

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109



# O. P. Jindal University

Raigarh-Chhattisgarh



*Scheme and Syllabus*  
*of*  
B.Tech

School of Engineering  
Session- 2025-29

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109



**PROGRAM OUTCOMES (POS):** At graduation, students will be able to: (From AY: 24-25)  
(refer next page for WK1 – WK9 (Knowledge and Attitude Profile))

PO-1	<b>Engineering Knowledge:</b> Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
PO-2	<b>Problem Analysis:</b> Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
PO-3	<b>Design/Development of Solutions:</b> Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)

### **Knowledge and Attitude Profile (WK)**

**WK1:** A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

**WK2:** Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

**WK3:** A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

**WK4:** Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

**WK5:** Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

**WK6:** Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

**WK7:** Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

**WK8:** Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

**WK9:** Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

**PROGRAM SPECIFIC OUTCOMES** - At graduation, students will be able to provide:

**PSO1: Applying Mechanical Engineering to Global Challenges**

Develop an attitude to meet global challenges and apply the knowledge of mechanical engineering to solve problems related to thermal, design, manufacturing, and interdisciplinary fields.

**PSO2: Technology-Driven Solutions for Industry & Society**

Demonstrate knowledge and skill for solving social, real industrial problems using modern software and hardware tools.

**PSO3: Utilizing Mechanical Engineering for Emerging Technologies**

Utilizing the knowledge of Mechanical Engineering to work effectively in cutting edge technologies such as Robotics, Artificial Intelligence, Mechatronics, and Automation.

Curriculum and Credit Framework for Undergraduate Programme (CCFUP)									
Semester	MAJOR		MINOR	AEC	SEC	Internship/ Apprentice- ship/Project/ Community outreach	VAC	MDC	Total Credits
	DSC	DSE							
<b>I</b>	16			2	2		2		22
<b>II</b>	13			2	2		2	3	22

\* Students on exit shall be Awarded Undergraduate Certificate (in the Field of Study/ Discipline) after securing the requisite 44 credits in Semesters I and II and complete one vocational course of 4 credits during the summer

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109



OPJU

**AEC:** Ability Enhancement Course

**SEC:** Skill Enhancement Course

**VAC:** Value addition Course

**MDC:** Multidisciplinary Course

**Level of courses:** There will be 5 level of courses on the basis of learning outcome and difficulty levels distributed across semesters in ascending order.

Level-1 (0-99), Level-2 (100-199), Level-3 (200-299), Level-4 (300-399), Level-5 (400-499) courses shall be pre-requisite, introductory, intermediate, higher level, and advanced courses respectively.

DEGREE	MAJOR		MINOR	AEC	SEC	INTERNSHIP/ PROJECT	VAC	MDC	TOTAL CREDIT
	CORE	ELECTIVE							
Honors	106	12	24	8	9	8	6	9	182
Honors with Research	94	12	24	8	9	20	6	9	182

*M*

*h*

*h*

*h*

*Majumdar*

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109



OPJU

**Course Structure for B. Tech Program (1<sup>st</sup> & 2<sup>nd</sup> Semester)-2025-29 batch**  
**(School of Engineering, Common to all departments)**

Year	FIRST SEMESTER (NHEQF Level: 4.5)											
	Sem	Course Code	Course Category	Name of the Course	Hours per week			Scheme of Examination and Marks				Credits : L+ T+ (P/2)
					L	T	P	PRE		ESE	Total	
								MID	TA			
First Year	1 <sup>st</sup>	MAT24-B-MJ111	MAJOR	Engineering Mathematics-I	3	0	0	15	15	70	100	3
		PHY24-B-MJ111	MAJOR	Applied Physics	2	0	0	7.5	7.5	35	50	2
		EE24-B-MJ101	MAJOR	Basic Electrical and Electronics	3	0	0	15	15	70	100	3
		ME24-B-MJ101	MAJOR	Engineering Graphics	2	0	2	15	15	70	100	3
		MME24-B-MJ101	MAJOR	Introduction to Engineering Materials	3	0	0	15	15	70	100	3
			AEC	Choose from the Pool	2	0	0	7.5	7.5	35	50	2
			SEC	Choose from the Pool	2	0	0	7.5	7.5	35	50	
					0	0	4	-	15	35	50	
			VAC	Choose from the Pool	2	0	0	7.5	7.5	35	50	2
		EE24-B-MJ102	MAJOR	Basic Electrical and Electronics Lab	0	0	2	-	15	35	50	1
		ME24-B-MJ102	MAJOR	Innovation and Skill Development	0	0	2	-	15	35	50	1
											22	

*M*

*Sri*

*A*

*nao*

*M. Singh*

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109



**Course Structure for B. Tech Program (1<sup>st</sup> & 2<sup>nd</sup> Semester)-2025-29 batch**  
**(School of Engineering, Common to all departments)**

Year	SECOND SEMESTER (NHEQF Level: 4.5)											
SEM	Course Code	Course Category	Name of the Course	Hours per week			Scheme of Examination and Marks				Credits: L+ T+ (P/2)	
				L	T	P	PRE		ESE	Total		
							MID	TA				
First Year	MAT24-B-MJ112	MAJOR	Engineering Mathematics-II	3	0	0	15	15	70	100	3	
	CHE24-B-MJ111	MAJOR	Applied Chemistry	2	0	0	7.5	7.5	35	50	2	
	ME24-B-MJ103	MAJOR	Fundamentals of Mechanics	3	0	0	15	15	70	100	3	
	CSE24-B-MJ101	MAJOR	Python Programming	3	0	0	15	15	70	100	3	
		AEC	Choose from the pool	2	0	0	7.5	7.5	35	50	2	
		SEC	Choose from the pool	2	0	0	7.5	7.5	35	50	2	
				0	0	4	-	15	35			
		VAC	Choose from the pool	2	0	0	7.5	7.5	35	50	2	
		MDC	Choose from the pool	3	0	0	15	15	70	100	3	
		ME24-B-MJ104	MAJOR	Mechanics Lab	0	0	2	-	15	35	50	1
		CHE24-B-MJ112	MAJOR	Applied Science Lab	0	0	2	-	15	35	50	1
											22	

*M*

*h*

*A*

*...*

*M. K. Singh*

**Exit option to qualify for Undergraduate Certificate (after completion of 1<sup>st</sup> year)**

1. An exit option is available for students those who have earned the total 44 credits at the End of Second Semester.
2. Student who wants to avail the exit option after first year have to earn additional 4 credits from the list of courses shown below.
3. These courses student have to complete within summer vacation after 1st Year.
4. After fulfillment as mentioned in 1 to 3 above, Students can earn U.G Certificate and same will be issued by the University.

**List of Exit Courses (Choose Any *TWO* Skill-based Courses)**

S. N.	Courses Code	Name of the Courses	L	T	P	Credit	Scheme of Examination and Marks			
							PRE		ESE	Total
							MID	TA		
1	CE24-B-EC101	Computer-Aided Drawing with AutoCAD	0	0	4	2	-	15	35	50
2	CSE24-B-EC101	Basic Computer Skills	0	0	4	2	-	15	35	50
3	CSE24-B-EC102	Computer Hardware Skills	0	0	4	2	-	15	35	50
4	EE24-B-EC101	Electrical Wiring & Testing	0	0	4	2	-	15	35	50
5	ME24-B-EC101	Advanced Mechanical Workshop	0	0	4	2	-	15	35	50

*M*  
*Sir*

*[Signature]*

*[Signature]*

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109



<b>Program:</b>	B. Tech.	<b>Semester:</b>	After 1 <sup>st</sup> Year
<b>Name of the Course:</b>	Advanced Mechanical Workshop	<b>Course Code:</b>	ME24-B-EC101
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Descriptions:**

This course provides hands-on training and practical exposure to basic manufacturing processes and advanced mechanical workshop practices essential for mechanical and production engineering students. The course is designed to familiarize students with the operation of hand tools, machines, and manufacturing techniques used in fitting, carpentry, welding, foundry, and machining shops. Students will perform a series of structured practical tasks to understand the material properties, working principles, and safety procedures of various fabrication and machining processes. The course aims to build foundational technical skills and promote confidence in handling real-world engineering problems related to fabrication, assembly, and component production.

**Course Outcomes:**

After Completion of the course, Students will be able to:

CO Number	Course Outcome
CO1	Create wooden components and joints (like mortise and tenon) and develop simple wooden products using carpentry tools.
CO2	Create wooden components and joints (like mortise and tenon) and develop simple wooden products using carpentry tools.
CO3	Perform basic welding operations including butt-joint, lap-joint, and fabrication of components using arc welding and spot-welding techniques.
CO4	Apply the foundry process by preparing molds using patterns and casting non-ferrous metals and complex shapes.
CO5	Operate basic machine tools like lathe, shaper, and milling machines to produce parts with eccentric, dovetail, and pocketing operations.

**Experiments to be performed (Minimum Ten experiments)**

**Fitting Shop**

1. Making a V- groove job using fitting tools.
2. Making a step cutting job using fitting tools.
3. Making a male-female joint using fitting tools.

**Carpentry Shop**

1. Making a two-piece pattern using carpentry tool.
2. Making a mortise and tenon joint using carpentry tools.
3. Making a laptop stand using carpentry tools (Combined job).

**Welding Shop**

1. Making a Butt-Joint using virtual welding 2.0.
2. Making a Lap-joint using spot welding.
3. Fabricating a steel chair using electric arc welding (Combined Job).

**Foundry Shop**

1. Preparing a mold using a two-piece pattern.
2. Casting of a non-ferrous metals using two-piece pattern.
3. Casting of a sculpture using metal pattern (Combined job).

**Machine Shop**

1. Preparing an eccentric job on a lathe machine.
2. Performing dovetail cutting operation on a shaper machine.
3. Performing circular pocketing operation on a milling machine.

**List of Tools/Equipment/Machines Required:**

1. Fitting tools.
2. Carpentry tools
3. Welding machines (MMAW/Virtual 2.0/Spot) and equipment.
4. Muffle furnace.
5. Lathe Machine.
6. Shaper Machine.
7. Milling Machine.

**CO, PO, & PSO Correlation**

CO Number	Program Outcome											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	2	3	1	2	1	1	2	2	1	2	3	2	-
CO2	3	2	3	1	2	1	1	2	2	1	2	3	2	-
CO3	3	2	3	2	3	2	1	2	2	2	2	3	3	-
CO4	3	2	3	3	3	2	2	2	2	2	2	3	3	-
CO5	3	3	3	3	3	2	2	2	2	2	2	3	3	-

Note: 1: Low 2: Moderate 3: High



**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109  
Department of Mechanical Engineering



# **O. P. Jindal University**

## **Raigarh–Chhattisgarh**



*Scheme and Syllabus*  
*of*  
**B Tech**  
**In**  
**Mechanical Engineering**  
**(01NUG040)**  
School of Engineering  
Session- 2024-28

**PROGRAM OUTCOMES (POS):** At graduation, student will be able to: (From AY: 24-25)

(refer next page for WK1 – WK9 (Knowledge and Attitude Profile))

PO-1	<b>Engineering Knowledge:</b> Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
PO-2	<b>Problem Analysis:</b> Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
PO-3	<b>Design/Development of Solutions:</b> Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
PO-4	<b>Conduct Investigations of Complex Problems:</b> Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8)
PO-5	<b>Engineering Tool Usage:</b> Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
PO-6	<b>The Engineer and The World:</b> Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7)
PO-7	<b>Ethics:</b> Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)
PO-8	<b>Individual and Collaborative Team work:</b> Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.
PO-9	<b>Communication:</b> Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences
PO-10	<b>Project Management and Finance:</b> Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO-11	<b>Life-Long Learning:</b> Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)
-------	---

### **Knowledge and Attitude Profile (WK)**

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

WK7: Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

**PROGRAM SPECIFIC OUTCOMES** - At graduation, students will be able to provide:

**PSO1: Applying Mechanical Engineering to Global Challenges**

Develop an attitude to meet global challenges and apply the knowledge of mechanical engineering to solve problems related to thermal, design, manufacturing, and interdisciplinary fields.

**PSO2: Technology-Driven Solutions for Industry & Society**

Demonstrate knowledge and skill for solving social, real industrial problems using modern software and hardware tools.

**PSO3: Utilizing Mechanical Engineering for Emerging Technologies**

Utilizing the knowledge of Mechanical Engineering to work effectively in cutting edge technologies such as Robotics, Artificial Intelligence, Mechatronics, and Automation.

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



**OPJU**

Semester	MAJOR		MINOR	AEC	SEC	Internship/ Apprenticeship/Project/ Community outreach	VAC	MDC	Total Credits
	DSC	DSE							
<b>I</b>	16			2	2		2		<b>22</b>
<b>II</b>	13			2	2		2	3	<b>22</b>
<i>* Students on exit shall be Awarded Undergraduate Certificate (in the Field of Study/ Discipline) after securing the requisite 44 credits in Semesters I and II and complete one vocational course of 4 credits during the summer vacation of First Year</i>									
<b>III</b>	11		4	2	2		2	3	<b>24</b>
<b>IV</b>	14		4	2	3			3	<b>26</b>
<i>** Students on exit shall be Awarded Undergraduate Diploma (in the Field of Study/ Discipline) after securing the requisite 94 credits on completion of Semester IV and complete one vocational course of 4 credits during the summer vacation of Second Year.</i>									
<b>V</b>	15	3	4			2			<b>24</b>
<b>VI</b>	14	3	4						<b>21</b>
<i>Students on exit shall be Awarded Bachelor of Voc [B-Voc] (in the Field of Study/Discipline) (Major and Minor) (3 years) after securing the requisite 139 credits on completion of Semester VI</i>									
<b>VII</b>	11	3	4			6			<b>24</b>
<b>VIII</b> (Honors)*	12	3	4						<b>19</b>
<b>VIII</b> (Honors with Research) **		3	4			12			
									<b>182</b>
<i>Students on exit shall be Awarded Bachelor of (in the Field of Study/Discipline) (Honours) or (Honours with Research) after securing the requisite 182 credits on completion of Semester VIII.</i>									

**AEC: Ability Enhancement Course**

**SEC: Skill Enhancement Course**

**VAC: Value addition Course**

**MDC: Multidisciplinary Course**

**Level of courses:** There will be 5 level of courses on the basis of learning outcome and difficulty levels distributed across semesters in ascending order.

Level-1 (0-99), Level-2 (100-199), Level-3 (200-299), Level-4 (300-399), Level-5 (400-499) courses shall be pre-requisite, introductory, intermediate, higher level, and advanced courses respectively.

**Curriculum and Credit Framework for Undergraduate Programme (CCFUP)**

**\*All the admitted students are eligible for the Honors degree**

**\*\*Students who secure 75% or more marks up to the 6<sup>th</sup> semester will only be eligible for honors with a research degree.**

DEGREE	MAJOR		MINOR	AEC	SEC	INTERNSHIP/ PROJECT	VAC	MDC	TOTAL CREDIT
	CORE	ELECTIVE							
Honors	106	12	24	8	9	8	6	9	182
Honors with Research	94	12	24	8	9	20	6	9	182

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



**OPJU**

**Course Structure for Mechanical Engineering (2024-28)**

Year	THIRD SEMESTER											
	SEM	Course Code	Course Category	Name of the Course	Hours per week			Scheme of Examination and Marks				Credits: L+ T+ (P/2)
					L	T	P	PRE		ESE	Total	
								MID	TA			
Second Year	3 <sup>rd</sup>	ME24-B-MJ201	MAJOR	Engineering Thermodynamics	3	0	0	15	15	70	100	3
		ME24-B-MJ202	MAJOR	Mechanics of Materials	3	0	0	15	15	70	100	3
		ME24-B-MJ203	MAJOR	Computational Mathematics	2	0	0	7.5	7.5	35	50	2
		ME24-B-MJ204	MAJOR	Computer-Aided Machine Drawing	1	0	2	7.5	7.5	35	50	2
			MINOR	Choose from the pool	4	0	0	15	15	70	100	4
			AEC	Choose from the pool	2	0	0	7.5	7.5	35	50	2
			SEC	Choose from the pool	2	0	0	7.5	7.5	35	50	2
		0			0	4	-	15	35	50	2	
			VAC	Choose from the pool	2	0	0	7.5	7.5	35	50	2
			MDC	Choose from the pool	3	0	0	15	15	70	100	3
			ME24-B-MJ205	MAJOR	Mechanics of Materials Lab	0	0	2	-	15	35	50
<b>Total</b>											<b>24</b>	

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



**OPJU**

**Course Structure for Mechanical Engineering (2024-28)**

Year	FOURTH SEMESTER											
	SEM	Course Code	Course Category	Name of the Course	Hours per week			Scheme of Examination and Marks				Credits: L+ T+ (P/2)
					L	T	P	PRE		ESE	Total	
								MID	TA			
Second Year	4 <sup>th</sup>	ME24-B-MJ206	MAJOR	Fluid Mechanics & Machinery	3	0	0	15	15	70	100	3
		ME24-B-MJ207	MAJOR	Manufacturing Technology - I	2	0	0	7.5	7.5	35	50	2
		ME24-B-MJ208	MAJOR	Kinematics of Machine	3	0	0	15	15	70	100	3
		ME24-B-MJ209	MAJOR	CORE (IKS)	4	0	0	15	15	70	100	4
			MINOR	Choose from pool	4	0	0	15	15	70	100	4
			AEC	Choose from the pool	2	0	0	7.5	7.5	35	50	2
			SEC	Choose from the pool	3	0	0	15	15	70	100	3
			MDC	Choose from the pool	3	0	0	15	15	70	100	3
		ME24-B-MJ210	MAJOR	Fluid Mechanics & Machinery Lab	0	0	2	-	15	35	50	1
		ME24-B-MJ211	MAJOR	Manufacturing Technology – I Lab	0	0	2	-	15	35	50	1
<i>Students on exit shall be Awarded Undergraduate Diploma (in the Field of Study/ Discipline) after securing the requisite 92 credits on completion of Semester IV and complete one vocational course of 4 credits during the summer vacation of Second Year</i>												

<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Engineering Thermodynamics	<b>Course Code:</b>	ME24-B-MJ201
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive understanding of engineering thermodynamics, covering fundamental principles, thermodynamic laws, properties of substances, and their application in power cycles. Students will develop the analytical skills necessary to solve engineering problems related to energy conversion and thermodynamic processes.

**Course Outcomes:** After completion of the course, students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand the fundamental concepts of thermodynamic systems, equilibrium, first law of thermodynamics.
<b>CO2</b>	Apply the second law of thermodynamics and entropy principles to analyze the performance of thermodynamic cycles and processes.
<b>CO3</b>	Develop fundamental relations between thermodynamic properties.
<b>CO4</b>	Analyze the thermodynamic properties of pure substances.
<b>CO5</b>	Visualize the performance of the vapour power cycle and the gas power cycle

**Syllabus:**

**Unit-1: Introduction:** Role and application of thermodynamics, macroscopic & microscopic view, thermodynamics system, thermodynamic equilibrium, state, process, and cycle.

**First Law of Thermodynamics:** definition of thermodynamic heat & work, sign conventions, First law referred to cycle, First law for change of state, internal energy, modes of energy, enthalpy, specific heat at constant pressure & volume, PMM of first kind, and First law applied to a control volume (open system).

**Unit-2: Second law of thermodynamics:** Limitations of the First law, thermal reservoir, heat engine, heat pump, parameters of performance, Second law of thermodynamics, Kelvin- Planck and Clausius statements and their equivalence, PMM of second kind, reversibility and

irreversibility, causes of irreversibility, Carnot cycle, Carnot theorem, and thermodynamic temperature cycle.

**Entropy:** Clausius theorem, the property of entropy, the inequality of Clausius, entropy principle and its applications, entropy change during different thermodynamic processes, introduction to availability.

**Unit-3: Thermodynamic Relationships:** Maxwell's equations, T-ds equations, difference in heat capacities, coefficient of volume expansion and isothermal compressibility, adiabatic compressibility, ratio of specific heat, energy equations, Joule-Kelvin effect, Clausius-Clapeyron equation.

**Unit- 4: Properties of Pure Substances:** Thermodynamic properties of pure substances in solid, liquid, and vapour phases, phase transformations, dryness fraction, triple point, critical state, p-v, p-T, T-s, h-s diagrams, use of steam tables and Mollier's diagram in the determination of steam properties.

**Unit-5: Vapour Power Cycle:** Rankine cycle; p-v, T-s and h-s diagrams, efficiency, steam rate, heat rate, comparison of Rankine and Carnot cycles, mean temperature of heat addition, reheat cycle, ideal and practical regenerative cycle.

**Gas Power Cycles:** An overview of reciprocating engine, Air standard cycle, Otto, Diesel, Dual cycle - Description and representation on p-v, and T-s diagram, thermal efficiency, mean effective pressures, and comparison of cycles.

**Text Books:**

1. P.K. Nag, Engineering Thermodynamics, McGraw Hill.
2. Y. A. Cengel and M.A. Boles, Thermodynamics an Engineering Approach, McGraw Hill.

**References Books:**

1. C.P. Arora, Thermodynamics, McGraw Hill.
2. M. J. Moran and H. M. Shapiro, Fundamentals of Engineering Thermodynamics, Wiley.
3. C. Borgnakke and R. E. Sonntag, Fundamentals of Thermodynamics, Wiley India.
4. R. Yadav, Fundamental of Engineering Thermodynamics, Central Publishing House.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	-	1	1	-	-	-	-	-	2	3	1	-
<b>CO2</b>	3	3	2	1	1	2	-	-	-	-	2	3	1	-
<b>CO3</b>	3	3	2	2	1	-	-	-	-	-	2	3	1	-
<b>CO4</b>	3	3	2	2	2	-	-	-	-	-	1	3	2	-
<b>CO5</b>	3	3	3	2	1	2	-	-	-	-	2	3	2	-

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Mechanics of Materials	<b>Course Code:</b>	ME24-B-MJ202
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course serves as the foundation for many advanced techniques that enable engineers to design machine components and mechanisms, predict failures, and understand the physical properties of materials. "Mechanics of Materials" provides students with essential tools for analyzing stress, strain, and deformation.

**Course Outcomes:** After completion of the course, students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Gain knowledge of different types of stresses, strains, and deformations induced in mechanical components due to external loads.
<b>CO2</b>	Draw shear force and bending moment diagrams for different types of loads and support conditions.
<b>CO3</b>	Compute and analyze the stresses induced in beams and mechanical components.
<b>CO4</b>	Understand the effects of component dimensions and shapes on deformation and stress.
<b>CO5</b>	Analyze the buckling phenomenon in columns and the failure phenomenon in pressure vessels.

**Syllabus:**

**Unit-1: Simple Stresses and Strains:** Introduction, Hooke's law, stress-strain diagram for ferrous and non-ferrous materials, Poisson's ratio, volumetric strain, Relation between Elastic constants, Stresses in Bars of varying cross sections, composite sections, Thermal stresses and strains, thermal stresses in composite sections, Strain energy, Resilience, Proof resilience, Modulus of resilience; gradually applied, suddenly applied and Impact loads.

**Unit-2: Shear Force & Bending Moment Diagrams:** Definitions, types of loading, types of beams, Shear force (S.F.) and bending moment (B.M.), sign conventions, S.F. and B.M. diagrams for Cantilever, simply supported beams subjected to Point loads, uniformly distributed loads and Combination of these loads, Point of contra-flexure.

**Unit-3: Bending Stresses in Beams:** Theory of simple bending, assumptions made in bending theory, Position of Neutral axis and neutral surface, Moment of resistance, Section Modulus of symmetrical sections such as rectangular, circular & I- sections, Bending stresses in symmetrical section, Beam of uniform strength.

**Shear Stresses in Beams:** Introduction, Shear stress equation, assumptions made, Distribution of shear stresses over various sections, such as rectangular, circular, I, L & T sections, Simple numerical problems.

**Deflection of Beams:** Introduction, Strength and Stiffness of a beam, Curvature of a bent beam, Derivation of equation for slope and deflections of beam in case of cantilever & simply supported beam loaded with point loads, uniformly distributed load, Simple numerical problems.

**Unit-4: Torsion of Shaft:** Definition of torsion, Assumptions, Torsion equation, Strength of solid and hollow circular shafts, Calculation of shaft diameter on the basis of strength and stiffness for given power transmitted, Torsional Rigidity, Maximum torque comparison of solid and hollow shaft, Size of shaft for a given torque.

**Principal Stresses:** Principal plane, Principal stress, Tangential and Normal stress, Maximum Shear stress, Major and Minor principal stresses derivation for different cases, Mohr's circle graphical method, Theories of Failure.

**Unit-5: Columns and Struts:** Definition, Crippling load, different end conditions, Slenderness ratio, equivalent length, Euler's theory, Limitation of Euler's formula, Rankine's formula, Rankine constant for different materials, Simple problems.

**Thin Pressure Vessels:** Cylindrical and spherical vessels subjected to internal pressure, Hoop stress, and longitudinal Stress.

**Case Study on: Column & Strut, Beams and Torsion of Shaft.**

**Text books:**

1. R. K. Rajput, Strength of Material, S. Chand Publications, Delhi.
2. Timoshenko and Young, Elements of Strength of Materials, East-West Press.
3. Subramanyam, Strength of Materials, Oxford University Press.
4. B.C Punmia, Ashok Jain, Arun Jain, Mechanics of Materials, Lakshmi Publications, New Delhi.
5. Basavarajaiah and Mahadevappa, Strength of Materials, Khanna Publishers, New Delhi.
6. Singer Harper, Strength of Materials, Row Publications.

**References Books**

1. James M. Gere, Mechanics of Materials, Thomson Learning.
2. S. Ramamrutham, Strength of Materials, Dhanpat Rai Pvt. Ltd.
3. S. S. Rattan, Mechanics of Materials, TMH Pvt. Ltd.
4. S. B. Junnarkar, Mechanics of Structures, Charotar Publication.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	-	-	2	1	-	-	-	-	2	3	2	1
<b>CO2</b>	3	3	2	-	3	1	-	-	-	-	1	3	3	1
<b>CO3</b>	3	3	2	2	3	1	-	-	-	-	1	3	2	2
<b>CO4</b>	3	2	2	1	2	1	-	-	-	-	2	2	2	2
<b>CO5</b>	3	3	2	2	2	2	-	-	-	-	1	3	3	2

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Computational Mathematics	<b>Course Code:</b>	ME24-B-MJ203
<b>Credits:</b>	2	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:** This course covers advanced mathematical tools essential for engineering. It includes Laplace transforms and their application in solving differential equations, numerical methods for solving algebraic and differential equations, and fundamentals of complex variables with analytic functions and series expansions. It also introduces basic statistics, probability theory, and random variables, emphasizing key distributions like binomial, Poisson, and normal. The course equips students with analytical skills required for modeling and solving real-world engineering problems.

**Course Outcomes:** After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Apply the Laplace transform to solve differential equations.
<b>CO2</b>	Understand various Numerical methods to solve differential and integral equations.
<b>CO3</b>	Analyze complex functions using Cauchy-Riemann equations, Cauchy's theorems, and represent them through Taylor and Laurent series expansions.
<b>CO4</b>	Analyze statistical data and use the basic probability rules
<b>CO5</b>	To know the importance of probability, random variables, and distributions in solving various mechanical engineering problems.

**Syllabus:**

**Unit-1: Laplace Transform:** Definition; Transform of elementary functions; Properties of Laplace transform; Transform of derivatives & integrals; Multiplication by  $t^n$ ; Division by  $t$ ; Inverse Laplace Transform; Convolution theorem; Unit step function; Unit impulse function; Periodic function; Application to solution of ordinary differential equations.

