigation	8
3	<b>Seeding and Planting Machines:</b> Methods of Seeding and Planting and their Mechanization, Tools and Implements for Intercultural Operations, Drills, Planters, Seed and Fertilizer Metering Devices	7
4	<b>Crop Protection and Harvesting:</b> Objectives and Types of Spraying and Dusting, Working Principle and Components of Sprayers and Dusters, Safety in Handling Plant Protection Machines, Machinery for transport and material handling, Crop Harvesting Methods and their Mechanization, Mowers, Reapers and Windrowers, Pickers and Stripers, Root crop harvesting machinery	8



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<b>5</b>	<p><b>Food processing technology:</b>          General aspects of food industry, world food demand and Indian scenario, quality and nutritive aspects, Food additives, Food additives, Preliminary food processing methods, thermal processing of foods, Steam generation, Fuel utilization, Electric Power Utilization, Process Controls in Food Processing</p>	<b>7</b>
<b>6</b>	<p><b>Introduction to food preservation:</b>          Objectives and techniques of food preservation, Canning, Preservation principle of canning of food items, Drying techniques, Low temperature food preservation, cold storage, freezing of food products, cryogenic freezing, Preservation by fermentation, Non-thermal and minimal processing technologies, Use of preservatives in foods, packaging of food.</p>	<b>6</b>

**Useful Learning Resources**

**Tutorials**

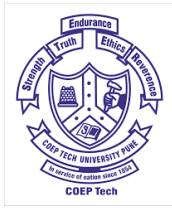
1. Study of Different Farm Operations and Familiarization with Farm Machines and Equipment.
2. Study of Power Requirement of Farm Machines and Equipments.
3. Visit to Agriculture farm site to explore various types of Farm machinery.
4. Case study to understand food preservation in case of milk products/beverages/poultry farm products/meat

**Text Books:**

1. Bernacki C, Haman J & Kanafajski CZ. 1972. Agricultural Machines, Oxford & IBH
2. Arthur W Judge 1967. High Speed Diesel Engines, Chapman & Hall
3. Boson ES, Verniaev OV & Sultan-Shakh EG. 1990. Theory, Construction and Calculations of Agricultural Machinery Vol. I. Scientific publishers (India).
4. Food Processing Technology: Principles and Practice (Woodhead Publishing Series in Food Science, Technology and Nutrition), Third addition, June 2009 by P.J. Fellows

**Weblinks:**

<http://www.digimat.in/nptel/courses/video/126105009/L01.html>



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**VI-Exit Option-01- Finite Element Analysis**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
< tbd >	Finite Element Analysis	3	1	0	0	4	30	20	50	--	--

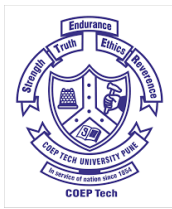
**Course Outcomes:**

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

1. Understand the different techniques used to solve mechanical engineering problems.
2. Derive and use 1-D and 2-D element stiffness matrices and load vectors from various methods to solve for displacements and stresses.
3. Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.
4. Solve complex problems in solid mechanics, vibrations and heat transfer.

**Syllabus :**

Unit	Contents	Hrs.
	<p><b>Fundamental Concepts of FEA</b></p> <p>Introduction: Solution methodologies to solve engineering problems, governing equations, mathematical modelling of field problems in engineering, discrete and continuous models. Brief history of FEM, Finite Element terminology (nodes, elements, domain, continuum, degrees of freedom, loads &amp; constraints), general steps involved in FEM, applications of FEM in various fields, advantages and disadvantages of FEM, consistent units system, essential and natural boundary conditions, symmetric boundary conditions.</p> <p>Introduction to different approaches used in FEA : Direct approach, Variational formulation- Principal of Minimum Potential Energy (PMPE), Galerkin weighted residual method, Principle of Virtual Work, Rayleigh-Ritz method, relation between FEM and Rayleigh-Ritz method</p> <p>Types of Analysis (Introduction) : Linear static analysis, Non-linear analysis, Dynamic analysis, Linear buckling analysis, Thermal analysis, Fatigue analysis, Crash analysis.</p>	<b>6</b>

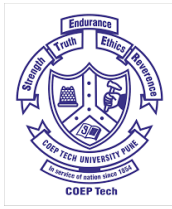


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<b>2</b>	<p><b>1D Elements</b>          Types of 1D elements, displacement function, global and local coordinate systems, polynomial form of interpolation functions- linear, quadratic and cubic, properties of shape function, primary and secondary variables.          Formulation of elemental stiffness matrix and load vector for bar, truss and beam using any approach, Formulation of load vector due to uniform temperature change (only for bar).          Assembly of global stiffness matrix and load vector, properties of stiffness matrix, half bandwidth, treatment of boundary conditions- elimination approach, stress and reaction forces calculations.</p>	<b>6</b>
<b>3</b>	<p><b>2D Elements</b>          Two-Dimensional Stress Analysis: Plane Stress/Strain problems in 2D elasticity, constitutive relations          Constant Strain Triangle (CST), Linear Strain Rectangle (LSR), displacement function, Pascal's triangle, compatibility and completeness requirement, geometric isotropy, convergence requirements, strain field, stress field, Formulation of element stiffness matrix and load vector for Plane Stress/Strain problems          Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), stress calculations</p>	<b>6</b>
<b>4</b>	<p><b>Isoparametric Elements and Numerical Integration</b>          Concept of isoparametric elements, Terms isoparametric, super parametric and subparametric.  <u>Coordinate mapping</u>: Natural coordinates, Area coordinates (for triangular elements), higher order triangular and quadrilateral elements (Lagrangean and serendipity elements), geometry associative mesh, quality checks, mesh refinement- p vs h refinements, Uniqueness of mapping - Jacobian matrix.  <u>Numerical integration</u>: Gauss Quadrature in one and two dimensions, Order of Gauss integration, full and reduced integration, sub-modeling, substructuring.</p>	<b>6</b>
<b>5</b>	<p><b>1D Steady State Heat Transfer Problems</b>          Introduction, One dimensional steady-state heat transfer problem- Governing differential equation, Finite Element formulation using Galerkin's approach for composite wall and thin Fin , essential and natural boundary conditions and solving for temperature distribution</p>	<b>6</b>
<b>6</b>	<p><b>Dynamic Analysis</b>          Types of dynamic analysis, general dynamic equation of motion, lumped and consistent mass, Mass matrices formulation of bar, truss and beam element.          Undamped-free vibration: Eigenvalue problem, evaluation of eigenvalues and eigenvectors          (characteristic polynomial technique).</p>	<b>6</b>

**Useful Learning Resources**



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**Textbooks**

1. Daryl L, A First Course in the Finite Element Method. Logan, 2007.
2. Chandrupatla T. R. and Belegunda A. D., Introduction to Finite Elements in Engineering, Prentice Hall India, 2002.
3. Y.M.Desai, T.I.Eldho and A.H.Shah, Finite Element Method with Applications in Engineering, Pearson Education, 2011
4. P., Seshu, Text book of Finite Element Analysis, PHI Learning Private Ltd. , New Delhi, 2010.

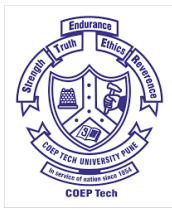
**Reference Books:**

1. Bathe K. J., Finite Element Procedures Prentice, Hall of India (P) Ltd., New Delhi.
2. R. D. Cook, et al., Concepts and Applications of Finite Element Analysis. Wiley, India
3. David V. Hutton, Fundamental of Finite Element Analysis, Tata McGraw-Hill
4. Gokhale N. S., et al., Practical Finite Element Analysis, Finite to Infinite, Pune, 2008.

**Weblinks:**

[https://onlinecourses.nptel.ac.in/noc22\\_me43/preview](https://onlinecourses.nptel.ac.in/noc22_me43/preview)

[https://onlinecourses.nptel.ac.in/noc20\\_me91/preview](https://onlinecourses.nptel.ac.in/noc20_me91/preview)



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**VI- Exit Option- 02-Generative Design**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
<td>	Generative Design	3	1	0	0	4	30	20	50	--	--

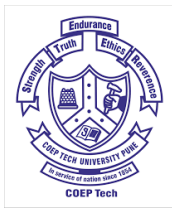
**Course outcomes:**

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

1. **Apply Generative Design Principles:** Understand and implement the fundamentals of generative design, including design space definition, objectives, and constraints, using both traditional and AI-driven methods.
2. **Develop Parametric and Algorithmic Models:** Create and manipulate parameter-driven and algorithmic models to enable automated design exploration and optimization workflows.
3. **Utilize Optimization and AI Tools:** Employ optimization techniques (topology, shape, evolutionary algorithms) and integrate AI/ML tools to guide and enhance mechanical design decisions.
4. **Solve Real-World Design Challenges:** Apply generative design tools and workflows to real-world engineering problems, incorporating data analysis, sustainability considerations, and advanced manufacturing technologies.

**Syllabus :**

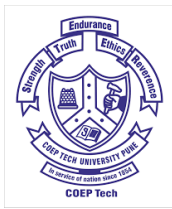
Unit	Contents	Hrs.
<b>01</b>	<p><b>Introduction to Generative Design</b></p> <p>Contrast between traditional CAD/hand-design methods with AI-driven design exploration, design objectives vs. constraints, design space definition, overview of role of algorithms in autonomous generation of many feasible designs, real-world examples.</p> <p>Self study: Study and discuss real-world examples (e.g. a generatively designed chair or bracket) to illustrate faster, lighter, cost-effective solutions. Study interdisciplinary links, e.g. how data on loads/materials feed into design goals.</p>	<b>6</b>



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<b>02</b>	<p><b>Parametric &amp; Algorithmic Modelling</b>          Parametric design and its role in generative workflows, parameter-driven models - the basis of automated design exploration, constraint-based modelling in Fusion 360 (or similar), introduction to algorithmic (programmatic) design concepts, and parameters/data used to generate geometry.  <b>Self Study:</b> Parametric variables in CAD, design tables. Basics of algorithmic design (e.g. using parameter lists or pseudocode to vary shapes). Comparison: parametric design vs. generative design. Setting up a CAD model for optimisation.</p>	<b>6</b>
<b>03</b>	<p><b>Optimisation Techniques in Mechanical Design Content:</b>          Introduces optimisation fundamentals, objective functions, types of constraints, and the difference between shape/topology optimisation and generative design, classic optimisation algorithms (gradient-based vs. evolutionary) and multi-objective trade-offs, Topology optimisation (material distribution) - a precursor to generative design, evolutionary algorithms (genetic algorithms, particle swarm) and machine learning to guide design choices. Compared to shape optimisation (one solution), generative design produces many iterative models optimised for varied criteria.  <b>Self Study:</b> Optimisation basics (objective, constraints), local vs. global optima. Topology optimisation (concept of removing material to achieve a light-weight design).</p>	<b>6</b>
<b>04</b>	<p><b>Unit 4: Generative Design Workflow and Tools</b>          Creating or importing a preliminary CAD model (the “design space”), applying loads and fixtures, setting up manufacturing constraints (like allowable manufacturing methods, symmetry), and specifying objectives (e.g. minimise weight), Use of cloud computing and AI simulation.  <b>Self Study:</b> Study the process which explores all possible permutations of a solution in a software, quickly generating design alternatives. Learn Key skills include filtering and comparing outcomes (e.g. by stiffness vs. mass) and selecting feasible designs.</p>	<b>6</b>



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<b>05</b>	<p><b>Data Science and AI Integration in Design</b>          Basic data analysis skills relevant to design: collecting performance data (from simulations or tests), plotting trends, and using simple statistics, machine learning models to predict design performance or assist optimization (e.g. regression to predict stress from geometry), the role of AI.          Self-Study: Learn how machine learning allows the system to learn from each design iteration and continuously improves the design outcomes. Conceptual overview of ML in design (prediction vs. optimisation). Interdisciplinary ties: how manufacturing data or material databases feed generative processes.</p>	<b>6</b>
<b>06</b>	<p><b>Applications, Projects, and Future Trends</b>          Real-world applications of generative design in mechanical engineering (automotive parts, aerospace components, biomedical implants, consumer products), additive manufacturing (3D printing) and the concept of sustainable design (multi-materials, eco-criteria). Current trends (e.g. AI-driven digital twins, integration with IoT sensor data) and outlook.          Self study: Additive manufacturing considerations (how design freedom allows complex shapes). Multi-objective optimisation (balancing weight, cost, aesthetics). Emerging trends: generative design in industry and research.</p>	<b>6</b>

**Note:** Content mentioned for self-study is integral part of the syllabus and it will be considered for evaluation of the course.

**Suggested Learning Resources**

**1. Autodesk: Generative Design in Manufacturing**

<https://www.autodesk.com/learn/ondemand/course/generative-design-in-manufacturing>

**2. Autodesk: Fusion 360 Generative Design Overview**

<https://help.autodesk.com/view/fusion360/ENU/?guid=GD-OVERVIEW>

**3. Formlabs: Generative Design 101**

<https://formlabs.com/global/blog/generative-design>

**4. GUVI: Generative Design in Mechanical Engineering**

<https://www.guvi.in/blog/generative-design-in-mechanical-engineering/>

**5. Autodesk University: Fusion 360 Introduction to Generative Design**

<https://www.autodesk.com/autodesk-university/article/Fusion-360-Introduction-Generative-Design>

**6. All3DP Pro: Fusion 360 Generative Design – Hands-On Tutorial**

<https://all3dp.com/2/fusion-360-generative-design-tutorial/>

**7. ASME Digital Collection: Generative Design – Reframing the Role of the Designer**

<https://asmedigitalcollection.asme.org/mechanicaldesign/article/145/4/041411/1156493/Generative-Design-Reframing-the-Role-of-the>

**8. University of California, Santa Cruz: CMPM147 – Generative Design Course**



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<https://courses.engineering.ucsc.edu/courses/cmpm147>

**9. Introduction to Generative Design for Manufacturing**

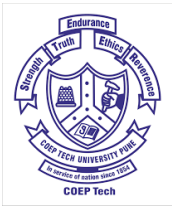
<https://www.autodesk.com/learn/ondemand/course/fusion360-generative-design-intro-expert>

**10. Generative Design Course**

<https://www.youtube.com/watch?v=PSSSt8wswNJQ>

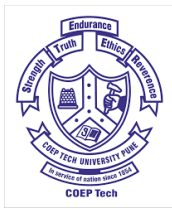
<https://www.youtube.com/watch?v=bDJQF0BbBBs>

<https://www.youtube.com/watch?v=oROzWsvK19o>



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# **Syllabus for Fourth Year B.Tech in Mechanical Engineering**



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**VII-01 : Energy Conversion**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Energy Conversion	2	0	0	0	2	30	20	50	–	–

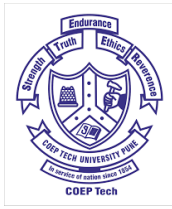
**Course Outcomes:**

Students completing this course will be able to:

1. Explain the fundamental principles of energy resources, energy conversion processes and global energy scenario.
2. Analyze the working principles and performance of thermodynamic power cycles used in energy conversion systems.
3. Evaluate the performance characteristics of internal combustion engines, gas turbines and steam power plants.
4. Apply energy conversion principles to renewable energy systems such as solar, wind, geothermal and biomass energy.
5. Assess environmental impacts and sustainability considerations of different energy conversion systems.

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Energy &amp; Energy Resources:</b> Global and Indian energy scenario, classification of energy resources, energy demand and supply, energy crisis, energy security. Primary and secondary energy resources, conventional vs non-conventional energy sources.	<b>6</b>
<b>2</b>	<b>Thermodynamic Power Cycles:</b> Review of thermodynamic laws, Carnot cycle, Otto, Diesel, Dual cycles; Brayton and Rankine cycles – analysis and comparison, combined cycles, cogeneration systems and trigeneration concepts.	<b>10</b>
<b>3</b>	<b>Mechanical Energy Conversion Systems:</b> Internal combustion engines – working principles and performance parameters; Steam power plant layout and components; Gas turbine systems and jet propulsion.	<b>6</b>
<b>4</b>	<b>Renewable Energy Conversion Systems:</b> Solar thermal and solar PV systems, wind energy conversion systems, biomass gasification, biogas plants, hydroelectric power systems, geothermal and tidal power.	<b>10</b>
<b>5</b>	<b>Energy Storage &amp; Environmental Impact:</b> Energy storage technologies – mechanical, chemical, thermal and electrical storage; hydrogen energy and fuel cells; environmental aspects, emissions, carbon footprint and sustainability.	<b>6</b>



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<b>6</b>	<b>Recent Advancements in Energy Systems:</b> Smart grid, waste heat recovery, ORC systems, nuclear fusion status, carbon capture and utilization.	<b>5</b>
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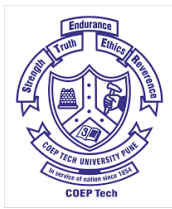
**Suggested learning resources:**

**Text Books**

1. B.H. Khan, *Non-Conventional Energy Resources*, McGraw Hill.
2. P.K. Nag, *Power Plant Engineering*, Tata McGraw Hill.
3. S.P. Sukhatme, *Solar Energy: Principles of Thermal Collection & Storage*, Tata McGraw Hill.

**Reference Books**

- Gilbert M. Masters, *Renewable and Efficient Electric Power Systems*, John Wiley.
- M.M. El-Wakil, *Power Plant Technology*, McGraw Hill.
- Godfrey Boyle, *Renewable Energy: Power for a Sustainable Future*, Oxford University Press.
- Yogesh Jaluria, *Energy and Thermal Systems*, CRC Press.