**Unit-2: Numerical Methods:** Numerical solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; single and multi-step methods for differential equations.

**Unit-3: Complex Variables:** Analytic functions; Cauchy-Riemann equations; Cauchy's integral theorem and integral formula; Taylor and Laurent series.

**Unit-4: Basic Statistics and Probability:** Descriptive measures: Measures of central tendency; Measures of dispersion; Measures of skewness and Measures of kurtosis; Theory of probability: Basic probability theory; Axiom of probability; Some elementary theorems; Conditional probability; Bayes' theorem.

**Unit-5: Random variables and Probability distribution:** Discrete Random variables; Discrete probability Distribution; Discrete probability distribution function; Continuous Random variables; Continuous probability distribution; Continuous probability distribution function; Expectation; Variance; Standard deviation; Moments; Moments generating function; Coefficient of skewness and coefficient of kurtosis; Binomial, Poisson, Normal and exponential distributions.

**Text Books:**

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
2. N.G. Das, Statistical Methods, McGraw Hill
3. S.C. Gupta, Fundamentals of Statistics, Himalaya Publishing House
4. Dr. B.S. Grewal, Numerical Methods in Engineering and Science, Khanna Publishers
5. S.S. Sastry, Numerical Methods, Prentice Hall Inc.

**Reference Books:**

1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons
2. R.K. Jain & S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House
3. M.K. Jain, S.R.K. Iyengar & R.K. Jain, Numerical Methods for Scientific and Engineering Computation, Wiley Eastern Limited
4. Irwin Miller & Marylees Miller, John E. Freund's Mathematical Statistics with Applications, PEARSON Publication
5. Richard L. Scheaffer, Madhuri S. Mulekar, & James T. McClave, Probability and Statistics for Engineers, Cengage Learning
6. Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier Academic Press

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	3	2	2	2	1	0	0	0	0	2	3	2	1
<b>CO2</b>	3	3	2	2	3	1	0	0	0	0	2	3	3	2
<b>CO3</b>	3	2	1	2	2	1	0	0	0	0	2	3	2	1
<b>CO4</b>	3	3	2	2	2	2	1	0	0	0	2	2	2	1
<b>CO5</b>	3	3	2	2	2	2	1	0	0	0	2	3	3	2

**Note:** 1: Low 2.: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



**OPJU**

<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Computer-Aided Machine Drawing	<b>Course Code:</b>	ME24-B-MJ204
<b>Credits:</b>	2	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:** This course covers engineering drawing standards, fasteners, sectional views, detail, and assembly drawings. Students will learn to create and interpret technical drawings, including limits, fits, tolerances, screw threads, welded joints, and sectional views. Practical application includes drawing machine components and assemblies like cotter joints and tool posts.

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand the different types of production drawings, including limits, fits, and tolerances, and the ability to interpret geometric tolerances and surface roughness symbols.
<b>CO2</b>	Draw various views of fasteners, riveted joints, and welded joints, including screw threads, nuts, bolts, washers, and welding symbols.
<b>CO3</b>	Apply the principles of sectional views to create accurate sectional orthographic views of machine elements, including different types of sections and hatching guidelines.
<b>CO4</b>	Develop detailed drawings from assembly drawings and vice versa, including components such as cotter and knuckle joints, keys, clapper blocks, and tool posts.
<b>CO5</b>	Create assembly drawings for mechanical components, representing conventional symbols for bearings, belts, pulleys, and various types of couplings and joints.

**Syllabus:**

**Unit-1: Fundamentals of Drawing Standards:** Types of production drawings, size, shape and description; Limits, Fits and tolerances, Allocation of fits for various mating parts, Tolerance data sheet, Tolerance table preparation, Geometric tolerance, surface roughness and surface roughness symbols, reading the blue prints.

**Unit-2: Fasteners and Riveted and welded joints:** Drawing of various views of Screw threads, metric and BSW threads, square threads and multi start threads, Nut bolts, washer, welding symbols, riveted joints, keys.

**Unit-3: Sectional Views:** Introduction, Types of section, guidelines for hatching, examples of sectional orthography view on all above types of sections of machine elements.

**Unit-4: Details Drawing:** Introduction to detail drawing, steps involved in preparing assembly drawing from details and vice versa. Cotter and knuckle joint, Clapper block, Single tool post, Lathe & Milling tail stock etc. (any four)

**Unit-5: Assembly Drawings:** I.S. conventional representation of bearings, Coupling, Cotter and knuckle joint, universal joint, Plummer block, Lathe tool post, tool head of shaping machine, tail stock, machine vice, piston, connecting rod, eccentric, screw jack, plumber block, pipe vice. (any four)

**Text Books:**

1. N.D. Bhatt & V. Panchal, Machine Drawing, Charotar Prakashan.
2. R.K. Dhawan, A text book of Machine Drawing, S. Chand.

**Reference Books:**

1. K. L. Narayana, P. Kannaiah, K. V. Reddy, Machine Drawing, New Age International.
2. K.C. John, A textbook of Machine Drawing, Phi Learning.
3. I.S. Code: SP 46: 2003, Engg. Drg. Practice, Standard Publication.
4. P.S. Gill, Machine Drawing, Kataria & Sons Publication House.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	2	-	2	1	-	-	1	-	2	3	2	1
<b>CO2</b>	3	2	3	-	2	1	-	-	1	-	2	3	2	1
<b>CO3</b>	3	2	3	1	2	1	-	2	2	2	2	3	3	3
<b>CO4</b>	3	2	3	1	2	1	-	2	2	2	2	3	3	3
<b>CO5</b>	3	2	3	1	2	1	-	2	2	2	2	3	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Mechanics of Materials Lab	<b>Course Code:</b>	ME24-B-MJ205
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

The objective of this Lab is to demonstrate the basic principles of strength, mechanics of materials, and structural analysis to undergraduate students through a series of experiments. In this lab, experiments are performed to measure the properties of materials such as impact strength, tensile strength, compressive strength, hardness, and ductility.

**Course Outcomes:** After completion of the course, students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Demonstrate the basic principles of strength and mechanics of materials.
<b>CO2</b>	Analyze and design structural members subjected to tension, compression, torsion, bending, and combined stresses.
<b>CO3</b>	Utilize appropriate materials in design, considering engineering properties, sustainability, cost, and weight.
<b>CO4</b>	Measure the properties of the materials, such as impact, tensile, and compressive strength, hardness, and ductility.
<b>CO5</b>	Perform engineering work as per ethical and economic constraints related to the design of structures and machine parts

**List of Experiments (Any Ten):**

1. To perform the Tensile Test of Mild Steel on Computerized U.T.M and to Draw Stress–Strain Curve
2. To perform the Compression test on Bricks, Concrete blocks using Computerized U.T.M and to Draw Stress–Strain Curve
3. To perform the Shear test on ductile material using Computerized U.T.M and to Draw Stress–Strain Curve
4. To determine strength of wood on U.T.M (i) Along the Grain (ii) Across the Grain.
5. To determine the Izod and Charpy values of a mild steel specimen by Impact Testing Machine.
6. To estimate the Spring Constant under Tension and Compression.
7. To perform a Torsion Test on a circular bar.
8. To determine the modulus of rigidity of open and closed Coiled Helical Spring material subjected to Axial Load by a spring testing machine.

9. To determine the Rockwell Hardness of the given material.
10. To determine the Brinell hardness of the given material.
11. To study the Cupping Test Machine and to determine the Erichsen value of Mild Steel sheet.
12. Solve minimum two design problems using MATLAB.
13. Solve minimum two design problems using ANSYS.

**Equipment/Machines/Instruments/Tools/Software Required:**

1. Universal Testing Machine
2. Impact Testing Machine
3. Fatigue Testing Machine
4. Spring Testing Machine
5. Torsion Testing Machine
6. Cupping Testing Machine
7. Rockwell Hardness Testing Machine
8. Brinell Hardness Machine
9. MATLAB Software
10. ANSYS Software

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	-	-	2	1	-	-	-	-	2	3	2	1
<b>CO2</b>	3	3	3	2	3	2	1	-	-	-	2	3	3	2
<b>CO3</b>	3	2	3	1	2	3	1	-	-	1	3	3	3	2
<b>CO4</b>	3	2	1	3	3	1	-	-	-	-	2	2	3	2
<b>CO5</b>	2	2	2	1	2	3	3	2	2	3	3	2	3	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Solar Energy Technology	<b>Course Code:</b>	ME24-B-MD201
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Descriptions:**

The course is intended to deliver comprehensive knowledge on renewable energy resources, solar radiation, solar radiation data analysis, fundamentals of the solar thermal and photovoltaic system, along with the effective design and performance analysis of solar energy conversion devices.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand characteristics and world distribution of solar radiation.
<b>CO2</b>	Know solar radiation and measurement techniques.
<b>CO3</b>	Understand the methods of calculation of solar radiation availability at a given location.
<b>CO4</b>	Acquire fundamentals of thermal and direct conversion of solar energy to power.
<b>CO5</b>	Understand the fundamentals of solar flat plate collectors, concentrating solar collectors.

**Syllabus:**

**Unit 1: Energy Resources & Solar Radiation:** World energy resources – Indian energy scenario – Environmental aspects of energy utilization. Renewable energy resources and their importance – Global solar resources. Solar spectrum – Electromagnetic spectrum, basic laws of radiation. Solar radiation on the earth surface, distribution of solar radiation. Depletion of solar radiation – Absorption, scattering. Beam radiation, diffuse and Global radiation. Measurement of solar radiation – Pyranometer, Pyrheliometer, Sunshine recorder.

**Unit 2: Solar Radiation Geometry and Calculations:** Solar radiation geometry – Earth–Sun angles – Solar angles. Calculation of angle of incidence – Surface facing due south, horizontal, inclined surface and vertical surface. Solar day length – Sun path diagram – Shadow determination. Estimation of Sunshine hours at different places in India. Calculation of total solar radiation on horizontal and tilted surfaces. Prediction of solar radiation availability.

**Unit 3: Solar Electrical Energy Conversion:** Solar photovoltaic energy conversion – Principles – Physics and operation of solar cells. Classification of solar PV systems, Solar cell energy conversion efficiency, I–V characteristics, effect of variation of solar insolation and temperature, losses. Solar PV power plants.

**Unit 4: Solar Thermal energy conversion:** Fundamentals of solar collectors as devices to convert solar energy to heat. Non–concentrating low temperature flat–plate and evacuated tube collectors. Collector performance – Useful energy gain, energy losses, efficiency. Use of selective coatings to enhance the collector efficiency. Concentrating collectors for middle and high temperature applications. Line–focusing and point–focusing concentrators: parabolic trough, parabolic dish, Fresnel lenses, compound parabolic concentrator. Sun tracking mechanisms.

**Unit 5: Other Solar Energy based technologies:** Concentrating collector performance – concentration ratio, useful energy gain, energy losses, efficiency. Solar collector design, testing, installation and operation. Application of non–concentrating collectors in low temperature solar thermal plants for space heating and cooling, drying, seawater desalination. Use of concentrating collectors for process heat production and power generation.

**Text Books:**

1. K. Sukhatme, Solar energy: Principles of thermal collection and storage, Tata McGraw Hill publishing Co. Ltd.
2. G. N. Tiwari, Solar Energy: Fundamentals, Design, Modelling and Applications, Narosa Publication New Delhi.

**Reference Books:**

1. R.K. Singhal, Non–Conventional Energy Resources, S.K. Kataria & Sons, Delhi.
2. Foster R., Ghassemi M., Cota A., Solar Energy, CRC Press.
3. Duffie J.A., Beckman W.A., Solar Engineering of Thermal Processes, Wiley & Sons.
4. De Vos, A., Thermodynamics of Solar Energy Conversion, Wiley & Sons.
5. Garg H.P., Prakash J., Solar Energy Fundamentals and Applications, Tata McGraw–Hill.
6. Kalogirou S., Solar Energy Engineering: Processes and Systems, Elsevier.
7. Artur V. Kilian, Solar Collectors: Energy Conservation, Design and Applications, Nova Science Publishers Incorporation.
8. Kalogirou S., Solar Energy Engineering: Processes and systems, Academic Press.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1:</b>	3	2	1	1	1	2	-	1	2	1	2	3	1	1
<b>CO2:</b>	3	3	1	3	3	1	-	1	2	1	2	3	3	1
<b>CO3:</b>	3	3	2	2	3	2	-	1	2	1	2	3	3	1
<b>CO4:</b>	3	2	3	1	2	2	-	1	2	1	2	3	2	2
<b>CO5:</b>	3	2	3	1	2	2	-	1	2	1	2	3	2	2

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	B. Tech.	<b>Semester:</b>	IV
<b>Name of the Course:</b>	Plant Maintenance & Safety	<b>Course Code:</b>	ME24-B-MD202
<b>Credits:</b>	3	<b>No of Hours:</b>	3 Hrs./Week
<b>Max Marks:</b>	100		

**Course Description:**

This course introduces students to essential concepts and practices in plant maintenance and industrial safety. It covers maintenance types and strategies, failure prevention methods including wear and corrosion control, condition monitoring techniques, and safety regulations. Students gain insights into modern maintenance tools like TPM and RCA, as well as safety compliance frameworks such as OSHA and IBR. The course also emphasizes recovery, reconditioning, retrofitting, and the erection and commissioning of machinery. By the end, students will be equipped with skills to ensure enhanced equipment reliability, efficient maintenance planning, and a safe industrial work environment.

**Course Outcomes:**

After completion of the course, students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Understand the principles of plant maintenance and industrial safety, and the role of maintenance planning and organization.
<b>CO2</b>	Identify and apply suitable maintenance strategies, wear and corrosion prevention techniques in industrial systems.
<b>CO3</b>	Utilize condition monitoring tools and diagnostic methods to detect and analyze faults in equipment.
<b>CO4</b>	Evaluate workplace hazards, apply statutory safety regulations, and suggest preventive and control measures.
<b>CO5</b>	Explain and apply the processes of recovery, reconditioning, retrofitting, and equipment commissioning in an industrial setup.

**Syllabus:**

**Unit 1: Introduction to Plant Maintenance and Safety:** Need for plant maintenance, safety in industrial operations. Objectives of Maintenance: Equipment availability, cost-effectiveness, safety assurance. Maintenance Planning: Scope, short-term and long-term planning, maintenance budgeting. Maintenance Organization: Structure of maintenance department, roles and responsibilities. Introduction to Safety Engineering: Role of safety in plants, accident statistics, case studies of major industrial accidents.

**Unit 2: Wear, Corrosion, and Their Prevention:** Types of wear, Wear reduction methods, Types and applications of lubricants, Corrosion and Its Prevention: Definition, principle, and factors affecting corrosion, Types of corrosion, Corrosion prevention methods.

**Types and Strategies of Maintenance:** Breakdown Maintenance (BM): Meaning, process, when it is suitable, disadvantages. Preventive Maintenance (PM): Scheduled maintenance, benefits, limitations. Predictive Maintenance (PdM): Principles, condition-based maintenance, technologies used. Corrective Maintenance: Process, advantages, repair vs replacement decisions. Total Productive Maintenance (TPM): Concept, 8 pillars of TPM, role of operators in maintenance, OEE (Overall Equipment Effectiveness).

**Unit 3: Condition Monitoring and Fault Diagnosis:** Condition Monitoring Techniques: Vibration analysis, thermography, oil analysis, ultrasonic testing, motor current analysis. Fault Detection Methods: Signal analysis, data interpretation, trending methods. Root Cause Analysis (RCA): Steps and tools (e.g., Fishbone Diagram, 5 Whys). Non-Destructive Testing (NDT): Common NDT methods used in maintenance (Visual, Ultrasonic, Eddy current).

**Unit 4: Industrial Safety and Hazard Control:** Factory Act, Occupational Safety and Health Administration (OSHA), Indian Boiler Regulation (IBR). Hazard Identification and Risk Assessment (HIRA): Risk matrix, severity-likelihood analysis. Personal Protective Equipment (PPE): Types, selection, and maintenance. Fire Safety and Explosion Hazards: Classification of fires, fire suppression systems, emergency response planning. Accident Investigation: Steps in investigation, documentation, learning from incidents.

**Unit 5: Recovery, Reconditioning, and Retrofitting:** Definition of recovery, reconditioning, and retrofitting, Methods of recovery and their applications, Selection criteria for recovery methods. **Reconditioning and Retrofitting:** Reconditioning process, features, and advantages, Retrofitting: concept, need, and applications. **Installation, Erection, and Commissioning:** Design and planning of foundation, Erection and commissioning of equipment, Alignment and testing of equipment.

**Text Books:**

1. R. C. Mishra and K. Pathak, Maintenance Engineering and Management, PHI Learning Pvt. Ltd.
2. Frank R. Spellman, Safety Engineering: Principles and Practices, Rowman & Littlefield.
3. Maintenance Engineering, H. P. Garg, S. Chand and Company.
4. Maintenance Engineering Handbook, Higgins & Morrow, DA Information Services

**Reference Books:**

1. S. K. Srivastava, Industrial Maintenance Management, S. Chand & Company.
2. B.S. Dhillon, Engineering Maintenance: A Modern Approach, CRC Press.
3. Amitabh Bhattacharya, Safety Management, Himalaya Publishing.
4. Donald V. LaCombe, Total Productive Maintenance, Productivity Press.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	2	1	2	2	2	1	1	1	2	3	2	1
<b>CO2</b>	3	3	3	2	2	2	1	1	1	1	2	3	3	2
<b>CO3</b>	3	3	2	3	3	2	1	1	1	1	2	3	3	2
<b>CO4</b>	2	3	2	2	2	3	3	2	1	1	2	2	2	1
<b>CO5</b>	3	3	3	2	3	2	2	2	1	2	2	3	3	2

**Note:** 1: Low 2.: Moderate 3: High



<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Engineering Tribology	<b>Course Code:</b>	ME24-B-MD203
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course focuses on the study of friction, wear, and lubrication in machine components. It covers surface interactions, lubrication mechanisms, and material properties to enhance system performance, improve efficiency, and minimize wear in mechanical systems for various engineering applications.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Explain the fundamental concepts of tribology, different types of lubricants, their properties, and lubrication mechanisms.
<b>CO2</b>	Analyze the theories of friction, different wear mechanisms, and approaches to minimize wear in engineering applications.
<b>CO3</b>	Evaluate surface roughness characteristics, measurement methods, and tribological behavior of bearings and gears.
<b>CO4</b>	Demonstrate the principles of hydrodynamic and elastohydrodynamic lubrication, along with pressure development and load-carrying capacity in bearings.
<b>CO5</b>	Illustrate the working of antifriction bearings, condition monitoring techniques, and emerging concepts like nano/micro tribology and green tribology.

**Syllabus:**

**Unit-1: Introduction to Tribology:** Historical background, practical importance, and subsequent use in the field.

**Lubricants:** Types and specific field of applications. Requisite properties of lubricants. Viscosity, its measurement, effect of temperature and pressure on viscosity, standard grades of lubricants, selection of lubricants. Lubricant Rheology, Lubrication Types, Basic equation of lubrication.

**Unit-2: Friction:** Origin, Friction Theories, measurement methods, friction of metals and non-metals.

**Wear:** Classification and Mechanisms of Wear, Delamination theory, Debris analysis, testing methods and standards, wear mechanism maps, and approach to wear reduction. Related Case Studies.

**Unit-3: Surface Roughness:** Standardization, measurement with contacting and non-contacting instruments, Statistical analysis of surface, characteristics of the surface, tribological behaviour of

asperities contact.

**Behaviour of Tribological components, Plain & Antifriction Bearings:** selection, effect of frictional torque, factors affecting performance, failure modes, bearing lubrication.

**Gears:** Friction & stresses, wear, lubrication & failure. Failure Case Studies.

**Unit-4: Hydrodynamic Bearings:** Mechanism of pressure development, classification, Idealized Journal Bearing, oil film thickness, pressure distribution, load carrying capacity. Failure Case Studies.

**Elastohydrodynamic Lubrication (EHL):** Theoretical considerations, line and point contacts, film thickness equations, different regimes in EHL contact.

**Unit-5: Antifriction Bearings:** Ball and roller bearings, geometry of ball bearings, radial load distribution, stresses and deformations, lubrication of ball bearings. Failure Case Studies.

**Monitoring of Equipment's Condition:** Condition monitoring techniques, lubricant, corrosion, temperature & surface roughness monitoring. Failure Case Studies.

Nano/Micro Tribology, Green Tribology.

**Text Books:**

1. Prasanta Sahoo, Engineering Tribology, Prentice Hall of India Pvt. Ltd.
2. S.K. Basu, S.N. Sengupta, B.B. Ahuja, Fundamentals of Tribology, PHI Learning Pvt. Ltd.
3. S.K. Shrivastava, Tribology in Industries, S. Chand & Company Ltd.
4. A. Harnoy, Bearing Design in Machinery: Engineering Tribology and Lubrication, Marcel Dekker Inc.

**Reference Books:**

1. G.W. Stachowiak, A.W. Batchelor, Engineering Tribology, Elsevier India Pvt. Ltd.
2. B.C. Majumdar, Introduction to Tribology of Bearings, S. Chand & Company Ltd., New Delhi.
3. T.A. Harris, Rolling Bearing Analysis, John Wiley & Sons, Inc.
4. J. Williams, Engineering Tribology, Cambridge University Press.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	1	-	1	2	1	2	-	-	2	3	1	-
<b>CO2</b>	3	3	2	2	2	2	1	2	1	-	2	3	2	-
<b>CO3</b>	3	3	3	2	2	2	1	2	1	-	2	3	2	-
<b>CO4</b>	3	3	3	2	2	2	1	2	-	-	2	3	2	-
<b>CO5</b>	3	3	3	3	2	3	1	3	1	1	3	3	3	-

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	MATLAB Programming Lab	<b>Course Code:</b>	ME24-B-SE201
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This course provides a comprehensive understanding of key mathematical concepts and their applications in engineering and scientific computing using MATLAB. The topics covered include complex variables, Laplace transforms, numerical methods, basic statistics and probability, random variables, and probability distributions. Through a combination of theoretical lectures and practical MATLAB-based exercises, students will develop the skills necessary to solve complex mathematical problems and apply these techniques in various engineering and scientific contexts.

**Course Outcomes:**

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

CO Number	Course Outcome
<b>CO1</b>	Able to use MATLAB effectively to analyze and visualize data
<b>CO2</b>	Apply a top-down, modular, and systematic approach to design, write, test, and debug sequential MATLAB programs to achieve computational objectives
<b>CO3</b>	Design and document computer programs and analyses in a careful and complete manner so as to effectively communicate results, to facilitate evaluation and debugging by another programmer, and to anticipate and resolve user errors
<b>CO4</b>	Create and control simple plot and user-interface graphics objects in MATLAB
<b>CO5</b>	Apply numeric techniques and computer simulations to solve engineering-related problems

**List of Experiments: (Minimum ten experiments to be performed)**

1. MATLAB Basics: Introduction, operation with arithmetic, logarithmic and trigonometric function.
2. Operations with arrays, polynomials, problem practice.
3. Script file, problem practice.
2. Function file, problem practice.
3. Programming: graphics, input / output.
4. Plotting of 2D and 3D curves, problem practice.

5. Roots: programming for general method.
6. Numerical integration formulas, numerical integration of functions.
7. Numerical differentiation, problem practice.
8. Ordinary differential equation problem practice.
9. Analyze and manipulate complex functions using MATLAB.
10. Laplace transforms using MATLAB.
11. Implement numerical algorithms for roots of algebraic and transcendental equations using MATLAB.
12. MATLAB implementation of descriptive statistics.
13. MATLAB simulations of probability experiments.
14. MATLAB implementation of hypothesis tests and confidence intervals.
15. MATLAB implementation of random variable simulations

**Equipment/Machines/Instruments/Tools/Software Required:**

1. MATLAB Software

**CO, PO, & PSO Correlation**

<b>CO Outcomes</b>	<b>Program Outcomes</b>											<b>PSOs</b>		
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>1</b>	<b>2</b>	<b>3</b>
<b>CO1</b>	3	2	2	2	3	1	0	1	1	1	2	2	3	3
<b>CO2</b>	3	3	3	2	3	1	0	1	1	1	2	2	3	3
<b>CO3</b>	2	2	3	2	3	1	1	1	2	2	2	2	3	2
<b>CO4</b>	2	2	2	2	3	1	0	1	1	1	2	1	3	3
<b>CO5</b>	3	3	3	3	3	2	1	1	1	2	3	3	3	3

Note: 1: Low 2: Moderate 3: High

<b>Programme:</b>	B.Tech	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Measurement and Control	<b>Course Code:</b>	ME24-B-SE202
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

The course is designed to familiarize the student with the functions and instrumentation available in a modern industry. This course covers the fundamentals of instrumentation used in industry. Emphasis is on electric, electronic, and other instruments. Student also learn the concepts of the mathematical modeling, feedback control and stability analysis in Time and Frequency domains.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand about different instruments that are used for measurement purpose.
<b>CO2</b>	Analyze the Performance characteristics of each instrument, analyses the data and generate report.
<b>CO3</b>	Understand how waveforms can be analyzed using wave analyzers, MATLAB and Simulink
<b>CO4</b>	Able to determine transfer function models of electrical, mechanical and electromechanical systems.
<b>CO5</b>	Able to determine stability/relative stability from characteristic equation.

**Syllabus:**

**Unit-1: Basics of Measurement Systems:** Static and dynamic characteristics of measurement systems. Measurement errors: Gross error, systematic error, absolute error and relative error, accuracy, precision, resolution and significant figures, Measurement error combination, basics of statistical analysis. Statistical analysis of data and curve fitting.

**Unit-2: Electrical and Electronic Measurements:** Bridges and potentiometers, measurement of R, L and C. Measurements of voltage, current, power, power factor and energy. AC & DC current probes. Extension of instrument ranges. Q-meter and waveform analyzer. Digital voltmeter and multi-meter. Time, phase and frequency measurements. Cathode ray oscilloscope. Serial and parallel communication. Shielding and groundings.

**Unit-3: Transducers, Mechanical Measurement and Industrial Instrumentation:** Resistive, Capacitive, Inductive and piezoelectric transducers and their signal conditioning. Measurement of displacement, velocity and acceleration (translational and rotational), force, torque, vibration and shock. Measurement of pressure, flow, temperature and liquid level. Measurement of pH, conductivity, viscosity and humidity.

**Unit-4: Control Systems:** Open loop and closed loop control systems, Feedback characteristics of control systems, Mathematical representation of physical systems, electrical, mechanical, hydraulic, thermal systems, Block diagram, algebra and signal flow graphs, Mason's gain formula. Time Domain Analysis, standard test signals, time response of first, second and higher order systems, performance indices. Error analysis, static and dynamic error coefficients. Stability, concept of stability, asymptotic and conditional stability, Routh Hurwitz criterion,

**Unit-5: Process Control:** Root locus technique (Concept and construction) Frequency Response Analysis Correlation between time and frequency response, Polar and inverse polar plots, Nyquist stability criterion, Bode plots, Time delay systems. Phase and gain margin. Mechanical, hydraulic and pneumatic system components. Synchro pair, servo and step motors. On-off, cascade, P, P-I, P-I-D, feed forward and derivative controller, Fuzzy controller.

**Text Books:**

1. Doebelin, E.O., Measurement systems, Applications and Design, McGraw–Hill (1982).
2. Nakra, B. C. and Chaudhry, K. K., Instrumentation Measurement and Analysis, Tata McGraw–Hill (2003).
3. Ogata, K., Modern Control Engineering, Prentice–Hall of India Private Limited (2001)
4. Nagrath, I.J. and Gopal, M., Control System Engineering, New Age International (P) Limited, Publishers (2003).
5. Gopal, M., Digital Control System, Wiley Eastern (1986).

**Reference Books:**

1. W Bolton- Instrumentation and control systems, Elsevier (2004).
2. Murthy, D.V.S., Transducers and Instrumentation, Prentice–Hall of India Private Limited (2003).
3. Sawhney, A.K., A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Co. (P) Ltd. (2007).
4. Kuo, B.C., Automatic Control System, Prentice–Hall of India Private Limited (2002).
5. Sinha, N.K., Control System, New Age International (P) Limited, Publishers (2002).

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	-	-	3	-	-	-	-	-	2	3	3	
<b>CO2</b>	3	3	-	3	3	-	-	2	3	-	2	3	3	2
<b>CO3</b>	3	2	-	2	3	-	-	-	2	-	3	3	3	3
<b>CO4</b>	3	3	-	3	3	-	-	-	2	-	3	3	3	3
<b>CO5</b>	3	3	-	3	3	-	-	-	-	-	3	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Fluid Mechanics & Machinery	<b>Course Code:</b>	ME24-B-MJ206
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course introduces fundamental principles of fluid mechanics. Students will explore fluid properties, statics, and dynamics, applying Bernoulli's equation to analyze flow. The course covers laminar and turbulent pipe flow, boundary layer theory, and hydraulic machines like turbines and pumps. Dimensional and model analysis techniques, including Buckingham's theorem and model laws, are also examined. This course provides a foundation for understanding fluid behavior and its applications in engineering systems.

**Course Outcomes:**

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

CO Number	Course Outcome
<b>CO1</b>	Analyze fundamental fluid properties and apply principles of fluid statics to determine pressure and forces.
<b>CO2</b>	Apply kinematic and dynamic principles to classify and analyze fluid flow, and utilize Bernoulli's equation for flow measurement.
<b>CO3</b>	Evaluate laminar and turbulent flow characteristics in pipes, quantify head losses, and analyze pipe network systems.
<b>CO4</b>	Apply dimensional analysis techniques to derive dimensionless parameters and understand the principles of similitude in model studies.
<b>CO5</b>	Analyze the operating principles, performance characteristics, and governing mechanisms of various pumps and turbines.

**Syllabus:**

**Unit-1: Fluid properties:** continuity equation-Hydrostatic law-pressure variation in static fluid hydrostatic force on a submerged plane and curved surface-location of hydrostatic force.

**Flow characteristics:** Eulerian and Lagrangian approach - Concept of control volume and system - Reynold's transportation theorem - Continuity equation, energy equation and momentum equation - Applications.

**Unit-2: Fluid Kinematics and Fluid Dynamics:** Classification of fluid flow, fluid flow lines, stream lines, streak line and path line, vortex flow, Euler's momentum equation, Bernoulli's equation-application of Bernoulli's equation-Flow measurement, pitot tube, venturimeter.

**Unit-3: Boundary Layer Concepts & Flow Through Pipes:** Boundary layer concepts - Types of boundary layer thickness. Reynold’s Experiment - Laminar flow through circular conduits - Darcy Weisbach equation - friction factor - Moody diagram - Major and minor losses - Hydraulic and energy gradient lines - Pipes in series and parallel.

**Unit-4: Dimensional Analysis & Model Studies:** Fundamental dimensions - Dimensional homogeneity - Rayleigh’s method and Buckingham Pi theorem - Dimensionless parameters - Similitude and model studies - Distorted and undistorted models.

**Unit-5: Pumps & Turbines:** Impact of jets - Velocity triangles - Theory of rotodynamic machines - Classification of turbines - Working principles - Pelton wheel - Modern Francis turbine - Kaplan turbine - Work done - Efficiencies - Draft tube - Specific speed - Performance curves for turbines - Governing of turbines.

**Classification of pumps:** Centrifugal pumps - Working principle - Heads and efficiencies– Velocity triangles - Work done by the impeller - Performance curves - Reciprocating pump working principle - Indicator diagram and it’s variations.

**Text Books:**

1. Modi and Seth, Fluid Mechanics and Hydraulic Machines, Rajsons Publications Pvt. Ltd.
2. R. K. Bansal, Fluid Mechanics and Hydraulic Machines, Laxmi Publications.
3. R. K. Rajput, A textbook of Fluid Mechanics, S. Chand & Company Ltd.

**References Books:**

1. Agarwal. S.K., Fluid Mechanics and Machinery-McGraw Hill.
2. Jain. A.K, Fluid Mechanics, Khanna Publishers.
3. D. S. Kumar, Fluid Mechanics & Fluid power Engineering, S.K. Kataria & Sons.
4. Yunus A. Cengel, John M. Cimbala, Fluid Mechanics, TMH.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	1	1	2	1	-	1	1	-	2	3	2	1
<b>CO2</b>	3	3	2	2	3	1	-	1	1	-	2	3	2	1
<b>CO3</b>	3	3	2	2	3	1	-	1	1	-	2	3	2	1
<b>CO4</b>	3	3	2	2	3	1	-	1	1	-	2	3	2	1
<b>CO5</b>	3	3	2	2	3	1	-	1	1	-	2	3	2	1

**Note:** 1: Low 2.: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Manufacturing Technology-I	<b>Course Code:</b>	ME24-B-MJ207
<b>Credits:</b>	2	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This course provides foundational knowledge of key manufacturing processes such as metal casting, forming, forging, extrusion, sheet-metal operations, plastics processing, and welding. It covers principles, techniques, equipment, materials, and defect analysis. Students gain practical skills to design, analyze, and improve manufacturing systems used in mechanical industries.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Develop a foundation in manufacturing processes.
<b>CO2</b>	Acquire knowledge and hands-on competence in applying the concepts of manufacturing process in the design and development of mechanical systems
<b>CO3</b>	Demonstrate creativeness in designing new systems components and processes in the field of engineering in general and mechanical engineering in particular
<b>CO4</b>	Develop an ability to identify, analyze and solve technical problems related to machine tools
<b>CO5</b>	Work effectively with engineering and science teams as well as with multidisciplinary designs

**Syllabus:**

**Unit-1: Introduction to Manufacturing Processes:** Definition, classification, and Importance of Manufacturing Processes.

**Metal Casting:** Basic principle, Advantages and limitations, Applications, Casting terms, Sand mould making procedure, Moulding materials, Moulding sand composition, Steps involved in making a casting. Patterns: Types of patterns, Materials used for patterns, Pattern allowances. Core: uses, core materials, types. Gating system: Elements of gating, Gating ratio and design of gating systems. Runner & Risers: Types, function and design.

**Solidification of Casting:** Concept, Solidification of pure metal and alloys. Special casting processes: CO<sub>2</sub> moulding, Shell moulding, Centrifugal casting, Die casting, and Investment casting, Casting defects & remedies.

**Unit-2: Metal Forming Process:** Advantages of forming operations, Nature of plastic deformation, hot working and cold working.

**Rolling:** Introduction, Principle and Classification of Rolling mills and products, roughing passes, finishing passes, roll pass design for continuous mill, Forces in rolling and power requirements, Defects in rolled products and remedies.

**Unit-3: Forging:** Introduction to forging operations and equipment, forging types: Smith, Drop, Press & Machine Forging, Roll and Rotary forging, Forging defects & remedies.

**Extrusion:** Introduction, Principle, and Characteristics of the Basic Extrusion Process. Hot and cold extrusion: Forward and backward extrusion, Impact extrusion, Hydrostatic extrusion, Seamless tubes. Extrusion defects and remedies.

**Unit-4: Sheet-Metal Operations:** Classification, Spring back in metals, Press operations: Blanking, Piercing and other operations. Clearance and Shear in press operations, Forces and power requirement in press Operations. Bending: Nomenclature, Types of bending dies, Spinning, Stretch forming, Embossing and Coining.

**Processing of Plastics:** Injection, Blow, Compression, and Transfer Moulding.

**Unit-5: Welding:** Principle and Classification of welding processes, types of welded joints, Welding terms, Filler materials, and application of welding process. Gas welding: Flame types, forward and backward welding, Arc welding: AC & DC, Selection of welding current, Voltage. Welding electrodes: Types, Composition and Specification. Metal arc welding (MAW), Submerged arc welding (SAW). Resistance welding; principle, types, Spot, seam & projection welding. Inert Gas welding: TIG & MIG welding, Thermit-welding, Friction welding, Laser welding, Soldering & Brazing. Welding defects: Causes and remedies.

**Text Books:**

1. P. N. Rao, Manufacturing Technology, TMH.
2. P. C. Sharma, Production Technology, S. Chand Publishers.

**References Books:**

1. Rosenthal, Principles of Metal Castings, Mc Graw Hill.
2. R. S. Parmar, Welding Engineering and Technology, Khanna Publishers.
3. S. Kalpakjian, Manufacturing Engineering and Technology, Pearson Education.
4. O. P. Khana, A Text Book of Production Technology, Dhanpat Rai & Sons.
5. A. Ghosh & A. K. Mallik, Manufacturing Science, East West Press Pvt. Ltd.
6. R. K. Jain, Production Technology, Khanna Publishers.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	2	1	2	1	1	1	1	1	2	3	2	1
<b>CO2</b>	3	3	3	2	3	1	1	1	2	2	2	3	3	2
<b>CO3</b>	3	2	3	2	2	1	1	1	2	2	2	3	2	2
<b>CO4</b>	3	3	2	3	2	1	0	1	1	1	2	3	2	2
<b>CO5</b>	2	2	2	1	2	1	1	3	3	3	2	2	2	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Kinematics of Machine	<b>Course Code:</b>	ME24-B-MJ208
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

The subject Kinematics of Machines is a very special course for Mechanical Engineers. This course tells us about the distinctive features of machines. It deals with the relative motions of different parts of a mechanism without taking into consideration the forces producing the motions. Thus, it is the study, from the geometric point of view, to know the displacement, velocity, and acceleration of a part of a mechanism.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand the principles of kinematic pairs, chains and their classification, Degree of freedom, inversions, equivalent chains, and planar mechanisms
<b>CO2</b>	Analyze the planar mechanisms for position, velocity, and acceleration
<b>CO3</b>	Construct and analyze cam profiles for a specified motion of the follower
<b>CO4</b>	Evaluate gear tooth geometry and select appropriate gears for the required applications. Analyze different types of gear trains.
<b>CO5</b>	Understand the application of friction in machine elements like bearings, clutches, brakes, and belt drives.

**Syllabus:**

**Unit-1: Fundamentals of Kinematics & Mechanisms:** Kinematic link, Types of links, 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, Four bar chain and its inversions, Grashoff’s law, Slider crank chain and its inversions, Double slider crank chain and its inversions, straight line motion mechanism, steering mechanism.

**Unit-2: Kinematics of Linkage Mechanisms:** Velocity and acceleration analysis of mechanisms, Velocities and accelerations by relative velocity method, Velocity analysis using instantaneous center method, Velocities and accelerations by Analytical method, Coriolis component of Acceleration.

**Unit-3: Kinematics of Cam Mechanisms:** Classification of cams and followers, Nomenclature of a radial cam, Description of follower movement, Displacement diagrams, Uniform and modified uniform motion, Simple harmonic motion, Uniform acceleration motion and its modifications,

Cycloidal motion, Synthesis of cam profile by graphical approach, and Considerations of pressure angle.

**Unit-4: Gears & Gear Trains:** Types of gears, Gear terminology, fundamental law of toothed gearing, Gear tooth forms, Involute and Cycloid tooth profile, Length of path of Contact, Arc of Contact, Contact ratio, Interference and Undercutting of Involute teeth, Minimum number of teeth on pinion to avoid interference. Simple, Compound, Reverted, and Epicyclic gear trains, computation of velocity ratio in gear trains by different methods.

**Unit-5: Friction in Machine Elements:** Applications of friction, Friction clutches, Belt Drives – Ratio of tensions for flat belt & V-belt, Centrifugal tension, condition for maximum power transmission, Friction in brakes– Simple block or shoe brake, Band brake, Band and Block brakes, Internal expanding shoe brake, Absorption dynamometer, Transmission dynamometer.

**Text Books:**

1. Uicker, J.J., Pennock G.R and Shigley, J.E, Theory of Machines and Mechanisms, Oxford University Press.
2. Rattan, S. S., Theory of Machines, Tata McGraw Hill.

**References Books:**

1. Thomas Bevan, Theory of Machines, CBS Publishers and Distributors.
2. Cleghorn. W. L., Mechanisms of Machines, Oxford University Press.
3. Robert L. Norton, Kinematics and Dynamics of Machinery, Tata McGraw Hill.
4. Allen S. Hall Jr., Kinematics and Linkage Design, Prentice Hall.
5. Ghosh. A and Mallick, A.K., Theory of Mechanisms and Machines, East–West Pvt. Ltd., New Delhi.
6. Rao J.S. and Dukkupati R.V., Mechanisms and Machine Theory, Wiley–Eastern Ltd., New Delhi.
7. Ramamurthi. V., Mechanics of Machines, Narosa Publishing House.
8. Khurmi, R.S., Theory of Machines, S Chand Publications.
9. Sadhu Singh, Theory of Machines, Pearson Education.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome											PSO		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	3	2	2	2	1	-	-	-	2	-	3	2	3
<b>CO2</b>	2	2	2	3	3	1	-	3	3	-	-	3	3	3
<b>CO3</b>	2	2	2	2	2	1	-	-	-	2	-	3	2	2
<b>CO4</b>	2	2	3	2	2	2	-	2	2	-	-	3	3	2
<b>CO5</b>	2	2	2	3	3	1	1	2	2	1	1	3	2	2

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	B. Tech.	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Indian Knowledge System	<b>Course Code:</b>	ME24-B-MJ209
<b>Credits:</b>	4	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course introduces engineers to the rich and diverse Indian Knowledge System (IKS), exploring its historical foundations, philosophical frameworks, and practical applications in science and technology. We will examine the ancient Indian contributions to mathematics, metallurgy, architecture, and other engineering domains, fostering an understanding of the relevance of traditional knowledge to modern engineering challenges. Through analyzing ancient texts and case studies, students will gain insights into indigenous problem-solving approaches and innovative techniques that can complement contemporary engineering practices.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand IKS foundations and history.
<b>CO2</b>	Analyze ancient Indian knowledge sources.
<b>CO3</b>	Demonstrate knowledge of the Indian numeral and measurement systems.
<b>CO4</b>	Examine historical Indian metallurgy.
<b>CO5</b>	Evaluate IKS applications in engineering and technology.

**Syllabus:**

**Unit-1: Indian Knowledge System-An Introduction:** Indian Knowledge System-An Overview, Learning Outcomes, IKS in Action, Do We Need Indian Knowledge System? Importance of Ancient Knowledge, Defining Indian Knowledge System, The IKS Corpus-A Classification Framework, Chaturdasa-Vidyasthana, IKS in Action, Chaturdasa-Vidyasthana and the Income Tax Act, 1961, Historicity of IKS, Some Unique Aspects of IKS, Nuances of an Oral Tradition, Typical Presentation Style -Sutras, Encryptions.

**Unit-2: Knowledge through ages, framework and classification:** Panchtantra, a treatise on statecraft through stories, Puranas, Maha purana, Up Purana, Content of Purana, Issues of interest in Purana, Ithihasa as a source of wisdom, Uniqueness of two epics : Ramyan and Mahabharat, Niti shastra, Subhashitani.

**Framework and classification:** Tarka: The Indian art of debate, The knowledge triangle, Prameya -A Vaisesikan Approach to Physical Reality, Dravyas -The Constituents of the Physical Reality, Attributes- The Properties of Substances, Action -The Driver of Conjunction and Disjunction IKS in Action, Vaisesikan Worldview of 'Existence, Pramana- The Means of Valid Knowledge Samsaya -Ambiguities in Existing Knowledge Framework for Establishing Valid Knowledge, Deductive/Inductive Logic Framework, Potential Fallacies in the Reasoning Process, Summaru.

**Unit-3: Number System and Units of Measurement:** Gautam Buddha on number system, Number system in in India- Historical Evidence, Salient features of the Indian numeral system, The concept of zero and its importance, Large numbers and their representation, Place value of Numerals, Decimal system, Unique Approaches to Represent Numbers, Bhūta-samkhya System, Katapayadi System, Measurements for Time, Distance, and Weight, IKS in Action: Measurement of Time -An Illustration from Purana, Pingala and the Binary System.

**Unit-4: Engineering and Technology: Metals and Metalworking:** Learning Outcomes, IKS in Action: Wootz Steel: The Rise and Fall of a Great Indian Technology, The Indian S & T Heritage, Mining and Ore Extraction, Metals and Metalworking Technology, Gold Extraction Process, Zinc Production, Copper Mining and Extraction Process, Copper Alloys, Mercury, Lead and Silver, Iron and Steel in India, Extraction of Iron from Biotite by Āyurvedic Method, Manufacture of Steel, Lost Wax Casting of Idols and Artefacts, Apparatuses Used for Extraction of Metallic Components.

**Unit-5: Engineering and Technology: Other Applications:** IKS in Action, irrigation Systems and Practices in South India, Literary Sources for Science and Technology, Physical Structures in India 287 V143 Irrigation and Water Management, Dyes and Painting Technology, IKS in Action: Distillation, Surgical Techniques, Shipbuilding, Sixty-four Art Forms (64 Kalās), Status of Indigenous S&T.

**Architecture and planning:** IKS in Action: Arthasastra on Town Planning, Indian Architecture - A Historical Perspective, Vastu-sastra -The Science of Architecture, Literary Sources, Vastu-purusa-mandala, Eight Limbs of Vastu, Town Planning, Unitary Buildings, Alternative Designs for Town Planning, Temple architecture.

**Text Books:**

1. Mahadevan B., Bhat V.R. and Pavana N.R.N., Introduction to Indian Knowledge System, Phi India publishers.
2. Dr. Rohidas Nitonde, Introduction to Indian Knowledge System : A Textbook for UG Students as per NEP 2020, Notion Press Media Pvt. Limited.

**References Books:**

1. Dr. Shashikant Awasthi, Indian Knowledge Systems: A Comprehensive Analysis of Various Contexts, Shashwat Publication, India
2. R.S. Sharma, India's Ancient Past, Oxford University Press
3. Books on Artha, Vymanik , Vaastu and other Shastras, Puranas and Upanishads
4. Online Sources: <https://www.valmiki.iitk.ac.in/>, <https://www.heritage.iitk.ac.in>.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	1	1	1	2	2	1	2	-	2	2	1	1
<b>CO2</b>	3	3	1	2	1	2	1	1	2	-	2	2	1	1
<b>CO3</b>	3	2	1	1	2	1	1	1	2	-	2	2	2	1
<b>CO4</b>	3	2	1	2	1	2	1	1	2	-	2	3	2	1
<b>CO5</b>	3	2	2	2	1	3	1	1	2	-	2	3	2	2

**Note:** 1: Low 2: Moderate 3: High



<b>Program:</b>	B. Tech.	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Fluid Mechanics & Machinery Lab	<b>Course Code:</b>	ME24-B-MJ210
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

### Course Description:

This lab course provides practical experience in fluid mechanics and hydraulic machinery. Students will verify Bernoulli's theorem, measure flow velocities, determine discharge coefficients for flow meters, and analyze jet impact. The course includes performance testing of turbines, pumps, and wind tunnels, alongside studies of industrial boiler feed pumps and airfoil lift/drag.

**Course Outcomes:** After completion of the course, students will be able to:

CO Number	Course Outcome
CO1	Validate fluid mechanics principles experimentally.
CO2	Determine turbine and pump performance.
CO3	Analyze pipe flow and losses.
CO4	Investigate airfoil lift and drag.
CO5	Study industrial fluid handling equipment.

### List of Experiments:

**(Minimum seven experiments and three studies)**

1. To verify Bernoulli's theorem experimentally.
2. To measure the velocity of flow using Pitot tube.
3. To determine the coefficient of discharge of Venturi meter.
4. To determine the coefficient of discharge of Orifice meter.
5. To determine the impact of jet through nozzle.
6. To plot hydraulic and energy gradient line Using Reynolds apparatus
7. To plot Performance characteristics of Pelton wheel turbine.
8. To plot Performance characteristics of Francis turbine.
9. Study of construction and working of a Kaplan turbine.
9. Performance characteristics of a single stage centrifugal pump.
10. Performance characteristics of multistage centrifugal pump.
11. Performance Characteristics of a reciprocating pump.
12. Study of Wind Tunnel (Open Circuit blower type)
13. Determination of Lift and drag force over an air foil.
14. Study of an industrial Boiler Feed pump and Vacuum

### Equipment/Machines/Instruments/Tools/Software Required:

1. Bernoulli's apparatus.
2. Complete setup for flow measurement using Pitot tube

3. Impact of jet apparatus.
4. Venturimeter Apparatus.
5. Orifice meter Apparatus
6. Pipe friction apparatus
7. Orifice apparatus
8. Reynolds's apparatus
9. Pelton Wheel Turbine Test Rig
10. Francis Turbine Test Rig
11. Kaplan Turbine setup
12. Rated Speed Centrifugal Pump Test Rig
13. Multi Stage Centrifugal Pump Test Rig
14. Reciprocating Pump Test Rig
15. Complete setup of Wind Tunnel (Open circuit blow type)
16. Airfoil with the provision of measurement of pressure distribution over the surface.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	3	1	3	3	1	-	2	2	-	2	3	3	1
<b>CO2</b>	3	3	2	3	3	2	-	2	2	1	2	3	3	1
<b>CO3</b>	3	3	2	3	3	2	-	2	2	1	2	3	3	1
<b>CO4</b>	3	3	2	3	3	2	-	2	2	1	2	3	3	1
<b>CO5</b>	3	3	2	3	3	2	-	2	2	1	2	3	3	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Manufacturing Technology-I Lab	<b>Course Code:</b>	ME24-B-MJ212
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

To impart knowledge to students to develop their technical skill sets for creating entities from raw material. To give “hands on” training and practice to students for use of various tools, devices, machines. To develop ability of students to understand, plan and implement various processes and operations to be performed on the raw material to create object of desired shape and size. To give exposure to inter disciplinary domains.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Students will demonstrate the ability to create green sand mould using two-piece patterns and successfully cast non-ferrous alloys.
<b>CO2</b>	Student will select appropriate joining processes to join work piece.
<b>CO3</b>	Students will acquire skills to join metal sheets and plates using spot welding, gas welding, MAG welding (in both 2F and 3F positions), and TIG welding (in the 1G position).
<b>CO4</b>	Students will study and understand the components and operation of robotic welding setups, including programming a robotic welder to perform basic welding task.
<b>CO5</b>	Students will develop the ability to analyse the troubleshoot common defects and issues in casting and welding process, implementing corrective measures to improve quality and efficiency.

**Experiments to be performed (Minimum Eight experiments)**

1. Making a green sand mould using a two-piece pattern.
2. Casting of a non-ferrous metals/alloys.
3. Joining metal sheets by spot welding.
4. Joining metal sheets by gas welding.
5. Joining mild steel plate in a 2F position by metal active gas (MAG) welding.
6. Joining mild steel plate in 3F position by MAG welding.
7. Joining mild steel plate in 1G position by MAG welding.
8. Joining metal by brazing.

9. Study of robotic welding setup.
10. Programming on robotic welding set-up to make a single bead on MS plate.

**List of Equipment/Instruments/Machines Required:**

1. Muffle furnace.
2. Welding machines (MMAW/MAG) and equipment's.
3. Resistance/spot welding machines and equipment's.
4. Oxy-acetylene gas welding setup.
5. Brazing Equipment's
6. Robotic welding setup.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	2	1	3	1	-	1	1	1	1	3	2	1
<b>CO2</b>	2	3	2	2	2	2	-	1	1	1	2	3	2	1
<b>CO3</b>	3	3	3	2	3	2	-	2	2	1	2	3	3	1
<b>CO4</b>	2	2	3	3	3	3	-	2	2	1	2	3	3	1
<b>CO5</b>	3	3	3	2	3	3	2	1	1	2	3	3	3	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program</b>	B. Tech	<b>Semester</b>	III Sem
<b>Name of the Course</b>	Fundamentals of Robotics	<b>Course Code</b>	ME24-B-MN201
<b>Credits</b>	4	<b>No of Hours</b>	4 Hours/week
<b>Max Marks</b>	100		

**Course Description:**

This subject provides insight to the fundamentals of Robotics, where the students will learn Introduction to Robotics, Basics of Robotics, Robotic Sensors, Arduino-based Robotics, and Arduino-based programming.

**Course Outcome:** Students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Recognize robotics-related terminology
<b>CO2</b>	Determine the robot's gripper, sensor, and actuator
<b>CO3</b>	Understand the sensors and machine vision system of a robot
<b>CO4</b>	Use Arduino board for different autonomous applications
<b>CO5</b>	Implement Arduino board for different autonomous applications

**Syllabus:**

**Unit-1: Introduction to Robotics:** Definition according to RIA, ISO, and others, Brief History, Robot Anatomy, Laws of Robotics.

**Unit-2: Basic Robotics:** Classification of robots, Robot terminologies: work volume, resolution, accuracy, repeatability, payload capacity, speed of response etc., Wrist assembly, Joint notations, Selection criteria of any robot.

**Unit-3: Robotic sensors:** Need for sensors, types of sensors used in Robotics, classification and applications of sensors, Characteristics of sensing devices, Selections of sensors.

**Unit-4: Arduino-based Robotics:** Description of Arduino board, Types of Arduino board, Different terminology of Arduino board. Detail discussion on connections and usage of ports in board, Bread Board, motor drive units, jumper wire and connection methods

**Unit-5: Arduino-based Programming:** Arduino IDE (Integrated Development Environment) coding for- Line follower robot; Bluetooth controlled robot; Voice controlled robot; Gesture controlled robot.

**Text Books:**

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education.
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press.
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House.

**Reference Books:**

1. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi.
2. S. B. Niku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	1	0	2	0	1	1	2	1	3	3	2	3
<b>CO2</b>	3	3	2	2	3	1	1	1	2	1	2	3	3	3
<b>CO3</b>	3	3	3	2	3	2	1	2	2	1	2	3	3	3
<b>CO4</b>	3	3	3	2	3	2	1	1	2	2	3	2	3	3
<b>CO5</b>	3	3	3	2	3	2	1	1	2	2	3	2	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Basics of Industrial Robotics	<b>Course Code:</b>	ME24-B-MN202
<b>Credits:</b>	4	<b>No of Hours:</b>	4 Hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive introduction to industrial robotics, covering key topics such as manipulator types, actuation systems, and end effectors. Students will explore advanced sensors, machine vision, and basic control systems, alongside understanding safety standards, socio-economic impacts, and the role of artificial intelligence in robotics. Emphasis is placed on practical applications and recent advancements in mobile robot locomotion and collaborative robots.