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**VII-02 : Refrigeration and Air conditioning**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Refrigeration and Air conditioning	2	0	2	1	3	30	20	50	50	50

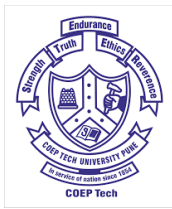
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the working of Vapour Compression refrigeration system.
2. Design the Vapour Compression refrigeration system for various applications.
3. Apply the knowledge of HVAC for multi-pressure systems.
4. Able to understand and apply the Psychrometry for air conditioning applications.
5. Able to design the duct for various air conditioning systems.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Refrigeration Systems:</b> Vapour Compression refrigeration system: A Refrigerating Machine, Types of refrigeration system, Vapour Compression refrigeration system and thermodynamic cycle, Effect of Evaporator Pressure, Effect of Condenser Pressure, Effect of refrigerant Superheating and Sub cooling, Actual Vapour Compression Cycle (Numerical treatment). Vapour Absorption Refrigeration Systems: Introduction, working principle, aqua-ammonia, Lithium-bromide and Electrolux Systems. Multipressure systems: Multi-evaporator Systems, Multistage Systems, Flash Gas Removal, Flash Intercooling, Choice of Intermediate Pressure, Complete Multistage Compression System, Multi-evaporator Systems, Cascade Systems, Solid Carbon Dioxide-Dry Ice, Manufacture of Solid Carbon Dioxide, System Practices for Multistage Systems (Numerical treatment)	12
2	<b>Refrigerants:</b> A Survey of Refrigerants, Designation of Refrigerants, Selection of a Refrigerant, Thermodynamic, Chemical, Physical, and safety Requirements, Secondary Refrigerants, Ozone depletion, Global warming, green house effect, Environment friendly refrigerant R134a, R410a, R600a, R290, R32. (Theoretical only)	3
3	<b>Refrigerant Compressors:</b> Types of Compressors, Thermodynamic Processes during Compression, Principal Dimensions of a Reciprocating Compressor, Performance Characteristics of a Reciprocating Compressor, Capacity Control of Reciprocating Compressors, Rotary Compressors, Screw Compressors, Centrifugal Compressors, Digital scroll compressors	5



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<b>4</b>	<b>Condensers, Evaporators and Expansion Devices:</b> Construction and working, Types of condensers, evaporators and expansion devices, Capillary Tube and Its Sizing, pumps, heat exchangers etc. Work done and heat transfer during steady flow processes.	<b>6</b>
<b>5</b>	<b>Psychometrics of Air – Conditioning Processes:</b> Properties of moist Air, Working Substance in Air Conditioning, Psychometric Properties, Psychometric Chart, Mixing Process, Basic Processes in Conditioning of Air Psychometric Processes in Air – conditioning Equipment comfort conditions, (Numerical Treatment).	<b>8</b>
<b>6</b>	<b>Load Calculation and Applied Psychometrics:</b> Preliminary Considerations, Internal Heat Gains, System Heat Gains, Break-up of ventilation Load and Effective Sensible Heat Factor, Cooling-load Estimate, Heating – load Estimate, Psychometric Calculations for Cooling, Design of air conditioning equipment, Numerical examples, Introduction to duct design by equal friction method. .	<b>6</b>

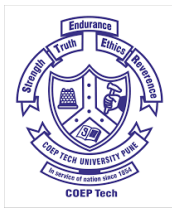
**Suggested learning resources:**

**Text Books:**

1. Arora R.C., Refrigeration and Air Conditioning, PHI, India
2. Dossat Ray J., Principal of Refrigeration, Pearson, India
3. Arora C P, Refrigeration and Air Conditioning, Tata McGraw Hill
4. Manohar Prasad, Refrigeration and Air-conditioning, Wiley Eastern Limited, 1983
5. S.N. Sapali “Refrigeration and Air-conditioning”, PHI ( Second Edition) 2016

**Reference Books:**

1. Threlkeld J.L., Thermal Environmental Engineering, Prentice Hall Inc. New Delhi
2. ASHRAE Handbook ( HVAC Equipments)
3. Stocker W.F. and Jones J.W., Refrigeration and Air-conditioning, McGraw Hill International editions 1982.
4. Roger Legg, Air conditioning systems: Design, Commissioning and maintenance
5. Shan Wang, Handbook of Refrigeration and Air Conditioning, McGrawHill Publications
6. Wilbert Stocker, Industrial Refrigeration, McGrawHill Publications
7. Keith Harold, Absorption chillers and Heat Pumps, McGrawHill publications
8. ASHRAE, Air Conditioning System Design Manual, IInd edition, ASHRAE.



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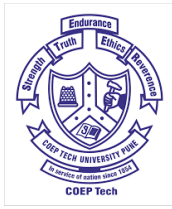
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**VII-02: Refrigeration and Air conditioning Lab**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Refrigeration and Air conditioning	3	0	2	1	3	--			50	50

**Laboratory Syllabus:**

Contents	Hrs.
<p><b>List of Experiments:</b></p> <ol style="list-style-type: none"> <li>1. Demonstration of a domestic refrigerator along with different auxiliary systems associated with a refrigerator.</li> <li>2. Trial on Vapour Compression Refrigeration System to determine cooling capacity and coefficient of performance.</li> <li>3. Trial on Vapour Compression Refrigeration System with R290 as a refrigerant</li> <li>4. Trial on Air conditioning test rig to determine cooling capacity and COP of VCR system.</li> <li>5. Trial on Air conditioning test rig to study the psychrometric processes.</li> <li>6. Trial on an Evaporative Air Cooler</li> <li>7. Trial on Ice Plant, to determine Coefficient of Performance for ice plant test rig</li> <li>8. Performance analysis of expansion devices at different operating conditions</li> <li>9. Study of Vapour Absorption refrigeration Systems.</li> <li>10. Design of cold storage with process layout</li> <li>11. Building heat load simulation using suitable software (Trace 700, Energy plus etc.)</li> </ol>	2 hours for each experiment



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**VII-03 : Vibration and Acoustics**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Vibration and Acoustics	2	0	2	1	3	30	20	50	50	50

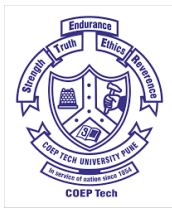
**Course Outcomes:**

Students completing this course will be able to:

1. Model a given vibratory system as SDOF or MDOF system, with or without damping, and with base or force excitation as periodic or aperiodic.
2. Evaluate continuous natural systems frequencies using and mode shapes of MDOF and modal analysis and computational methods such as Rayleigh-Ritz method and Holzer method.
3. Explain various terminologies used in acoustics and acoustic wave transmission and estimate sound pressure level.
4. Summarize the mechanism of hearing by human and principles of Psychoacoustics and noise control.

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Systems with one degree of freedom:</b> Review of one degree of freedom, Energy method, Undamped, damped free and forced vibrations	<b>5</b>
<b>2</b>	<b>General forced response:</b> Impulse response function, response to an arbitrary input, response to an arbitrary periodic input, response to random input, shock spectrum, stability.	<b>6</b>
<b>3</b>	<b>Systems with more than one degree of freedom system:</b> Undamped free vibration: principal modes, semidefinite systems, steady state undamped forced vibrations, damped free vibrations, steady state forced vibrations with damping, influence coefficients, Generalised coordinates and coordinate coupling, principle coordinates, The langrage equation.	<b>6</b>
<b>4</b>	<b>Multi degree of freedom system matrix method:</b> Undamped free vibration: principal modes, Normal coordinates, orthogonality of the principal modes of vibrations, systems with equal frequencies, Natural frequencies and principal modes by matrix iteration. Damped free vibrations, forced vibrations, Eigenvalues and natural frequencies, Modal analysis, modal analysis of the forced response. Design for vibration suppression, Vibration isolation, vibration absorbers	<b>7</b>
<b>5</b>	<b>Plane Acoustic waves:</b> Plane acoustic waves, derivation of plane wave equation relationship between acoustic pressure, particle displacement and velocity, velocity	<b>6</b>



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	of plane acoustic waves, specific acoustic impedance, Sound power, sound intensity, sound pressure and sound intensity levels. Transmission Phenomena, transmission from one fluid medium to another, normal incidence reflection at the surface, of a solid, standing wave patterns.	
<b>6</b>	<b>Psychoacoustics:</b> Speech, Hearing and Noise, anatomy of the ear, mechanism of hearing, thresholds of the ear, loudness, pitch and timbre.	<b>8</b>

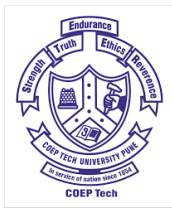
**Suggested learning resources:**

**Text Books:**

1. Francis S. Tse, Ivan E. Morse, Rolland “Mechanical Vibrations” 1963.
2. Robert K. Vierck, “Vibration Analysis” 1967.
3. Inmann Daniel J. , “Engineering Vibration”, 4th Edition, Pearson, 2014.
4. Thomson W.T., “Theory of vibrations with applications”, CBS Publishers, Delhi, 2008.
5. Rao S.S., “Mechanical Vibrations”, Wiley Publishing Co., 2003.
6. G. K. Grover, “Mechanical Vibrations” 1998.
7. Kinsler Lawrence E. and Frey Austin R. “Fundamentals of Acoustics”, Wiley Eastern Ltd., 2000

**Reference Books:**

1. Timoshenko S, “Vibration problems in Engineering”, Wiley, 1990.
2. Meirovitch Leonard, “Fundamentals of vibrations”, McGraw Hill International Edition, 2003.
3. Rettinger Michael, “Acoustic Design and Noise Control”, Vol. I & II. , Chemical Publishing Co., New York, 1977.
4. Shriniwasan P., “Mechanical Vibration Analysis”, Tata McGraw Hill, 1982.



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**PEC-7.1 : Advanced CAD/CAM**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Advanced CAD/CAM	3	0	0	0	0	30	20	50	—	—

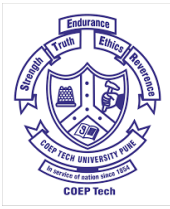
**Course Outcomes:**

Students completing this course will be able to:

1. Develop an ability to create automated solid model using CAD Customization.
2. Understand CAD/CAM data exchange formats.
3. Understand applications of CAD for computer aided Advanced Manufacturing Methods
4. Understand concept of Product Life Cycle Management (PLM)

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Python Programming:</b> Data Types, Variables, Basic Input-Output Operations, Basic Operators. Boolean Values, Conditional Execution, Loops, Lists and List Processing. Writing functions in Python	<b>6</b>
<b>2</b>	<b>CAD Customization:</b> Need of Cad customization. OLE interfaces in CAD/CAM software; Use of General programming interfaces like VB, VBS, VC++, Open GL programming and System dependent programming interfaces like Visual LISP (AutoCAD), GRIP (Unigraphics), Pro-Programming (Pro/Engineer). Creating automated Solid modeling using Customization through API	<b>6</b>
<b>3</b>	<b>Data Exchange Formats:</b> Introduction to CAD/Cam data exchange formats. Direct and Indirect translators. Neutral file formats: Data Exchange format (DXF), Standard Triangular Languages (STL), Initial Graphics Exchange Specification (IGES), 3MF etc.	<b>6</b>
<b>4</b>	<b>Surface and Hyper patch Modeling:</b> Surface modeling methods, twist vector, algebraic and control point based hyper patch modeling techniques	<b>6</b>
<b>5</b>	<b>Additive Manufacturing Processes:</b> Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies of following: Solid-based Rapid Prototyping Systems: Fused Deposition Modeling (FDM), Laminated Object Manufacturing (LOM). Liquid based Rapid Prototyping Systems: Stereo lithography Apparatus (SLA). Powder Based Rapid Prototyping Systems: Selective laser sintering (SLS) .	<b>7</b>
<b>6</b>	<b>Introduction to Product Life Cycle Management:</b> Background, Overview, Need, Benefits, and Concept of Product Life Cycle, Components / Elements of PLM,	<b>4</b>



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Emergence of PLM, Significance of PLM, Customer Involvement, Threads of PLM-computer aided design (CAD), engineering data management (EDM), Product data management (PDM), computer integrated manufacturing (CIM, comparison of PLM to Engineering resource planning (ERP).
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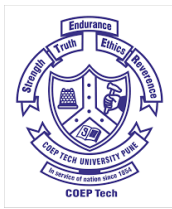
**Suggested learning resources:**

**Text Books:**

1. Solid Modelling, MarttiMantilya, Computer Science Press,2014
2. Rapid prototyping: Principles and Applications, Chua C.K., Leong K.F. and LIM C.S, World Scientific publications , Third Edition, 2010
3. Geometric modeling, Michael Morteanson,John Wiley publication
4. Python Programming: An Introduction to Computer Science (3rd Edition), John M. Zelle

**Reference Books:**

1. Manuals of Professional CAD software such as Creo Parametric, NX, CATIA
2. Additive Manufacturing Technologies, 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, 2013, Gibson, Ian, Rosen, David, Stucker, Brent.



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**PEC-7.2 : Advanced Computational Fluid**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Advanced Computational Fluid Dynamics	3	0	0	0	0	30	20	50	—	—

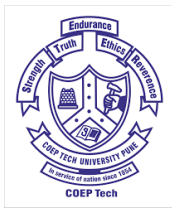
**Course Outcomes:**

Students completing this course will be able to:

1. Understand governing equations of fluid flow, including Navier–Stokes equations, and their numerical formulation.
2. Apply discretization techniques such as FDM, FVM, FEM and evaluate their accuracy, stability and convergence.
3. Implement numerical schemes for convection–diffusion equations and pressure–velocity coupling.
4. Solve turbulence modelling problems using RANS, LES and hybrid approaches.
5. Use advanced CFD techniques for engineering case studies and assess validation & verification requirements

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to CFD &amp; Governing Equations:</b> Overview of CFD applications in mechanical and aerospace engineering, differential conservation equations, integral forms, tensor notation, classification of PDEs (elliptic–parabolic–hyperbolic), well-posedness of CFD problems.	<b>7</b>
<b>2</b>	<b>Discretization &amp; Numerical Approximations:</b> Finite Difference, Finite Volume and Finite Element methods; spatial discretization concepts: truncation errors, consistency, stability and convergence; grid generation, structured vs unstructured grids, mesh quality.	<b>8</b>
<b>3</b>	<b>Numerical Schemes for Convection–Diffusion Problems:</b> Central, upwind, QUICK, hybrid and higher-order schemes; stability analysis, CFL condition, artificial diffusion, treatment of source terms, multi-dimensional formulations.	<b>8</b>
<b>4</b>	<b>Pressure–Velocity Coupling &amp; Solution Algorithms:</b> SIMPLE, SIMPLER, PISO, fractional step methods, Poisson equation solvers, iterative solution methods (Jacobi, Gauss–Seidel, SOR), convergence acceleration & multigrid methods.	<b>7</b>



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5	<b>Turbulence Modelling:</b> Reynolds decomposition and closure problem, RANS models ( $k-\epsilon$ , $k-\omega$ , SST), LES and filtering concepts, wall modelling, hybrid LES/RANS approaches, DNS fundamentals, CFD model selection for engineering problems.	8
6	<b>Advanced Topics &amp; Applications:</b> Compressible CFD framework, shock capturing methods (TVD, ENO/WENO), multiphase & reacting flows overview, HPC and parallel computing introduction, verification & validation (V&V), case studies using commercial & open-source solvers.	7

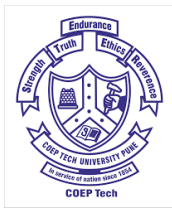
**Suggested learning resources:**

**Text Books**

1. Versteeg & Malalasekera, *An Introduction to Computational Fluid Dynamics — The Finite Volume Method*, Pearson.
2. John D. Anderson, *Computational Fluid Dynamics: The Basics with Applications*, McGraw-Hill.
3. H.K. Versteeg, *Computational Methods for Fluid Flow*, Springer.

**Reference Books**

1. Ferziger & Peric, *Computational Methods for Fluid Dynamics*, Springer.
2. Pope S.B., *Turbulent Flows*, Cambridge University Press.
3. Moukalled, Mangani & Darwish, *The Finite Volume Method in CFD*, Springer.
4. Charles Hirsch, *Numerical Computation of Internal and External Flows*, Vol. I & II, Wiley.



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**PEC-7.3 : Industrial Engineering**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Industrial Engineering	3	0	0	0	0	30	20	50	—	—

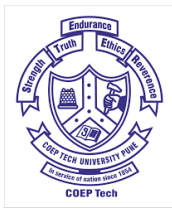
**Course Outcomes:**

Students completing this course will be able to:

1. Apply the Industrial Engineering concept in the industrial environment.
2. Manage and implement different concepts involved in methods study and understanding of work content in different situations.
3. Undertake project work based on the course content.
4. Describe different aspects of work system design and facilities design pertinent to manufacturing industries.
5. Identify various cost accounting and financial management practices widely applied in industries.
6. Develop capability in integrating knowledge of design along with other aspects of value addition in the conceptualization and manufacturing stage of various products.

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Industrial Engineering and Productivity:</b> Introduction: Definition and Role of Industrial Engineering, Contribution of Taylor and Gilbreth, Organisation : Concept of organisation, characteristics of organisation, elements of organisation, organisational structure, organisation charts; Types of organisation- formal line, military organisation, functional organization, line & staff organisation; Introduction to management principles, authority and responsibility, span of control, delegation of authority. Productivity : Definition of productivity, Productivity of materials, land, building, machine and power. Measurement of productivity: factors affecting the productivity, Productivity Models and Index (Numerical), productivity improvement programmers.	<b>6</b>
<b>2</b>	<b>Method Study:</b> Work Study : Definition, objective and scope of work-study. Human factors in work-study. Method Study : Definition, objective and scope of method study, activity recording and exam aids, Charts to record moments in shop - operation process charts, flow process charts, travel chart, two handed chart and multiple activity charts. Charts to record movement at work place - principles of motion economy, classification of moments, SIMO chart, and micro motion study. Definition and installation of the improved method, brief concept about synthetic motion study and related Numericals.	<b>6</b>



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<b>3</b>	<b>Work Measurements:</b> Work Measurements: Definition, objectives and uses; Work measurement techniques. Work sampling - need, confidence levels, sample size determinations, random observation, conducting study with the simple problems. Time study: Definition, time study equipment, selection of job, steps in time study. Breaking jobs into elements, recording information. Rating and standard rating, standard performance, scales of rating, factors affecting rate of working, allowances and standard time determination; Introduction to PMTS and MTM. (Numerical), Introduction to MOST	<b>6</b>
<b>4</b>	<b>Production Planning and Control:</b> Introduction: Types of production systems, Need and functions of PPC, Aggregate production planning, Capacity Planning, ERP: Modules, Master Production Schedule; MRP and MRP-II; Forecasting techniques: Causal and time series models, moving average, exponential smoothing, trend and seasonality; (Numerical).	<b>6</b>
<b>5</b>	<b>Facility Design:</b> Facility Location Factors and Evaluation of Alternate Locations; Types of Plant Layout; Computer Aided Layout Design Techniques; Assembly Line Balancing (Numerical); Material Handling: Principles, Types of Material Handling Devices; ) Industrial Safety: Safety Organisation, Safety Programme, General Safety Rules. Stores Management	<b>6</b>
<b>6</b>	<b>Engineering Economy:</b> Engineering Economy and Costing: Elementary Cost Accounting and Methods of Depreciation; Breakeven Analysis (Numerical). Inventory Control: Functions, costs, classifications- Concept of EOQ, purchase model without shortages (Numerical); ABC ,VED and other Analysis	<b>6</b>

**Suggested learning resources:**

**Text Books**

1. M Mahajan, "Industrial Engineering and Production Management", DhanpatRai and Co, 2015.
2. O. P. Khanna, "Industrial engineering and management", DhanpatRai publication, 2010
3. Martend Telsang, "Industrial Engineering", S. Chand Publication, 2006.
4. Banga and Sharma, "Industrial Organisation & Engineering Economics", Khanna publication, 2003.

**Reference Books**

1. Introduction to Work Study by ILO, Oxford & IBH Publishing Company, New Delhi, Second Indian Adaptation, 2008.
2. H. B. Maynard, K Jell, "Maynard's Industrial Engineering Hand Book", McGraw Hill Education.
3. Askin, "Design and Analysis of Lean Production System", Wiley, India
4. Zandin K.B., "Most Work Measurement Systems", CRC Press, 2002
5. Martin Murry, "SAP ERP: Functionality and Technical Configuration", SAP Press; 3rd New edition (2010).
6. Barnes, "Motion and time Study design and Measurement of Work", Wiley India



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**PEC-7.4 : Hybrid and Electric Vehicles**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Hybrid and Electric vehicles	3	0	0	0	0	30	20	50	—	—

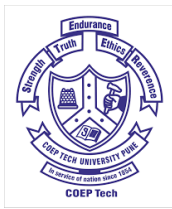
**Course Outcomes:**

Students completing this course will be able to:

1. Apply basic principles of hybrid and electric vehicle to design vehicle.
2. Select appropriate cycle source of energy for the hybrid electric vehicle based on driving.
3. Analyze the power and energy needs of the various hybrid electric vehicle.
4. Measure and estimate the energy consumption of the Hybrid Vehicles.
5. Evaluate energy efficiency of the vehicle for its drive trains.