**Course Outcome:** Students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the basics of industrial robotics
<b>CO2</b>	Understand actuation system and end effector mechanism of industrial robot.
<b>CO3</b>	Understand the sensors and vision system of industrial robot.
<b>CO4</b>	Understand the control system of robot.
<b>CO5</b>	analyze the AI needs and applications for development of robots

**Syllabus:**

**Unit-1: Introduction to Industrial Robotics:** Introduction to manipulators, different types of industrial robot, collaborative robot, Futuristic robotics.

**Unit-2: Actuation system & End Effectors:** Types of drives – Hydraulic, Pneumatic and Electric, Comparison of all such drives, DC servo motors, Stepper motors, AC servo motor – salient features and applications, pulse count calculations End effectors - Types of Grippers – Mechanical, Magnetic, vacuum, pneumatic and hydraulic, selection and design considerations.

**Unit-3: Robot sensors and Machine Vision:** Advance sensors, Image sensor, Robot Vision setup (RVS), block diagram, components, working of RVS, Human vision Vs Robot Vision, Gradient calculations, Applications of RVS.

**Unit-4: Basic Control systems:** Introduction, Different types of controllers, Proportional, Integral, Differential and their combination controllers. Open-loop and closed-loop control systems, Feedback and its importance, Linear vs. nonlinear systems, Time-invariant vs. time-variant system, Examples of Control systems.

**Unit-5: Safety and Locomotion:** Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, mobile robotics, New trends & recent updates in robotics. Mobile Robot locomotion: Types of locomotion, hopping robots, legged robots, wheeled robots, stability, manoeuvrability, controllability.

**Text Books:**

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education.
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press.
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House.

**Reference Books:**

1. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi.
2. S. B. Niku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	1	1	2	1	1	1	2	1	3	3	2	3
<b>CO2</b>	3	3	2	2	3	1	1	1	2	1	3	3	3	3
<b>CO3</b>	3	3	2	2	3	1	1	1	2	1	3	3	3	3
<b>CO4</b>	3	3	3	2	3	2	1	1	2	2	3	3	3	3
<b>CO5</b>	3	3	3	2	3	2	1	1	2	2	3	3	3	3

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



**OPJU**

<b>Program:</b>	B. Tech.	<b>Semester:</b>	3 <sup>rd</sup>
<b>Name of the Course:</b>	Ethics In Engineering Practice	<b>Course Code:</b>	ME24-B-AE201
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Descriptions:**

This course is designed to introduce students to the ethical dimensions of engineering practice and the professional responsibilities of engineers in society. It explores the foundations of ethical theory, codes of professional conduct, and the role of personal and organizational ethics in decision-making. Through case studies, real-world scenarios, and discussions, students will develop critical thinking skills to navigate complex ethical dilemmas in engineering contexts.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand and apply fundamental ethical theories and principles in engineering.
<b>CO2</b>	Analyze professional codes of ethics across engineering disciplines.
<b>CO3</b>	Evaluate ethical issues in the context of safety, sustainability, and global responsibility.
<b>CO4</b>	Develop strategies for ethical decision-making in real-world engineering scenarios.
<b>CO5</b>	Foster a sense of professional responsibility and commitment to ethical conduct.

**Syllabus:**

**The Course Will run through the NPTEL**

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109  
Department of Mechanical Engineering



<b>Program:</b>	B. Tech.	<b>Semester:</b>	3 <sup>rd</sup>
<b>Name of the Course:</b>	Engineering Economic Analysis	<b>Course Code:</b>	ME24-B-AE202
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Descriptions:**

This course provides a systematic framework for evaluating the economic merits of engineering alternatives in both public and private sector projects. It introduces fundamental concepts of engineering economy including time value of money, cost estimation, cash flow analysis, depreciation, replacement analysis, and break-even analysis.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand the principles of engineering economics and their application in decision-making
<b>CO2</b>	Evaluate investment alternatives using techniques such as NPV, IRR, and payback period.
<b>CO3</b>	Analyze project feasibility considering cost, benefit, depreciation, and inflation.
<b>CO4</b>	Apply break-even and sensitivity analysis in project evaluation.
<b>CO5</b>	Demonstrate competence in life-cycle costing and replacement decisions.

**Syllabus:**

**The Course Will run through the NPTEL**

<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	MATLAB Programming Lab	<b>Course Code:</b>	ME24-B-SE201
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This course provides a comprehensive understanding of key mathematical concepts and their applications in engineering and scientific computing using MATLAB. The topics covered include complex variables, Laplace transforms, numerical methods, basic statistics and probability, random variables, and probability distributions. Through a combination of theoretical lectures and practical MATLAB-based exercises, students will develop the skills necessary to solve complex mathematical problems and apply these techniques in various engineering and scientific contexts.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Able to use MATLAB effectively to analyze and visualize data
<b>CO2</b>	Apply a top-down, modular, and systematic approach to design, write, test, and debug sequential MATLAB programs to achieve computational objectives
<b>CO3</b>	Design and document computer programs and analyses in a careful and complete manner so as to effectively communicate results, to facilitate evaluation and debugging by another programmer, and to anticipate and resolve user errors
<b>CO4</b>	Create and control simple plot and user-interface graphics objects in MATLAB
<b>CO5</b>	Apply numeric techniques and computer simulations to solve engineering-related problems

**List of Experiments: (Minimum ten experiments to be performed)**

1. MATLAB Basics: Introduction, operation with arithmetic, logarithmic and trigonometric function.
2. Operations with arrays, polynomials, problem practice.
3. Script file, problem practice.
2. Function file, problem practice.
3. Programming: graphics, input / output.
4. Plotting of 2D and 3D curves, problem practice.

5. Roots: programming for general method.
6. Numerical integration formulas, numerical integration of functions.
7. Numerical differentiation, problem practice.
8. Ordinary differential equation problem practice.
9. Analyze and manipulate complex functions using MATLAB.
10. Laplace transforms using MATLAB.
11. Implement numerical algorithms for roots of algebraic and transcendental equations using MATLAB.
12. MATLAB implementation of descriptive statistics.
13. MATLAB simulations of probability experiments.
14. MATLAB implementation of hypothesis tests and confidence intervals.
15. MATLAB implementation of random variable simulations

**Equipment/Machines/Instruments/Tools/Software Required:**

1. MATLAB Software

**CO, PO, & PSO Correlation**

CO Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	2	2	3	1	0	1	1	1	2	2	3	3
<b>CO2</b>	3	3	3	2	3	1	0	1	1	1	2	2	3	3
<b>CO3</b>	2	2	3	2	3	1	1	1	2	2	2	2	3	2
<b>CO4</b>	2	2	2	2	3	1	0	1	1	1	2	1	3	3
<b>CO5</b>	3	3	3	3	3	2	1	1	1	2	3	3	3	3

Note: 1: Low 2: Moderate 3: High

<b>Programme:</b>	B.Tech	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Measurement and Control	<b>Course Code:</b>	ME24-B-SE202
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

### Course Description:

The course is designed to familiarize the student with the functions and instrumentation available in a modern industry. This course covers the fundamentals of instrumentation used in industry. Emphasis is on electric, electronic, and other instruments. Student also learn the concepts of the mathematical modeling, feedback control and stability analysis in Time and Frequency domains.

### Course Outcomes:

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand about different instruments that are used for measurement purpose.
<b>CO2</b>	Analyze the Performance characteristics of each instrument, analyses the data and generate report.
<b>CO3</b>	Understand how waveforms can be analyzed using wave analyzers, MATLAB and Simulink
<b>CO4</b>	Able to determine transfer function models of electrical, mechanical and electromechanical systems.
<b>CO5</b>	Able to determine stability/relative stability from characteristic equation.

### Syllabus:

**Unit-1: Basics of Measurement Systems:** Static and dynamic characteristics of measurement systems. Measurement errors: Gross error, systematic error, absolute error and relative error, accuracy, precision, resolution and significant figures, Measurement error combination, basics of statistical analysis. Statistical analysis of data and curve fitting.

**Unit-2: Electrical and Electronic Measurements:** Bridges and potentiometers, measurement of R, L and C. Measurements of voltage, current, power, power factor and energy. AC & DC current probes. Extension of instrument ranges. Q-meter and waveform analyzer. Digital voltmeter and multi-meter. Time, phase and frequency measurements. Cathode ray oscilloscope. Serial and parallel communication. Shielding and groundings.

**Unit-3: Transducers, Mechanical Measurement and Industrial Instrumentation:** Resistive, Capacitive, Inductive and piezoelectric transducers and their signal conditioning. Measurement of displacement, velocity and acceleration (translational and rotational), force, torque, vibration and shock. Measurement of pressure, flow, temperature and liquid level. Measurement of pH, conductivity, viscosity and humidity.

**Unit-4: Control Systems:** Open loop and closed loop control systems, Feedback characteristics of control systems, Mathematical representation of physical systems, electrical, mechanical, hydraulic, thermal systems, Block diagram, algebra and signal flow graphs, Mason's gain formula. Time Domain Analysis, standard test signals, time response of first, second and higher order systems, performance indices. Error analysis, static and dynamic error coefficients. Stability, concept of stability, asymptotic and conditional stability, Routh Hurwitz criterion,

**Unit-5: Process Control:** Root locus technique (Concept and construction) Frequency Response Analysis Correlation between time and frequency response, Polar and inverse polar plots, NY Quist stability criterion, Bode plots, Time delay systems. Phase and gain margin. Mechanical, hydraulic and pneumatic system components. Synchro pair, servo and step motors. On-off, cascade, P, P-I, P-I-D, feed forward and derivative controller, Fuzzy controller.

**Text Books:**

1. Doebelin, E.O., Measurement systems, Applications and Design, McGraw–Hill (1982).
2. Nakra, B. C. and Chaudhry, K. K., Instrumentation Measurement and Analysis, Tata McGraw–Hill (2003).
3. Ogata, K., Modern Control Engineering, Prentice–Hall of India Private Limited (2001)
4. Nagrath, I.J. and Gopal, M., Control System Engineering, New Age International (P) Limited, Publishers (2003).
5. Gopal, M., Digital Control System, Wiley Eastern (1986).

**Reference Books:**

1. W Bolton- Instrumentation and control systems, Elsevier (2004).
2. Murthy, D.V.S., Transducers and Instrumentation, Prentice–Hall of India Private Limited (2003).
3. Sawhney, A.K., A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Co. (P) Ltd. (2007).
4. Kuo, B.C., Automatic Control System, Prentice–Hall of India Private Limited (2002).
5. Sinha, N.K., Control System, New Age International (P) Limited, Publishers (2002).

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	-	-	3	-	-	-	-	-	2	3	3	
<b>CO2</b>	3	3	-	3	3	-	-	2	3	-	2	3	3	2
<b>CO3</b>	3	2	-	2	3	-	-	-	2	-	3	3	3	3
<b>CO4</b>	3	3	-	3	3	-	-	-	2	-	3	3	3	3
<b>CO5</b>	3	3	-	3	3	-	-	-	-	-	3	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Solar Energy Technology	<b>Course Code:</b>	ME24-B-MD201
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Descriptions:**

The course is intended to deliver comprehensive knowledge on renewable energy resources, solar radiation, solar radiation data analysis, fundamentals of the solar thermal and photovoltaic system, along with the effective design and performance analysis of solar energy conversion devices.

**Course Outcomes:**

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand characteristics and world distribution of solar radiation.
<b>CO2</b>	Know solar radiation and measurement techniques.
<b>CO3</b>	Understand the methods of calculation of solar radiation availability at a given location.
<b>CO4</b>	Acquire fundamentals of thermal and direct conversion of solar energy to power.
<b>CO5</b>	Understand the fundamentals of solar flat plate collectors, concentrating solar collectors.

**Syllabus:**

**Unit 1: Energy Resources & Solar Radiation:** World energy resources – Indian energy scenario – Environmental aspects of energy utilization. Renewable energy resources and their importance – Global solar resources. Solar spectrum – Electromagnetic spectrum, basic laws of radiation. Solar radiation on the earth surface, distribution of solar radiation. Depletion of solar radiation – Absorption, scattering. Beam radiation, diffuse and Global radiation. Measurement of solar radiation – Pyranometer, Pyrheliometer, Sunshine recorder.

**Unit 2: Solar Radiation Geometry and Calculations:** Solar radiation geometry – Earth–Sun angles – Solar angles. Calculation of angle of incidence – Surface facing due south, horizontal, inclined surface and vertical surface. Solar day length – Sun path diagram – Shadow determination. Estimation of Sunshine hours at different places in India. Calculation of total solar radiation on horizontal and tilted surfaces. Prediction of solar radiation availability.

**Unit 3: Solar Electrical Energy Conversion:** Solar photovoltaic energy conversion – Principles – Physics and operation of solar cells. Classification of solar PV systems, Solar cell energy conversion efficiency, I–V characteristics, effect of variation of solar insolation and temperature, losses. Solar PV power plants.

**Unit 4: Solar Thermal energy conversion:** Fundamentals of solar collectors as devices to convert solar energy to heat. Non–concentrating low temperature flat–plate and evacuated tube collectors. Collector performance – Useful energy gain, energy losses, efficiency. Use of selective coatings to enhance the collector efficiency. Concentrating collectors for middle and high temperature applications. Line–focusing and point–focusing concentrators: parabolic trough, parabolic dish, Fresnel lenses, compound parabolic concentrator. Sun tracking mechanisms.

**Unit 5: Other Solar Energy based technologies:** Concentrating collector performance – concentration ratio, useful energy gain, energy losses, efficiency. Solar collector design, testing, installation and operation. Application of non–concentrating collectors in low temperature solar thermal plants for space heating and cooling, drying, seawater desalination. Use of concentrating collectors for process heat production and power generation.

**Text Books:**

1. K. Sukhatme, Solar energy: Principles of thermal collection and storage, Tata McGraw Hill publishing Co. Ltd.
2. G. N. Tiwari, Solar Energy: Fundamentals, Design, Modelling and Applications, Narosa Publication New Delhi.

**Reference Books:**

1. R.K. Singhal, Non–Conventional Energy Resources, S.K. Kataria & Sons, Delhi.
2. Foster R., Ghassemi M., Cota A., Solar Energy, CRC Press.
3. Duffie J.A., Beckman W.A., Solar Engineering of Thermal Processes, Wiley & Sons.
4. De Vos, A., Thermodynamics of Solar Energy Conversion, Wiley & Sons.
5. Garg H.P., Prakash J., Solar Energy Fundamentals and Applications, Tata McGraw–Hill.
6. Kalogirou S., Solar Energy Engineering: Processes and Systems, Elsevier.
7. Artur V. Kilian, Solar Collectors: Energy Conservation, Design and Applications, Nova Science Publishers Incorporation.
8. Kalogirou S., Solar Energy Engineering: Processes and systems, Academic Press.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1:</b>	3	2	1	1	1	2	-	1	2	1	2	3	1	1
<b>CO2:</b>	3	3	1	3	3	1	-	1	2	1	2	3	3	1
<b>CO3:</b>	3	3	2	2	3	2	-	1	2	1	2	3	3	1
<b>CO4:</b>	3	2	3	1	2	2	-	1	2	1	2	3	2	2
<b>CO5:</b>	3	2	3	1	2	2	-	1	2	1	2	3	2	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	IV
<b>Name of the Course:</b>	Plant Maintenance & Safety	<b>Course Code:</b>	ME24-B-MD202
<b>Credits:</b>	3	<b>No of Hours:</b>	3 Hrs./Week
<b>Max Marks:</b>	100		

**Course Description:**

This course introduces students to essential concepts and practices in plant maintenance and industrial safety. It covers maintenance types and strategies, failure prevention methods including wear and corrosion control, condition monitoring techniques, and safety regulations. Students gain insights into modern maintenance tools like TPM and RCA, as well as safety compliance frameworks such as OSHA and IBR. The course also emphasizes recovery, reconditioning, retrofitting, and the erection and commissioning of machinery. By the end, students will be equipped with skills to ensure enhanced equipment reliability, efficient maintenance planning, and a safe industrial work environment.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the principles of plant maintenance and industrial safety, and the role of maintenance planning and organization.
<b>CO2</b>	Identify and apply suitable maintenance strategies, wear and corrosion prevention techniques in industrial systems.
<b>CO3</b>	Utilize condition monitoring tools and diagnostic methods to detect and analyze faults in equipment.
<b>CO4</b>	Evaluate workplace hazards, apply statutory safety regulations, and suggest preventive and control measures.
<b>CO5</b>	Explain and apply the processes of recovery, reconditioning, retrofitting, and equipment commissioning in an industrial setup.

**Syllabus:**

**Unit 1: Introduction to Plant Maintenance and Safety:** Need for plant maintenance, safety in industrial operations. Objectives of Maintenance: Equipment availability, cost-effectiveness, safety assurance. Maintenance Planning: Scope, short-term and long-term planning, maintenance budgeting. Maintenance Organization: Structure of maintenance department, roles and responsibilities. Introduction to Safety Engineering: Role of safety in plants, accident statistics, case studies of major industrial accidents.

**Unit 2: Wear, Corrosion, and Their Prevention:** Types of wear, Wear reduction methods, Types and applications of lubricants, Corrosion and Its Prevention: Definition, principle, and factors affecting corrosion, Types of corrosion, Corrosion prevention methods.

**Types and Strategies of Maintenance:** Breakdown Maintenance (BM): Meaning, process, when it is suitable, disadvantages. Preventive Maintenance (PM): Scheduled maintenance, benefits, limitations. Predictive Maintenance (PdM): Principles, condition-based maintenance, technologies used. Corrective Maintenance: Process, advantages, repair vs replacement decisions. Total Productive Maintenance (TPM): Concept, 8 pillars of TPM, role of operators in maintenance, OEE (Overall Equipment Effectiveness).

**Unit 3: Condition Monitoring and Fault Diagnosis:** Condition Monitoring Techniques: Vibration analysis, thermography, oil analysis, ultrasonic testing, motor current analysis. Fault Detection Methods: Signal analysis, data interpretation, trending methods. Root Cause Analysis (RCA): Steps and tools (e.g., Fishbone Diagram, 5 Whys). Non-Destructive Testing (NDT): Common NDT methods used in maintenance (Visual, Ultrasonic, Eddy current).

**Unit 4: Industrial Safety and Hazard Control:** Factory Act, Occupational Safety and Health Administration (OSHA), Indian Boiler Regulation (IBR). Hazard Identification and Risk Assessment (HIRA): Risk matrix, severity-likelihood analysis. Personal Protective Equipment (PPE): Types, selection, and maintenance. Fire Safety and Explosion Hazards: Classification of fires, fire suppression systems, emergency response planning. Accident Investigation: Steps in investigation, documentation, learning from incidents.

**Unit 5: Recovery, Reconditioning, and Retrofitting:** Definition of recovery, reconditioning, and retrofitting, Methods of recovery and their applications, Selection criteria for recovery methods.

**Reconditioning and Retrofitting:** Reconditioning process, features, and advantages, Retrofitting: concept, need, and applications. **Installation, Erection, and Commissioning:** Design and planning of foundation, Erection and commissioning of equipment, Alignment and testing of equipment.

**Text Books:**

1. R. C. Mishra and K. Pathak, Maintenance Engineering and Management, PHI Learning Pvt. Ltd.
2. Frank R. Spellman, Safety Engineering: Principles and Practices, Rowman & Littlefield.
3. Maintenance Engineering, H. P. Garg, S. Chand and Company.
4. Maintenance Engineering Handbook, Higgins & Morrow, DA Information Services

**Reference Books:**

2. S. K. Srivastava, Industrial Maintenance Management, S. Chand & Company.
3. B.S. Dhillon, Engineering Maintenance: A Modern Approach, CRC Press.
4. Amitabh Bhattacharya, Safety Management, Himalaya Publishing.
5. Donald V. LaCombe, Total Productive Maintenance, Productivity Press.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	2	1	2	2	2	1	1	1	2	3	2	1
<b>CO2</b>	3	3	3	2	2	2	1	1	1	1	2	3	3	2
<b>CO3</b>	3	3	2	3	3	2	1	1	1	1	2	3	3	2
<b>CO4</b>	2	3	2	2	2	3	3	2	1	1	2	2	2	1
<b>CO5</b>	3	3	3	2	3	2	2	2	1	2	2	3	3	2

1: Low 2.: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Engineering Tribology	<b>Course Code:</b>	ME24-B-MD203
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course focuses on the study of friction, wear, and lubrication in machine components. It covers surface interactions, lubrication mechanisms, and material properties to enhance system performance, improve efficiency, and minimize wear in mechanical systems for various engineering applications.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Explain the fundamental concepts of tribology, different types of lubricants, their properties, and lubrication mechanisms.
<b>CO2</b>	Analyze the theories of friction, different wear mechanisms, and approaches to minimize wear in engineering applications.
<b>CO3</b>	Evaluate surface roughness characteristics, measurement methods, and tribological behavior of bearings and gears.
<b>CO4</b>	Demonstrate the principles of hydrodynamic and elastohydrodynamic lubrication, along with pressure development and load-carrying capacity in bearings.
<b>CO5</b>	Illustrate the working of antifriction bearings, condition monitoring techniques, and emerging concepts like nano/micro tribology and green tribology.

**Syllabus:**

**Unit-1: Introduction to Tribology:** Historical background, practical importance, and subsequent use in the field.

**Lubricants:** Types and specific field of applications. Requisite properties of lubricants. Viscosity, its measurement, effect of temperature and pressure on viscosity, standard grades of lubricants, selection of lubricants. Lubricant Rheology, Lubrication Types, Basic equation of lubrication.

**Unit-2: Friction:** Origin, Friction Theories, measurement methods, friction of metals and non-metals.

**Wear:** Classification and Mechanisms of Wear, Delamination theory, Debris analysis, testing methods and standards, wear mechanism maps, and approach to wear reduction. Related Case Studies.

**Unit-3: Surface Roughness:** Standardization, measurement with contacting and non-contacting instruments, Statistical analysis of surface, characteristics of the surface, tribological behaviour of

asperities contact.

**Behaviour of Tribological components, Plain & Antifriction Bearings:** selection, effect of frictional torque, factors affecting performance, failure modes, bearing lubrication.

**Gears:** Friction & stresses, wear, lubrication & failure. Failure Case Studies.

**Unit-4: Hydrodynamic Bearings:** Mechanism of pressure development, classification, Idealized Journal Bearing, oil film thickness, pressure distribution, load carrying capacity. Failure Case Studies.

**Elastohydrodynamic Lubrication (EHL):** Theoretical considerations, line and point contacts, film thickness equations, different regimes in EHL contact.

**Unit-5: Antifriction Bearings:** Ball and roller bearings, geometry of ball bearings, radial load distribution, stresses and deformations, lubrication of ball bearings. Failure Case Studies.

□ Condition monitoring techniques, lubricant, corrosion, temperature & surface roughness monitoring. Failure Case Studies.

Nano/Micro Tribology, Green Tribology.

**Text Books:**

1. Prasanta Sahoo, Engineering Tribology, Prentice Hall of India Pvt. Ltd.
2. S.K. Basu, S.N. Sengupta, B.B. Ahuja, Fundamentals of Tribology, PHI Learning Pvt. Ltd.
3. S.K. Shrivastava, Tribology in Industries, S. Chand & Company Ltd.
4. A. Harnoy, Bearing Design in Machinery: Engineering Tribology and Lubrication, Marcel Dekker Inc.

**Reference Books:**

1. G.W. Stachowiak, A.W. Batchelor, Engineering Tribology, Elsevier India Pvt. Ltd.
2. B.C. Majumdar, Introduction to Tribology of Bearings, S. Chand & Company Ltd., New Delhi.
3. T.A. Harris, Rolling Bearing Analysis, John Wiley & Sons, Inc.
4. J. Williams, Engineering Tribology, Cambridge University Press.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	1	-	1	2	1	2	-	-	2	3	1	-
<b>CO2</b>	3	3	2	2	2	2	1	2	1	-	2	3	2	-
<b>CO3</b>	3	3	3	2	2	2	1	2	1	-	2	3	2	-
<b>CO4</b>	3	3	3	2	2	2	1	2	-	-	2	3	2	-
<b>CO5</b>	3	3	3	3	2	3	1	3	1	1	3	3	3	-

**Note:** 1: Low 2: Moderate 3: High

<b>Program</b>	B. Tech	<b>Semester</b>	III Sem
<b>Name of the Course</b>	Fundamentals of Robotics	<b>Course Code</b>	ME24-B-MN201
<b>Credits</b>	4	<b>No of Hours</b>	4 Hours/week
<b>Max Marks</b>	100		

**Course Description:**

This subject provides insight to the fundamentals of Robotics, where the students will learn Introduction to Robotics, Basics of Robotics, Robotic Sensors, Arduino-based Robotics, and Arduino-based programming.

**Course Outcome:** Students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Recognize robotics-related terminology
<b>CO2</b>	Determine the robot's gripper, sensor, and actuator
<b>CO3</b>	Understand the sensors and machine vision system of a robot
<b>CO4</b>	Use Arduino board for different autonomous applications
<b>CO5</b>	Implement Arduino board for different autonomous applications

**Syllabus:**

**Unit-1: Introduction to Robotics:** Definition according to RIA, ISO, and others, Brief History, Robot Anatomy, Laws of Robotics.

**Unit-2: Basic Robotics:** Classification of robots, Robot terminologies: work volume, resolution, accuracy, repeatability, payload capacity, speed of response etc., Wrist assembly, Joint notations, Selection criteria of any robot.

**Unit-3: Robotic sensors:** Need for sensors, types of sensors used in Robotics, classification and applications of sensors, Characteristics of sensing devices, Selections of sensors.

**Unit-4: Arduino-based Robotics:** Description of Arduino board, Types of Arduino board, Different terminology of Arduino board. Detail discussion on connections and usage of ports in board, Bread Board, motor drive units, jumper wire and connection methods

**Unit-5: Arduino-based Programming:** Arduino IDE (Integrated Development Environment) coding for- Line follower robot; Bluetooth controlled robot; Voice controlled robot; Gesture controlled robot.

**Text Books:**

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education.
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press.
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House.

**Reference Books:**

1. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi.
2. S. B. Niku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	1	0	2	0	1	1	2	1	3	3	2	3
<b>CO2</b>	3	3	2	2	3	1	1	1	2	1	2	3	3	3
<b>CO3</b>	3	3	3	2	3	2	1	2	2	1	2	3	3	3
<b>CO4</b>	3	3	3	2	3	2	1	1	2	2	3	2	3	3
<b>CO5</b>	3	3	3	2	3	2	1	1	2	2	3	2	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Basics of Industrial Robotics	<b>Course Code:</b>	ME24-B-MN202
<b>Credits:</b>	4	<b>No of Hours:</b>	4 Hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive introduction to industrial robotics, covering key topics such as manipulator types, actuation systems, and end effectors. Students will explore advanced sensors, machine vision, and basic control systems, alongside understanding safety standards, socio-economic impacts, and the role of artificial intelligence in robotics. Emphasis is placed on practical applications and recent advancements in mobile robot locomotion and collaborative robots.

**Course Outcome:** Students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the basics of industrial robotics
<b>CO2</b>	Understand actuation system and end effector mechanism of industrial robot.
<b>CO3</b>	Understand the sensors and vision system of industrial robot.
<b>CO4</b>	Understand the control system of robot.
<b>CO5</b>	analyze the AI needs and applications for development of robots

**Syllabus:**

**Unit-1: Introduction to Industrial Robotics:** Introduction to manipulators, different types of industrial robot, collaborative robot, Futuristic robotics.

**Unit-2: Actuation system & End Effectors:** Types of drives – Hydraulic, Pneumatic and Electric, Comparison of all such drives, DC servo motors, Stepper motors, AC servo motor – salient features and applications, pulse count calculations End effectors - Types of Grippers – Mechanical, Magnetic, vacuum, pneumatic and hydraulic, selection and design considerations.

**Unit-3: Robot sensors and Machine Vision:** Advance sensors, Image sensor, Robot Vision setup (RVS), block diagram, components, working of RVS, Human vision Vs Robot Vision, Gradient calculations, Applications of RVS.

**Unit-4: Basic Control systems:** Introduction, Different types of controllers, Proportional, Integral, Differential and their combination controllers. Open-loop and closed-loop control systems, Feedback and its importance, Linear vs. nonlinear systems, Time-invariant vs. time-variant system, Examples of Control systems.

**Unit-5: Safety and Locomotion:** Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, mobile robotics, New trends & recent updates in robotics. Mobile Robot locomotion: Types of locomotion, hopping robots, legged robots, wheeled robots, stability, manoeuvrability, controllability.

**Text Books:**

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education.
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press.
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House.

**Reference Books:**

1. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi.
2. S. B. Niku, Introduction to Robotics – Analysis, Control, Applications, 3rd edition, John Wiley & Sons Ltd.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
<b>CO1</b>	3	2	1	1	2	1	1	1	2	1	3	3	2	3
<b>CO2</b>	3	3	2	2	3	1	1	1	2	1	3	3	3	3
<b>CO3</b>	3	3	2	2	3	1	1	1	2	1	3	3	3	3
<b>CO4</b>	3	3	3	2	3	2	1	1	2	2	3	3	3	3
<b>CO5</b>	3	3	3	2	3	2	1	1	2	2	3	3	3	3

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109  
Department of Mechanical Engineering



**O. P. Jindal University**

**Raigarh–Chhattisgarh**



*Scheme and Syllabus*

*of*

**B Tech**

**In**

**Mechanical Engineering**

**(01UG040)**

School of Engineering

Session- 2023-27

**(POs) Program Outcomes for Engineering Graduate**

1. **Engineering Knowledge and Problem Analysis** — Apply the knowledge of engineering domain with adequate amalgamation of science, mathematics, and management to Identify, formulate, and critically analyze complex engineering problems.
2. **Modern tools and techniques for investigating complex problems** – Apply appropriate tools and techniques to analyze, predict and simulate the data for valid conclusion with clear understanding of limitations.
3. **Design and development of innovative systems:** design and develop system components or processes to provide solutions of complex engineering problems that meet the specified conditions of societal, health, safety, and environmental needs.
4. **Communication and Teamwork** – Develop skills to communicate effectively to diverse platforms and contribute meaningfully to different capacities as a leader, team member or individual.
5. **Project management and finance:** Develop and apply knowledge of engineering, management, and finance principles to handle a project in a multidisciplinary environment.
6. **Life-long learning:** Acquire fundamental knowledge for lifelong learning to participate in the extensive context of socio-technological change as a self-directed member and a leader.
7. **Ethics and citizenship:** Apply ethical principles and commit to professional ethics, norms, and responsibilities of the engineering practice; and act with informed awareness to participate in civic life activities.
8. **Society, Sustainability and Environment** — Understand the impact of various solutions in the context of societal, economical, health, safety legal and environmental impact for sustainable development.

**(PSOs) Program Specific Outcomes of Mechanical Engineering Department (01UG040)**

**PSO 1:** Develop an attitude to meet global challenges and apply the knowledge of mechanical engineering to solve problem related with thermal, design, manufacturing and interdisciplinary field.

**PSO 2:** Demonstrate knowledge and skill for solving social, real industrial problems using modern software and hardware tools.

**Scheme of Teaching and Examination**

**B. Tech in Mechanical Engineering (V - Semester)**

S. No.	Subject Code	BOS	Type of Course (NEP)	Subject	Periods per week			Scheme of Exam. and Marks				Credit L+(T+P) /2
					L	T	P	PRE		ESE	Total	
								MID	TA			
1	SOE-B-ME-23-501	ME	CC	Thermal Engineering	3	0	0	30	20	50	100	3
2	SOE-B-ME-23-502	ME	SEC	Hybrid & Electric Vehicles	3	0	0	30	20	50	100	3
3	SOE-B-ME-23-503	ME	CC	Dynamics of Machines	3	0	0	30	20	50	100	3
4	SOE-B-ME-23-504	ME	CC	Operation Research Technique	4	0	0	30	20	50	100	4
5	SOE-B-ME-23-505	ME	CC	Mechatronics and Robotics	4	0	0	30	20	50	100	4
6	SOE-B-ME-23-506	ME	CC	Thermal Engineering Lab	0	0	2	–	30	20	50	1
7	SOE-B-ME-23-507	ME	CC	KOM & DOM Lab	0	0	2	–	30	20	50	1
8	SOE-B-ME-23-508	ME	CC	Mechatronics and Robotics Lab	0	0	2	-	30	20	50	1
9	SOE-B-ME-23-509	ME	SEC	Metrology & Mechanical Measurement Lab	0	0	2	–	30	20	50	1
				<b>TOTAL</b>	<b>17</b>	<b>0</b>	<b>08</b>	<b>150</b>	<b>220</b>	<b>330</b>	<b>700</b>	<b>21</b>

L: Lecture; T: Tutorial; P: Practical  
 CC: Core Course; SEC: Skill Enhancement Course.

<b>Program:</b>	B. Tech.	<b>Semester:</b>	V Sem
<b>Name of the Course:</b>	Thermal Engineering	<b>Course Code:</b>	SOE-B-ME-23-501
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course covers the fundamental concepts of compressible fluid flow, steam turbines, air compressors, boilers, and steam condensers. Topics include isentropic flow, steam nozzle performance, impulse and reaction turbines, velocity diagrams, governing methods, and efficiency calculations. The course also explores reciprocating and axial flow air compressors, their efficiencies, and power requirements. Additionally, it provides insights into boiler types, performance evaluation, and heat balance analysis. Steam condensers, cooling towers, and their efficiency assessments are also discussed, emphasizing practical applications in mechanical engineering.

**Course Outcomes:** After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Describe the characteristics of compressible fluid and steam flow through a nozzle.
<b>CO2</b>	Analyze the steam flow through the impulse and reaction steam turbine with the help of velocity diagrams.
<b>CO3</b>	Examine various efficiencies of the steam turbine and illustrate turbine governing.
<b>CO4</b>	Apply knowledge of turbo machinery for understanding, formulating, and solving engineering problems
<b>CO5</b>	Classify the boilers, condensers, and cooling towers, and solve the condenser design problems

**Syllabus:**

**Unit-1: Compressible Fluids:** Velocity of pressure waves in a fluid, Mach number, isentropic stagnation state, stagnation enthalpy, temperature, pressure, density, one-dimensional steady isentropic flow, area velocity relationship, critical properties-choking in isentropic flow, dimensionless velocity.

**Nozzle:** Flow of steam through nozzle, throat area for maximum discharge, effect of back pressure on the performance of nozzle, supersaturated flow in nozzle.

**Unit-2: Steam Turbine:** Principle of operation of steam turbine, classification of steam turbine, impulse turbine, compounding of steam turbine, velocity diagram for impulse turbine, force on the blade and work done. Blade or diagram efficiency, axial thrust, gross stage efficiency, efficiency of multi-stage turbine.

**Impulse Reaction Turbine:** Velocity diagram, degree of reaction, impulse-reaction turbine with similar blade section and half degree of reaction. (Parson's turbine) height of reaction turbine blading, losses in steam turbine, internal losses, and external losses.

**Unit-3: State Point Locus and Reheat Factor:** Stage efficiency of impulse turbines, state point locus of an impulse turbine, state point locus for multistage turbine, reheat factor. Internal efficiency, overall efficiency, relative efficiency, governing of steam turbine, Throttle governing, nozzle governing, bypass governing, combination of throttle and nozzle, governing and combination of bypass and throttle governing, effect of governing on the performance of steam turbine.

**Unit-4: Reciprocating Air Compressors:** Classification of air compressors, working of single acting single cylinder compressors, single acting reciprocating compressors with and without clearance- equation of work, volumetric efficiency. Multistage reciprocating air compressors. Two-stage air compressor: minimum work, indicator diagram, mean effective pressure and indicated power, compressor power, efficiencies, shaft power of the compressor.

**Axial Flow Compressor:** Construction and working, velocity diagram, calculation of power and efficiency. Degree of reaction, work done factor, stalling.

**Unit-5: Boilers:** Classification of boiler, difference between water tube and fire tube boiler, High pressure boiler- advantages, construction and working of boiler, function of various boiler mounting and accessories, performance of boiler: Evaporation rate, equivalent evaporation, factor of evaporation, boiler efficiency, boiler trial, and heat balance sheet of boiler. Introduction to industrial boilers.

**Steam Condensers:** The function of condenser, element of a water-cooled condensing unit, types of condensers, advantages and disadvantages of various types of condensers, condenser vacuum, mass of circulating water required, source of air, its effects and removal, vacuum efficiency, condenser efficiency.

**Cooling towers:** Cooling towers, classification, working principles, and performance calculations.

**Text Books:**

1. B.K. Sarkar, Thermal Engineering, Tata McGraw-Hill Publishers, 2007.
2. P.K. Nag, Engineering Thermodynamics, TMH Publishers.
3. R.K. Rajput, Thermal Engineering, S. Chand Publishers, 2000.

4. R. Yadav, Steam and Gas Turbine and Power Plant Engineering, Central Publishing House, Allahabad.
5. S. M. Yahya, Turbine, Compressors and Fan, TMH, Delhi.

**References Books:**

1. S. K. Kulshrestha, Thermal Engineering, Vikas Publishing House Pvt. Ltd, New Delhi.
2. Mahesh Rathore, Thermal Engineering, Tata McGraw Hill, Delhi.
3. V. Ganeshan, Gas Turbine, TMH, Delhi.
4. S.M. Yahya, Fundamentals of Compressible Flow, TMH, Delhi.
5. S.K. Kulshrestha, Gas Dynamics with Application, Khanna Publishers.
6. P. Balachandran, Fundamentals of Compressible Fluid Dynamics, PHI, Delhi.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcome								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	1	-	-	2	1	2	3	2
<b>CO2</b>	3	3	2	1	-	2	1	2	3	3
<b>CO3</b>	3	3	2	-	-	2	1	2	3	2
<b>CO4</b>	3	3	3	2	2	2	2	2	3	3
<b>CO5</b>	3	3	3	2	2	3	3	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Programme:</b>	B. Tech.	<b>Semester:</b>	V Sem
<b>Name of the Course:</b>	Hybrid and Electric Vehicle	<b>Course Code:</b>	SOE–B–ME-23-502
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course offers students a comprehensive understanding of Electric Vehicles (EVs) and Hybrid Vehicles (HVs), focusing on their design, technology, and the mechanical aspects of their operation. The course will explore the principles and components that drive these sustainable transportation solutions, with an emphasis on mechanical engineering-related topics.

**Course Outcomes:** After completion of the course, students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Explain the fundamental concepts of vehicle propulsion systems, powertrain technologies, and emission control methods in Internal Combustion Engine Vehicles (ICEVs).
<b>CO2</b>	Describe the architecture, working principles, and energy management systems of Electric Vehicles (EVs), Hybrid Electric Vehicles (HEVs), and Fuel-Cell Electric Vehicles (FCEVs).
<b>CO3</b>	Analyze the performance characteristics of Internal Combustion Engines, electric motors, and transmission systems in EV and HEV powertrains.
<b>CO4</b>	Demonstrate knowledge of battery technologies, charging systems, and battery management systems used in electric and hybrid vehicles.
<b>CO5</b>	Evaluate vehicle propulsion and braking systems for electric and hybrid vehicles.

**Syllabus:**

**Unit-1: Introduction to Vehicle Propulsion and Powertrain Technologies:** History of Vehicle Development, Internal Combustion Engine Vehicles (ICEVs)-The Four-Stroke Gasoline Engine, The Four-Stroke Diesel Engine, ICE Performance Characteristic, ICE Vehicle Emissions, Vehicle Emission Control Technologies, Vehicles with Alternative Fuels - Natural Gas Vehicles (NGVs), Liquefied Petroleum Gas Vehicles (LPGVs), Biodiesel, Hydrogen, Powertrain Technologies - Rear-Wheel Drive Powertrains, Front-Wheel Drive (FWD) Powertrains, Multi-Wheel Drive Powertrains. Transmission Systems: Manual and Automatic Transmission/Transaxle Systems, Automated Manual Transmissions (AMTs), Continuous Variable Transmissions (CVTs), Drivetrain and Differentials.

**Unit-2: Electric and Hybrid Powertrain Technologies:** Introduction to Battery Electric Vehicles (BEVs), Fuel-Cell Electric Vehicles (FCEVs). Hybrid Electric Vehicles: Degree of Hybridization, Parallel Hybrid Configuration, Series Hybrid Configuration, Power-Split Configuration, Compound Hybrid Configuration. Plug-in Hybrid Electric Vehicles (PHEVs), Hybrid Hydraulic Vehicles (HHVs), Pneumatic Hybrid Vehicles (PHVs), Power/Energy Management Systems.

**Unit-3: Modelling and Characteristics of EV/HEV Powertrains Components:** Introduction to ICE Performance Characteristics: Power and Torque Generation, Mean Effective Pressure, Specific Fuel Consumption, Fuel Conversion Efficiency, Mechanical Efficiency, Air–Fuel Ratio, Volumetric Efficiency, Compression Ratio, Specific Emissions. Transmission and Drivetrain Characteristics: Gearboxes, Planetary Gear Set, V-Belt, Continuously Variable Transmission (CVT), Driveline Losses.

**Electric Motor Performance Characteristics:** Power and Torque Generation, Efficiency, DC Motors, Induction AC Motors, Steady-State Performance Analysis, Permanent-Magnet AC Motors.

**Unit- 4: Battery and Charging Technology:** Types of Battery, Super capacitors and flywheels, Battery Performance Characteristics: Battery Capacity, Open Circuit and Terminal Voltages, Charge/Discharge Rate, State of Charge/Discharge, Wireless charging, Depth of Discharge, Battery Energy Density and Specific Energy, Battery Power Density and Specific Power, Battery Efficiency.

**Battery Management System:** Importance of battery management system, battery management system design, onboard chargers, cell balancing, battery life optimization, battery cooling systems.

**Unit-5: Propulsion and Braking:** Introduction- Vehicle Propulsion Modeling and Analysis, Internal Combustion Engine Vehicles, Electric Vehicles, Hybrid Electric Vehicles, Vehicle Braking Modeling and Analysis, Regenerative Braking Characteristics.

**Text Books:**

1. Amir Khajepour, Saber Fallah and Avesta Goodarzi, Electric and hybrid Vehicle: Technologies, Modeling and Control: A Mechatronic Approach - John Wiley & Sons.
2. Tom Denton, Electric and Hybrid Vehicles, Taylor & Francis.

**References Books:**

1. M. Ehsani, Yimin Gao, and Ali Emadi, Modern electric, hybrid electric, and Fuel cell Vehicles fundamentals: Theory and Design, CRC Press
2. Wei Liu, Hybrid Electric Vehicle System Modeling and Control, General Motors, USA, John Wiley & Sons, Inc.

3. Rashid M.H., Power Electronics Circuits, Devices and Applications, Prentice Hall India.
4. Ali Emadi, Handbook of Automotive Power Electronics and Drives, Taylor & Francis Group.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcomes								PSOs		
	1	2	3	4	5	6	7	8	1	2	3
<b>CO1</b>	3	-	-	-	-	2	2	2	3	-	3
<b>CO2</b>	3	-	2	-	-	-	2	2	3	-	3
<b>CO3</b>	3	2	2	2	-	-	-	-	3	3	3
<b>CO4</b>	3	2	2	-	-	-	2	2	3	3	3
<b>CO5</b>	3	2	2	2	-	-	2	-	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	V Sem
<b>Name of the Course:</b>	Dynamics of Machine	<b>Course Code:</b>	SOE–B–ME-23-503
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course explores the principles of dynamic force analysis, governors, balancing, gyroscopic effects, and mechanical vibrations. Topics include inertia forces, turning moment diagrams, flywheels, and governor performance. Balancing techniques for rotating and reciprocating masses, gyroscopic effects in vehicles and aircraft, and vibration analysis of mechanical systems are covered. The course emphasizes practical applications in mechanical engineering, ensuring a deep understanding of motion dynamics and system stability.

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand the force–motion relationship in components subjected to external forces, characterize and design flywheels
<b>CO2</b>	Analyze and design centrifugal governors
<b>CO3</b>	Analyze balancing problems in rotating and reciprocating machinery
<b>CO4</b>	Understand the gyroscopic effects in ships, airplanes, and road vehicles
<b>CO5</b>	Understand free and forced vibrations of single–degree freedom systems

**Syllabus:**

**Unit–1: Dynamic Force Analysis:** Inertia force and Inertia torque, D-Alembert’s principle, dynamic Analysis in reciprocating engines, gas forces, inertia effect of connecting rod, bearing loads, crankshaft torque. Turning moment diagram for single and multi–cylinder internal combustion engine, coefficient of fluctuation of speed, coefficient of fluctuation of energy, flywheel for engines and punching presses.

**Unit–2: Governors:** Characteristics of centrifugal governors, Gravity controlled governors, Porter and Proell. Spring controlled centrifugal governor: Hartnell & Hartung. Performance parameter: sensitivity, stability, Isochronism, hunting, coefficient of insensitiveness, controlling force, governor effort and power.

**Unit-3: Balancing:** Balancing of rotating masses, static and dynamic balancing, determination of balancing masses in two plane balancing, balancing of internal combustion engines, balancing of in-line engines, firing order, balancing of V-twin and radial engines, forward and reverse crank method, balancing of rotors.

**Unit-4: Gyroscope:** Gyroscopic forces and couple, gyroscopic effect in airplanes, ship motion, and four wheeled vehicles moving on a curved path.

**Unit-5: Mechanical Vibrations:** One-dimensional, longitudinal, transverse, and torsional vibrations, natural frequency, Effect of damping on vibrations, Different types of damping. Forced vibration, forces, displacement, transmissibility, vibration Isolation, vibration sensors: seismometer and accelerometers, whirling of shafts with a single rotor.

**Text Books:**

1. Uicker, J.J., Pennock G.R. and Shigley, J.E., Theory of Machines and Mechanisms, Oxford University Press.
2. Rattan, S.S., Theory of Machines, Tata McGraw-Hill.
3. Thomas Bevan, Theory of Machines, CBS Publishers and Distributors.

**References:**

1. Robert L. Norton, Kinematics and Dynamics of Machinery, Tata McGraw-Hill.
2. Ghosh. A and Mallick, A.K., Theory of Mechanisms and Machines, East-West Pvt. Ltd., New Delhi.
3. Rao. J.S. and Dukkipati R.V., Mechanisms and Machine Theory, Wiley-Eastern Ltd.
4. Ramamurthi. V., Mechanics of Machines, Narosa Publishing House.
5. Sadhu Singh, Theory of Machines, Pearson Education.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	2	1	-	-	-	3	2
<b>CO2</b>	3	3	2	3	1	-	2	-	2	2
<b>CO3</b>	3	3	2	3	3	-	-	-	3	3
<b>CO4</b>	3	3	3	-	1	-	-	-	2	2
<b>CO5</b>	3	3	3	3	2	-	2	1	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B.Tech.	<b>Semester:</b>	V Sem
<b>Name of the Course:</b>	Operation Research Technique	<b>Course Code:</b>	SOE–B–ME-23-504
<b>Credits:</b>	4	<b>No of Hours:</b>	4 Hrs./Week
<b>Max Marks:</b>	100		

**Course Description:**

This course helps in defining the problems existing in industries, then formulating a mathematical model of the problem, after that it helps in finding an optimal solution of the problem, and finally it will help in interpreting and implementing the found solution using various methods of operations research techniques.

**Course Outcomes:** After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Apply operations research techniques such as linear programming, simplex method, duality, and transportation and assignment models to optimize decision-making in real-world applications.
<b>CO2</b>	Analyze and solve sequencing and network problems using techniques like CPM and PERT to optimize scheduling and project management.
<b>CO3</b>	Evaluate different inventory models, including deterministic and stochastic approaches, to determine optimal stock levels and minimize costs.
<b>CO4</b>	Utilize queuing models and simulation techniques, including Monte Carlo methods, to assess system performance and optimize service processes.
<b>CO5</b>	Apply decision-making models, game theory, and replacement strategies to optimize resource allocation and maintenance planning in dynamic environments.

**Syllabus:**

**Unit–1: Linear Models:** Introduction to operations research, linear programming, mathematical formulation, graphical method, simplex method, duality, two – phase simplex method, transportation problems, northwest corner method, Vogel’s approximation method, Modi method, assignment problems.

**Unit–2: Sequencing:** Sequencing, problem with n jobs and 2 machines, 3 machines and m machines.

**Network models:** basic concepts, construction of networks, project network, CPM and PERT, critical path scheduling, crashing of network.

**Unit-3: Inventory Models:** Inventory models, various costs and concepts, economic order quantity, deterministic inventory models, production models, stochastic inventory models, buffer stock.

**Unit-4: Queuing Models:** Queuing models, Poisson arrivals and Exponential service times, Single channel models and multi-channel models.

**Simulation:** Basic concepts, advantages and disadvantages, random number generation, Monte-Carlo Simulation, Simulation models.

**Unit-5: Decision Models:** Decision models, game theory, two-person zero sum game, graphic solution, property of dominance, algebraic solution.

**Replacement models:** Items that deteriorate with time – when money value changes, items that fail completely, individual replacement, and group replacement.

**Text Books:**

1. Hira & Gupta, Operation Research, S. Chand & Co.
2. S.D. Sharma, Operation Research, S. Chand & Co.
3. A M Natarajan, P Balasubramani, A Tamilarasi, Operations Research, Pearson Education Inc.
4. Maurice Sasien, Arthur Yaspan and Lawrence Friedman, Operations Research—methods and problems, John Wiley and Sons.

**References Books:**

1. Hamdy Tah, Operations Research: An Introduction, Pearson.
2. P Mariappan, Operations Research, Pearson.
3. H. N. Wagner, Operations Research, Prentice Hall.
4. Ronald Rardin, Optimization in Operations Research, Pearson Education Inc.
5. R. Paneerselvam, Operations Research, Prentice Hall of India Pvt. Ltd.
6. N D Vohra, Quantitative Techniques in Management, Tata McGraw-Hill.

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSO	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	1	2	2	-	1	3	2
<b>CO2</b>	3	3	2	2	2	2	-	2	3	3
<b>CO3</b>	3	2	2	1	3	2	-	2	3	3
<b>CO4</b>	3	3	2	2	2	3	-	2	2	3
<b>CO5</b>	3	2	3	2	3	3	-	2	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B.Tech.	<b>Semester:</b>	V Sem
<b>Name of the Course:</b>	Mechatronics & Robotics	<b>Course Code:</b>	SOE–B–ME-23-505
<b>Credits:</b>	4	<b>No of Hours:</b>	4 Hrs./Week
<b>Max Marks:</b>	100		

### Course Description:

This course provides a comprehensive foundation in the principles and applications of Mechatronics and Robotics. It begins with an introduction to mechatronic systems and their real-world applications, followed by an in-depth study of microprocessors and microcontrollers, including architecture, programming, and peripheral interfacing. Students will explore pneumatic and hydraulic actuation systems, PLCs, and automation circuit design. The course also covers control system fundamentals, including modeling, PID control, system response, and stability analysis. The final unit focuses on robotics, covering classification, specifications, programming, machine vision, and industrial applications. Practical exposure and problem-solving are emphasized throughout to prepare students for real-world engineering challenges.

### Course Outcomes:

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Able to demonstrate the basic structure of a mechatronics system, its process, and its applications
<b>CO2</b>	explain principles of operation/interfacing of microprocessors, microcontrollers, PLCs, in mechanical systems
<b>CO3</b>	Evaluate the various types of hydraulic and pneumatic actuators used in mechatronics, and they will be able to design and develop simple hydraulic and pneumatic automation circuits.
<b>CO4</b>	Discover the basics of a control system and explore its types, time domain analysis, and analyze the mathematical models of dynamics systems
<b>CO5</b>	Carry out frequency domain analysis to assess the stability of a system

### Syllabus:

**Unit 1: Introduction to Mechatronics:** Mechatronics systems in factory, home and business applications, basic components of mechatronic systems, mechatronics design process, objectives.

**Unit 2: Overview of micro-processors and micro-controllers:** Microprocessor: organization of 8085: architecture, internal register organization, and pin configuration – instruction set of 8085 –

addressing modes – instruction machine cycles with states and timing diagram – 8085 assembly language programming– examples.

**Microcontrollers:** functional block diagram and architecture, 14 instruction set and assembly language programming. interfacing of: hex–keyboards, LCD display, ADC, DAC, and stepper motor.

**Unit 3: Pneumatic and Hydraulic actuation systems:** Pneumatic and hydraulic systems. electro–pneumatic systems, electro–hydraulic systems. Development of circuits for industrial automation PLC in automation: basic structure, I/O processing. Ladder logic diagram, selection of PLC.

**Unit 4: Introduction to control systems:** Open loop and closed loop systems, mathematical modeling of control systems, concept of transfer function, block diagram algebra, process control systems, on–off control, p–i–d control. Control system components: servomotor, stepper motors. Transient response analysis of first and second-order systems, time domain specifications. Step response of second order system, classification of control systems according to ‘type’ of systems, steady state errors, static error constants, steady state analysis of different types of systems using step, ramp, and parabolic inputs.

**Stability analysis:** introduction to concepts of stability, the Routh and Hurwitz stability criteria, relative stability analysis.

**Unit 5: Robotics:** Introduction, Classification based on geometry, control and path movement, Robot Specifications, Robot Performance Parameters, Robot Programming, Machine Vision, Teach pendants, Industrial Applications of Robots.

**Text Books:**

1. Uchino, Kenji, and Jayne Giniewicz, Micromechatronics, CRC Press.
2. Gaonkar, Ramesh S., Microprocessor architecture, programming, and applications with the 8085, Prentice–Hall, Inc.
3. Nagrath, I. J., and Madan Gopal, Textbook of Control Systems Engineering, New Age International.
4. Ogata, Katsuhiko and Yanjuan Yang, Modern control engineering, Prentice Hall.
5. Kenneth, J. Aiyala, The 8051 Microcontroller, Architecture, programming and applications, Delmar Cengage Learning.
6. Fawcett, John R., Pneumatic circuits and low-cost automation, Brookfield Publishing Company.
7. S K Saha, Introduction to Robotics, McGraw-Hill.

**Reference Books:**

1. Horowitz, Paul, and W. Hill, Art of electronics, Cambridge University Press.

2. Fundamentals of Pneumatics: Festo Series, Festo Manual
3. Fundamentals of Electro–Pneumatics: Festo Series. Festo Manual.
4. H. M. T., Mechatronics, Tata McGraw-Hill Hill New Delhi (1968).
5. Pippenger, John J., Hydraulic valves and controls: selection and application, Marcel Dekker Inc.
6. Dukkipati, Rao V., Analysis and design of control systems using MATLAB, New Age International, 2006.
7. Shetty, Devdas, and Richard A. Kolk, Mechatronics System Design, SI Version, Cengage Learning.
8. John Craig, Introduction to Robotics, Mechanics and Control, Pearson.