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Electric Vehicle:</b> History of Electric Vehicles, Development towards 21st Century, Types of Electric Vehicles in use today – Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions.	<b>6</b>
<b>2</b>	<b>Induction to Hybrid Electric Vehicle:</b> Social and environmental importance of hybrid and electric vehicles, impact of modern drivetrains on energy supplies. Hybrid Electric drivetrains: Basic concept of hybrid traction, introduction to various hybrid Drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.	<b>6</b>
<b>3</b>	<b>Electric Drive Trains:</b> Basic concept of electric traction, introduction to various electric drive- train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.	<b>8</b>
<b>4</b>	<b>Types of Storage Systems:</b> Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric	<b>7</b>



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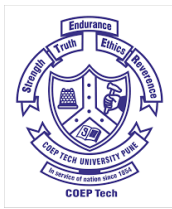
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	machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Calculation for the ratings.	
<b>5</b>	<b>Modelling of Hybrid Electric Vehicle Range:</b> Driving Cycles, Types of Driving Cycles, Range modelling for Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Case study of 2-wheeler, 3-wheeler and 4-wheeled vehicles.	<b>7</b>
<b>6</b>	<b>Energy Management Strategies:</b> Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Introduction to various charging techniques and schematic of charging stations.	<b>7</b>

**Suggested learning resources:**

**Reference Books:**

1. James Larminie, J. Lowry, "Electric Vehicle Technology Explained", John Wiley & Sons Ltd. 2003.
2. M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
3. S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies", Springer, 2015.
4. Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.



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**PEC-7.5 : Mechanics of Composites of Materials**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Mechanics of Composite Materials	3	0	0	0	0	30	20	50	—	—

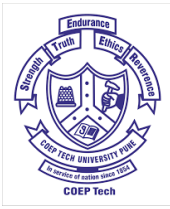
**Course Outcomes:**

Students completing this course will be able to:

1. Differentiate the basic concepts and difference between composite materials with conventional materials.
2. Determine role of constituent materials in defining the average properties and response of composite materials on macroscopic level.
3. Knowledge for finding failure envelopes and stress-strain plots of laminates.
4. Utilize subject knowledge using computer programs to solve problems at structural level.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction:</b> Definition and characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus	3
2	<b>Basic Concepts and Characteristics:</b> Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Macromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials	4
3	<b>Elastic Behavior of Unidirectional Lamina:</b> Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters.	5
4	<b>Strength of Unidirectional Lamina:</b> Micromechanics of failure; failure mechanisms, Macromechanical strength parameters, Macromechanical failure theories, Applicability of various failure theories	5
5	<b>Elastic Behavior of Laminate:</b> Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates Hygrothermal Effects:Hygrothermal effects on mechanical behavior, Hygrothermal stress-strain relations, Hygro-thermoelastic stress analysis of laminates, Residual stresses, Warpage	8



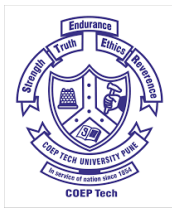
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<b>6</b>	<b>Stress and Failure Analysis of Laminates</b> : Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials	<b>5</b>
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**Suggested learning resources:**

**Reference Books:**

1. Isaac M. Daniels, OriIshai, “Engineering Mechaincs of Composite Materials”, Oxford University Press, 1994.
2. Bhagwan D. Agarwal, Lawrence J. Broutman, “Analysis and Performance of fiber composites”, John Wiley and Sons, Inc. 1990.
3. Mathews, F. L. and Rawlings, R. D., “Composite Materials: Engineering and Science”, CRC Press, Boca Raton, 2003.
4. MadhujitMukhopadhyay, “Mechanics of Composite Materials and Structures”, University Press, 2004.
5. Mazumdar S. K., “Composaites Manufacturing – Materials, Product and Processing Engineering”, CRC Press, Boca Raton, 2002.
6. Robert M. Jones, “Mechanics of Composite Materials”, Taylor and Francis, Inc., 1999.



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**PEC-7.6 : Design of Thermal Systems**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Design of Thermal System	3	0	0	0	0	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Understand the basic principles of thermal design.
2. Apply modeling and analytical knowledge of applied thermodynamics and heat transfer to systems such as heat exchangers, evaporators, condensers, boilers, binary mixtures and turbomachinery.
3. Construct simulations of thermal systems for performance evaluation.
4. Understand fundamentals of optimum system design and apply optimization approaches.

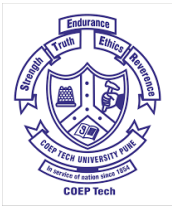
**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction and Fundamentals of Thermal System Design:</b> Fundamental concepts of engineering design, design methodology, economic analysis, present worth analysis, rate of return, payback period, cost estimation, cost analysis, equation fitting, solution of linear and nonlinear equation sets.	<b>8</b>
<b>2</b>	<b>Design of Thermal Systems and Components:</b> Fundamentals of design and selection of heat exchangers, evaporators, condensers, boilers, cooling towers, binary mixture equipment and turbomachinery. System performance criteria and design standards.	<b>10</b>
<b>3</b>	<b>Mathematical Modelling of Thermal Systems:</b> Model formulation, assumptions, development of governing equations, control-volume and distributed modelling, steady and transient modelling, numerical solution considerations.	<b>8</b>
<b>4</b>	<b>Simulation of Thermal Systems:</b> Simulation methodology, system simulation vs component simulation, modular modeling, sequential modular and equation-oriented simulation, solving system-level models, applications to real-life thermal systems.	<b>9</b>
<b>5</b>	<b>Optimization of Thermal Systems:</b> Fundamentals of optimum design, objective functions, constraints, search methods, Lagrange multipliers, linear and nonlinear optimization, numerical optimization strategies, optimization of selected thermal equipment, and system case studies.	<b>10</b>

**Suggested learning resources:**

**Text Books**

1. William F. Stoecker, *Design of Thermal Systems*, McGraw-Hill.
2. Jaluria Yogesh, *Design and Optimization of Thermal Systems*, CRC Press.

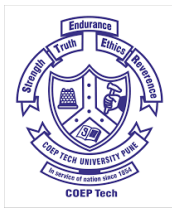


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3. R. K. Shah & D. P. Sekulic, *Fundamentals of Heat Exchanger Design*, John Wiley & Sons.

**Reference Books**

1. J.P. Holman, *Heat Transfer*, McGraw-Hill.
2. Bejan A., *Advanced Engineering Thermodynamics*, Wiley.
3. Incropera & DeWitt, *Fundamentals of Heat and Mass Transfer*, Wiley.
4. S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere.



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**PEC-7.7 : Reverse Engineering**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Reverse Engineering	3	0	0	0	0	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Explain the fundamentals, scope, and applications of reverse engineering and product development.
2. Understand and apply techniques for the measurement and digitization of physical components.
3. Analyze design parameters, materials, manufacturing processes, and functional intent of existing products.
4. Develop 3D CAD models from physical parts using reverse engineering workflows.
5. Suggest improvements and redesign strategies for engineering products and assemblies.

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Reverse Engineering:</b> Definition, history, applications, ethics, reverse engineering workflow, comparison of forward vs reverse engineering. Product teardown and benchmarking.	<b>6</b>
<b>2</b>	<b>Component Measurement &amp; Inspection Methods:</b> Manual measurement tools, coordinate measurement machines (CMM), optical scanners, CT scanning, structured light scanning, surface digitization, accuracy and data processing.	<b>9</b>
<b>3</b>	<b>3D CAD Reconstruction:</b> Point cloud processing, polygon mesh creation, surface reconstruction, parametric and free-form modeling, feature recognition, CAD modeling from scan data	<b>9</b>
<b>4</b>	<b>Materials &amp; Manufacturing Process Identification:</b> Material characterization methods, mechanical and thermal properties estimation, nondestructive testing, identifying manufacturing processes from geometry and surface features.	<b>7</b>
<b>5</b>	<b>Product Function Analysis:</b> Functional decomposition, design intent recovery, tolerance analysis, assembly relationships, failure analysis, DFMA (Design for Manufacturing & Assembly) considerations.	<b>7</b>
<b>6</b>	<b>Re-Design &amp; Future Technologies:</b> Design improvement strategies, optimization basics, rapid prototyping, 3D printing, digital twins, generative design, use of AI and automation in reverse engineering.	<b>7</b>



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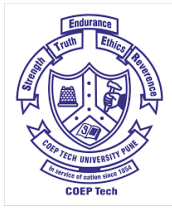
**Suggested learning resources:**

**Text Books**

1. Wego Wang, *Reverse Engineering: Technology of Reinvention*, CRC Press.
2. Gideon Halevi, *Process and Operation Planning*, Springer.
3. Ibrahim Zeid, *Mastering CAD/CAM*, McGraw Hill.

**Reference Books**

1. Vinesh Raja & Kiran J. Fernandes, *Reverse Engineering: An Industrial Perspective*, Springer.
2. Kaushik Kumar, *Engineering Metrology and Measurements*, Wiley.
3. M. Grujicic, *Rapid Prototyping and Engineering Applications*, Springer.
4. Richard Budynas, *Advanced Strength and Applied Stress Analysis*, McGraw-Hill.



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**PEC-7.8 : Aerospace Engineering**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Aerospace Engineering	3	0	0	0	0	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Explain the fundamentals of aerospace engineering, atmospheric properties, and vehicle performance.
2. Analyze basic aerodynamic forces, airfoil behavior, and aircraft performance parameters.
3. Identify the structure and functioning of aircraft components and flight control systems.
4. Explain the working principles of propulsion systems such as piston engines, gas turbines, and rocket propulsion.
5. Understand stability and control characteristics of aircraft and spacecraft.

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Aerospace Engineering &amp; Flight Environment:</b> Evolution of aviation, classification of aircraft, spacecraft categories, atmosphere and its properties, International Standard Atmosphere (ISA), speed regimes (subsonic, transonic, supersonic, hypersonic).	<b>6</b>
<b>2</b>	<b>Aerodynamics:</b> Basic aerodynamics principles, Bernoulli's equation, airfoil nomenclature, aerodynamic forces and moments, lift and drag forces, drag polar, boundary layer concepts, flow separation, high lift devices.	<b>9</b>
<b>3</b>	<b>Aircraft Performance:</b> Level flight, climbing and gliding performance, range and endurance for jet and propeller aircraft, turning performance, take-off and landing performance.	<b>8</b>
<b>4</b>	<b>Aircraft Structures &amp; Materials:</b> Airframe components, wing, fuselage, tail design; loads and stresses; composite materials, fatigue and fracture, structural failure modes, aerospace material selection.	<b>7</b>
<b>5</b>	<b>Propulsion Systems:</b> Internal combustion engines, turboprop and turbojet basics, turbofan thrust production, ramjet and scramjet principles, fundamentals of rocket propulsion.	<b>8</b>
<b>6</b>	<b>Stability and Control / Space Systems Overview:</b> Static and dynamic stability, control surfaces, longitudinal and lateral stability. Introduction to spacecraft systems, orbit fundamentals, space missions.	<b>7</b>

**Suggested learning resources:**



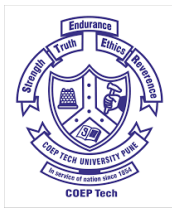
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**Text Books**

1. Anderson J.D., *Introduction to Flight*, McGraw-Hill.
2. Kermode A.C., *Mechanics of Flight*, Pearson Education.
3. T.H.G. Megson, *Aircraft Structures for Engineering Students*, Butterworth-Heinemann.

**Reference Books**

1. John D. Anderson, *Fundamentals of Aerodynamics*, McGraw-Hill.
2. Sutton & Biblarz, *Rocket Propulsion Elements*, Wiley.
3. Nelson R. C., *Flight Stability and Automatic Control*, McGraw-Hill.
4. B. V. Mohan, *Aerospace Engineering Fundamentals*, Universities Press.



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**PEC-7.9 : Condition Monitoring**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Condition Monitoring	3	0	0	0	0	30	20	50	—	—

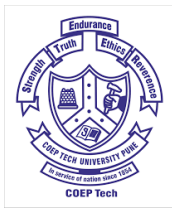
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the concept of condition-based maintenance of plant, machinery, equipment and structures, etc., in online and offline mode
2. Understand the types of signals and sensors used to acquire vital health parameters of machineries to monitor changes that precede equipment failures.
3. Analyze the fault in the machinery like gear boxes, bearings and shafts by using a variety of monitoring techniques.
4. Interpret the data of rotating machinery and detect the onset of impending faults through vibration signature, acoustic emissions, thermography, oil-debris analysis, motor current signature analysis and /or several other NDT methods (Eddy Current Testing, Ultrasonic Testing, Radiography, etc.).
5. Understand the techniques and analyze electronic component heat generation, leak detection as an aid to condition monitoring.
6. Understand the techniques for the condition monitoring of the buildings, structures etc

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Condition Monitoring and Principles of Maintenance:</b> Machinery Condition Monitoring, Fault Diagnosis and Prognosis, Overview of Different Techniques of Condition Monitoring, Principles of Maintenance, Reactive, Preventive, Predictive Maintenance, Bath Tub Curve, Brief concept of Failure Modes Effects and Criticality Analysis (FMECA), RAMS standards (Reliability, Availability, Maintainability and Safety)	<b>5</b>
<b>2</b>	<b>Digital Signal Processing and Instrumentation:</b> Introduction, Classification of Digital Signal Processing, Fundamentals of Fast Fourier Transform, Computer-Aided Data Acquisition, Signal Conditioning, Engine Vibration, Static and Dynamic Measurements, Frequency Response, Dynamic Range, Basic Measuring Equipment, Signal Amplifiers, RMS/Peak Meters, Oscilloscope, Signal Filter, etc., Laser-Based Measurements, Current Measurements, Chemical Composition Measurement, Data Recorders, etc.	<b>6</b>
<b>3</b>	<b>Machinery Vibrations and Vibration Based CBM:</b> Introduction to Vibration, Forced Vibration Response, Characteristics of Vibrating Systems, Vibration of Continuous Systems, Experimental Modal Analysis, Mode Shapes and Operational	<b>10</b>



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	Deflection Shapes, Rotodynamics, Unbalance Response and Critical Speed, Journal Bearings, Condition Monitoring in Large Rotor Systems Misalignment Detection, Eccentricity Detection, Cracked Shaft, Bowed and Bent Shaft, Rub, Looseness, Bearing Defects, Gear Faults, etc, and case studies thereof.	
<b>4</b>	<b>Noise Monitoring and Electrical Machinery Faults:</b> Introduction to Acoustical terminologies, Sound Pressure Level, A-Weighting, Sound Power Level, Sound Intensity Level, Octave Frequency Bands, Sound Fields, Near-Field Condition, FarField Condition, Anechoic/Reverberation Chamber, Noise Measurements, Acoustic Emission. Faults and fault detection in Electric Motors, Fault Detection in Electro-Mechanical Systems by MCSA, Relation between Vibration and Motor Current, Fault Detection in a Submersible Pumps, etc.	<b>7</b>
<b>5</b>	<b>Thermography and Wear Debris Analysis:</b> Introduction to Thermography, Thermal Imaging Devices: Optical Pyrometer, Infrared Cameras, Industrial Applications of Thermography in Condition Monitoring Electrical and Electronic Component Heat Generation, Leakage Detection, Introduction to Wear Debris Analysis, Mechanisms of Wear, Detection of Wear Particles, Common Wear Materials, Oil Sampling Technique, Oil Analysis, Limits of Oil Analysis, Other Methods: Eddy Current Testing, Ultrasonic Testing, Radiography, etc.	<b>7</b>
<b>6</b>	<b>Cutting Tool Condition Monitoring:</b> Introduction, Tool Wear, Sensor Fusion in TCM, Sensors for Tool Condition Monitoring, Direct Tool Wear Measurements: Dimensional Deviation, Tool-Work Electric Resistance, Optical Sensors, Force/Torque Sensor, Vibration Sensor, Surface Roughness, Acoustic Emission Sensor, Use of IoT, ML, AI and Data analytics in condition monitoring and fault diagnosis, etc.	<b>6</b>

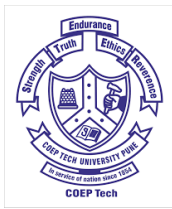
**Suggested learning resources:**

**Text Books**

1. Mohanty R A, Machinery, Condition Monitoring Principles and Practices, CRC Press, Taylor and Francis Group, (2015).
2. P Girdhar, Machinery vibration analysis and predictive maintenance, Elsevier Newnes Publications. (2004)
3. Collacott R.A., Mechanical fault diagnosis and condition monitoring, London: Chapman and Hall (1977).
4. Rao, B. K. N., Handbook of condition monitoring, Elsevier advanced technology, Oxford. (1996)
5. A Davis – Handbook of condition monitoring, London: Chapman and Hall. (1998)

**Reference Books**

1. R G Eisenmann et-al – Machinery malfunction diagnosis and correction, HewlettPackard professional books. (1997)
2. Robert Bond Randall, Vibration-based Condition Monitoring: Industrial, Aerospace and Automotive Applications (Google eBook) John Wiley & Sons. (2011)
3. Ron Barron, Engineering condition monitoring: practice, methods and applications, Longman, (1996)
4. E. D. Yardley, Condition Monitoring: Engineering the Practice, Wiley. (2002)



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**PEC-7.10 : Mathematical Modelling and Analysis of Thermal System**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Mathematical Modelling and Analysis of Thermal System	3	0	0	0	0	30	20	50	—	—

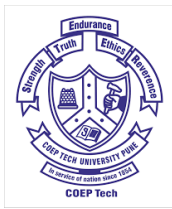
**Course Outcomes:**

Students completing this course will be able to:

1. Develop mathematical models for thermal systems using physical laws, assumptions, and simplifying constraints.
2. Formulate and solve systems of ordinary and partial differential equations relevant to thermal engineering.
3. Analyze steady and unsteady heat transfer problems using analytical and numerical methods.
4. Apply lumped and distributed parameter modelling approaches to real engineering components.
5. Evaluate performance characteristics of thermal systems through simulation and sensitivity analysis.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction to Mathematical Modeling of Thermal Systems:</b> Need for modelling, classification of models, configuration of thermal systems, thermodynamic and heat transfer basics, formulation of governing equations.	6
2	<b>Model Development Using Conservation Laws:</b> Control volume analysis, conservation of mass, momentum and energy, differential equations for thermal processes, assumptions and boundary conditions.	8
3	<b>Lumped &amp; Distributed Parameter Systems:</b> Biot and Fourier numbers, transient conduction models, system response using lumped modeling, conduction PDE formation for 1D–2D systems.	8
4	<b>Analytical &amp; Approximate Solutions:</b> Separation of variables, superposition method, integral method, usage of Heisler charts, introduction to similarity solutions, error estimation.	8
5	<b>Numerical Modelling Methods:</b> Finite difference formulation for transient and steady conduction, stability and convergence, 1D explicit/implicit schemes, basic CFD concepts for convection modelling.	8



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<b>6</b>	<b>System Simulation &amp; Performance Evaluation:</b> Thermal system modeling in engineering applications such as heat exchangers, HVAC systems, solar collectors and energy storage. Sensitivity analysis, optimization considerations.	<b>8</b>
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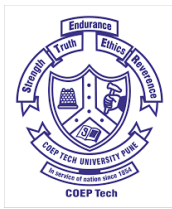
**Suggested learning resources:**

**Text Books**

1. Özisik, *Heat Conduction*, John Wiley & Sons.
2. Frank P. Incropera, *Fundamentals of Heat and Mass Transfer*, Wiley.
3. S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere.