**CO, PO & PSO Correlation**

<b>Course Outcomes</b>	<b>Program Outcomes</b>								<b>PSOs</b>	
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>1</b>	<b>2</b>
<b>CO1</b>	3	1	2	1	-	1	-	-	3	1
<b>CO2</b>	3	3	3	1	-	1	1	1	3	3
<b>CO3</b>	3	3	3	2	2	2	1	-	3	3
<b>CO4</b>	2	2	2	1	-	-	-	1	2	1
<b>CO5</b>	2	3	2	1	-	-	-	-	2	3

**Note:** 1: Low 2: Moderate 3: High



<b>Program:</b>	B. Tech.	<b>Semester:</b>	V Sem
<b>Name of the Course:</b>	Thermal Engineering Lab	<b>Course Code:</b>	SOE–B–ME-23-506
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

In this course, learners will study and perform experiments on thermal systems such as surface condensers, cooling towers, solar panels, and axial flow compressors. In the study part, learners will get an insight into various boilers and their accessories & mountings. This course covers the study of important thermal power plant components and experimentation on some of them.

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Analyze the surface steam condenser performance.
<b>CO2</b>	Test the performance characteristics of axial and reciprocating air compressors.
<b>CO3</b>	Classify boilers, accessories & mountings.
<b>CO4</b>	Experiment with cooling towers and determine their performance.
<b>CO5</b>	Experiment with solar P-V modules and examine their performance characteristics.

**List of Experiments (minimum ten experiments):**

1. Performance and testing of surface steam condenser.
2. Performance and testing of axial flow air compressor.
3. Performance and testing of the Reciprocating Compressor.
4. Study of convergent-divergent nozzles.
5. To determine the efficiency of the nozzle.
6. Performance testing of Cooling Tower.
7. To study Benson Boiler and its mountings and accessories.
8. To study La Mont Boiler and its mountings and accessories.
9. To study Velox Boiler and its mountings and accessories.
10. To calculate the different losses in Boiler and its efficiency (Case Study in Industry).
11. To analyze different parameters affecting condenser efficiency (Case study in Industry).
12. Performance analysis on Indoor Solar Power Plant Simulator for I-V Characteristics for a given 40 Wp/ 75 Wp solar panel.

13. Performance analysis on Indoor Solar Power Plant Simulator for I-V Characteristics of two 40 Wp/ 75 Wp solar panels connected in series and parallel.
14. Performance analysis on Indoor Solar Power Plant Simulator for the effect of shading on a 40 Wp/ 75 Wp solar panel.

**Equipment/Machines/Instruments/Tools/Software Required:**

1. Surface steam condenser.
2. Reciprocating compressor.
3. Axial flow air compressor.
4. Nozzle with complete setup.
5. Cooling Tower setup.
6. Model of Benson boiler.
7. Model of Velox boiler.
8. Model of La Mont boiler
9. Indoor Solar PV Simulator.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	3	2	1	-	2	1	2	3	2
<b>CO2</b>	3	3	2	1	-	2	1	2	2	3
<b>CO3</b>	3	2	2	-	-	2	1	2	3	2
<b>CO4</b>	2	3	2	1	2	2	2	3	3	3
<b>CO5</b>	3	2	3	1	2	3	2	3	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	V Sem
<b>Name of the Course:</b>	Kinematics of Machine & Dynamics of Machine Lab	<b>Course Code:</b>	SOE-B-ME-23-507
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

### Course Description:

This laboratory course provides hands-on experience in understanding the principles of kinematics and dynamics in mechanical systems. Students will conduct experiments to analyze mechanisms, motion characteristics, force distribution, and vibration effects in machine components. The course covers the study of gears, cams, gyroscopes, balancing of rotating masses, and various types of governors. Through practical applications, students will develop skills in motion analysis, force measurement, and dynamic balancing, which are essential for designing efficient and stable mechanical systems.

### Course Outcomes (COs)

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

CO Number	Course Outcome
<b>CO1</b>	Explain the jump phenomenon and construct the displacement diagram for the motion of the cam follower.
<b>CO2</b>	Understand the working principle of mechanical brakes and dynamometers
<b>CO3</b>	Apply the principles of gyroscopic effects and mechanical governing.
<b>CO4</b>	Determine the vibration parameters of different systems.
<b>CO5</b>	Apply the principles of balancing masses to various links, mechanisms, and engines.

### List of Experiments: (At least ten experiments are to be performed by each student)

- To determine the jump phenomena of cam follower apparatus.
- To find out the percentage slip at fixed belt tension by varying load with slip & creep apparatus.
- Study of Four bar mechanism and its inversions.
- To measure the transmitted torque and holding torque in an epicyclic gear train.
- To study rope brake dynamometer and calculation of torque and power.
- To find natural frequency of vibration by universal vibration apparatus.
- To measure the frequency of torsional vibrations of single rotor system with universal vibration apparatus.

8. To find out the radius of gyration of bi–filler suspension with universal vibration apparatus.
9. To find out the Gyroscopic couple and prove the gyroscopic law with Gyroscope apparatus.
10. To determine the position of sleeve against controlling force and speed of a Hartnell governor and to plot the characteristic curve of radius of rotation.
11. To verify the static and dynamic balancing for different planes and masses by balancing apparatus.
12. To measure the vibration of a machine by using uni–axial accelerometer.
13. To measure the vibration of a machine by using tri–axial accelerometer.
14. To measure Sound pressure level of a running machine using Sound level meter.

**List of Equipment/Instruments/Machines Required:**

1. Cam analysis apparatus.
2. Coriolis component of acceleration apparatus.
3. Slip & Creep Measurement Apparatus in Belt Drive.
4. Epicyclic Gear Train and Holding Torque Apparatus.
5. Rope brake dynamometer apparatus (with all accessories).
6. Universal Vibration Apparatus.
7. Gyroscope apparatus.
8. Governor apparatus with differential attachments.
9. Static and dynamic balancing apparatus.
10. Single and tri-axial accelerometer with data acquisition system.
11. Sound level meter.

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	-	2	-	-	1	3	2
<b>CO2</b>	2	3	2	3	-	-	-	1	3	3
<b>CO3</b>	2	2	2	-	2	-	-	1	3	2
<b>CO4</b>	2	2	3	2	2	-	-	2	3	3
<b>CO5</b>	2	3	2	2	2	-	-	1	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	V Sem
<b>Name of the Course:</b>	Mechatronics & Robotics Lab	<b>Course Code:</b>	SOE–B–ME-23-508
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

The main objectives of the course are to familiarize students with robotic systems and their applications. Also, to enhance understanding of robotic arm configurations and humanoid robots.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Application of 8085 microprocessor and 8051 microcontrollers
<b>CO2</b>	To provide hands-on experience in designing automation circuits.
<b>CO3</b>	Operate and program robotic arms for pick-and-place applications.
<b>CO4</b>	Analyse the working of 5-axis and 6-axis robots in industrial settings.
<b>CO5</b>	Study and evaluate the functionality of humanoid NAO robots.

**List of Experiments (Minimum ten experiments are to be carried out)**

1. To construct a Pneumatic circuit for SAC, DAC and the Air motor for the given purpose
2. To develop different hydraulic circuits for simple applications.
3. To develop different pneumatic circuits for simple applications
4. To Construct Meter-In, Meter Out Pneumatic/Hydraulic Circuit for The Given Purpose
5. To Construct Pneumatic/Hydraulic Circuit for The Given Sequencing of Operations.
6. To Construct a Pneumatic Circuit for The Given Logic Functions (AND/OR/TIME DELAY).
7. To Develop a Circuit for Simple Machine Tool Applications, Such As Milling Machine, Shaper Machine, Grinding Machine
8. To perform a pick and place operation with a robotic arm
9. To find the gripper movement from 0 to 50mm.
10. To find the object distance, 30mm to 300 mm.
11. To study various robotics arm configurations
12. To design a semi-autonomous robot with a remote control.
13. Study of 5-axis Robot
14. Study of 6-axis Robot.
15. Study and analysis of the Humanoid NAO Robot

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	-	2	-	-	1	3	2
<b>CO2</b>	2	3	2	3	-	-	-	1	3	3
<b>CO3</b>	2	2	2	-	2	-	-	1	3	2
<b>CO4</b>	2	2	3	2	2	-	-	2	3	3
<b>CO5</b>	2	3	2	2	2	-	-	1	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	V Sem
<b>Name of the Course:</b>	Metrology & Mechanical Measurement Lab	<b>Course Code:</b>	SOE–B–ME-23-509
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

The Laboratory is a well-equipped laboratory which provides ideas on hands-on experience with various measuring instruments to utilize in industries. on evaluating the mechanical properties of a given specimen or structure. This laboratory is scheduled for the 5th semester Mechanical Engineering students.

**Course Outcomes:**

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

CO Number	Course Outcome
<b>CO1</b>	Understand the principles, working of various measuring instruments.
<b>CO2</b>	Selection of proper instruments for measurement, handling of measuring instruments, and Care and maintenance of instruments. Setting the instruments for zero error adjustment and calculation of the least count of the instrument.
<b>CO3</b>	Proper alignment of the instrument with work workpiece. Measure the angle, surface finish using the instruments.
<b>CO4</b>	Use a variety of equipment and techniques to measure force, flow, pressure, temperature, speed, strain, and rotational position.
<b>CO5</b>	Demonstrate the methods of measurement for various quantities like Pressure, temperature, displacement, velocity, and acceleration.

**Metrology Lab to Be Performed (Minimum Five Numbers)**

1. Measurements of lengths, heights, and diameters by Vernier Calipers, Vernier Height Gauge, and Micrometers.
2. Measurement of various angles using Bevel Protractor, Sine Bar & Combination Set.
3. Determining the accuracy of the Electrical and Optical Comparator.
4. Determine the Surface Flatness and Contour using the Interferometer.
5. Determine the Effective Diameter of screw threads by using Two wire & Three wire methods.
6. Measurement of Gear Elements using Profile Projector and image analyzer.

7. Measurement of Tool Angles of a Single Point Cutting Tool by using Tool Makers Microscope.
8. Calibration of Vernier Caliper, Micrometer, Height Gauge, Depth Micrometer using Slip Gauges.
9. Measurement of Rail profile using various rail gauges.

**Measurement Lab to Be Performed (Minimum Five Numbers)**

1. To Measure Pressure Using Bourdon Pressure Gauge.
2. To Calibrate Pressure Gauge Using Dead Weight Pressure Gauge Tester.
3. To Measure Displacement Using LVDT
4. To Measure Temperature Using Thermister
5. To Measure Torque Using Torque Transducer
6. To Measure Strain Using Strain Cantilever Beam.
7. To Measure Temperature Using RTD.
8. To Measure Temperature Using Thermo Couple.
9. To Measure Temperature Using Thermal Imager.
10. To measure Noise using Sound meter
11. To perform the following experiments using Data Acquisition System
  - a. To measure Temperature by Themocouple
  - b. To measure Temperature by Thermistor
  - c. To measure Temperature by RTD.
  - d. To measure Strain.
  - e. Vibration Measurement

**List of Equipment/Machine Required**

MEASUREMENT	METROLOGY
1. Data Acquisition System	1. Vernier Calipers
2. Software compatible with DAS	2. Vernier Height Gauge
3. Displacement Measurement Tutor Using (LVDT)	3. Depth Micrometers
4. Pressure Measurement Tutor Using Pressure Transducer	4. Set of Slip Gauges
	5. Interferometer
	6. Tool Makers Microscope

<p>5. Strain Measurement Tutor Using Strain Cantilever Beam</p> <p>6. Torque Measurement Tutor Using Torque Transducer</p> <p>7. Temperature Measurement Tutor Using RTD Sensor</p> <p>8. Temperature Measurement Tutor Using Thermocouple</p> <p>9. Temperature Measurement Tutor Using Thermister</p> <p>10. Angular Measurement Tutor Using Angular Sensor</p> <p>11. Rotameter Trainer Module</p> <p>12. Dead Weight Pressure Gauge Tester</p> <p>13. Bourdon Gauge Trainer</p> <p>14. Image Analyzer</p>	<p>7. Profile Projector</p> <p>8. Bevel Protector</p> <p>9. Sine Bar</p> <p>10. Combination Set</p> <p>11. Optical &amp; Electrical Comparator</p> <p>12. Optical Flats</p> <p>13. Surface Plates</p> <p>14. Dial Indicators</p> <p>15. Snap and Ring Gauges (GO and NO-GO type)</p>
---	--

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	3	-	-	2	-	-	3	3
<b>CO2</b>	3	3	2	-	-	2	-	1	2	2
<b>CO3</b>	3	2	1	-	-	1	-	2	2	2
<b>CO4</b>	-	-	-	3	2	3	3	3	1	1
<b>CO5</b>	3	3	3	-	-	2	-	2	2	3

**Note:** 1: Low 2.: Moderate 3: High

**Scheme of Teaching and Examination**

**B. Tech in Mechanical Engineering (VI - Semester)**

S. No.	Subject Code	BOS	Type of Course (NEP)	Subject	Periods per week			Scheme of Exam. and Marks				Credit L+(T+P)/2
					L	T	P	PRE		ESE	Total	
								MID	TA			
1	SOE-B-ME-23-601	ME	CC	Heat & Mass Transfer	3	0	0	30	20	50	100	3
2	SOE-B-ME-23-602	ME	CC	Manufacturing Technology II	3	0	0	30	20	50	100	3
3	SOE-B-ME-23-603	ME	CC	Machine Design	3	0	0	30	20	50	100	3
4	SOE-B-ME-23-604	ME	CC	Specialization Subject I	3	0	0	30	20	50	100	3
5	SOE-B-ME-23-605	ME	CC	Specialization Subject II	3	0	0	30	20	50	100	3
6	SOE-B-ME-23-606	ME	CC	Professional Elective I	2	0	0	15	10	25	50	2
7	SOE-B-ME-23-607	ME	CC	Heat and Mass Transfer Lab	0	0	2	-	30	20	50	1
8	SOE-B-ME-23-608	ME	CC	Manufacturing Technology II Lab	0	0	2	-	30	20	50	1
9	SOE-B-ME-23-609	ME	CC	Specialization Lab	0	0	2	-	30	20	50	1
10	SOE-B-ME-23-610	ME	MDC	Data Visualization and Analysis	0	0	2	-	30	20	50	1
				<b>TOTAL</b>	<b>17</b>	<b>0</b>	<b>8</b>	<b>165</b>	<b>230</b>	<b>355</b>	<b>750</b>	<b>21</b>

L: Lecture; T: Tutorial; P: Practical

CC: Core Course; AECC: Ability Enhancement Compulsory Courses; GE: Generic Elective

Specialization- I (**Robotics & AI**)

Specialization Subject I (**Robotics & AI**)

Sr. No	Subject Code	Courses
1.	SOE-B-ME-23-604 (S1)	Kinematics and Dynamics of Robot

Specialization Subject II (**Robotics & AI**)

Sr. No	Subject Code	Courses
1.	SOE-B-ME-23-605 (S1)	Industrial Robotics

Specialization Lab (**Robotics & AI**)

Sr. No	Subject Code	Courses
1.	SOE-B-ME-23-610 (S1)	Industrial Robotics Lab

Specialization -II (**Mechatronics & Automation**)

Specialization Subject I (**Mechatronics & Automation**)

Sr. No	Subject Code	Courses
1.	SOE-B-ME-23-604 (S2)	Mechatronics System Design

Specialization Subject II (**Mechatronics & Automation**)

Sr. No	Subject Code	Courses
1.	SOE-B-ME-23-604 (S2)	Industrial Automation

Specialization Lab (**Mechatronics & Automation**)

Sr. No	Subject Code	Courses
1.	SOE-B-ME-23-604 (S2)	Industrial Automation Lab



Professional Elective I (**Annexure-I**)

<b>Sr. No</b>	<b>Subject Code</b>	<b>Courses</b>
1.	SOE-B-ME-23-606 (1)	Gas Dynamics and Jet Propulsion
2.	SOE-B-ME-23-606 (2)	Computational Fluid Dynamics
3.	SOE-B-ME-23-606 (3)	Welding Technology
4.	SOE-B-ME-23-606 (4)	Material Handling System and Equipment
5.	SOE-B-ME-23-606 (5)	Additive Manufacturing
6.	SOE-B-ME-23-606 (6)	Power Plant Engineering

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Heat and Mass Transfer	<b>Course Code:</b>	SOE-B-ME-23-601
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course offers lecture and laboratory classes to impart teaching and learning. The course is designed to provide a detailed knowledge of heat and mass transfer. The course started with the fundamentals of heat transfer and progress with the detailed discussion on different modes of heat transfer. At the end of the course various engineering devices/components will be discussed with respect to heat transfer involved.

**Course Outcomes:** After Completion of the course Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Illustrate and solve governing differential equations for steady one- dimensional heat conduction.
<b>CO2</b>	Apply and solve governing equations for conduction and convection for different fin configurations and examine transient heat transfer.
<b>CO3</b>	Apply the concepts of fluid flow and convection heat transfer to analyze the thermal system.
<b>CO4</b>	Describe radiative interactions and properties of different kinds of surfaces and estimate radiative heat exchange between two or more.
<b>CO5</b>	Evaluate performance of heat exchangers using LMTD & effectiveness method and recognize basic mass transfer.

**Syllabus:**

**Unit-1: Fundamental:** Modes of heat transfer, effect of temperature on thermal conductivity of different solids, liquids and gases, derivation of generalized equation in Cartesian, cylindrical and spherical coordinates and its reduction to specific cases, General laws of heat transfer.

**Conduction:** Fourier's law, one dimensional steady state conduction, heat conduction through plane and composite walls, cylinders and spheres, electrical analogy, critical radius of insulation for cylinder and sphere, overall heat transfer coefficient.

**Unit-2: Transient heat conduction:** lumped heat capacity analysis, time constant, transient heat conduction in solids with finite conduction and convective resistances.

**Heat transfer from extended surface:** Types of fin, heat flow through rectangular fin, solution

for infinitely long fin, insulated tip, finite long and heat transfer from fin tip, efficiency and effectiveness of fin.

**Unit-3: Convection:** Newton's law of cooling, dimensional analysis applied to forced and free convection, dimensionless numbers and their physical significance, empirical correlations for free and forced convection continuity, momentum and energy equations, thermal and hydrodynamic boundary layer, Blasius solution for laminar boundary layer, general solution of Von-Karman integral momentum equation.

**Unit-4: Radiation:** Absorptive, reflectivity and transmissivity, black, white and grey body, emissive power and emissivity, laws of radiation - Planck, Stefan-Boltzmann, Wein's displacement, Kirchhoff's law, intensity of radiation and solid angle, Lambert's cosine law. Radiation heat exchange between black bodies, shape factor, heat exchange between non-black bodies- infinite parallel planes and infinite long concentric cylinders.

**Unit-5: Boiling and Condensation:** Boiling of liquids, Pool boiling curve, different types of pool boiling, Film wise & drop wise condensation.

**Heat exchanger:** Classification, heat exchanger analysis, LMTD and e-NTU method for parallel and counter flow exchanger, cross flow heat exchanger.

**Introduction to Mass Transfer:** Mass and mole concentrations, molecular diffusion, eddy diffusion, Molecular diffusion from an evaporating fluid surface, Introduction to mass transfer in laminar and turbulent convection Combined heat and mass transfer, the wet and dry bulb thermometer.

**Text Books:**

1. P.K. Nag, Heat & Mass Transfer, McGraw Hill.
2. Yunus Cengel, Heat and Mass Transfer: Fundamentals and Application, McGraw Hill.
3. Incropera and Dewitt, Fundamental of Heat and Mass Transfer, Wiley Publication.
4. Mills and Ganesan, Heat Transfer, Pearson Education.

**References Books:**

1. J P Holman, Heat Transfer, McGraw Hill.
2. R K Rajput, Heat and Mass Transfer, S. Chand Publication.
3. Dutta, Binay K, Heat Transfer: Principles and Applications, PHI Publication.

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	1	0	2	0	1	3	2
<b>CO2</b>	3	3	2	2	1	2	1	2	3	2
<b>CO3</b>	3	3	2	2	1	2	1	2	3	3
<b>CO4</b>	3	2	1	1	0	2	2	2	2	2
<b>CO5</b>	3	3	3	2	1	2	1	2	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Manufacturing Technology-II	<b>Course Code:</b>	SOE-B-ME-23-602
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:** The subject trains the students in the metal cutting domain so as to equip them with adequate knowledge about the various processes like turning, shaping, planning, drilling, milling, and grinding. To emphasize the prominent theories, concepts, and constructional features of machines related to them. To provide an insight into the superfinishing operations of lapping and honing. To lay the groundwork for further studies in the manufacturing stream.

**Course Outcomes:** After the completion of the course, the student will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand the working of lathe, shaper, and planer, comprehend the speed and feed mechanisms of machine tools
<b>CO2</b>	Understand the working of drilling, milling, and grinding machines, Comprehend the speed and feed mechanisms of machine tools
<b>CO3</b>	Develop relations for chip reduction coefficient, shear angle, shear strain, forces, power, specific energy, and temperature in orthogonal cutting
<b>CO4</b>	Understanding the machinability aspects, selection of cutting fluids, and tool materials to control tool wear and temperature
<b>CO5</b>	Understand the working principles, applications, and importance of unconventional machining processes

## Syllabus

**Unit: 1: Machine Tools:** Concept and definition of machining and machine tools, history of developments of machine tools, concept of producing geometrical surfaces by generatrix and directrix, kinematic systems and structures of conventional machine tools. Classification, specification, construction, working principle and application of following machine tools.

**Lathe:** operations–facing, turning, knurling, taper turning, thread cutting, drilling, boring, reaming, work holding devices & tools, mechanism and attachments for various operations, semi–automatic and automatic lathes.

**Shaper:** Operations – horizontal cutting, vertical cutting, angular cutting, irregular cutting, Quick return Mechanisms. Table feed mechanism, work holding devices. Planner. Electromechanical and hydraulic drives and control of the above machine tools. Machine tool automation.

**Unit-2: Machine Tools:** Classification, specification, Construction, working principle, and application of the following machine tools.

**Milling:** Milling operations – plain, face, slotting, gear cutting mechanisms and attachments for milling, indexing–simple, compound, and differential.

**Drilling:** Drill nomenclature, other operations like counter boring, counter sinking, spot facing etc. Reaming: description of reamers.

**Boring:** Boring operations, boring tools. Electromechanical and hydraulic drives and control of above machine tools, machine tool automation.

**Grinding:** Processes, grinding wheels, characteristics–abrasive type, grain size, bonding material, structure, and grade, wheel specification and selection, wheel life, types of grinding operations, specification of grinding wheel, economics of grinding.

**Surface finishing operations:** Honing, lapping, super finishing, polishing, buffing, process parameters, and attainable grades of surface finish.

**Unit-3: Machining:** Cutting tools– types, requirements, specifications, and applications. Tool geometry, mechanism of chip formation, mechanics of machining, theories of metal cutting, types of chips, chip breakers, orthogonal and oblique cutting, stress and strain in the chip, velocity relations, power and energy requirement in metal cutting.

**Unit-4: Machinability:** Concept and evaluation of machinability, mechanism of tool failure, tool wear mechanism, tool life, tool life equation, machinability index, factors affecting machinability. Thermal Aspects in machining and cutting fluid: source of heat in metal cutting and its distributions, temp measurement in metal cutting, function of cutting fluid, types of cutting fluid, cutting temperature causes, effects, estimation, measurement and control.

**Unit-5: Advanced Machining Processes:** Introduction; Chemical Machining; Electrochemical Machining: Pulsed, Electrochemical Machining; Electrochemical Grinding; Electrical–discharge Machining: Wire EDM, Electrical–discharge Grinding; Laser–beam Machining; Electron–beam Machining; Water–jet Machining; Abrasive–jet Machining; Hybrid Machining Systems.

**Text Books:**

1. P.N. Rao, Manufacturing Technology (Vol. – I & II), Tata McGraw Hill.
2. P.C. Sharma A Textbook of Production Technology (Manufacturing Processes), S. Chand and Company Ltd,
3. G.R. Nagpal, Machine Tool Engineering, Khanna Publishers.
4. B.S. Raghuvanshi, A course in workshop Technology (Vol– I & II), Dhanpat Rai & Sons.

**Reference Books:**

1. A. Ghosh & A.K. Mallik, Manufacturing Science, East West Press Pvt. Ltd.
2. S. Kalpakjian & S.R. Schmid, Manufacturing Engineering and Technology, Addison Wesley Longman.
3. R. K. Jain, Production Technology, Khanna Publishers.
4. O.P. Khanna, A Textbook of Production Technology (Vol. I & II), Dhanpat Rai & Sons.
5. Sen, Bhattacharya, Principle of Metal Cutting, New Central Book Agency.
6. W. A. J. Chapman, Workshop Technology Part 1–3, Trans-Atlantic Publications.
7. Juneja, B. L., Fundamentals of metal cutting and machine tools, New Age International.
8. HMT, Production technology, Tata McGraw–Hill Education.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcome								PSO	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	2	1	1	2	2	1	1	2	2	1
<b>CO2</b>	2	2	1	2	2	2	1	2	2	2
<b>CO3</b>	3	3	2	2	3	2	2	3	3	2
<b>CO4</b>	3	2	3	3	3	2	3	3	3	2
<b>CO5</b>	2	3	2	2	3	2	2	2	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Machine Design	<b>Course Code:</b>	SOE-B-ME-23-603
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course will integrate the knowledge of Statics, Dynamics, Strength of Materials and Engineering Materials into the design process of machine elements. Students will learn the fundamentals of the design process, and the design of some common machine elements will be the focus. The students will apply the concepts in the design of a simple machine.

**Course Outcomes (COs):** After Completion of the course Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Demonstrate knowledge on basic machine elements used in machine design.
<b>CO2</b>	To examine and identify the role of material selection, manufacturing requirements, aesthetic, and ergonomic needs in the design of machine elements.
<b>CO3</b>	To formulate and analyze stresses and strains in machine elements subjected to static and fluctuating load conditions.
<b>CO4</b>	Design machine elements to perform functions in order to obtain desired objectives under various operating conditions.
<b>CO5</b>	Conduct a failure analysis for the design of mechanical components to select suitable materials and manufacturing considerations.

**Syllabus**

**Unit-1:** Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design, Design Standards, I.S. codes, Preferred Series and numbers. Material properties and their uses in design, Manufacturing considerations in design: tolerances, types of fits, selection of fits, Design considerations of casting and forging. Theories of failures, Factor of safety

Design against static Loads: Cotter joint, knuckle joint. Power Screw– Design of Screw Presses.

**Unit-2:** Design against Fluctuating Loads, Variable stresses: reversed, repeated, fluctuating stresses Fatigue Failure– Static and fatigue stress concentration factors, Endurance limit estimation of endurance limit Design for finite and infinite life– Soderberg and Goodman design criteria, Fatigue design under combined stresses. Numerical problems.

**Unit-3:** Design of shaft– power transmitting, power distribution, shafts under static and fatigue criteria. Keys–Types of Keys and their selection based on shafting condition. Couplings– Classification of coupling. Selection of Standard Bush Pin coupling.

**Unit-4:** Design of springs– Helical compression, tension springs under static and variable loads. Design of Laminated Springs.  
 Bolted and Riveted Joints – eccentrically loaded bolted and riveted joints Welded Joints – Design of single transverse, double transverse parallel fillet, eccentrically Loaded welded joint

**Unit-5:** Design of Belts –Flat and V belt with Pulley construction, timing belts and pulleys, Selection of Standard Roller chains.

**Text Books:**

1. V. B. Bhandari, Design of machine elements, Tata McGraw Hill Education.
2. Shigley, Joseph E., Charles R. Mischke, and Richard G. Budynas, Mechanical engineering design, McGraw Hill.
3. V. Bhandari, Machine Design Data Book, McGraw Hill Education
4. Mahadevan K., Reddy K.B., Design Data Handbook for Mechanical Engineering in SI and Metric Units, CBS.
5. PSG Design Data Book, PSG College, Coimbatore.

**Reference Books:**

1. Spottes M.F., Terry E. S., and Lee E.H., Design of machine elements. Vol. 2., Pearson Education India.
2. Deutschman, D., Michels, W.J. and Wilson, C.E., Machine Design Theory and Practice, Macmillan.
3. Juvinal, R.C., Fundamentals of Machine Component Design, John Wiley.

**CO, PO, & PSO Mapping**

Course Outcome	Program Outcome								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	1		1	1	1	1	1	3	1
<b>CO2</b>	2	2	2	2	2	1	2	2	2	2
<b>CO3</b>	3	3	1	-	-	-	-	1	3	3
<b>CO4</b>	3	3	3	2	2	1	1	2	2	2
<b>CO5</b>	2	3	2	1	2	1	1	2	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Specialization Subject I: Kinematics and Dynamics of Robot	<b>Course Code:</b>	SOE-B-ME-23-604 (S1)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive understanding of robotic manipulator kinematics and dynamics. It covers position and orientation analysis, direct and inverse kinematics, workspace analysis, and trajectory planning. Students will explore mathematical modeling techniques such as D-H representation, Lagrange-Euler, and Newton-Euler formulations. The course emphasizes real-world applications in industrial robotics, including SCARA and articulated robots.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Gain a comprehensive understanding of the position, orientation, and transformations of robotic manipulators.
<b>CO2</b>	Perform direct kinematic analysis of various robotic configurations.
<b>CO3</b>	To determine inverse kinematics solutions for different configurations of the manipulator.
<b>CO4</b>	Evaluate workspace constraints and implement trajectory planning techniques.
<b>CO5</b>	Develop a strong foundation in the dynamics of robotic manipulators.

**Unit-1: Introduction:** Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effector, Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates.

**Unit-2: Direct Kinematics:** Link coordinates D-H Representation, Direct kinematic analysis two-axis, three-axis Manipulators, SCARA Robot and Articulated Robots.

**Unit-3: Inverse Kinematics:** The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of two- axis, three-axis Manipulators.

**Unit-4: Workspace Analysis and Trajectory Planning:** Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place

operations, Joint space technique - continuous path motion, Interpolated motion, straight line motion and Cartesian space technique in trajectory planning.

**Unit-5: Manipulator Dynamics:** Introduction, Lagrange's equation kinetic and potential energy. link Jacobian Manipulator inertia tensor. Gravity, Generalized forces, Lagrange-Euler Dynamic model, Dynamic model of a Two-axis planar robot, Lagrange Euler formulation, problems.

**Text Books:**

1. Bijay K. Ghosh, Ning Xi, TJ. Tam, Control in Robotics and Automation Sensor Based integration, Academic Press.
2. Mittal RK, Nagrath 11, Robotics and Controls, Tata McGraw Hill Publications.
3. Robert J. Schilling, Fundamentals of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd.
4. Richard D. Klafter, Thomas. A, Chmielewski, Michael Negin, Robotics Engineering an Integrated Approach, Prentice Hall of India Pvt. Ltd.
5. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Mc Graw Hill Publishing company Ltd.

**Reference Books:**

1. Gonzalez and Lee, Robotics (Control, sensing, vision, and intelligence), Tata Mc Graw Hill Publishing company Ltd.
2. Tsuneo Yohikwa, Foundations of Robotics Analysis and Control, Prentice Hall of India Pvt. Ltd.
3. John J. Craig, Introduction to Robotics Mechanics and Control, Second Edition, Addison Wesley Longman Inc. International Student edition.
4. Francis N-Nagy Andras Siegler, Engineering foundation of Robotics, Prentice Hall Inc.
5. Bernard Hodges, Industrial Robotics, Second Edition, Jaico Publishing house.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	1	1	2	-	2	3	2
<b>CO2</b>	3	3	2	2	1	2	-	2	2	3
<b>CO3</b>	3	3	3	2	2	2	-	2	3	3
<b>CO4</b>	3	3	2	3	2	3	-	3	2	3
<b>CO5</b>	3	2	3	2	2	3	-	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Programme:</b>	B.Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Specialization Subject I: Mechatronics System Design	<b>Course Code:</b>	SOE-B-ME-23-604 (S2)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

### Course Description:

This course introduces Mechatronics principles, covering system design, modeling, and interfacing techniques. Students explore industrial design, ergonomics, mixed system simulations, and communication protocols. Real-world case studies and advanced control methods, including fuzzy logic, PID, and RFID, are discussed. The course also explores micro-mechatronic systems, emphasizing micro-scale components, actuation, and applications in modern automation and intelligent systems.

### Course Outcomes:

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand key elements of a Mechatronics system.
<b>CO2</b>	Familiar with basic system modelling
<b>CO3</b>	Understand the concept of engineering system and dynamic response of the system
<b>CO4</b>	Realize the concept of real-time interfacing and data acquisition
<b>CO5</b>	Understand the concept of design of mechatronics systems through case studies.

### Syllabus:

**Unit 1: Fundamentals:** Introduction to Mechatronics system-key element Mechatronics Design process-Types of design-Design Parameter-Traditional and Mechatronics designs-Advanced approaches in Mechatronics Industrial design and ergonomics, safety.

**Unit 2: System Modelling:** Introduction, model categories, fields of application, model development, model verification, model validation, model simulation, design of mixed systems, electro-mechanical design, model transformation, domain-independent description forms, simulator coupling

**Unit 3: System Interfacing:** Introduction, selection of interface cards, DAQ card, single channel, multichannel, RS232/422/485 communication, IEEE 488 standard interface, GUI card, GPIB-Ethernet Switch, Man-machine interface.

**Unit 4: Case Studies of Mechatronics System:** Introduction, Fuzzy based Washing machine, pH control system, Autofocus Camera, exposure control, Motion control using D. C. Motor & Solenoids, Engine management systems. Controlling the temperature of a hot/cold reservoir using PID Control of pick and place robot, Part identification and tracking using RFID, and Online surface measurement using image processing.

**Unit 5: Micro Mechatronic System:** Introduction, System principle, Component design, System design, Scaling laws, Micro actuation, Micro robot, Micro pump, Applications of micro mechatronic components.

**Text Books:**

1. Devdas Shetty, Richard A. Kolk, “Mechatronics System Design,” PWS Publishing company
2. Boukas K, Al-Sunni, Fouad M “Mechatronic, Systems Analysis, Design and Implementation,” Springer,
3. Sabri Cetinkunt, “Mechatronics with Experiments,” 2nd Edition, Wiley
4. Janschek, Klaus, “Mechatronic Systems Design,” Springer

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	1	1	2	-	2	3	2
<b>CO2</b>	3	3	2	2	1	2	-	2	2	3
<b>CO3</b>	3	3	3	2	2	2	-	2	3	3
<b>CO4</b>	3	3	2	3	2	3	-	3	2	3
<b>CO5</b>	3	2	3	2	2	3	-	3	3	3



<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Specialization Subject II: Industrial Robotics	<b>Course Code:</b>	SOE-B-ME-23-605 (S1)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course covers the fundamentals of robotics, including robot types, configurations, and motion control. It explores grippers, sensors, automation techniques, and industrial applications such as welding, assembly, and underwater operations. Automated inspection, machine vision, and robotic performance evaluation are also discussed. Emphasis is placed on design, efficiency, and the impact of robotics on industry and society.

**Course Outcomes:**

After completion of the course, students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Understand the Fundamentals of Industrial Robotics
<b>CO2</b>	Understand the Grippers and Sensors in Robotics
<b>CO3</b>	Apply Automation Concepts Using Hydraulics and Pneumatics
<b>CO4</b>	Evaluate Automated Inspection and Testing Methods
<b>CO5</b>	Understand Industrial Applications of Robotics

**Syllabus:**

**Unit-1: Introduction:** Definition of Robots, Types of Robots, Degrees of Freedom, Degrees of Movements, Robot Configuration, Definition and factor affecting the Control Resolution, Spatial Resolution, Accuracy and Repeatability; Specification of a robot.

**Unit-2: Grippers and Sensors for Robotics:** Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper system. Sensors for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensors and vision system in the working and control of a robot.

**Unit-3: Hydraulics and Pneumatics:** Fundamentals of automation, necessity and architecture of automated systems. Principles and architectures for automation in industry. Levels of automation, automation safety, maintenance, error detection and repair diagnostics. Elements of automated system, types of systems such as hydraulic, pneumatic, hybrid systems. Assembly-line automation - Conveyor, part feeders, material transport systems, and automated assembly. Hydraulic and pneumatic circuits.

**Unit-4: Automated Inspection and Testing:** Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods. Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection.

**Unit-5: Industrial Application:** Application of Robots in welding, Spray painting, assembly operation, cleaning, robot for underwater applications. Gripper force analysis and gripper design for typical applications. robot performance testing- Impact of robot on industry and society.

#### **Text Books:**

1. Ashitava Ghoshal, Robotics-Fundamental Concepts and Analysis', Oxford University Press
2. Richaerd D Klafter, Thomas Achmielewski and MickaelNegin, "Robotic Engineering – An integrated Approach" Prentice Hall India
3. Deb S R and Deb S, —Robotics Technology and Flexible Automation, Tata McGraw Hill Education Pvt. Ltd
4. Mikell P Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson Education

#### **Reference Books**

1. Stephen J. Derby, "Design of Automatic Machinery", Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd
2. J J Craig, —Introduction to Robotics: Mechanics and Control, Prentice Hall
3. R M Murray, Z. Li and S S Sastry, "A Mathematical Introduction to Robotic Manipulation", CRC Press.

**CO, PO, & PSO Correlation**

<b>Course Outcomes</b>	<b>Program Outcomes</b>								<b>PSOs</b>	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	1	1	2	-	2	3	2
<b>CO2</b>	3	3	2	2	1	2	-	2	2	3
<b>CO3</b>	3	3	3	2	2	2	-	2	3	3
<b>CO4</b>	3	3	2	3	2	3	-	3	2	3
<b>CO5</b>	3	2	3	2	2	3	-	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Programme:</b>	B.Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Specialization Subject II: Industrial Automation	<b>Course Code:</b>	SOE-B-ME-23-605 (S2)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

### Course Description:

The Course Learning Objectives are to introduce the importance of automation techniques in manufacturing and process industries. To impart the role of PLC in industry automation. To be exposed to various control techniques employed in process automation. To develop an automation system for manufacturing and process industries.

### Course Outcomes:

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Familiar with various automation technologies in manufacturing and process industries.
<b>CO2</b>	Understand various automation tools and methods in the manufacturing industry.
<b>CO3</b>	Implement various control and automation methods in process industries.
<b>CO4</b>	Familiar with automation circuit design using PLC
<b>CO5</b>	Familiar with various communication technologies in manufacturing and process industries.

### Syllabus:

**Unit 1: Automation in Manufacturing Industries:** Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, Advanced automation functions, Levels of automations, Automated flow lines and transfer mechanisms, Analysis of transfer lines without storage, Automated flow lines with storage buffers.

**Unit 2: Material handling and identification technologies:** Overview of material handling systems, Types of material handling equipment, Design of the system, Conveyor system, Automated guided vehicle system, Automated storage systems, Interfacing handling and storage with manufacturing, Overview of Automatic Identification Methods.

**Unit 3: Automation in Process Industries:** Introduction to computer based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation.

**Unit 4: Programmable Logic Controller (PLC):** Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.

**Unit 5: Distributed Control System:** Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS)

**Text Books:**

1. M.P.Groover, "Automation, Production Systems and Computer Integrated Manufacturing", 5th Edition, Pearson Education, 2009.
2. John W. Webb and Ronald A. Reis, "Programmable Logic Controllers: Principles and Applications", 5th Edition, Prentice Hall Inc., New Jersey, 2003.
3. Krishna Kant, "Computer - Based Industrial Control", 2nd Edition, Prentice Hall, New Delhi, 2011.
4. Frank D. Petruzella, "Programmable Logic Controllers", 5th Edition, McGraw- Hill, New York, 2016.

**Reference Books**

1. Curtis D. Johnson, "Process Control Instrumentation Technology", 8th Edition, Pearson New International, 2013.
2. Lukas M.P, "Distributed Control Systems", Van Nostrand Reinhold Co., New York, 1986.
3. N. Viswanandham, Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", 1st Edition, 2009.
4. <https://nptel.ac.in/syllabus/108108098/>

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	1	1	2	-	2	3	2
<b>CO2</b>	3	3	2	2	1	2	-	2	2	3
<b>CO3</b>	3	3	3	2	2	2	-	2	3	3
<b>CO4</b>	3	3	2	3	2	3	-	3	2	3
<b>CO5</b>	3	2	3	2	2	3	-	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Heat and Mass Transfer Lab	<b>Course Code:</b>	SOE-B-ME-23-607
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This Lab course offers experiments to impart teaching and learning. In this course, learners will study and perform experiments on heat and mass transfer systems such as heat exchangers, fins, and also study the heat transfer in steady and unsteady scenarios. This course helps learners to understand the heat transfer phenomenon in different modes of heat transfer such as conduction, convection, and radiation.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Apply experimental methods to determine the thermal conductivity of various materials (insulating powders, metals, liquids, slabs, composite walls, and lagged pipes) and analyze the temperature distribution in steady-state conduction scenarios.
<b>CO2</b>	Investigate and quantify convective heat transfer phenomena, including natural and forced convection, by determining surface heat transfer coefficients for different geometries (pin fins, heated cylinders, and tubes).
<b>CO3</b>	Analyze radiative heat transfer by experimentally determining surface emissivity and validating the Stefan-Boltzmann law, thereby understanding the radiative properties of surfaces.
<b>CO4</b>	Evaluate the performance of heat exchangers through experimental determination of LMTD and effectiveness in parallel and counter-flow configurations, and analyze the operational characteristics of simple heat pipes.
<b>CO5</b>	Experimentally investigate the heat transfer mechanisms associated with condensation and boiling, including the determination of heat transfer coefficients in dropwise and film wise condensation, and the measurement of critical heat flux in saturated pool boiling.

**List of Experiments (minimum ten experiments):**

1. To determine the thermal conductivity of insulating powders.
2. To determine the thermal conductivity of a good conductor of heat (metal rod).
3. To measure the thermal conductivity of liquid.
4. To determine the thermal conductivity and thermal resistance of the given composite wall.
5. To determine the thermal conductivity of given slab material.

6. To determine the thermal conductivity of different lagging in a lagged pipe.
7. To study the rates of heat transfer for different materials and geometries.
8. To study the lumped heat capacity method.
9. To determine the surface heat transfer coefficient for heated vertical cylinder in natural convection.
10. To determine the heat transfer rate & temperature distribution of a pin fin.
11. To find the heat transfer coefficient in forced convection in a tube.
12. To measure the emissivity of the test plate surface.
13. To determine Stefan Boltzmann constant of radiation heat transfer.
14. To study the performance of simple heat pipes.
15. To study and compare LMTD and effectiveness in parallel and counter flow heat exchangers.
16. To determine the heat transfer coefficient in drop wise & film wise condensation.
17. To determine the critical heat flux in saturated pool boiling.

**Equipment/Machines/Instruments/Tools/Software Required:**

1. Thermal conductivity of insulating powder apparatus.
2. Thermal conductivity of metal bar apparatus.
3. Thermal conductivity of liquid apparatus.
4. Transfer rate and temperature distribution for a pin fin apparatus.
5. Emissivity of the test plate surface apparatus.
6. Stefan–Boltzmann constant of radiation of heat transfer apparatus.
7. Surface heat transfer coefficient for heated vertical cylinder in natural convection apparatus.
8. Heat transfer coefficient in drop wise and film wise condensation apparatus.
9. Critical heat flux in saturated pool boiling apparatus.
10. Performance of different heat pipe apparatus.
11. Heat transfer rate through heat exchanger apparatus.
12. Heat transfer coefficient in forced convection of air in a tube apparatus.
13. Heat transfer through composite wall apparatus.
14. Thermal conductivity of insulating slab apparatus.
15. Heat transfer through lagged pipe apparatus.
16. Unsteady state heat transfer apparatus.
17. Testing and performance test rig for heat insulators.

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	3	2	2	1	2	1	2	3	2
<b>CO2</b>	3	3	2	2	1	2	1	2	3	2
<b>CO3</b>	3	2	1	1	1	2	2	2	2	2
<b>CO4</b>	3	3	3	2	2	2	1	2	3	3
<b>CO5</b>	3	3	2	2	1	2	2	2	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Manufacturing Technology-II Lab	<b>Course Code:</b>	SOE-B-ME-23-608
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

Machine tools and machining processes introduces the types of cutting tools; Selection of cutting speeds and feed; Simple machining operations on lathe, shaping, slotting, milling, grinding, and wire electrical discharge machines.

**Course Outcomes (COs):**

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

CO Number	Course Outcome
CO1	To explain the various parts and operations of the lathe, shaper, milling, drilling, and grinding machines
CO2	Perform plain turning, step turning, knurling, threading, eccentric turning, chamfering, and facing operations on a lathe
CO3	Ability to interpret job drawing, application of processes, and operations to produce basic components from raw material
CO4	Machine gears on a milling machine
CO5	Measuring the material removal rate (MRR) on WEDM and estimating the chip reduction coefficient and shear angle on a shaping machine.

**Laboratory Component:** (the student should perform a minimum ten experiments)

**Machine tools & Machining:**

1. Operation of Taper turning, Knurling, Grooving and Thread cutting in a Lathe.
2. Operation of Slot cutting in Shaper.
3. Operation of Gear cutting in milling machine using indexing head.
4. Operation of square pocketing/circular pocketing on milling machine.
5. Alignment testing of Lathe.
6. Operation of Drilling, boring and reaming of a hole.
7. Study of turning tool of Lathe (Tool signature) and re sharpening of turning tool to specific geometry.
8. Study of twist drill and re-sharpening of drilling tool to specific geometry.

9. Study of dressing of grinding wheel.
10. Measurement of cutting forces and surface finish in turning, drilling, milling and grinding.
11. Measurement of cutting temperature and tool life in turning.
12. Determine the optimal combination of Wire Electrical Discharge Machining (WEDM) parameters to achieve the desired machining characteristics.
13. Measuring the Material Removal Rate (MRR) under different WEDM conditions to optimize machining speed.
14. Inspection of screw threads.
15. Inspection of gear teeth.

**List of Equipment/Instruments/Machines Required:**

1. Lathe Machine.
2. Shaper Machine.
3. Radial Drilling Machine.
4. Bench drilling machine.
5. Universal Milling Machine.
6. Bench Grinding Machine.
7. Thermal Imager.
8. Wire Electrical Discharge Machine (WEDM).

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	3	2	1	1	-	1	3	2
<b>CO2</b>	3	2	2	3	1	2	-	2	3	2
<b>CO3</b>	3	2	3	3	2	2	-	2	3	3
<b>CO4</b>	3	2	3	3	1	2	-	2	3	2
<b>CO5</b>	3	3	3	2	1	2		2	3	3

**Note:** 1: Low 2: Moderate 3: High



<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Specialization Lab: Industrial Robotics Lab	<b>Course Code:</b>	SOE-B-ME-23-609 (S1)
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This laboratory course offers hands-on experience in the design, development, and analysis of hydraulic, pneumatic, and robotic systems used in industrial automation. Students will begin by constructing basic and advanced pneumatic and hydraulic circuits. This course equips students with the practical knowledge and technical skills to solve engineering problems using fluid power and robotic systems, bridging the gap between theoretical concepts and industrial applications.

**Course Outcomes:**

After completion of the course, students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Design and Develop Fluid Power Circuits
<b>CO2</b>	Implement Automation in Machine Tools
<b>CO3</b>	Develop and Execute Robot Programming
<b>CO4</b>	Design and Control Semi-Autonomous Robots
<b>CO5</b>	Analyse Multi-Axis Robot Systems

**List of Experiments (Minimum Ten Experiments are to Be Carried Out):**

1. To Construct Pneumatic circuit for SAC, DAC and Air motor for the given purpose
2. To Develop different hydraulic circuits for simple applications.
3. To Develop different pneumatic circuits for simple applications
4. To Construct Meter-In, Meter Out Pneumatic/Hydraulic Circuit for The Given Purpose
5. To Construct Pneumatic/Hydraulic Circuit for The Given Sequencing of Operations.
6. To Construct Pneumatic Circuit for The Given Logic Functions (AND/OR/TIME DELAY).
7. To Develop Circuit for Simple Machine Tool Applications Such as Milling Machine, Shaper Machine, Grinding Machine
8. Develop the robot programming for pick and place of objects.
9. Develop the robot programming for material handling applications
10. Develop the robot programming for welding process
11. To design a semi-autonomous robot with a remote control.

12. Study of 5- axis Robot
13. Study of 6- axis Robot

**Equipment/Machines/Instruments/Tools/Software Required**

1. Hydraulic Training Kit
2. Pneumatic Training Kit
3. PLC and IoT Training Kit
4. Industrial Manipulator
5. Welding Arm

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	1	1	2	-	2	3	2
<b>CO2</b>	3	3	2	2	1	2	-	2	2	3
<b>CO3</b>	3	3	3	2	2	2	-	2	3	3
<b>CO4</b>	3	3	2	3	2	3	-	3	2	3
<b>CO5</b>	3	2	3	2	2	3	-	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Programme:</b>	B.Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Specialization Lab: Industrial Automation Lab	<b>Course Code:</b>	SOE-B-ME-23-609 (S2)
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hours/week
<b>Max Marks:</b>	50		

### Course Description:

The main objectives of the course are

1. To introduce industrial automation using pneumatic and hydraulic systems.
2. To provide hands-on experience in designing automation circuits.
3. To develop skills in sequencing and logic-based automation.
4. To Familiarize students with robotic systems and their applications.
5. To enhance understanding of robotic arm configurations and humanoid robots.

### Course Outcomes:

After Completion of the course Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Design and implement Basic pneumatic and hydraulic circuits for automation.
<b>CO2</b>	Develop automation sequences using logic functions and circuit design.
<b>CO3</b>	Design and implement electro-pneumatic and electro-hydraulic circuits for automation.
<b>CO4</b>	Design and implement pneumatic and hydraulic circuits for automation using PLC.
<b>CO5</b>	Design and implement pneumatic and hydraulic circuits for speed control.

### List of Experiments

1. To Construct Pneumatic circuit for SAC, DAC and Air motor for the given purpose
2. To Develop different hydraulic circuits for simple applications.
3. To Develop different pneumatic circuits for simple applications
4. To Construct Meter-In, Meter Out Pneumatic/Hydraulic Circuit for The Given Purpose
5. To Construct Pneumatic/Hydraulic Circuit for The Given Sequencing of Operations.
6. To Construct Pneumatic Circuit for The Given Logic Functions (AND/OR/TIME DELAY).

7. To Develop a Circuit for Simple Machine Tool Applications, such as Milling Machine, Shaper Machine, Grinding Machine

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	1	1	2	-	2	3	2
<b>CO2</b>	3	3	2	2	1	2	-	2	2	3
<b>CO3</b>	3	3	3	2	2	2	-	2	3	3
<b>CO4</b>	3	3	2	3	2	3	-	3	2	3
<b>CO5</b>	3	2	3	2	2	3	-	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Data Visualization and Analysis	<b>Course Code:</b>	SOE-B-ME-23-610
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

The "Data Visualization and Analysis" course equips students with skills to preprocess data, apply visualization techniques, and analyze patterns using tools like Matplotlib, Seaborn, Tableau, and Power BI. With applications in industries such as healthcare and finance, it enables students to derive actionable insights and solve real-world problems effectively.

**Course Outcomes:** After Completion of the course, Students will be able to:

CO Number	Course Outcomes
<b>CO1</b>	Apply effective data visualization techniques to represent data.
<b>CO2</b>	Evaluate and preprocess datasets to ensure accuracy and reliability.
<b>CO3</b>	Describe the use of advanced tools like Matplotlib, Seaborn, Tableau, and Power BI.
<b>CO4</b>	Analyze data to identify patterns, trends, and correlations.
<b>CO5</b>	Apply visualization techniques to solve real-world problems across industries.

**List of Experiments: (Minimum ten experiments to be performed)**

1. Create basic visualizations (bar charts, pie charts, line graphs) using Python (Matplotlib/Seaborn).
2. Perform data cleaning techniques (handling missing data, removing outliers) on raw datasets.
3. Develop a scatter plot to visualize correlations and include a regression line using Seaborn.
4. Design interactive dashboards using Tableau or Power BI for a given dataset.
5. Generate a heatmap to analyze correlations in a dataset and interpret findings.
6. Perform exploratory data analysis (EDA) and visualize the data distribution using histograms and box plots.
7. Create a geospatial visualization (e.g., plotting data on maps) using Plotly or Tableau.
8. Conduct a case study by comparing sales trends across regions and visualizing them through a dashboard.
9. Visualize time-series data (e.g., stock prices) using line graphs and moving averages.
10. Use Python to create a bubble chart to analyze multi-dimensional data.

11. Develop a dashboard with dynamic filters and drill-down functionality in Power BI.
12. Conduct a group project where students choose a real-world dataset, analyze it, and present their findings using appropriate visualizations.

**Text Books:**

1. Kieran Healy (2018), Data Visualization: A Practical Introduction, Princeton University Press, ISBN: 9780691181622.
2. Cole Nussbaumer Knaflic (2015), Storytelling with Data: A Data Visualization Guide for Business Professionals, Wiley, ISBN: 9781119002253.
3. Edward R. Tufte (2001), The Visual Display of Quantitative Information, Graphics Press, ISBN: 9780961392147.

**Reference Books:**

1. Stephen Few (2006), Information Dashboard Design: Displaying Data for At-a-Glance Monitoring, O'Reilly Media, ISBN: 9780596100162.
2. Julie Steele & Noah Iliinsky (2010), Beautiful Visualization: Looking at Data Through the Eyes of Experts, O'Reilly Media, ISBN: 9781449379865.
3. Foster Provost & Tom Fawcett (2013), Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, O'Reilly Media, ISBN: 9781449361327.

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	3	2	1	-	-	-	-	3	2
<b>CO2</b>	2	2	-	-	-	-	-	-	2	-
<b>CO3</b>	2	2	2	2	-	-	-	-	2	1
<b>CO4</b>	3	3	3	2	2	1	1	1	3	3
<b>CO5</b>	3	3	3	2	2	1	1	1	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Professional Elective I: Gas Dynamics and Jet Propulsion	<b>Course Code:</b>	SOE–B–ME-23-606 (1)
<b>Credits:</b>	2	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course covers the fundamentals of compressible fluid flow, including isentropic flows, flow through ducts, and shock waves. It explores jet propulsion principles, analyzing turbojet, turbofan, and ramjet engines. Additionally, it introduces space propulsion, rocket engine types, propellant systems, and performance analysis for space applications.