**Reference Books**

1. Cengel & Ghajar, *Heat and Mass Transfer*, McGraw Hill.
2. Jaluria Yogesh, *Design and Optimization of Thermal Systems*, CRC Press.
3. Suhas V. Patankar & Spalding, *Mathematical & Computational Methods in Heat Transfer*, Hemisphere.
4. Holman J. P., *Heat Transfer*, McGraw-Hill.



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**PEC-7.11 : Production and Operations Management**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Production and operations management	3	0	0	0	0	30	20	50	—	—

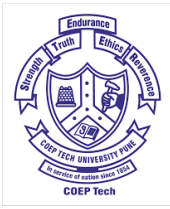
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the fundamentals, role, and strategic importance of production and operations management in engineering industries.
2. Analyze forecasting, capacity planning, facility layout, and production system types.
3. Evaluate inventory control models, material requirement planning (MRP), and supply chain operations.
4. Apply scheduling and work-study methods for productivity improvement.
5. Assess quality improvement tools, lean manufacturing concepts, and continuous improvement strategies.

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Production &amp; Operations Management:</b> Definition, objectives, scope, functions and responsibilities of POM, manufacturing vs service operations, productivity and factors affecting productivity, decision making in operations.	<b>6</b>
<b>2</b>	<b>Product Design &amp; Process Planning:</b> Product life-cycle, value engineering and value analysis, selection of processes, process planning steps, process selection criteria, computer-aided process planning (CAPP), design for manufacturability.	<b>7</b>
<b>3</b>	<b>Production System &amp; Facility Planning:</b> Types of production systems (continuous, intermittent, project), plant location, factors affecting location, facility layout types (product, process, cellular and fixed layout), line balancing basics.	<b>8</b>
<b>4</b>	<b>Forecasting, Capacity Planning &amp; Scheduling:</b> Qualitative and quantitative forecasting methods, demand management, capacity measurement and strategies, aggregate planning, master production scheduling (MPS), Gantt charts, sequencing rules (FCFS, SPT, EDD etc.).	<b>8</b>
<b>5</b>	<b>Inventory &amp; Materials Management:</b> Types of inventory, EOQ model, reorder point, ABC/VED/FSN classification, material requirement planning (MRP), manufacturing resource planning (MRP-II), Just-In-Time (JIT), supply chain management basics.	<b>8</b>



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<b>6</b>	<b>Work Study, Quality Management &amp; Lean Systems:</b> Method study, motion economy, work measurement, time study and PMTS systems, statistical quality control, TQM, Six Sigma, lean concepts, Kaizen, 5S, Poka-yoke, value stream mapping.	<b>8</b>
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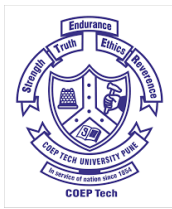
**Suggested learning resources:**

**Text Books**

1. Kanishka Bedi, *Production and Operations Management*, Oxford University Press.
2. Norman Gaither & Greg Frazier, *Operations Management*, Cengage Learning.
3. S.N. Chary, *Production and Operations Management*, McGraw Hill.

**Reference Books**

1. Jay Heizer & Barry Render, *Operations Management*, Pearson.
2. Lee J. Krajewski, *Operations Management: Processes and Supply Chains*, Pearson.
3. Elwood S. Buffa, *Modern Production/Operations Management*, Wiley.
4. B.S. Goel, *Work Study and Industrial Engineering*, Pearson.



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**PEC-7.12 : Design of Defense Equipment**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Design of Defense Equipment	3	0	0	0	0	30	20	50	—	—

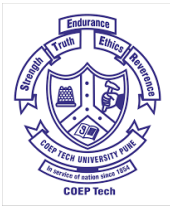
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the basic principles, operational requirements, and constraints in the design of defense equipment.
2. Analyze strength, reliability, survivability, and environmental factors influencing defense system design.
3. Explain the functioning and design considerations of small arms, armored vehicles, naval, and aerospace defense systems.
4. Evaluate materials, manufacturing methods and safety standards required for military-grade equipment.
5. Apply systems engineering and design methodology to develop conceptual designs for defense applications.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction to Defense Equipment Design:</b> Need and scope, defense system classifications (land, naval, air defense systems), operational and tactical requirements, design methodology.	6
2	<b>Design Factors &amp; Standards:</b> Strength requirements, ballistic impact, blast resistance, fatigue and reliability, ergonomics, maintainability, environmental specifications (temperature, shock, vibration, corrosion). Introduction to MIL-STD and ISO standards.	9
3	<b>Military Materials &amp; Manufacturing:</b> High-strength steels, armor composites, ceramics, smart materials, alloys used in missiles and aircraft; additive manufacturing in defense, joining technologies, and coatings..	8
4	<b>Design of Small Arms &amp; Ground Vehicles:</b> Working principles of firearms, recoil mechanisms, barrel design, targeting systems. Armored vehicles, suspension systems, power transmission, weapon mounting, and survivability.	8
5	<b>Defense Aerospace &amp; Naval Systems:</b> Missile and UAV structural requirements, stealth technology basics, electronic warfare components, naval vessel hull design fundamentals, and underwater weapon systems introduction.	8



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<b>6</b>	<b>Systems Engineering &amp; Future Technologies:</b> Conceptual design process, requirement flow down, risk assessment, testing & validation, digital twin & simulation environments, AI & robotics in defense systems.	<b>6</b>
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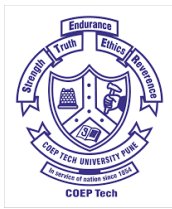
**Suggested learning resources:**

**Text Books**

1. Sadraey M., *Aircraft Design: A Systems Engineering Approach*, Wiley.
2. Przemieniecki J. S., *Theory of Matrix Structural Analysis*, McGraw-Hill.
3. R.H. Kuhn, *Modern Weapons and Warfare*, Springer.

**Reference Books**

1. George M. Chinn, *The Machine Gun* (Vol. I–V), U.S. Navy Publications.
2. Military Standards Compendium — MIL-STD-810H, MIL-STD-1472G (Ergonomics), MIL-STD-331.
3. Richard M. Ogorkiewicz, *Technology of Tanks*, Jane's Information Group.
4. Amitabh Bhattacharya, *Metallic and Ceramic Armor Materials*, CRC Press.



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**PEC-7.13 : Automatic Control System**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Automatic Control System	3	0	0	0	0	30	20	50	—	—

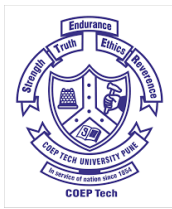
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the basic control concepts, control actions and control systems.
2. Find the transfer function for linear, time-invariant mechanical systems and produce analogous electrical, thermal and fluid-flow circuits/systems.
3. Analyse quantitatively the transient response of first and second order systems.
4. Apply frequency response techniques for stability analysis.
5. Study of system in time & frequency domain and understand concept of stability.

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction to Automatic Control System</b> :Need of control system, Manual Vs. Automatic Control System, Advantages of Automatic Control System, Open Loop and Closed Loop Control System and their comparison, Concept of Feedback, Generalized Control System and concept of Transfer Function. Representation of Control System Components: Study of various types of control system components and their mathematical representation used in systems like Mechanical system, Electrical System, Thermal System, Fluid System, Grounded chair representation, Analogies,Block representation of System Elements, Block Diagram Algebra, Block Diagram Reduction	<b>6</b>
<b>2</b>	<b>Transient Response Analysis:</b> Transient and Steady State Response Analysis: Introduction, Various types of standard input signals, First order response to Step, Ramp and Impulse Input, Response of second order system to step input, 8 System specifications, Concept of time constant and its importance in speed response, Effect of Damping ratio on response of Second Order System.	<b>6</b>
<b>3</b>	<b>Control Action and Controllers:</b> Basic types of control action like ON/OFF, Proportional, Integral, Derivative type and their combinations (P,I,PI,PD and PID), Pneumatic and Hydraulic Controllers, Comparison of Pneumatic and Hydraulic Control System. Electrical Systems: Detail study of AC and DC Servo motors, Stepper motors, Servomechanism, Position Control System	<b>6</b>
<b>4</b>	<b>Frequency Response Analysis and Root Locus Technique:</b> Stability analysis, System Stability and Routh's Stability Criteria, Relative Stability Concepts, Polar plots, Phase and Gain Margin, Stability analysis using Bode plots, Simplified Bode	



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	plot Root Locus Plots: Definition of Root loci, General Rules for constructing Root Locus, Analysis using Root Locus Plots, Use of MATLAB software in control system.	<b>6</b>
<b>5</b>	<b>MATLAB, SIMULINK and LABVIEW:</b> Application of MATLAB in Automatic Control, Dynamic system simulation and PID control using MATLAB and SIMULINK, Introduction to LABVIEW	<b>6</b>
<b>6</b>	<b>Digital Control:</b> Introduction to digital/computer based measurement and control systems, Role of computers in process control, Basic components of computer based measurement and control system, sample and hold, ADC /DAC, Architecture of computer based control, Human Machine Interface (HMI), Interfacing computer system with process, Hardware and software of computer based process control system	<b>6</b>

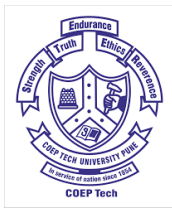
**Suggested learning resources:**

**Text Books**

1. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India, 5th Edition, 2010.
2. Norman S. Nise, "Control Systems Engineering", John Wiley & Sons, 6th Edition, 2010.
3. Rudrapratap, "Getting started with MATLAB", Oxford university press, 12 th Edition, 2009

**Reference Books**

1. Francis H. Raven, "Automatic Control Engineering", TMH, 5th edition, 1994.
2. Benjamin and C.Kuo, Farid Golnaraghi, "Automatic Control Systems", John Wiley & Sons, 9th Edition, 2014.



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**PEC-7.14 : AI and ML for Mechanical Engineers**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	AI and ML for Mechanical Engineers	3	0	0	0	0	30	20	50	—	—

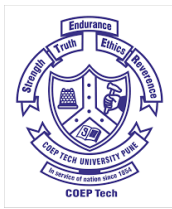
**Course Outcomes:**

Students completing this course will be able to:

1. Demonstrate fundamentals of AI&ML, apply feature extraction and selection techniques
2. Apply machine learning algorithms for classification and regression problems
3. Devise and develop a machine learning model using various steps
4. Explain concepts of reinforced and deep learning
5. Simulate machine learning model in mechanical engineering problems

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	<b>Introduction:</b> History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Machine Learning Basics: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation. Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical. Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning	<b>7</b>
<b>2</b>	<b>Development of ML Model:</b> Problem identification: Classification, Clustering, Regression, Ranking. Steps in ML modelling: Data Collection, Data pre-processing, Model Selection, Feature Extraction, Feature Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions	<b>8</b>
<b>3</b>	<b>Feature Extraction and Selection:</b> Feature extraction: Statistical features, Principal Component Analysis. Feature selection: Ranking, Decision tree - Entropy reduction & information gain, Exhaustive, best first, Greedy forward & backward	<b>7</b>
<b>4</b>	<b>Classification &amp; Regression Classification:</b> Decision tree, Random forest, Naive Bayes, Support vector machine. Regression: Logistic Regression, Support Vector Regression. Regression trees: Decision tree, random forest, K-Means, K-Nearest Neighbour (KNN)	<b>8</b>



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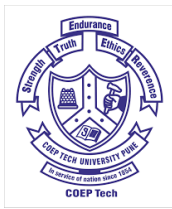
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<b>5</b>	<p><b>Deep &amp; Reinforced Learning:</b> Introduction to Deep learning: Artificial neural networks, Deep neural networks, Convolutional neural network, Recurrent neural network, Long short term memory LSTM, Auto encoder (AE), Dip belief network, Generative adversarial network, Extreme learning machine, Deep residual network.</p> <p>Introduction to reinforced learning: Motivation, background, characteristics, Algorithms for control learning: Criterion of optimality, Brute force, Value function, direct policy search, Model-based algorithms, Associative reinforcement learning, Deep reinforcement learning, Inverse reinforcement learning, Safe Reinforcement Learning, Partially Supervised Reinforcement Learning (PSRL)</p>	<b>7</b>
<b>6</b>	<p><b>Advanced &amp; Recent Techniques:</b> Pitfalls of traditional ML models, Data expansion and augmentation, Adversarial Machine learning (AML), Domain generalization and adaptation, Transfer Learning (TL), Explainable AI (XAI), Digital Twin (DT), Multi-models, Multi-agent adaptation, Self-paced learning</p>	<b>8</b>

**Suggested learning resources:**

**Text Books**

1. Tom M. Mitchell, "Machine Learning", McGraw-Hill, 1997
2. ShaiShalev-Shwartz and Shai Ben-David, "Understanding Machine Learning", Cambridge University Press, 2017.
3. Mehryar Mohri, Afshin Rostamizadeh and Ameet Talwalkar, "Foundations of Machine Learning", MIT Press, 2012
4. P. Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data. First Edition", Cambridge University Press, 2012.
5. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.



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**PEC-7.15 : Automotive Control Systems**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
<td>	Automotive control systems	3	0	0	0	0	30	20	50	—	—

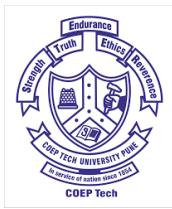
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the process of controller development in automotive applications.
2. Understand the basics of powertrain controls (engine and motor control).
3. Gain an overall understanding of vehicle control systems (dynamics).
4. Simulate and design the behavior of automotive control systems using contemporary software tools and communicate the outcomes of such studies

**Syllabus:**

Unit	Contents	Hrs
1	<b>Vehicle Electronics and Microcontrollers:</b> Vehicle Electronics: Semiconductor diodes, FETs, Rectifiers, Small signal amplifiers, OPAMPs and Automotive applications and case studies. <b>Vehicle Microcontrollers:</b> Introduction to modern computer logic, Programming inputs and outputs, Interrupts and system design, Typical controllers used in vehicles	6
2	<b>Sensors, Actuators, and Signal Conditioning:</b> Types of sensors & Actuators, Sensors & Actuators calibration and Signal attenuation, shielding etc.,	6
3	<b>Engine Control &amp; Calibration:</b> Control Systems Overview, Control Strategies – Gasoline & Diesel, Open and closed loop control strategies, Components for electronic engine management system, Digital Engine Control System, Open loop and close loop control system, Calibration Process & Equipment, Calibration Techniques such as: Cranking, Warm Up, Idle & Idle Stability, Open Loop & Closed Loop, Steady State, Transients, EGR Control, Phased Injection, Calibration for Drivability, Performance & Emissions, Adaptive Control Strategies, Fail-Safe Scenarios. Engine cooling and warm up control, idle speed control, acceleration and full load enrichment, deceleration fuel cutoff. Fuel control maps, open loop control of fuel injection and closed loop lambda control exhaust emission control.	6
4	<b>Vehicle Communication and Networking:</b> Various networks used, topology etc., Basic architecture of CAN systems, Security protocols and vulnerabilities	6



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<b>5</b>	<p><b>EMC/EMI and Diagnostics:</b>  <b>Electromagnetic Compatibility (EMC) / Interference (EMI):</b> Basics of EMC / EMI, Component segregation, cable routing etc., Grounding, shielding, common impedance coupling, Classification of EMC environments, EMC test methods.  <b>Diagnostics:</b> Overview of diagnostic, OBD1, OBD2 Protocols, Fault isolation, Types of diagnostic, tools used, Scope of Diagnostic, case study.</p>	6
<b>6</b>	<p><b>Advanced Vehicle Control and Intelligent Systems:</b>  <b>Automotive Control Systems:</b> Transmission and powertrain control system, Brake control systems - ABS, EBD, Traction control systems.  <b>Intelligent Vehicle Systems &amp; ADAS:</b> In-vehicle electronic sensors, Future of automotive electronics &amp; control, Active Cruise Control &amp; Adaptive Systems, Electronic dash board instruments.</p>	6

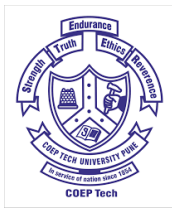
**Suggested learning resources:**

**Text Books**

1. U Kiencke, L Nielsen, “Automotive Control Systems for Engine, Driveline, and Vehicle”, Springer.
2. Ronald K. Jurgen, “Automotive Electronics Handbook”, McGraw-Hill, Inc.
3. Tao, F., Cheng, Y., & Zhang, M. - Digital Twin Driven Smart Manufacturing (Elsevier)
4. Alasdair Gilchrist - Industry 4.0: The Industrial Internet of Things

**Reference Books:**

1. Allan W.M. Bonnick, “Automotive Computer Controlled systems, Diagnostic tools and techniques”
2. Bechfold, Understanding Automotive electronics, SAE, 1998.
3. William, B. Ribbens, Understanding Automotive electronics, ButterWorth Heinemann 1998.
4. Robert N. Brandy, Automotive computers and Digital Instrumentation, Prentice Hall Eaglewood Cliffs, New Jersey, 1988



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**OE-3 : Computer Aided 3D Geometric Modelling**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
VSEC-01	Computer Aided 3D Geometric Modelling	1	0	2	1	2	CIE:100			—	—

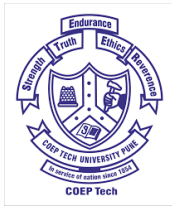
**Course Outcomes:**

Students completing this course will be able to:

1. Draw 2D geometric figures using CAD software
2. Modify 2D geometric figures using CAD software
3. Use software to dimension and write text on existing 3D geometric entities
4. Create isometric drawing using CAD software.
5. Use layers and blocks to create digital drawings.
6. Use appropriate 3D toolbars& commands to create 3D models.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Orthographic Projections:</b> Principles of Orthographic Projections, types of orthographic projections–First angle and third angle projections, Obtaining orthographic projections of given solids and machine elements by using first angle projection method along with sectional views.	02
2	<b>Fundamentals of CAD drawing setup</b> Various software for computer aided drafting and its applications. Co-ordinate system. CAD initial setting commands. Object selection methods	03
3	<b>Draw, Zoom and Formatting Commands</b> <b>Draw Commands :</b> Line, Arc, circle, rectangle, polygon, ellipse, spline, block , hatch etc. <b>Zoom Commands :</b> All, previous, In, Out, extent, dynamic, Window, Pan etc <b>Formatting Commands :</b> Layers, line type, line weight, color etc.	02
4	<b>Edit and Modify Commands:</b> <b>Edit Commands :</b> Move, Copy, Lengthen, stretch <b>Modify Commands :</b> Erase, Trim, Mirror, Offset Fillet, Chamfer, Array, Rotate, Scale, Break	02
5	<b>Dimensioning, Text and plot commands</b> <b>Dimensioning Commands :</b> Dimension style, Dimension modify, Dimension tolerance	02



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<b>6</b>	<b>Introduction to 3D Modeling</b> 3D Model Making. Use of appropriate toolbars and commands to create 3D models	<b>03</b>
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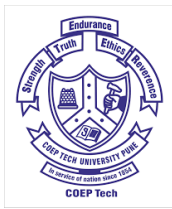
**Suggested learning resources:**

**Text Books**

1. M.L.Dabhade, "Engineering Graphics" I, Vision Publications, Pune
2. Dhananjay Jolhe, "Engineering Drawing with an introduction to AUTOCAD", Tata McGraw Hill publishing company Ltd., New Delhi

**Reference Books:**

1. Shah, M.B. & Rana B.C. , "Engineering Drawing and Computer Graphics", Pearson Education



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**OE-4 : Engineering Thermodynamics and Heat Transfer**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							TA 1	TA 2	ESE	ISE	ESE
ME 20012	Engineering Thermodynamics and Heat Transfer	3	1	0	0	4	20	20	60	—	—

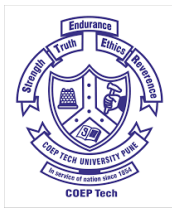
**Course Outcomes:**

Students completing this course will be able to:

1. Recall the Laws of Thermodynamics using Steam Tables to Calculate Various Performance Parameters of Rankine Cycle.
2. Analyze Products of Combustion.
3. Estimate the Heat in One Dimensional Steady State Heat Conduction.
4. Quantify the Amount of Heat Conducted in Convection, Heat transfer Calculation & Evaluate Performance of Heat Exchangers.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Elementary Thermodynamics:</b> Heat and Work, First Law of Thermodynamics, Steady Flow Energy Equation, Carnot Cycle and Concept of Heat Engine, Reverse Carnot Cycle and Concept of Heat Pump and Refrigeration, Second Law of Thermodynamics, Concept of Actual Work and Maximum Possible Work, Introduction to Entropy and Second Law Efficiency	7
2	<b>Steam Turbines:</b> Steam Generation and its Properties, Measurement of Dryness Fraction. Ideal Rankine Cycle, Calculation of Thermal Efficiency, Specific Steam Consumption, Work Ratio. Simple Impulse Turbine and Parson's Reaction Turbine, Construction and Working Principle (No numerical treatment)	7
3	<b>Fuels and Combustion:</b> Types of Fuel, Theoretical Combustion Equations and Determination of Theoretical A: F Ratio. Concept of Lean and Rich Mixtures., Gravimetric and Volumetric Analysis of Products of Combustion. Air Standard Otto, Diesel Cycles (Elementary Numerical Treatment)	6
4	<b>Conduction Heat Transfer:</b> Application Areas of Heat Transfer in Manufacturing and Machine Tools. Modes and Fundamental Laws of Heat Transfer, Thermal Conductivity, Thermal Diffusivity, One Dimensional Steady State Heat Conduction in Simple and Composite Slab, Composite Cylinder, Composite Sphere, Concept of Thermal Resistance and Electrical Analogy,	7



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	Overall Heat Transfer Coefficient. Critical Radius of Insulation for Cylinders and Spheres (Elementary Numerical Treatment).	
<b>5</b>	<p><b>Fundamentals of convection:</b> Mechanism of Natural and Forced Convection, Local and Average Convective Coefficient, Hydrodynamic and Thermal Boundary Layer, Laminar and Turbulent Flow Over a Flat Plate and Through a Duct, Empirical Correlations for Free and Forced convection for Heat Transfer in Laminar and Turbulent Over a Flat Plate and Through a Duct (Elementary Numerical Treatment).</p> <p><b>Fundamentals of Radiation:</b> Fundamental Concepts of Radiation, Different Laws of Radiation, Concept of Shape Factor, Radiation between two Black and Diffuse Gray Surfaces, Radiation Shields. (No Numerical).</p>	<b>8</b>
<b>6</b>	<p><b>Heat Exchangers:</b> Introduction to Heat Exchangers, Classification and Applications; Heat Exchanger Analysis: -LMTD for Parallel and Counter Flow Heat Exchanger, Effectiveness-NTU Method for Parallel and Counter Flow Heat Exchanger (Elementary Numerical Treatment).</p>	<b>6</b>

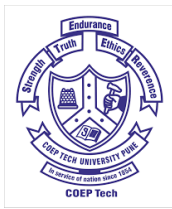
**Suggested learning resources:**

**Text Books**

1. R.K. Rajput, "Thermal Engineering", Laxmi Publications.
2. R. S. Khurmi and Gupta, "Thermal Engineering", S. Chand Publication

**Reference Books:**

1. S.P. Sukhatme, "Heat Transfer", Orient Longman.
2. Y.A. Cengel, "Thermodynamics – an Engineering approach", Tata McGraw Hill.
3. Eastop, A. Mc'conkey, "Applied Thermodynamics", Pearson Publishers.
4. Holman J.P., "Heat Transfer", Tata McGraw Hill.



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**OE-5 : Introduction to Aerospace Engineering**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
ME 25005	Introduction to Aerospace Engineering	2	0	0	0	2	30	20	60	—	—

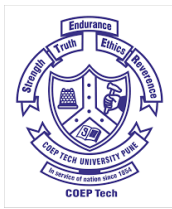
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the theoretical knowledge behind the design and development of aircrafts. Gain knowledge about the basic Aerodynamics, Flight mechanics and aircraft structures which are the foundation stones for knowledge based exams.
2. Discuss the principle constituents of the transportation system involved in aircrafts and understanding the working of space propulsion systems.
3. Understand about the Spacecrafts and missiles and latest trends in planetary and reusable missions .
4. Develop one- self to gain knowledge about current technical terms which helps to extend the outputs of research.
5. Ability to summarize the efficiency of the design in achieving the mission goal and safety of flight. Choose a concept or idea of technical real time problems to form solutions for the country's needs in various engineering branches .

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction to Aerospace Vehicles:</b> Anatomy of flight vehicles, components of an airplanes and their function, configuration of space vehicle, earth's atmosphere and gravitational field, bluff bodies v/s streamlined body, airfoil, NACA nomenclature, lift generation, significance of L/D ratio, aerodynamic forces. Helicopter , Autogyro, and Convertiplanes and rotary screw machine concept. Rotor configurations and applications of Helicopters, Basics of UAV's	8
2	<b>Aircrafts:</b> History of aviation – standard atmosphere – aerodynamic forces – airfoils and wings – drag polar – concept of static stability – anatomy of an aircraft – mechanism of thrust production – propellers – jet engines and their operation – helicopters – aircraft performance – simple maneuvers – aerospace materials and structural elements – aircraft instrument	6
3	<b>Space Vehices and Missiles:</b> Elements of rocket propulsion Liquid and solid stages - Boosters and Thrust vector Control – launch vehicle dynamics – basic orbital mechanics – satellite applications and orbits – future challenges and novel concepts in aerospace engineering.	8



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	Development of ISRO in India and recent rockets of Space X .Missile types and their applications	
4	<b><i>Avionics and Instrumentation:</i></b> Measurements in aerodynamics pitot tubes, velocity and pressure measurements , flight structures, and flight control, Aircraft Instrumentation (flight Instrumentation, Engine Instrumentation and Navigation Instrumentation), principles of navigation, celestial, radio, and inertial navigation, Introduction to computer based data acquisition	8

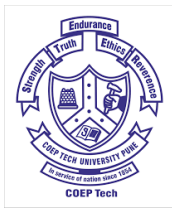
**Suggested learning resources:**

**Text Books**

1. Anderson, J. D., "Introduction to Flight", McGraw-Hill, 2000.
2. John Fay, " The Helicopter : History, Piloting and How it Flies ", Sterling Book House, 2007.
3. Newman D, "Interactive Aerospace Engineering and Design", McGraw-Hill, 1st Edition, 2002
4. Shevel, "Fundamentals of Flight", Prentice Hall, 1989.
5. Ian Moir and Allan Seabridge , " Aircraft Systems, Wiley,2012

**Reference Books:**

1. Kermode, A. C., "Flight without Formulae", Pitman, 1970
2. Turner, M. J. L., "Rocket and Spacecraft Propulsion: Principles Practice and New Developments, Springer, 2009, 3rd Edition.



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**OE-5 : Automotive Technology**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
OEC 25006	Automotive Technology	2	0	0	0	2	30	20	60	—	—

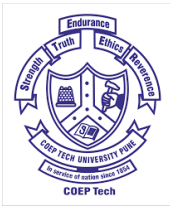
**Course Outcomes:**

Students completing this course will be able to:

1. Explain the structure of the automotive industry, stages of product development, and vehicle classification systems.
2. Describe the working principles of IC engines and transmission systems and evaluate performance parameters through basic calculations.
3. Identify the functions and components of chassis, suspension, steering, and braking systems used in modern vehicles.
4. Illustrate the role of electrical and electronic systems, including sensors, actuators, and infotainment, in vehicle operation and safety.
5. Discuss the fundamentals of electric vehicles and compare them with conventional IC engine vehicles.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction to automotive engineering:</b> Overview of automotive industry: Structure, key players, trends, Product development cycle and product lifecycle, Vehicle classification and components: Types of vehicles, major assemblies and components, Automotive manufacturing processes: Process flow from design to production, different manufacturing practices, Automotive materials: Properties and various materials used in automotive industry.	6
2	<b>Engine and Transmission</b> <b>Engine systems:</b> IC Engines: Working principle, various thermodynamic cycles, engine components, Engine performance: Factors affecting engine performance, fuel systems, lubrication, and cooling systems, Numerical on engine efficiency, fuel consumption, etc. <b>Transmission systems:</b> Manual transmission: Gears, gear selection mechanism, clutch operation, Automatic transmission: Torque converters, planetary gear sets, valve bodies, Continuously variable transmission (CVT): Working principle and applications	8
3	<b>Chassis and Auxiliary systems</b> <b>Chassis system:</b> Suspension systems: Types of suspensions, springs, shock absorbers, anti-roll bars, Steering systems: Types of steering mechanisms (rack and pinion,	6



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	recirculating ball), power steering systems, Braking systems: Hydraulic brakes, disc brakes, drum brakes, anti-locking braking system (ABS), electronic stability control. <b>Electrical and Electronic systems:</b> Batteries, Charging and starting systems, Lighting systems, Sensors and Actuators, Body control modules, Infotainment systems	
4	<b>Hybrid and Electrical Vehicles</b> Introduction to hybrid vehicles, types of hybrid vehicles, types of electric vehicles, future of electric and hybrid vehicles in India and World, Introduction to hydrogen vehicles.	5

**Suggested learning resources:**

**Text Books**

1. Kirpal Singh, “ Automobile Engineering Vol 1”
2. Hussain, “ Electric and Hybrid vehicles”



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**MDM 1 : Agriculture Fundamentals**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
MDM 1	Agriculture Fundamentals	3	0	0	1	3	30	20	50	—	—

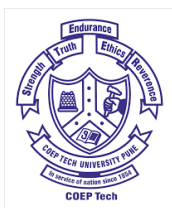
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the importance of Agriculture and other associated occupation related to Agriculture in Indian economy.
2. To familiarize the students with soil and physical, chemical and biological properties of soil.
3. To introduce the students with varied cultivation practices including handling of different manures, fertilisers, pesticides, fungicides and herbicides.
4. To develop knowledge about different farming systems, cropping pattern, different important schemes and policies related to Agriculture

**Syllabus:**

Unit	Contents	Hrs
1	<b>Agricultural Sciences Foundation:</b> Targets and achievements in foodgrain production in India since independence and its future projections, sustainable crop production, commercialization of agriculture and its scope in India , Classification of field crops based on their utility-cereals, pulses, oils seeds, fibre, sugar, and forage crops. Introduction to Agricultural Botany, Principles of Plant Physiology, Agricultural Chemistry. Biochemistry: pH and buffers, Classification and nomenclature of carbohydrates; proteins; lipids; vitamins, and enzyme	6
2	<b>Soil, Soil fertility, Fertilizers, and Manures:</b> Soil, soil pH, Soil texture, soil structure, soil organisms, soil tilth, soil fertility, and soil health. Essential plant nutrients, their functions, and deficiency symptoms. Soil types of India and their characteristics. Organic manure, common fertilizers including straight, complex, fertilizer mixtures and biofertilizers; integrated nutrient management system	6
3	Crop Production and Management: Crop Cultivation Techniques, Principles of Agronomy, Seedbed preparation, seed treatment, time and method of sowing/planting, seed rate; dose, method, and time of fertilizer application, irrigation, intercultural and weed control; common pests and diseases, caused by bacteria, fungi viruses, and nematode and their control, integrated pest management, harvesting, threshing, postharvest technology: storage, processing, and marketing of major field crops-Sugarcane, Rice, wheat, maize, sorghum, pearl millet, groundnut, mustard, pigeon-pea, gram, cotton, and berseem. Organic Farming and Sustainable Agriculture. Principles of weed control, methods of weed control.	6



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<b>4</b>	Horticulture: Importance of fruits and vegetables in the human diet, Crop diversification & processing Industry. Orchard- location and layout, ornamental gardening, and kitchen garden. Planting system, training, pruning, intercropping, protection from frost and sunburn. Trees, shrubs, climbers, annuals, perennials-definition and examples. Propagation by seed, cutting, budding, layering, and grafting. Cultivation practices, processing, and marketing of (i) Fruits - mango, papaya, banana, guava, citrus, grapes. (ii) Vegetables - Radish, carrot, potato, onion, cauliflower, brinjal, tomato, spinach, and cabbage. (iii) Flowers - Gladiolus, canna, chrysanthemums, roses and marigold. Principles and methods of fruit and vegetable preservation. Preparation of jellies, jams, ketchup, chips and their packing.	<b>6</b>
<b>5</b>	Irrigation : Concepts, Sources, Types of Irrigation with Special Emphasis on MicroIrrigation, Fertigation. Water requirement of crops, Irrigation Requirements, Irrigation Efficiency and Scheduling of Irrigation. Drainage–concept, types and importance.	<b>6</b>
<b>6</b>	Overview of Major crops in India : Classifications of crops. Types of crops based on seasons Kharif Crops, rabbi crops,Zaid Crops.Types of crops based on usage food crops, Forage crops,Fibre crops Oil crops, Ornamental crops Industrial (cash) crops. Types of crops based on life cycle Annual crops, Biennial crops,Perennial crops. overview and details of sugarcane, and bamboo crops	<b>6</b>



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**MDM 2 : Biomass Processing Technologies**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
MDM 2	Biomass Processing Technologies	3	1	0	0	4	30	20	50	—	—

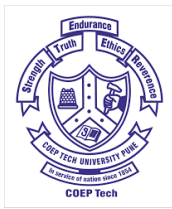
**Course Outcomes:**

Students completing this course will be able to:

1. Classify different types of biomass, including lignocellulosic materials and bio-based wastes, and their roles in producing energy and chemicals.
2. Describe the principles of biorefineries and the economic aspects of process integration and product options.
3. Understand the processes for producing bioethanol and apply Monod kinetics to optimize fermentation.
4. Assess technologies like gasification and pyrolysis for energy production and resource recovery.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction to Biomass Energy :</b> Global energy scenario and fossil fuel depletion. Biomass as a renewable energy source. Availability, abundance, and energy potential of biomass. Photosynthesis and energy production. Types of biomass: virgin, waste (municipal, industrial, agricultural, forestry). Energy crops: maize, sorghum, sugarcane, perennial herbaceous crops, woody crops. Microalgae as biofuel feedstock. Challenges in improving biomass for biofuel conversion.	6
2	<b>Biorefinery Concepts and Feedstocks :</b> Introduction to biorefineries. Types of biorefineries and their feedstocks. Feedstock properties and selection. Economic aspects of biorefineries. Market demand, production costs, scalability. Case studies on successful biorefineries.	7
3	<b>Biomass Pretreatment and Conversion Processes :</b> Challenges in lignocellulosic biomass conversion. Pretreatment methods: acid, alkali, autohydrolysis, hybrid methods. Role of pretreatment in biomass processing. Physical and thermal conversion processes. Equipment, applications, and products. Thermal conversion products: syngas, biooil, biochar. Case studies on successful thermal conversion.	8
4	<b>Microbial Conversion and Biofuels:</b> Microbial conversion processes. Biodiesel production from vegetable oils, microalgae, and syngas. Transesterification and biodiesel purification. Bioethanol and biobutanol production. Fermentation technologies and microorganisms. Biohydrogen and biogas production. Fuel cell integration. Biooil and biochar production and upgradation.	8



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<b>5</b>	<b>Organic Commodity Chemicals and Integrated Biorefineries :</b> Biomass as feedstock for organic chemicals. Production of lactic acid, succinic acid, acetic acid, PHA. Integrated biorefineries: corn, soybean, sugarcane, lignocellulosic, algal. Hybrid chemical and biological conversion processes. Techno-economic evaluation and life-cycle assessment of biorefineries.	<b>7</b>
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**Suggested learning resources:**

**Text Books**

1. "Biomass to Renewable Energy Processes" by Jay Cheng
2. "Biomass Processing Technologies" by Rajesh Kumar Sharma and Sandeep Kumar
3. "The Biorefinery: A Sustainable Approach to the Production of Fuels and Chemicals" by David S. Armenta
4. "Biofuels: Production and Utilization" by S. K. Singh and M. S. Ranjan
5. "Lignocellulosic Biomass for Bioenergy" by R. A. B. D. Bevan



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**Mechanical Engineering Department**

**MDM 3 : Advances in Farm Equipment and Food Technology**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
MDM 3	Advances in Farm Equipment and Food Technology	3	1	0	1	4	30	20	50	—	—

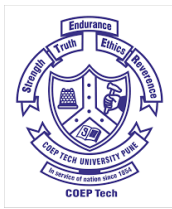
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the importance of Farm Machinery and its implementation in context of India.
2. Study the need and implements of Ploughing and its implements
3. Comprehend various Methods and Equipment of Seeding and Planting
4. Learn about different methods of crop Protection and Harvesting
5. Develop understanding of food processing and preservation techniques

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction to farm machinery:</b> Modern trends, principles, procedures, fundamentals and economic considerations of Farm machinery, Importance of farm machinery in the contest of enhanced production, multiple cropping, labour scarcity	6
2	<b>Primary and Secondary Tillage implements:</b> Definition and Objectives of Tillage, Primary and Secondary Tillage, Physical, Chemical and Biological Influences of Tillage, Concept of ploughing, Tools used for ploughing, Disc Ploughs, Harrows, Seedbed preparation and irrigation	6
3	<b>Seeding and Planting Machines:</b> Methods of Seeding and Planting and their Mechanization, Tools and Implements for Intercultural Operations, Drills, Planters, Seed and Fertilizer Metering Devices	6
4	<b>Crop Protection and Harvesting:</b> Objectives and Types of Spraying and Dusting, Working Principle and Components of Sprayers and Dusters, Safety in Handling Plant Protection Machines, Machinery for transport and material handling, Crop Harvesting Methods and their Mechanization, Mowers, Reapers and Windrowers, Pickers and Stripers, Root crop harvesting machinery	6
5	<b>Food processing technology:</b> General aspects of food industry, world food demand and Indian scenario, quality and nutritive aspects, Food additives, Food additives, Preliminary food processing methods, thermal processing of foods, Steam generation, Fuel utilization, Electric Power Utilization, Process Controls in Food Processing	6



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<b>6</b>	<b>Introduction to food preservation:</b> Objectives and techniques of food preservation, Canning, Preservation principle of canning of food items, Drying techniques, Low temperature food preservation, cold storage, freezing of food products, cryogenic freezing, Preservation by fermentation, Non-thermal and minimal processing technologies, Use of preservatives in foods, packaging of food	<b>6</b>
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**Suggested learning resources:**

**Text Books**

1. Bernacki C, Haman J & Kanafajski CZ.1972. Agricultural Machines Oxford & IBH
2. Arther W Judge 1967. High Speed Diesel Engines, Chapman & Hall
3. Bosoi ES, Verniaev OV & Sultan-Shakh EG. 1990. Theory, Construction and Calculations of Agricultural Machinery Vol. I. Oxonian Press.
4. Food Processing Technology: Principles and Practice (Woodhead Publishing Series in Food Science, Technology and Nutrition),Third addition, June 2009 by P.J. Fellows



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**MDM 4 : Advances in Agriculture Technology and Smart Farming**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
MDM 4	Advances in Agriculture Technology and Smart Farming	3	1	0	1	4	30	20	50	—	—

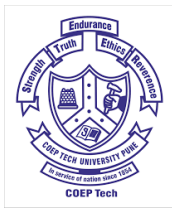
**Course Outcomes:**

Students completing this course will be able to:

1. Explore the significance of smart farming, including precision agriculture, automation, and digital technologies, while addressing challenges like climate change and food security.
2. Understand Geographic Information Systems (GIS) for spatial data collection, precision farming, soil mapping, and crop health monitoring through remote sensing.
3. Learn to apply machine learning for predictive modeling of soil conditions and crop yields, enhancing decision-making and resource optimization.
4. Examine the role of automation and robotics in farming, including autonomous machines for planting and harvesting, drones for monitoring, and AI integration for operational efficiency.
5. Discover smart irrigation technologies, including precision systems and automated water control, with a focus on sustainable water management practices.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction to Smart Farming and Agricultural Technologies:</b> Overview of smart farming and its significance. Key concepts of precision farming, automation, and digital technologies. Role of sensors, drones, and IoT in agriculture. Importance of data-driven decision-making. Addressing challenges such as climate change, resource efficiency, and food security.	6
2	<b>Geographic Information Systems (GIS) in Agriculture:</b> Introduction to Geographic Information Systems (GIS) in agriculture. Spatial data collection methods and applications. Use of GIS for precision farming and soil mapping. Crop health monitoring through remote sensing. Efficient land management and irrigation planning.	6
3	<b>Machine Learning for Soil and Crop Management:</b> Application of machine learning in agriculture. Predictive modeling for soil conditions and crop yields. Data acquisition techniques and their practical uses. Role of artificial intelligence in resource optimization. Enhancing crop management efficiency through ML.	6



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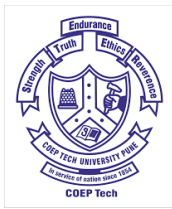
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4	<b>Automation and Robotics in Agriculture:</b> Advancements in automation and robotics in farming. Use of autonomous machines for planting and harvesting. Applications of drones in agriculture. Robotic systems for spraying and monitoring. Integration of AI and sensors for improved operational efficiency.	6
5	<b>Advances in Agricultural Engineering:</b> Innovations in agricultural machinery and equipment. Mechanized planting and smart irrigation technologies. Pest control advancements and post-harvest solutions. Focus on sustainable engineering practices. Enhancing productivity while minimizing environmental impact.	6
6	<b>Smart Irrigation and Water Management:</b> Introduction to smart irrigation technologies. Precision irrigation systems, including drip irrigation. Automated water control methods. Role of sensors and IoT in monitoring soil moisture. Sustainable water management practices to optimize usage.	6

**Suggested learning resources:**

**Text Books**

1. Precision Agriculture for Sustainability and Environmental Protection by John M. Stafford
2. Smart Agriculture: An Approach to Sustainable Development by R. K. Sharma
3. Agricultural Robotics: Fundamentals and Applications by Rajesh P. Singh and Jagannath P. Singh



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**Mechanical Engineering Department**

**Double Minors-Mechanical Engineering**

**Energy storage system for EV**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Energy Storage system for EV	3	1	0	1	4	30	20	50	—	—

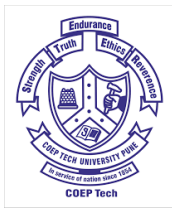
**Course Outcomes:**

Students completing this course will be able to:

1. Explain the role and importance of energy storage systems in electric vehicles and compare different storage technologies based on performance metrics such as energy density, power density, efficiency, and safety.
2. Analyze the operating principles and characteristics of various battery technologies used in EVs, including lithium-ion chemistries, and select appropriate batteries for specific EV applications.
3. Develop and analyze battery models and apply state estimation techniques (SOC, SOH) while understanding the architecture and functionality of Battery Management Systems (BMS).
4. Evaluate advanced energy storage technologies such as supercapacitors and hybrid energy storage systems and assess their integration in electric vehicle powertrains.
5. Analyze EV charging technologies and design considerations for battery thermal management systems with emphasis on safety, reliability, and performance.
6. Design and evaluate an EV energy storage system through range estimation, battery pack configuration, and analysis of real-world case studies.

**Syllabus:**

Unit	Contents	Hrs
1	Introduction to Energy Storage Systems: Overview of Electric Vehicles (EVs) and Hybrid Electric Vehicles (HEVs), Role of energy storage in EV performance, Classification of energy storage systems, Key performance metrics: energy density, power density, efficiency, life cycle, safety. Comparison of batteries, supercapacitors, and fuel cells	6
2	Battery Technologies for EVs: Fundamentals of electrochemical energy storage Lead-acid, Nickel-based batteries, Lithium-ion battery chemistries (LFP, NMC, NCA, LTO), Battery characteristics: charge–discharge behavior, C-rate, aging Battery selection criteria for EV applications	6
3	Battery Modeling and Management Systems (BMS): Electrical equivalent circuit models of batteries SOC, SOH, SOP estimation techniques, Battery thermal behavior and heat generation, Battery Management System (BMS): architecture and functions, Cell balancing techniques (passive and active)	6



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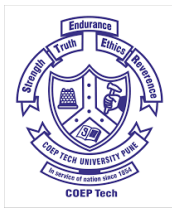
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<b>4</b>	<b>Advanced Energy Storage Systems</b> , Supercapacitors: principles, characteristics, and applications, Hybrid energy storage systems (battery–supercapacitor combinations), Flywheels and hydrogen fuel cells (overview), Energy storage integration strategies in EVs	<b>6</b>
<b>5</b>	<b>Charging Technologies and Thermal Management</b> : AC and DC charging standards (CCS, CHAdeMO, GB/T), Fast charging and wireless charging concepts, Battery thermal management systems (air, liquid, phase change materials), Safety, reliability, and thermal runaway issues	<b>6</b>
<b>6</b>	<b>EV Energy Storage System Design and Case Studies</b> : Energy requirement calculation for EVs, Battery pack design and configuration, Range estimation and degradation analysis, Case studies of commercial EV battery systems, Future trends in EV energy storage	

**Suggested learning resources:**

**Text Books**

1. Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice Hall of India, New Delhi, 2005.
2. R.C. Johnson, “Optimum Design of Mechanical Elements”, Willey, New York, 1980.
3. Kalyanmoy Deb, “Evolutionary multi-objective optimization, Willey, New York.
4. S. S. Stricker, “Optimising performance of energy systems” Battelle Press, New York, 1985.
1. J. S. Arora, “Introduction to Optimum Design”, McGraw Hill, New York, 1989.
2. L.C.W. Dixon, “Non-Linear Optimisation - Theory and Algorithms”, Birkhauser, Boston, 1980.
3. R.J. Duffin, E.L. Peterson and C.Zener “Geometric Programming-Theory and Applications”, Willey, New York, 1967.



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**Mechanical Engineering Department**

**IoT for Electric Vehicle**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	IoT for Electric Vehicle	3	1	0	1	4	30	20	50	—	—

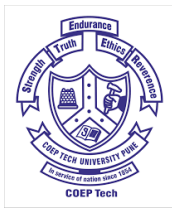
**Course Outcomes:**

Students completing this course will be able to:

1. Explain the fundamentals of IoT architecture and its role in enabling connected, intelligent, and smart electric vehicle ecosystems.
2. Identify and integrate appropriate sensors and data acquisition systems for monitoring battery, motor, and vehicle performance in electric vehicles.
3. Analyze communication protocols and networking technologies used in EV IoT systems, including in-vehicle and vehicle-to-infrastructure communication.
4. Apply cloud computing platforms and data analytics techniques to store, process, and visualize EV operational data for performance monitoring and decision making.
5. Design IoT-based solutions for EV applications such as battery health monitoring, smart charging, fleet management, and fault diagnostics.
6. Evaluate real-world IoT implementations in electric vehicles and analyze future trends, challenges, and cybersecurity issues in connected EV systems.

**Syllabus:**

Unit	Contents	Hrs
1	Introduction to IoT and EV Ecosystem: Fundamentals of Internet of Things (IoT) IoT architecture: sensing, communication, cloud, and analytics, EV ecosystem and smart mobility concepts, Role of IoT in connected and autonomous vehicles	6
2	Sensors and Data Acquisition in EVs: Sensors used in EVs: current, voltage, temperature, speed, vibration, Battery and motor monitoring sensors, Data acquisition systems and embedded controllers, CAN, LIN, FlexRay communication protocols	6
3	Communication Technologies for EV IoT: Wired and wireless communication technologies, Bluetooth, Wi-Fi, Cellular (4G/5G), LoRa, Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication, Cybersecurity issues in connected EVs	6
4	<b>Cloud Platforms and Data Analytics for EVs</b> , Cloud platforms for IoT (AWS, Azure, Google Cloud – overview), Data storage, processing, and visualization, Predictive analytics for battery health and maintenance, Digital twins for EV systems	6
5	IoT Applications in Electric Vehicles: Real-time battery and vehicle health monitoring, Smart charging and energy management, Fleet management and telematics, Fault detection and diagnostics using IoT	6



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<b>6</b>	Case Studies and Future Trends:IoT-enabled EV charging infrastructure, Connected EV case studies, Integration of AI and ML with IoT for EVs, Challenges, standards, and future scope of IoT in EVs	
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**Suggested learning resources:**

**Text Books**

5. Kalyanmoy Deb, “Optimization for Engineering Design”, Prentice Hall of India, New Delhi, 2005.
6. R.C. Johnson, “Optimum Design of Mechanical Elements”, Willey, New York, 1980.
7. Kalyanmoy Deb, “Evolutionary multi-objective optimization, Willey, New York.
8. S. S. Stricker, “Optimising performance of energy systems” Battelle Press, New York, 1985.
4. J. S. Arora, “Introduction to Optimum Design”, McGraw Hill, New York, 1989.
5. L.C.W. Dixon, “Non-Linear Optimisation - Theory and Algorithms”, Birkhauser, Boston, 1980.
6. R.J. Duffin, E.L. Peterson and C.Zener “Geometric Programming-Theory and Applications”, Willey, New York, 1967.

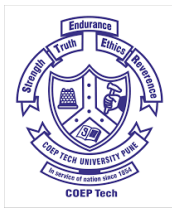
**Optimization Techniques in Design**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Optimization Techniques in Design	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Formulate an optimization problem.
2. Apply algorithms for unconstrained optimization.



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3. Apply algorithms for constrained optimization.

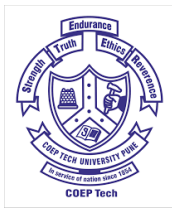
**Syllabus:**

Unit	Contents	Hrs
1	Introduction to optimization, classification of optimisation problems, classical optimisation techniques,	6
2	Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's methods,	6
3	Non-Linear Programming: - One dimensional minimization, unconstrained and constrained minimization, direct and indirect methods,	6
4	Geometric programming, Optimum design of mechanical elements like beams, columns, gears, shafts, etc.	6
5	Introduction to multi-objective optimization, genetic Algorithms, Operators, applications in multi-objective optimization.	6

**Suggested learning resources:**

**Text Books**

1. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, New Delhi, 2005.
2. R.C. Johnson, "Optimum Design of Mechanical Elements", Willey, New York, 1980.
3. Kalyanmoy Deb, "Evolutionary multi-objective optimization, Willey, New York.
4. S. S. Stricker, "Optimising performance of energy systems" Battelle Press, New York, 1985.
5. J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 1989.
6. L.C.W. Dixon, "Non-Linear Optimisation - Theory and Algorithms", Birkhauser, Boston, 1980.
7. R.J. Duffin, E.L. Peterson and C.Zener "Geometric Programming-Theory and Applications", Willey, New York, 1967.



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**Introduction to modeling and simulation of hydrogen technology**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
	Introduction to modeling and simulation of hydrogen technology	3	1	0	0	4	30	20	50	--	--

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:



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1. Explain key modeling and simulation philosophies and tools for hydrogen energy systems, with distinctions between 0D–3D and steady-state vs. dynamic models.
2. Apply fundamental principles of electrochemistry and thermodynamics to model hydrogen production and consumption processes, including the calculation of relevant thermodynamic properties.
3. Develop and analyze simulation models for hydrogen production technologies such as water electrolysis, with an ability to implement steady-state and dynamic simulations.
4. Construct equivalent models for hydrogen application technologies (including fuel cells, engines, and turbines) and evaluate their performance using simulation tools.
5. Perform techno-economic assessments of hydrogen systems using levelized cost analysis and critically appraise the economic viability of advanced hydrogen technologies.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Overview of modelling and simulation approaches:</b> Modelling and simulation philosophy, type of models – 0D-3D, steady-state vs dynamic, physics-based models, data-driven models, hybrid models, availability of 0D/1D simulation environments – MATLAB/Simulink, Python, GT-POWER.	6
2	<b>Basic principles in Hydrogen production and consumption processes:</b> Overview of electrochemistry - chemical equilibrium, reaction rates, basic thermodynamics – enthalpy, entropy, Gibbs free energy, calculation of reversible voltages at STP, basic power electronics – rectifiers, inverters, DC/DC and AC/AC converters.	7
3	<b>Modeling Hydrogen production technologies – Water Electrolysis:</b> Overview of various Hydrogen generation technologies – biomass gasification, thermolysis (solar, nuclear, with and without catalysts), photocatalysis, methane decomposition, water electrolysis. Overview of water electrolysis techniques for Green Hydrogen production (Alkaline, PEM and solid oxide). PEM electrolyzer cell example - Deep dive into electrical, chemical and mechanical equivalent steadystate models in 0D, steady-state vs dynamic simulation.	6
4	<b>Modeling Hydrogen application technologies – Fuel cells:</b> Challenges with Hydrogen storage and transportation design, Overview of various Hydrogen application technologies – Hydrogen internal combustion engine, Hydrogen gas turbine, fuel cells. Overview of power generation techniques using Fuel cells (Alkaline, PEM and solid oxide). PEM fuel cell example - Deep dive into electrical, chemical and mechanical equivalent steady-state models in 0D, steadystate vs dynamic simulation.	7
5	<b>Modeling for techno-economic analysis of advanced energy devices:</b> Key performance indicators to assess technology, levelized cost of X analysis e.g. LCOH, making various investment decisions, future trends in modelling and simulations, future trends in Hydrogen technologies	8



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**Suggested learning resources:**

**Reference Books:**

1. Modeling, Design, and Simulation of Systems with Uncertainties, Authors: Andreas Rauh, Ekaterina Auer, 1st Edition, 2011, Springer-Verlag Berlin Heidelberg ISBN: 978-3642159558, Book Link
2. Hydrogen and Fuel Cells: Emerging Technologies and Applications, Authors: Bent Sørensen, Giuseppe Spazzafumo, 3rd Edition, 2018, Academic Press (Elsevier) ISBN: 978-0-08-100708-2, Book Link
3. Hydrogen Fuel: Production, Transport, and Storage, Editor: Ram B. Gupta, 1st Edition, 2008, CRC Press (Taylor & Francis), ISBN: 978-1-4200-4575-8, BookLink
4. Muralidhar K (Author), Sundararajan, Computational Fluid Flow & Heat Transfer, Narosa Publishing House.
5. Fuel Cell Fundamentals, Authors: Ryan O'Hayre, Suk-Won Cha, Whitney Colella, Fritz B. Prinz, 3rd Edition, 2016, Wiley, ISBN: 978-1-119-11380-5, Book Link
6. Electrochemical Methods: Fundamentals and Applications, Authors: Allen J. Bard, Larry R. Faulkner, Henry S. White, 3rd Edition, 2022, Wiley, ISBN: 978-1-119-33406-4 BookLink
7. The Hydrogen Economy: Opportunities and Challenges, Editors: Michael Ball, Martin Wietschel, 1st Edition, 2010, Cambridge University Press, ISBN: 978-0-521-88216-3 Book Link
8. Renewable Hydrogen Technologies: Production, Purification, Storage, Applications and Safety, Editors: Luis M. Gandía, Gurutze Arzamendi, Pedro M. Diéguez, 1st Edition, 2013, Elsevier, ISBN: 978-0-444-56352-1, Book Link

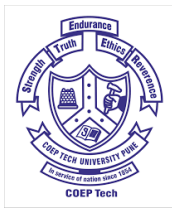
**Honors- Mechanical Engineering - Design Engineering**

**MATLAB Programming and Simulink Modeling**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	MATLAB Programming and Simulink Modeling	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:



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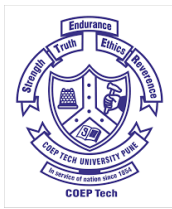
1. Demonstrate proficiency in the MATLAB environment by creating scripts and performing basic operations such as matrix creation, transformation, arithmetic operations, and evaluation of determinants.
2. Apply matrix algebra techniques to analyze and solve engineering problems involving rank determination, systems of linear equations, eigenvalues, and eigenvectors using numerical methods.
3. Develop structured MATLAB programs using conditional statements, loops, logical operators, and indexing techniques to solve computational problems efficiently.
4. Implement numerical methods and solve ordinary differential equations using built-in MATLAB solvers, and visualize engineering data through effective plotting techniques.
5. Model and simulate dynamic engineering systems using Simulink by employing source and sink blocks, subsystems, lookup tables, logic operations, and transfer function representations.
6. Analyze and control real-world dynamic systems such as tank level systems, spring–mass–damper systems, and DC servomotors by developing simulation models and designing PID controllers in Simulink.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction:</b> Introduction to MATLAB, Running MATLAB, creating calculator, Matrix creation, combination and transformation of Matrices, Matrix arithmetic, Matrix operations, Determinant	6
2	<b>Matrix operations:</b> Rank of matrix, solution to system of linear equations, Gauss Elimination, Gauss Sidel Elimination, Eigen values, Eigen vectors	6
3	<b>Functions and loops:</b> If statements, relational and logical operators, Nested If else, for loop, do while loops, break statements, logical indexing,	6
4	<b>Programming:</b> ODE solvers, implementation of numerical methods, plotting with MATLAB	6
5	<b>Simulink:</b> Introduction to simulink, source blocks, sink blocks, look up tables, logic operations, sub systems, Laplace transform and transfer functions, Mechanical system modeling, electrical system modeling, hydraulic system modeling	6
6	<b>Simulink:</b> Modeling and simulation of a tank level, building spring mass damper model, modeling and simulation of DC servomotor, tank level controller using PID controller	6

**Suggested reading**

**Textbooks:**



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1. Getting started with MATLAB by Rudra Pratap
2. Beginning MATLAB and Simulink by Sulaymon L. Eshkabilov

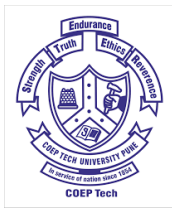
**Design for Manufacturing and Assembly**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Design for Manufacturing and Assembly	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Comprehend the product development cycle
2. Identify the manufacturing issues that must be considered in the mechanical engineering design process
3. Apply the principles of assembly to minimize the assembly time



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4. Make out the effect of manufacturing process and assembly operations on the cost of product
5. Apply tools and methods to facilitate development of manufacturable mechanical designs.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction:</b> Need Identification and Problem Definition; Concept Generation and Evaluation; Embodiment Design	6
2	<b>Selection of Materials:</b> Selection of Materials and Shapes: Properties of Engineering Materials; Selection of Materials; Selection of Shapes; Co-selection of Materials and Shape	6
3	<b>Selection of Manufacturing Processes:</b> Selection of Manufacturing Process: Review of Manufacturing Processes; ; Design for Bulk Deformation Processes: Design for Sheet Metal Forming Processes; Design for Machining; Design for Powder Metallurgy; Design for Polymer Processing; Co-selection of Materials and Processes	6
4	<b>Assembly:</b> Assembly Processes: Review of Assembly Processes; Design for Welding; Design for Brazing and Soldering; Design for Adhesive Bonding; Design for Joining of Polymers; Design for Heat Treatment	6
5	<b>Design for Reliability:</b> Design for Reliability and Quality: Failure Mode and Effect Analysis; Design for Quality; Design for Reliability; Approach to Robust Design	6
6	<b>Modern Manufacturing Methods:</b> Modern methods of Manufacturing: Rapid Prototyping & Reverse Engineering, their applications	6

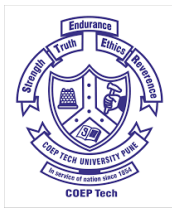
**Suggested learning resources:**

**Text Books**

1. G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, John Wiley, NY: Marcel Dekkar, 1994.

**Reference Books**

1. M F Ashby and K Johnson, Materials and Design - the art and science of material selection in product design, Butterworth-Heinemann, 2003.
2. G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 2000.



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**Stress Analysis**

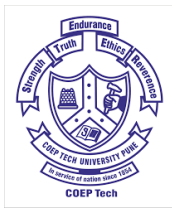
Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Stress Analysis	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Students will understand the tensorial approach of continuum mechanics and will be able to comprehend modern research material.
2. Student will learn basic field equations such as equilibrium equations, compatibility and constitutive relationship.
3. Students will be able to apply basic field equations to torsion, bending and two dimensional problems, energy methods and plastic hinges.

**Syllabus:**



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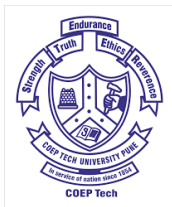
**Mechanical Engineering Department**

Unit	Contents	Hrs
1	Continuum & Tensors, Stress tensor	6
2	Displacement and strains, compatibility relations.	6
3	Two dimensional problems, Torsion, Bending, Energy methods	6
4	Two dimensional problems, Torsion, Bending, Energy methods,	6
5	Plasticity in structures,	6
6	Thick cylinders and Disks, Contact stresses	6

**Suggested learning resources:**

**Text Books**

7. Sadd, Martin H., Elasticity: Theory, applications and Numerics, Academic Press 2005 (Text Book)
8. Srinath, L S, Advanced Mechanics of Solids, Tata McGraw Hill Education Pvt. Limited, New Delhi, 2009
9. Budynas, R. G. Advance strength and Applied Stress Analysis, Second Edition, WCB/ McGraw Hill 1999
10. Dally, J. W. and W.F. Riley, Experimental Stress Analysis, McGraw Hill International, Third Edition, 1991



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**Optimization Techniques in Design**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Optimization Techniques in Design	3	1	0	1	4	30	20	50	—	—

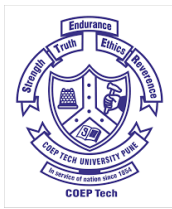
**Course Outcomes:**

Students completing this course will be able to:

1. Formulate an optimization problem.
2. Apply algorithms for unconstrained optimization.
3. Apply algorithms for constrained optimization.

**Syllabus:**

Unit	Contents	Hrs
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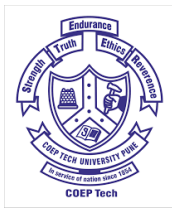
**Mechanical Engineering Department**

1	Introduction to optimization, classification of optimisation problems, classical optimisation techniques,	6
2	Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's methods,	6
3	Non-Linear Programming: - One dimensional minimization, unconstrained and constrained minimization, direct and indirect methods,	6
4	Geometric programming, Optimum design of mechanical elements like beams, columns, gears, shafts, etc.	6
5	Introduction to multi-objective optimization, genetic Algorithms, Operators, applications in multi-objective optimization.	6

**Suggested learning resources:**

**Text Books**

1. Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, New Delhi, 2005.
2. R.C. Johnson, "Optimum Design of Mechanical Elements", Willey, New York, 1980.
3. Kalyanmoy Deb, "Evolutionary multi-objective optimization, Willey, New York.
4. S. S. Stricker, "Optimising performance of energy systems" Battelle Press, New York, 1985.
5. J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 1989.
6. L.C.W. Dixon, "Non-Linear Optimisation - Theory and Algorithms", Birkhauser, Boston, 1980.
7. R.J. Duffin, E.L. Peterson and C.Zener "Geometric Programming-Theory and Applications", Willey, New York, 1967.



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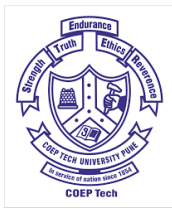
**Advanced Vibration and Acoustics**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Advanced Vibration and Acoustics	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. The students will be able to model a given vibratory system as SDOF or MDOF system, with or without damping. He would also identify the type of given base or force excitation as periodic or a periodic. He would be able to write, mathematically, the excitations of the types such as impulse, step, ramp, half sinusoidal, or such simple arbitrary excitations.
2. The student will be able to predict response of a SDOF system, damped or undamped, subjected to simple arbitrary base or force excitations mentioned above using convolution



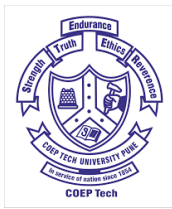
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integral; They will be able to obtain Shock Response Spectrum of SDOF systems for such excitations and understand use of the SRS.

3. The students will be able to write differential equations of motion for MDOF systems, and through the technique of decoupling and orthogonal properties of natural modes, should be able to obtain the eigen-values and mode shapes of natural vibrations and response to harmonic and arbitrary excitations.
7. The students will be able to obtain the eigen-values and mode shapes of natural vibrations and response to harmonic excitations using orthogonal properties of natural modes.
8. Student will be able to obtain natural frequencies and mode shapes of MDOF and continuous systems using computational methods such as Rayleigh-Ritz method, Holzer method, Dunckerley's method, and Stodola's method.
9. Student will know various terminologies used in acoustics and acoustic wave transmission.
10. The student will able to derive plane and spherical wave equations, and will be able to obtain sound pressure level at a given distance from a simple sound source of known strength.
11. Students will be able to understand the mechanism of hearing by human and principles of Psychoacoustics and noise control.
12. The student will be able to measure and analyze signals received from vibrating and/or noise radiating structure by use of accelerometers, microphones and signal analyzer. They should be able to carry out FFT analysis and know the dominant frequency components in the signal and their correlation with the vibration of the structure. They should be able to identify correlation between two signals being received from two sources.

**Syllabus:**

Unit	Contents	Hrs
1	Transient Vibrations, Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response function	6
2	Free, damped and forced vibrations of two degree of freedom systems, use of Lagrange's equations to derive the equations of motion, normal modes and their properties, multi degree of freedom systems, Eigen values and Eigen vectors, mode summation method.	6
3	Continuous Systems, Vibrations of strings, bars, shafts and beams, discretised models of continuous systems and their solutions using Rayleigh – Ritz method, Mode summation method,	6
4	Continuous Systems, Vibrations of strings, bars, shafts and beams, discretised models of continuous systems and their solutions using Rayleigh – Ritz method, Mode summation method,	6



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<b>5</b>	Plane and Spherical acoustic waves, Transmission Phenomena, transmission from one fluid medium to another, normal incidence, reflection at the surface of a solid, standing wave patterns, transmission through three media, Resonators and filters, Absorption of sound waves in fluids : Phase lag between pressure and condensation, viscous absorption of plane waves, heat conduction as a source of acoustic attenuation,	<b>6</b>
<b>6</b>	Speech, Hearing and Noise, The voice mechanism, acoustic power output of a speech, anatomy of the ear, mechanism of hearing, thresholds of the ear, loudness, pitch and timbre, beats, aural harmonics and combination tones, masking by pure tones, masking by noise.	<b>6</b>

**Suggested learning resources:**

**Text Books**

1. Thomson W.T., “Theory of Vibrations with applications”, George Allen and Unwh Ltd. London, 1981.
2. S.S. Rao, Addison, “Mechanical Vibrations”, Wesley Publishing Co., 1990.
3. Leonard Meirovitch, “Fundamentals of vibrations”, McGraw Hill International Edition.
4. S. Timoshenko, “Vibration problems in Engineering”, Wiley, 1974.
5. Lawrence E. Kinsler and Austin R.Frey, “Fundamentals of acoustics”, Wiley Eastern Ltd., 1987.
6. Michael Rettinger, “Acoustic Design and Noise Control”, Vol. I & II. , Chemical Publishing Co., New York, 1977.

**Honors- Mechanical Engineering - Thermal Engineering**

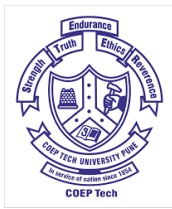
**MATLAB Programming and Simulink Modeling**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	MATLAB Programming and Simulink Modeling	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Demonstrate proficiency in the MATLAB environment by creating scripts and performing basic operations such as matrix creation, transformation, arithmetic operations, and evaluation of determinants.



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2. Apply matrix algebra techniques to analyze and solve engineering problems involving rank determination, systems of linear equations, eigenvalues, and eigenvectors using numerical methods.
3. Develop structured MATLAB programs using conditional statements, loops, logical operators, and indexing techniques to solve computational problems efficiently.
4. Implement numerical methods and solve ordinary differential equations using built-in MATLAB solvers, and visualize engineering data through effective plotting techniques.
5. Model and simulate dynamic engineering systems using Simulink by employing source and sink blocks, subsystems, lookup tables, logic operations, and transfer function representations.
6. Analyze and control real-world dynamic systems such as tank level systems, spring–mass–damper systems, and DC servomotors by developing simulation models and designing PID controllers in Simulink.

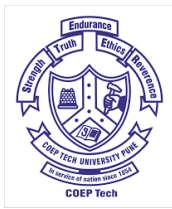
**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction:</b> Introduction to MATLAB, Running MATLAB, creating calculator, Matrix creation, combination and transformation of Matrices, Matrix arithmetic, Matrix operations, Determinant	6
2	<b>Matrix operations:</b> Rank of matrix, solution to system of linear equations, Gauss Elimination, Gauss Sidel Elimination, Eigen values, Eigen vectors	6
3	<b>Functions and loops:</b> If statements, relational and logical operators, Nested If else, for loop, do while loops, break statements, logical indexing,	6
4	<b>Programming:</b> ODE solvers, implementation of numerical methods, plotting with MATLAB	6
5	<b>Simulink:</b> Introduction to simulink, source blocks, sink blocks, look up tables, logic operations, sub systems, Laplace transform and transfer functions, Mechanical system modeling, electrical system modeling, hydraulic system modeling	6
6	<b>Simulink:</b> Modeling and simulation of a tank level, building spring mass damper model, modeling and simulation of DC servomotor, tank level controller using PID controller	6

**Suggested reading**

**Textbooks:**

1. Getting started with MATLAB by Rudra Pratap



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2. Beginning MATLAB and Simulink by Sulaymon L. Eshkabilov

**Renewable Energy Systems**

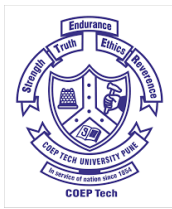
Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Renewable Energy Systems	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Analyze the performance of solar energy conversion systems.
2. Performance analysis of various wind energy conversion systems.
3. Compare various bio-energy conversion methods
4. Explore various ocean energy resources such as tidal, wave and ocean thermal energy and geothermal energy systems.

**Syllabus:**



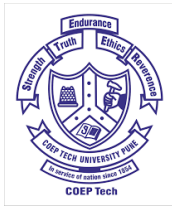
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Unit	Contents	Hrs
1	<b>Introduction:</b> Energy demand growth and supply: Historical Perspectives, Fossil fuels, Consumption and Reserve; Environmental Impacts of Burning of Fossil fuels. Sustainable development and role of renewable energy sources.	6
2	<b>Solar Energy:</b> The Sun as an energy source and its movement in the sky. Solar energy received on the earth; Primary and Secondary Solar energy and Utilization of Solar Energy. Solar concentrators and tracking; Dish and Parabolic trough concentrating generating systems, Central tower solar thermal power plants; Solar ponds. Photovoltaic cells.	6
3	<b>Wind Energy:</b> Types of turbines, Coefficient of Power, Betz limit, Wind electric generators, Power curve; wind characteristics and site selection; Potential of wind electricity generation in India and its current growth rate.	6
4	<b>PBiomass Energy: Biomass:</b> Sources and Characteristics; Wet biogas plants; Biomass gasifiers: Classification and Operating characteristics; Updraft and Downdraft gasifiers; Gasifier based electricity generating systems.	6
5	<b>Ocean Energy:</b> Tidal power plants: single basin and double basis plants, Variation in generation level; Ocean Thermal Electricity Conversion (OTEC);	6
6	<b>Power generation from Waves:</b> Shoreline and Floating wave systems. Geothermal Energy: Conversion technologies- Steam and Binary systems; Geothermal power plants.	6

**Suggested learning resources:**

**Text Books**

1. G.D Rai, "Non-Conventional Energy Source", Khanna Publishers, 2008.
2. D.O. Hall and R.P. Overend, "Biomass Regenerable Energy", John Wiley and Sons, New York, 1987. 11.
3. Freris L.L, "Wind Energy Conversion Systems", Prentice Hall 1990
4. John W. Twidell and Anthony D. Weir, "Renewable Energy Resource", Taylor & Francis, 2006.
5. Sukhatme, S.P. and Nayak, J.K., "Solar Energy - Principles of Thermal Collection and Storage", Tata McGraw Hill, New Delhi, 2008.
6. John A. Duffie, William A and Beckman "Solar Engineering of Thermal Processes" Fourth Edition, Wiley, 2013



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**Electronic Cooling Systems**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Electronic Cooling Systems	3	1	0	1	4	30	20	50	—	—

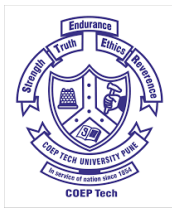
**Course Outcomes:**

Students completing this course will be able to:

1. Understand the heat transfer mechanisms of electronic cooling systems and assess their capability and applicability
2. Describe different cooling techniques and its applications in various domains
3. Analyse new cooling methods in the present scenario and use of commercial tools

**Syllabus:**

Unit	Contents	Hrs
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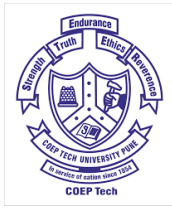
**Mechanical Engineering Department**

<b>1</b>	<b>Introduction:</b> objectives of thermal control, heat sources, heat transmission, steady and unsteady heat transfer. Electronic equipment for airplanes, missiles, satellites, spacecraft, ships, submarines, personal computers, microcomputers and microprocessors.	<b>6</b>
<b>2</b>	<b>Cooling techniques:</b> i) air cooling-natural cooling ii) air cooling-forced convection iii) liquid cooling. Thermal contact conductance, fundamentals of heat transfer across an interface, real contact area, applications to microelectronics, enhancement of contact conductance. Extended surface arrays for air cooled systems, parameterizations, the fin input admittance, the limitations of the fin efficiency	<b>6</b>
<b>3</b>	Introduction to impinging jet theory, description of the principal flow regimes, single nozzle and multi-nozzle test rig, Taxonomy of liquid jet impingement conditions. Unconfined: free surface and submerged jets, semi confined, submerged jets. Heat transfer for unconfined free-surface and submerged jets i) circular ii) planar jets. Multiple impinging jets. Synthetic jets design and measurement approaches, enhancing heat transfer with synthetic jets (free and forced convection).	<b>6</b>
<b>4</b>	Introduction to heat pipe, working principle, thermal performance, design, thermal resistance considerations, types of heat pipes, cylindrical, flat, micro and oscillating heat pipes	<b>6</b>

**Suggested learning resources:**

**Text Books**

1. Kakac Sadik, Yuncu Hafit, Hijikata, K. "Cooling of Electronic systems", Springer Science Business Media, Dordrecht, 1994.
2. Dave S. Steinberg "Cooling Techniques for Electronic Equipment", John Wiley and sons Inc, Canada, 1991.
3. S M Sohel Murshed "Electronics Cooling", ExLi4EvA, 2016
4. Madhusudan Iyengar, Karl J L Geisler, Bahgat Sammakia "Cooling of Microelectronic and Nanoelectronic Equipment: Advances and Emerging Research", WSPC Ltd, Singapore, 2015
5. Bahman Zohuri "Heat pipe Design and Technology", Taylor and Francis ltd, U.S., 2011



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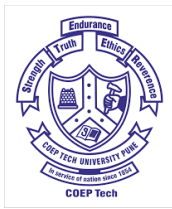
### Computational Fluid Dynamics

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
	Computational Fluid Dynamics	3	1	0	0	4	30	20	50	--	--

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Understand the discretization procedure of the governing equations
2. Prepare the problem definition of a given fluid flow heat transfer problem
3. Decide the governing equations, boundary conditions, initial conditions etc for the given problem
4. To carry out the simulations and obtain the results in terms of dependent variables



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5. Analyze the CFD results through post processing to obtain engineering parameters

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Introduction to CFD:</b> Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations.	6
2	<b>Governing Equations:</b> Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy.	7
3	<b>Finite Volume Method:</b> Domain discretizations, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach	6
4	<b>Geometry Modelling and Grid Generation:</b> Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance	7
5	<b>Methodology of CFDHT:</b> Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation	8
6	<b>Solution of N-S Equations for Incompressible Flows:</b> Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows	8

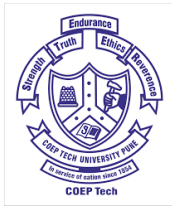
**Suggested learning resources:**

**Reference Books:**

1. John A. Anderson, Jr., Computational Fluid Dynamics, The Basic with applications by John A. Anderson, Jr., McGraw Hill International editions, Mechanical Engineering series.
2. Dr. Suhas Patankar, Numerical Heat Transfer and Fluid Flow, Crc Press.
3. H.K. Versteeg, W.Malalasekera, Introduction to Computational Fluid Dynamics, An: The Finite Volume Method, PHI; 2nd edition.
4. Ferziger and Peric, Computational Methods for Fluid Dynamics, Springer Publication.
5. Chuen-Yen Chow, An Introduction to Computational Fluid Mechanics, Seminole Pub Co.
6. Muralidhar K (Author), Sundararajan, Computational Fluid Flow & Heat Transfer, Narosa Publishing House.

**Weblinks:**

<https://nptel.ac.in/courses/112105045>



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**Introduction to modeling and simulation of hydrogen technology**

Course Code	Course Name	Teaching Scheme (Weightage in Hr.)					Evaluation Scheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ES E	ISE	ESE
	Introduction to modeling and simulation of hydrogen technology	3	1	0	0	4	30	20	50	--	--

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Explain key modeling and simulation philosophies and tools for hydrogen energy systems, with distinctions between 0D–3D and steady-state vs. dynamic models.



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2. Apply fundamental principles of electrochemistry and thermodynamics to model hydrogen production and consumption processes, including the calculation of relevant thermodynamic properties.
3. Develop and analyze simulation models for hydrogen production technologies such as water electrolysis, with an ability to implement steady-state and dynamic simulations.
4. Construct equivalent models for hydrogen application technologies (including fuel cells, engines, and turbines) and evaluate their performance using simulation tools.
5. Perform techno-economic assessments of hydrogen systems using levelized cost analysis and critically appraise the economic viability of advanced hydrogen technologies.

**Syllabus:**

Unit	Contents	Hrs.
1	<b>Overview of modelling and simulation approaches:</b> Modelling and simulation philosophy, type of models – 0D-3D, steady-state vs dynamic, physics-based models, data-driven models, hybrid models, availability of 0D/1D simulation environments – MATLAB/Simulink, Python, GT-POWER.	6
2	<b>Basic principles in Hydrogen production and consumption processes:</b> Overview of electrochemistry - chemical equilibrium, reaction rates, basic thermodynamics – enthalpy, entropy, Gibbs free energy, calculation of reversible voltages at STP, basic power electronics – rectifiers, inverters, DC/DC and AC/AC converters.	7
3	<b>Modeling Hydrogen production technologies – Water Electrolysis:</b> Overview of various Hydrogen generation technologies – biomass gasification, thermolysis (solar, nuclear, with and without catalysts), photocatalysis, methane decomposition, water electrolysis. Overview of water electrolysis techniques for Green Hydrogen production (Alkaline, PEM and solid oxide). PEM electrolyzer cell example - Deep dive into electrical, chemical and mechanical equivalent steadystate models in 0D, steady-state vs dynamic simulation.	6
4	<b>Modeling Hydrogen application technologies – Fuel cells:</b> Challenges with Hydrogen storage and transportation design, Overview of various Hydrogen application technologies – Hydrogen internal combustion engine, Hydrogen gas turbine, fuel cells. Overview of power generation techniques using Fuel cells (Alkaline, PEM and solid oxide). PEM fuel cell example - Deep dive into electrical, chemical and mechanical equivalent steady-state models in 0D, steadystate vs dynamic simulation.	7
5	<b>Modeling for techno-economic analysis of advanced energy devices:</b> Key performance indicators to assess technology, levelized cost of X analysis e.g. LCOH, making various investment decisions, future trends in modelling and simulations, future trends in Hydrogen technologies	8

**Suggested learning resources:**

**Reference Books:**



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**Mechanical Engineering Department**

1. Modeling, Design, and Simulation of Systems with Uncertainties, Authors: Andreas Rauh, Ekaterina Auer, 1st Edition, 2011, Springer-Verlag Berlin Heidelberg ISBN: 978-3642159558, Book Link
2. Hydrogen and Fuel Cells: Emerging Technologies and Applications, Authors: Bent Sørensen, Giuseppe Spazzafumo, 3rd Edition, 2018, Academic Press (Elsevier) ISBN: 978-0-08-100708-2, Book Link
3. Hydrogen Fuel: Production, Transport, and Storage, Editor: Ram B. Gupta, 1st Edition, 2008, CRC Press (Taylor & Francis), ISBN: 978-1-4200-4575-8, BookLink
4. Muralidhar K (Author), Sundararajan, Computational Fluid Flow & Heat Transfer, Narosa Publishing House.
5. Fuel Cell Fundamentals, Authors: Ryan O'Hayre, Suk-Won Cha, Whitney Colella, Fritz B. Prinz, 3rd Edition, 2016, Wiley, ISBN: 978-1-119-11380-5, Book Link
6. Electrochemical Methods: Fundamentals and Applications, Authors: Allen J. Bard, Larry R. Faulkner, Henry S. White, 3rd Edition, 2022, Wiley, ISBN: 978-1-119-33406-4 BookLink
7. The Hydrogen Economy: Opportunities and Challenges, Editors: Michael Ball, Martin Wietschel, 1st Edition, 2010, Cambridge University Press, ISBN: 978-0-521-88216-3 Book Link
8. Renewable Hydrogen Technologies: Production, Purification, Storage, Applications and Safety, Editors: Luis M. Gandía, Gurutze Arzamendi, Pedro M. Diéguez, 1st Edition, 2013, Elsevier, ISBN: 978-0-444-56352-1, Book Link

**Honors- Mechanical Engineering - Hybrid and Electric Vehicle**

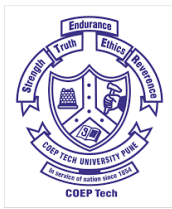
**MATLAB Programming and Simulink Modeling**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	MATLAB Programming and Simulink Modeling	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Demonstrate proficiency in the MATLAB environment by creating scripts and performing basic operations such as matrix creation, transformation, arithmetic operations, and evaluation of determinants.



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2. Apply matrix algebra techniques to analyze and solve engineering problems involving rank determination, systems of linear equations, eigenvalues, and eigenvectors using numerical methods.
3. Develop structured MATLAB programs using conditional statements, loops, logical operators, and indexing techniques to solve computational problems efficiently.
4. Implement numerical methods and solve ordinary differential equations using built-in MATLAB solvers, and visualize engineering data through effective plotting techniques.
5. Model and simulate dynamic engineering systems using Simulink by employing source and sink blocks, subsystems, lookup tables, logic operations, and transfer function representations.
6. Analyze and control real-world dynamic systems such as tank level systems, spring–mass–damper systems, and DC servomotors by developing simulation models and designing PID controllers in Simulink.

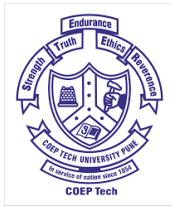
**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction:</b> Introduction to MATLAB, Running MATLAB, creating calculator, Matrix creation, combination and transformation of Matrices, Matrix arithmetic, Matrix operations, Determinant	6
2	<b>Matrix operations:</b> Rank of matrix, solution to system of linear equations, Gauss Elimination, Gauss Sidel Elimination, Eigen values, Eigen vectors	6
3	<b>Functions and loops:</b> If statements, relational and logical operators, Nested If else, for loop, do while loops, break statements, logical indexing,	6
4	<b>Programming:</b> ODE solvers, implementation of numerical methods, plotting with MATLAB	6
5	<b>Simulink:</b> Introduction to simulink, source blocks, sink blocks, look up tables, logic operations, sub systems, Laplace transform and transfer functions, Mechanical system modeling, electrical system modeling, hydraulic system modeling	6
6	<b>Simulink:</b> Modeling and simulation of a tank level, building spring mass damper model, modeling and simulation of DC servomotor, tank level controller using PID controller	6

**Suggested reading**

**Textbooks:**

1. Getting started with MATLAB by Rudra Pratap
2. Beginning MATLAB and Simulink by Sulaymon L. Eshkabilov



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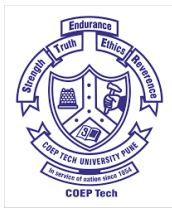
**Automotive Engineering Systems**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Automotive Engineering systems	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Identify the need of transmission system, it's function, and discuss different types of Passenger car transmission systems.
2. Calculate vehicle resistance, predict vehicle power requirement curve.
3. Calculate transmission gear ratio's & predict vehicle performance.



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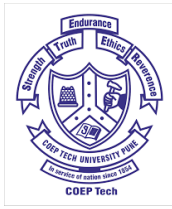
4. Categorize different vehicles bodies & layout's, it's nomenclature, structural elements and synthesis it to meet vehicle crashworthiness requirements.
5. Describe the different breaking & suspension systems in an automobile & demonstrate the vehicle safety.

**Syllabus:**

Unit	Contents	Hrs
1	<b>Introduction:</b> History, Development of Vehicles & Drive Units, Stages in the Development of Automotive Transmissions, Development of Gear-Tooth Systems and other, Transmission Components. Basic Elements of Vehicle and Transmission Engineering, Need of Gearboxes, Functions of Vehicle Transmissions, and Fundamental Performance Features of Vehicle Transmissions, Trends in Transmission Design, Transmission Losses and Efficiency.	6
2	<b>Basic Design Principles :</b> Arrangement of the Transmission in Passenger / Commercial / All-Wheel Drive Passenger Cars / Transverse and Longitudinal Dynamics with All-Wheel Drive. Transmission Formats & Designs, Basic Gearbox Concept. Passenger Car Transmissions: Manual Passenger Car Transmissions (MT); Automated Manual Passenger Car Transmissions (AMT); Dual Clutch Passenger Car Transmissions (DCT); Automatic Passenger Car Transmissions (AT); Passenger Car Hybrid Drives; Continuously Variable Passenger Car Transmissions (CVT). Final Drives: Axle Drives for Passenger Cars, Axle Drives for Commercial Vehicles, Differential Gears and Locking Differentials, Hub Drives for Commercial Vehicles; Transfer Gearboxes.	6
3	<b>Passenger Vehicle Body:</b> The Automobile Body, Description of the Automobile Body Types (space frame, central frame, Body-on-frame, Monocoque), Body Nomenclature, Body Mass Benchmarking, Steel used in passenger vehicle. Vehicle layout, Different types of Car Body Style, Automotive Body Structural Elements, Overview of Classical Beam Behavior, Design of Automotive Beam Sections, Design for Crashworthiness: Standardized Safety Test Conditions and Requirements, Front Barrier, Side Impact, Note on Rear Impact.	6
4	<b>Brakes, Suspension Systems:</b> Type of brakes, Disc & Drum brake theory, constructional details, advantages, Brake actuating systems, Materials, and braking torque. Factors affecting brake performance, Parking & Exhaust brakes, power assisted brakes, Antilock Breaking System (ABS). Testing of brakes, thermal Considerations. Construction of suspension system, Solid Axles & Independent Suspension system, four-link & multi-link, Trailing Arm, Short Long Arm (SLA), MacPherson Strut suspension system, Anti-Squat, Anti-Pitch, and Anti-Dive suspension system, Roll Center & stability Analysis.	6

**Suggested learning resources:**

**Reference Books:**



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1. Harald Naunheimer, Bernd Bertsche, Joachim Ryborz, Wolfgang Novak “Automotive Transmission: Fundamentals, Selection, Design & Application” 2<sup>nd</sup> Edition, Springer-Verlag Berlin Heidelberg 1994, 2011
2. Donald E. Malen “Fundamentals of Automobile Body Structure Design” SAE International Publication.
3. K. Newton, W.Steeds and T.K.Garret, “The Motor Vehicle”, 13<sup>th</sup> Edition, Butterworth Heinemann, India, 2004.
4. P.M.Heldt, “Automotive Chassis”, Chilton Co., New York, 1982.
5. W.Steed, “Mechanics of Road Vehicles”, Illiffe Books Ltd., London. 1992.
6. Heinz Heisler, “Advanced Vehicle Technology”, second edition, Butterworth – Heinemann, New York, 2002.

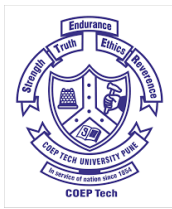
**Automotive Mechatronics**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Automotive Mechatronics	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Understand the basic components of automotive mechatronics and control systems.
2. Understand the basics of sensors, actuators and its interaction with automotive parameters.
3. Understand the basics of electronic engine management system for SI and CI Engine Management System.
4. Identify the use of multiplex networking for automotive applications

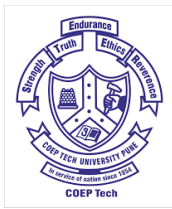


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5. Identify the applications of automotive mechatronics in different sub-domains of automobiles

**Syllabus:**

Unit	Contents	Hrs
<b>1</b>	Fundamentals of Automotive Mechatronics & Control System: Fundamentals of Mechatronics, Electronics Components, Microprocessor, Ports, Memory, Buses, Microcontroller, Fetch-Execute sequence, Programming, Electronic Control Unit, Testing of Microcontroller Systems. Control System: Open and closed loop control strategies, PID control, Look up tables, Modern control strategies: Fuzzy logic and adaptive control.	<b>6</b>
<b>2</b>	Sensors & Actuators: Hall Effect, hot wire, thermistor, piezo electric, piezoresistive, based sensors. Introduction, basic sensor arrangement, types of sensors, oxygen concentration sensor, lambda sensor, crankshaft angular position sensor, cam position sensor, Mass air flow (MAF) rate, Manifold absolute pressure (MAP), Throttle plate angular position, engine oil pressure sensor, vehicle speed sensor, detonation sensor, emission sensors, Actuators: solenoid actuator, stepper motors, relays, electrohydraulic actuators.	<b>6</b>
<b>3</b>	Electronic Engine Management System: Electronics Fuel Injection, Types of EFI, TBI, MPFI & GDI, Ignition System, Electronic Ignition System and its advantages, Fuel control maps, CI Engine Management. Fuel injection system, parameters affecting combustion, noise and emissions in CI engines. Pilot, main, advanced, post injection and retarded post injection. Electronically controlled Unit Injection system. Exhaust emission control systems, 2 and 3way catalytic converter.	<b>6</b>
<b>4</b>	Automotive Tools, Diagnosis & Networking: Wiring Harness, Limitations of Wiring Harness, Multiplex data bus, Basic principle of Networking, Classification of automotive multiplex bus, Controller Area Network, Local Interconnect Network, FlexRay, Most, Automotive Ethernet, Connected Cars. Diagnosis: tools and equipment, Oscilloscope, onboard diagnosis system, Electromagnetic compatibility & tests for EMC.	<b>6</b>
<b>5</b>	Applications for different domains and current trends: Lighting systems: LED, adaptive front lighting system, Comfort systems: Cruise control, adaptive cruise control, central locking, Electric mirrors, windows, multimedia systems, Safety &	<b>6</b>



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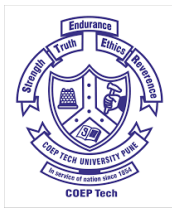
**Mechanical Engineering Department**

	security systems: Airbag, Chassis Systems: ABS, TC, ESP, TPMS, Active Suspension, Active Steering system, Automatic Transmission, Use of Machine learning and data analytics for the automotive applications (ADAS, vehicle Autonomy, prognostics, health monitoring).	
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**Suggested learning resources:**

**Reference Books:**

1. Automotive Mechatronics: Automotive Networking, Driving Stability Systems, Electronics (Bosch Professional Automotive Information), by Konrad Reif, Springer Fachmedien Wiesbaden, 2014.
2. Automobile Electrical & Electronic Equipments - Young, Griffiths - Butterworths, London.
3. Understanding Automotive Electronics, William B. Ribbens, 5th Edition, Newnes, Butterworth-Heinemann.
4. Diesel Engine Management by Robert Bosch, SAE Publications, 3rd Edition, 2004
5. Gasoline Engine Management by Robert Bosch, SAE Publications, 2nd Edition, 2004.
6. Understanding Automotive Electronics – Bechfold SAE 1998
7. Automobile Electronics by Eric Chowanietz SAE.
8. Fundamentals of Automotive Electronics - V.A.W.Hilliars - Hatchin, London
9. Automotive Computer & Control System – Tomwather J. R., Cland Hunter, Prentice Inc. NJ.
10. Automotive Computers & Digital Instrumentation – Robert N. Brandy, Prentice Hall Eaglewood, Cliffs, NJ
11. The Fundamentals of Electrical Systems - John Hartly - Longman Scientific & Technical
12. Automobile Electrical & Electronic Systems – Tom Denton, Allied Publishers Pvt. Ltd.
13. Anderson, J. M., Nidhi, K., Stanley, K. D., Sorensen, P., Samaras, C., & Oluwatola, O. A. (2014). Autonomous vehicle technology: A guide for policymakers. Rand Corporation.
14. James D. Halderman, Advanced Automotive Electricity and Electronics, Pearson, 2013.
15. Tom Denton, Advanced Automotive Fault Diagnosis, Routledge, 2006
16. Nicolas Navet, Francoise Simonot-Lion, Automotive Embedded Systems Handbook, CRC Press, 2008.



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**Hybrid and Electrical Vehicle**

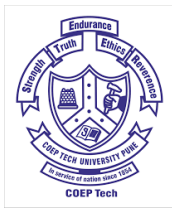
Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Hybrid and Electrical Vehicle	3	1	0	1	4	30	20	50	—	—

**Course Outcomes:**

Students completing this course will be able to:

1. Understand the basic components of the hybrid systems
2. Understand the variations (different types) of hybrid configurations
3. Develop understanding of batteries, and motors
4. Design and develop the hybrid and electric vehicles
5. Understand the speed control mechanisms for electric motors and generators

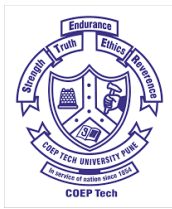
**Syllabus:**



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Unit	Contents	Hrs
1	<b>Introduction to Hybrid Electric Vehicles:</b> History of hybrid and electric vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies.	6
2	<b>Conventional Vehicles:</b> Basics of vehicle performance, vehicle power source characterization, transmission characteristics, and mathematical models to describe vehicle performance.	6
3	<b>Hybrid Electric Drive-trains:</b> Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis. <b>Electric Drive-trains:</b> Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis.	6
4	<b>Electric Propulsion unit:</b> Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.	6
5	<b>Energy Storage:</b> Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices.  <b>Sizing the drive system:</b> Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, supporting subsystems.	6
6	<b>Energy Management Strategies:</b> Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies.  <b>Case Studies:</b> Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle	6

**Suggested learning resources:**



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**Reference Books:**

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

**Automotive Transmission and Control**

Course Code	CourseName	Teaching Scheme (Weightage in Hr.)					EvaluationScheme (Weightage in %)				
		L	T	P	S	Cr	Theory			Laboratory	
							MSE	TA	ESE	ISE	ESE
	Automotive Transmission and Control	3	1	0	1	4	30	20	50	—	—

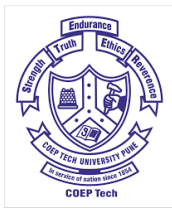
**Course Outcomes:**

Students completing this course will be able to:

1. Understand basics of automotive transmission.
2. Understand shift mechanism and clutch control.
3. Get familiar with function development of transmission control systems.
4. Understand various types of transmission such as AT, AMT, MT

**Syllabus:**

Unit	Contents	Hrs



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<b>1</b>	Introduction to Automotive transmission: Working principle and construction of Automotive Transmissions, Types of automotive transmissions, Manual Transmissions, CVT, DCT	<b>6</b>
<b>2</b>	<b>Transmission System Design</b> : Transmission requirement in a vehicle, gear ratios, Selecting the Ratios, Overall Gear Ratio, Selecting the Largest Powertrain Ratio, Selecting the Smallest Powertrain Ratio, Final Ratio. Selecting the Intermediate Gears, matching of powertrain.	<b>6</b>
<b>3</b>	<b>Automated Manual Transmission (AMT) &amp; Automatic Transmission (AT)</b> : Introduction to Automated manual transmissions, working and construction, different configurations of AMT, actuators in AMT, Automatic transmission, working and construction, shifting strategies, features of AMT & AT, comparison with MT	<b>6</b>
<b>4</b>	Transmission Control System : Introduction to Transmission Control System, Transmission control unit, Function Development of Transmission Control System, Sensors and Actuators	<b>6</b>
<b>5</b>	<b>EV transmissions</b> : Requirements of transmission in electric vehicle, features of EV transmission, types, configurations, performance parameters , design consideration for EV transmission,	<b>6</b>
<b>6</b>	Hybrid Vehicle Transmission : HEV requirements of torque, different types of configurations in HEV, performance of hybrid transmissions, design parameters of HEV transmission systems	<b>6</b>

**Suggested learning resources:**

**Reference Books:**

1. Vehicle Powertrain Systems, Behrooz Mashadi , David Crolla, John Wiley & Sons, Ltd, 2012
2. Automotive Engineering Powertrain, Chassis System and Vehicle Body, David Crolla, Butterworth-Heinemann, 2009