**Course Outcomes:**

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Explain energy and momentum equations of compressible fluid flow, Mach waves, and isentropic flows
<b>CO2</b>	Analyze Rayleigh and Fanno flow in constant area ducts and their impact on flow properties.
<b>CO3</b>	Apply governing equations to normal and oblique shocks and interpret Prandtl–Meyer relations.
<b>CO4</b>	Evaluate jet propulsion systems, thrust power, and propulsive efficiency for various aircraft engines.
<b>CO5</b>	Describe rocket propulsion, propellant systems, combustion, and space flight performance parameters.

**Syllabus:**

**Unit–1: Basic Concepts and Isentropic Flows:** Energy and momentum equations of compressible fluid flows, Stagnation states, Mach waves and Mach cone, Effect of Mach number on compressibility, Isentropic flow through variable ducts, Nozzle and Diffusers.

**Unit–2: Flow through Ducts:** Flow through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow), variation of flow properties.

**Unit-3: Normal and Oblique Shocks:** Governing equations, variation of flow parameters across the normal and oblique shocks, Prandtl’s–Meyer relations, applications.

**Unit-4: Jet Propulsion:** Theory of jet propulsion, thrust equation, Thrust power and propulsive efficiency, Operating principle, cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines.

**Unit-5: Space Propulsion:** Types of rocket engines, propellants–feeding systems, ignition and combustion, theory of rocket propulsion, performance study, staging, terminal and characteristic velocity, applications, space flights.

**Text Books:**

1. Anderson, J.D., Modern Compressible flow, McGraw Hill.
2. S. M. Yahya, Fundamentals of Compressible Flow, New Age International (P) Limited.

**Reference Books:**

1. P. Balachandran, Fundamentals of Compressible Fluid Dynamics, PHI Learning India Private Ltd.
2. Cohen H., Rogers G. E. and Saravanamuttoo, Gas Turbine Theory, Longman.
3. Sutton G. P. Rocket, Propulsion Elements, John Wiley, New York.
4. Shapiro A. H., Dynamics and Thermodynamics of Compressible Fluid Flow, Vol.–I, John Wiley.
5. Radhakrishnan E., Gas Dynamics, Prentice Hall of India Pvt. Ltd.

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	1	-	-	2	1	-	3	2
<b>CO2</b>	3	3	2	1	-	2	1	2	2	3
<b>CO3</b>	3	2	2	-	-	2	1	-	3	3
<b>CO4</b>	3	3	3	2	2	2	2	2	3	2
<b>CO5</b>	3	2	3	2	2	3	3	3	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Professional Elective I: Computational Fluid Dynamics	<b>Course Code:</b>	SOE–B–ME-23-606 (2)
<b>Credits:</b>	2	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This course provides a comprehensive introduction to Computational Fluid Dynamics (CFD), covering fundamental concepts, numerical methods, and applications in fluid flow and heat transfer. Students will gain practical experience in solving fluid flow and heat transfer problems using CFD techniques.

**Course Outcomes:**

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

CO Number	Course Outcome
<b>CO1</b>	Explain the fundamental concepts of CFD, its applications, and the governing equations of fluid mechanics and heat transfer.
<b>CO2</b>	Understand and use direct and iterative methods to solve a system of linear algebraic equations
<b>CO3</b>	Discretize partial differential equations using the Finite Difference Method and analyze the accuracy and stability of numerical solutions.
<b>CO4</b>	Understand and apply the finite volume method used in CFD to solve fluid flow and heat transfer problems
<b>CO5</b>	Explain and apply turbulence modeling techniques

**Syllabus:**

**Unit-1: Introduction and Governing Equations:** History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD, Review of basic fluid mechanics, Governing equations of fluid mechanics and heat transfer: Continuity equation, Momentum equation, Energy equation, Navier-Stokes equation for Newtonian fluid, and general structure of conservation equations. Boundary conditions, classification of partial differential equations, and their physical behaviors.

**Unit-2: Mathematical Preliminaries:** Solution of a system of linear algebraic equations, direct methods: Matrix inversion and Gauss-elimination, Indirect or Iterative methods: Jacobi method, Gauss-Seidel method, Relaxation methods, and tri-diagonal matrix algorithm (TDMA).

**Unit-3: Discretization and Finite Difference Method:** Basic aspects of discretization, Introduction to the finite Difference Method, Finite difference equations using Taylor series expansion: Central, Forward, & Backward difference for first & second order derivative, Finite difference approximation for non-uniform mesh & mixed derivative. Application of Finite difference method to model steady problems, implicit and explicit approaches, errors and stability analysis.

**Unit- 4: Finite Volume Method:** Introduction to Finite Volume Method (FVM), FVM for one- and two-dimensional diffusion problems, FVM for steady convection-diffusion problems, Central, Upwind, Hybrid and QUICK differencing scheme, and introduction to pressure-velocity coupling.

**Unit-5: Turbulence Modeling:** Introduction, types of turbulence modeling, Reynolds Time Averaging, Reynolds Time Averaged conservation equations – Boussinesq approach, One equation  $k - \epsilon$  model.

**Text Books:**

1. H.K Versteeg and V. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson.
2. J.D. Anderson, Jr., Computational, Fluid Dynamics – The basics with applications, Tata McGraw Hill.

**References Books:**

1. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing.
2. K. Muralidhar, T. Sundarajan, Computational Fluid Flow and Heat Transfer, Naros.
3. M. Peric and J. H. Ferziger, Computational Methods for Fluid Dynamics, Springer.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	-	-	-	2	-	-	2	1
<b>CO2</b>	3	3	-	-	-	2	-	-	3	2
<b>CO3</b>	3	3	2	-	-	2	-	-	3	2
<b>CO4</b>	3	3	2	-	-	2	-	-	3	2
<b>CO5</b>	3	3	2	-	-	2	-	-	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Professional Elective I: Welding Technology	<b>Course Code:</b>	SOE–B–ME-23-606 (3)
<b>Credits:</b>	2	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

After going through this course, the student will be able to understand basic concepts of welding, to understand the theoretical aspects of welding technology in depth. To understand the basic metallurgy of the melted and heat-affected zone of a metal or alloy. To know the welding parameters and techniques to optimize the weldment properties. To check the weldments' quality using various inspection and testing methods.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand the theoretical aspects of welding technology in depth.
<b>CO2</b>	Describe the basic metallurgy of the melted and heat-affected zone of a metal
<b>CO3</b>	Identify the cause of welding defects and avoid them
<b>CO4</b>	Choose or adjust welding parameters and techniques to optimize the weldment's properties
<b>CO5</b>	Demonstrate their ability to check the weldments' quality using various inspections and testing methods

**Syllabus:**

**Unit-1: Introduction to Welding and Joining Processes:** Introduction to consolidation processes, classification of welding processes, types of fusion welds and joints, design considerations, heat effects, weld ability and join ability. Welding terms and definitions, welding positions, elements and construction of welding symbols.

**Unit-2: Welding Metallurgy:** Fundamentals of physical metallurgy, solidification of weld metal: principle of solidification of weld metal, modes of solidification, effect of welding parameters on weld structure, heat affected zone and weld metal: transformations in HAZ of steel, factors affecting changes in microstructure and mechanical properties of HAZ, reactions in weld pool-gas metal reaction, slag metal reaction. Metallurgical issues in weld joints: mechanisms, causes, and remedies of cold cracking, solidification cracking.

**Unit-3: Weld Joint Preparation and Temperature Control:** Checks prior to weld joint preparation, joint preparation checks, aims of preheating, interpass heating, post-weld heating,

heating processes, post heat treatments, insulation of heated joints, temperature distribution in welding.

**Unit–4: Cracks and Defects in Welds:** Classification of weld cracks, nomenclature, location and orientation of weld cracks, factors contributing to weld cracking, specific weld cracks, classification of weld defects, general sources of weld defects, arc welding defects, resistance welding defects, defects in friction welding.

**Unit–5: Weldments Inspection and Testing:** Chemical, metallurgical, and mechanical testing of weldments: comparison of destructive and non-destructive tests, forms of corrosion, testing for corrosion resistance. selection of NDT method, relationship of welding processes, discontinuities and inspection methods, visual inspection prior to, during and after welding, liquid penetrant test, magnetic particle and radiographic inspection, ultrasonic inspection, eddy current inspection, acoustic emissions, proof tests and leak tests, inspection of pressure vessels. Introduction to weld 4.0.

**Text Books:**

1. R. S. Parmer, Welding Engineering and Technology, Khanna Publishers.
2. S.P. Tewari and S.A. Rizvi, Advanced Welding Technology, S. K. Kataria & Sons.

**Reference Books:**

1. J.T. Black, Ronald Kohser, Materials and processes in Manufacturing, Wiley Publication.
2. Lancaster J. F., Metallurgy of welding, Allen and Unwin Co.
3. K. E. Esterling, Introduction to Physical Metallurgy of Welding, Butterworth-Heinemann Publisher.
4. Welding Handbook, Volumes 1, 2 and 3, 9th edition, American Welding Society.
5. Larry J and Jeffus L, Welding Principles and Application, Delmer Publications.
6. Hull, Non–Destructive Testing, ELBS Edition.

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	2					2			3	
<b>CO2</b>		1				2			1	1
<b>CO3</b>	2					2			3	2
<b>CO4</b>	2	2	2			2			2	
<b>CO5</b>	2		1			2			2	

**Note:** 1: Low 2: Moderate 3: High



<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Professional Elective I: Material Handling Systems and Equipment	<b>Course Code:</b>	SOE–B–ME-23-606 (4)
<b>Credits:</b>	2	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This course provides an introduction to the field of material handling and to introduce to the importance of proper material handling and storage techniques. To introduce to selection of material handling equipment. To introduce to design considerations of mechanical handling equipment and load lifting attachments.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Gain a strong foundation in the Material handling system.
<b>CO2</b>	Identify material handling equipment requirements for a specific process and for various locations and working conditions
<b>CO3</b>	Understand the design requirement of material handling systems
<b>CO4</b>	able to understand the benefit of an efficient material handling system
<b>CO5</b>	able to recognize the importance of material storage equipment's.

**Syllabus:**

**Unit–1: Elements of Material Handling System:** importance, terminology, objectives and benefits of better material handling, principles and features of material handling system, interrelationships between material handling and plant layout, physical facilities and other or organizational functions, classification of material handling equipment.

**Unit–2: Material handling Equipment's and Systems for Various Materials:** storing equipment's like pallets, bins, racks, decking, order picking, positioning equipment's. hoisting equipment's like jacks, pulleys, hand trolleys, hoists, power hoist, various types of cranes and elevators. Conveying equipment's like belt, chain, roller, wheel, trolley, tray conveyors, gravity and vibratory type conveyors, screw conveyors. mobile equipment's like hand trucks, fork lift trucks, powered industrial trucks and tractors, powered stackers, reach trucks, order pickers.

**Unit-3: Selection of Material Handling Equipment:** factors affecting selection of material handling equipment, material handling equation, choices of material handling equipment, general procedure for selection, basic analytical techniques, selection of suitable types of material handling systems, functions and parameters, affecting service, packing and storage material, selection of material handling equipment in green sand moulding foundry, sugar manufacturing industry.

**Unit-4: Design of Mechanical Handling Equipment:** design of hoists, drives for hoisting, components and hoisting mechanisms, rail traveling components and mechanisms. Design of cranes, hand-propelled and overhead traveling cranes, traveling mechanisms of cantilever and monorail cranes, design considerations for structures of rotary and cranes with fixed radius, fixed post and overhead traveling cranes.

**Unit-5: Systems and Equipment used for Material Storage, Safety and Training:** need, environmental and human factors in material handling, safety regulations, objectives of storage, bulk material handling, gravity flow of solid through slides and chutes, storage in bins and hoppers, belt conveyors, bucket-elevators, screw conveyors, cabin vibratory mobile racks etc.

**Text Books:**

1. N. Rudenko, Material Handling Equipment, Peace Publishers.
2. James M. Apple, Material Handling System Design, John-Wiley Publication.

**References:**

1. Allegri T H, Materials Handling Principles and Practice, CBS Publication.
2. John R. Immer, Material Handling, McGraw-Hill Co. Ltd.
3. M. P. Nexandr, Material Handling Equipment, MIR Publication, Moscow.
4. C. R. Cock and J. Mason, Bulk Solid Handling, Leonard Hill Publication Co. Ltd.
5. R. A Kulwiac, Material Handling Hand Book, John Willy Publication.

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	2	3	2	2		2		2	3	2
<b>CO2</b>	2	1	2		2	2	2		1	1
<b>CO3</b>	2		2			2		2	3	2
<b>CO4</b>	2	2	2	2		2	2		2	
<b>CO5</b>	2	2	1		2	2		2	2	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Professional Elective I: Additive Manufacturing	<b>Course Code:</b>	SOE–B–ME-23-606 (5)
<b>Credits:</b>	2	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This course is designed to provide an overview of available AM processes and basic scientific understanding of this emerging technology. The main aim is to introduce students, the basics of additive manufacturing/rapid prototyping and its applications in various fields, reverse engineering techniques. To familiarize students with different processes in rapid prototyping systems. To teach students about mechanical properties and geometric issues relating to specific rapid prototyping applications. To explore different applications of Additive Manufacturing Processes.

**Course Outcomes:** After completion of the course, students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand the importance of Additive Manufacturing.
<b>CO2</b>	Classify the different AM processes.
<b>CO3</b>	Design for AM processes.
<b>CO4</b>	Understand the applications of AM.
<b>CO5</b>	Differentiate the post-processing processes.

**Syllabus:**

**Unit-1: Introduction to Additive Manufacturing (AM):** Introduction to AM, AM evolution, distinction between AM and CNC machining, advantages of AM. AM process chain: Conceptualization, CAD, conversion to STL, transfer to AM, STL file manipulation, machine setup, build, removal and clean up, post processing. Classification of AM processes: liquid polymer system, discrete particle system, molten material systems, and solid sheet system.

**Unit-2: Introduction to Rapid prototyping (RP):** Need of RP in context of batch production. Basic principles of RP, Steps in RP, process chain in RP in integrated CAD– CAM environment, advantages of RP, medical applications.

**Unit-3: Classification of different RP techniques:** based on raw materials, layering technique (2-D or 3-D) and energy sources: Process technology, Stereo-lithography (SL), photo polymerization, liquid thermal polymerization, solid foil polymerization.

**Unit- 4: AM Applications:** Functional models, pattern for investment and vacuum casting, medical models, art models, engineering analysis models, rapid tooling, new materials development, bi-metallic parts, re-manufacturing. Application examples for aerospace, defense, automobile, bio-medical and general engineering industries.

**Unit-5: Post Processing of AM Parts:** Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.

**Text Books:**

1. Chua Chee Kai, Leong Kah Fai, Rapid Prototyping: Principles and Applications, World Scientific.
2. Ian Gibson, David W. Rosen, Brent Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer.

**Reference Books:**

1. Ali K. Kamrani, Emand Abouel Nasir, Rapid Prototyping: Theory and Practice, Springer.
2. D. T. Pham, S. S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer.
3. Andreas Gebhardt, Understanding Additive Manufacturing, Hanser Publishers.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSO	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	2		3		2	2			2	2
<b>CO2</b>		1		2	2	2	2	2	1	1
<b>CO3</b>	2				1	2	2		2	2
<b>CO4</b>	2	2	2	2		2	2	2	2	1
<b>CO5</b>	2		1		2	2			2	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VI Sem
<b>Name of the Course:</b>	Professional Elective I: Power Plant Engineering	<b>Course Code:</b>	SOE–B–ME-23-606 (6)
<b>Credits:</b>	2	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This Course provides a simple understanding of the power plant engineering. The course contains the details of General sources of energy and generation, steam power plants, hydro power plants, nuclear power plants, along with solar, and wind energy. The economics of power generation and the environmental aspect of power generation are also being addressed in this course.

**Course Outcomes:** After completion of the course, students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Compare different energy resources and choose the most appropriate based on local conditions.
<b>CO2</b>	Understand working, principle and constructions of Thermal Power Plant.
<b>CO3</b>	Understand working, principle and constructions of Hydroelectric Power Plant and Wind Energy Conversion System.
<b>CO4</b>	Understand working, principle and constructions of Nuclear Power Plant and its important elements.
<b>CO5</b>	Evaluate economic feasibility and its implications on power generating units.

**Syllabus:**

**Unit-1: Introduction:** General sources of energy and generation of electricity, future trends in power industry, coordination of power from different sources. Introduction, working Principle and applications of Renewable Energy sources (Solar, Wind, Hydroelectric only) Prospects of Renewable Energy Sources.

**Unit-2: Thermal Power Plant:** General layout, site selection and working of thermal power plant, basic thermodynamic cycles, coal handling, coal storage, Preparation & feeding, combustion and combustion equipment's, ash handling and dust collection, cooling system, draught system.

**Unit-3: Hydroelectric Power plant and Wind Energy:** Hydrograph, flow duration and mass curves, site selection, General arrangement of Hydroelectric Power Plant and its operation, Storage and pond age, Classification of Hydroelectric Power Plant, selection of prime movers, Governing of turbines, Cavitation's in turbines.

**Wind Energy:** Basic principles of wind energy conversion, wind energy estimation, site selection consideration. Basic components of wind energy conversion system, Types of wind mills, generating systems, energy storage, advantages & disadvantages of WECS. Applications of Wind energy.

**Unit-4: Nuclear Power Plant:** Principle of release of nuclear energy, fusion and fission reactions, nuclear fuels used in reactors, elements of nuclear reactors, moderators, control rods, fuel rods, coolants. Types of reactors PWR, BWR, Sodium graphite reactor, fast breeder reactor, Homogenous reactor and gas cooled reactor, radiation hazard, and shielding, radioactive waste disposal.

**Unit-5: Power Plant Economics:** Cost of energy production, selection of plant, performance and operating characteristics of power plants and generating equipment's. Tariffs for electrical energy, environmental aspects of power generation. Load estimation, load duration curve, load factor, capacity factor, diversity factor and demand factor, effect of variable load on power plant, selection of number and size of units.

**Text Books:**

1. P.K. Nag, Power Plant Engineering, Tata McGraw–Hill Publications Company.
2. V.M. Domkundwar & S.C. Arora, A Course in Power Plant Engineering, Dhanpat Rai Publications Company.

**Reference Books:**

1. R.K. Rajput, Textbook of Power Plant Engineering, Laxmi Publications.
2. P.C. Sharma, Power Plant Engineering, S.K. Kataria & Sons.
3. G.R. Nagpal, Power Plant Engineering, Khanna Publishers.
4. R. Yadav, Steam and gas turbine and power plant engineering, CPH.
5. Skrotizke and Vopar, Power Station Engineering Economics, Tata McGraw–Hill Education.
6. Joel Weisman & Ray Eckart, Modern Power Plant Engineering, Prentice hall International Inc Publications.
7. M.M.E.I. Wakil, Power Plant Engineering, McGraw Hill Education (I) Pvt. Ltd.
8. Black & Veatch, Power Plant Engineering, CBS Publishers.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	-	2	2	1	-	-	-	3	1
<b>CO2</b>	3	2	2	-	2	1	2	2	2	3
<b>CO3</b>	3	2	-	-	2	1	-	-	3	1
<b>CO4</b>	3	2	2	-	2	-	-	1	2	3
<b>CO5</b>	2	2	3	-		2	-	2	3	2

Note: 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109  
Department of Mechanical Engineering



**O. P. Jindal University**

**Raigarh, Chhattisgarh**



*Scheme and Syllabus*

*of*

**B. Tech.**

**In**

**Mechanical Engineering**

**(01UG040)**

# School of Engineering

## Session - 2022-26

### Program Outcomes (POs) for Engineering Graduate

**PO 1: Engineering Knowledge and Problem Analysis:** Apply the knowledge of engineering domain with adequate amalgamation of science, mathematics, and management to Identify, formulate, and critically analyze complex engineering problems.

**PO 2: Modern tools and techniques for investigating complex problems:** Apply appropriate tools and techniques to analyze, predict and simulate the data for valid conclusion with clear understanding of limitations.

**PO 3: Design and development of innovative systems:** design and develop system components or processes to provide solutions of complex engineering problems that meet the specified conditions of societal, health, safety, and environmental needs.

**PO 4: Communication and Teamwork:** Develop skills to communicate effectively to diverse platforms and contribute meaningfully to different capacities as a leader, team member or individual.

**PO 5: Project management and finance:** Develop and apply knowledge of engineering, management, and finance principles to handle a project in a multidisciplinary environment.

**PO 6: Life-long learning:** Acquire fundamental knowledge for lifelong learning to participate in the extensive context of socio-technological change as a self-directed member and a leader.

**PO 7: Ethics and citizenship:** Apply ethical principles and commit to professional ethics, norms, and responsibilities of the engineering practice; and act with informed awareness to participate in civic life activities.

**PO 8: Society, Sustainability and Environment:** Understand the impact of various solutions in the context of societal, economical, health, safety legal and environmental impact for sustainable development.

### Program Specific Outcomes (PSOs) of Mechanical Engineering Department (01UG040)

**PSO 1:** Develop an attitude to meet global challenges and apply the knowledge of mechanical engineering to solve problem related with thermal, design, manufacturing and interdisciplinary field.

**PSO 2:** Demonstrate knowledge and skill for solving social, real industrial problems using modern software and hardware tools.

Scheme of Teaching and Examination  
 B. Tech. in Mechanical Engineering (01UG040)

**VII- Semester**

S. No.	Subject/ Course Code	BOS	Name of the Subject/Course	Periods per week			Scheme of Examination and Marks				Credit L+(T+P)/2
				L	T	P	PRE		ESE	Total	
							MID	TA			
1	SOE-B-ME701	ME	Refrigeration & Air Conditioning System	3	0	0	30	20	50	100	3
2	SOE-B-ME702	ME	Robotics & Automation	3	0	0	30	20	50	100	3
3	SOE-B-ME703	ME	Refrigeration and Air Conditioning Lab	0	0	2	0	15	10	25	1
4	SOE-B-ME704	ME	Robotics and Automation Lab	0	0	2	0	15	10	25	1
5	SOE-B-ME705	ME	Industry Internship*	0	0	20	0	125	125	250	10
6	HUM-B-SOE701	CDC	Professional Development-I	0	0	2	0	15	10	25	1
7	SOE-B-ME706	ME	Skill Development Course from MOOCs#	0	0	4	0	30	20	50	2
<b>TOTAL</b>				<b>06</b>	<b>0</b>	<b>32</b>	<b>60</b>	<b>240</b>	<b>280</b>	<b>575</b>	<b>21</b>

L: Lecture    T: Tutorial    P: Practical    ESE: End Semester Examination    TA: Teacher's Assessment.    PRE: Progressive Review Examination

\*\*\*Internship should be of minimum 10 and Maximum 12 weeks duration (June to August).

#Course duration should be a minimum of 15 hrs. The department will prepare a list of courses available in Coursera. After the completion of the course if the student submits the completion certificate, then he will be allotted 100% TA otherwise, the department will conduct viva for TA.

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



Skill Development Course from Coursera# (Annexure-II)

<b>S. No.</b>	<b>Subject Code</b>	<b>Courses</b>
1.	SOE-B-ME706 (1)	AI for Mechanical Engineers
2.	SOE-B-ME706 (2)	Applied Computational Fluid Dynamics
3.	SOE-B-ME706 (3)	Digital Manufacturing & Design Technology Specialization
4.	SOE-B-ME706 (4)	Modern Robotics – Mechanics, Planning, and Control
5.	SOE-B-ME706 (5)	Introductions to Robotics: Modeling, Control, and Path Planning
6.	SOE-B-ME706 (6)	Introductions to Robotics: Fundamentals of Robotics & Industrial Automation

<b>Programme:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Refrigeration & Air Conditioning System	<b>Course Code:</b>	SOE-B-ME701
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course is designed to provide a simple and basic understanding of the fundamentals of Refrigeration and Air-conditioning to the learners. In this course learners will be introduced to the different refrigeration cycles and key concepts of psychrometry and psychrometric processes needed for designing air-conditioning systems. In addition to it, the estimation of cooling/heating load for comfort air-conditioning is also addressed in this course.

**Course Outcomes:** After completion of the course, students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Explain the need for refrigeration systems, basic units of refrigeration, and analyze vapor compression refrigeration cycles and their performance.
<b>CO2</b>	Understand different types of air-refrigeration systems and assess their limitations and applications.
<b>CO3</b>	Differentiate between vapour compression and vapour absorption refrigeration systems, evaluate refrigerants based on their properties and understand the functioning of key refrigeration components.
<b>CO4</b>	Apply psychrometric principles to analyze air conditioning processes and human comfort.
<b>CO5</b>	Estimate cooling/heating loads for different applications and select suitable air conditioning systems.

**Syllabus:**

**Unit-1: Introduction to Refrigeration:** Refrigeration and second law of thermodynamics, refrigeration effect and unit of refrigeration, heat pump, reversed Carnot cycle, simple vapour compression refrigeration system, analysis of simple vapour compression refrigeration cycle by p-h and T-S diagram, effect of operating conditions, liquid vapour heat exchangers, actual refrigeration cycle, introduction to multiple evaporator and compound compression systems.

**Unit-2: Gas Cycle Refrigeration:** Limitation of Carnot cycle with gas, reversed Brayton cycle, Brayton cycle with regenerative heat exchanger, air cycle for aircraft, necessity of cooling of aircraft, basic cycle, boot strap, regenerative, and reduced ambient type air refrigeration cycle.

**Unit-3: Vapour Absorption System:** Simple vapour absorption system, Electrolux refrigerator, analysis of ammonia absorption refrigeration system, lithium bromide absorption refrigeration system.

**Refrigerants:** Classification, nomenclature, selection of refrigerants, global warming potential of CFC refrigerants.

**Refrigeration Equipment's:** Compressor, condenser, evaporator, expansion devices - types and working.

**Unit-4: Psychrometry:** Psychrometric properties, relations, charts and processes, cooling coils, by-pass factor and air washers, human comfort mechanism of body heat losses, factors affecting human comfort, effective temperature, comfort chart.

**Unit-5: Cooling Load Calculations:** Internal heat gain, system heat gain, RSHF, ERSHF, GSHF, cooling load estimation, heating load estimation, psychrometric calculation for cooling, selection of air conditioning, apparatus for cooling and dehumidification, air conditioning system, central, split and window air conditioning system.

**Text Books:**

1. C. P. Arora, Refrigeration and Air Conditioning, TMH.
2. Arora and Domkundwar, Refrigeration and Air Conditioning, Dhanpat Rai.
3. R. S. Khurmi and J. K. Gupta, A textbook of Refrigeration and Air Conditioning, S. Chand Publication.

**References Books:**

1. R. K. Rajput, Refrigeration & Air Conditioning, Kataria, S. K., & Sons.
2. P. L. Ballaney, Refrigeration and Air Conditioning, Khanna Pub.
3. Stocker and Jones, Refrigeration and Air Conditioning, McGraw Hill.
4. P. N. Ananthanarayanan, Basic Refrigeration and Air-Conditioning, TMH.
5. Roy J. Dossat, Principles of Refrigeration, Pearson.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
CO1	3	2	2	-	-	2	-	1	3	2
CO2	3	2	2	-	-	2	-	1	3	2
CO3	3	2	2	-	-	2	2	3	3	2
CO4	3	3	2	-	-	2	-	1	3	2

**Unit-3: Trajectory Planning:** Introduction, trajectory interpolators, basic structure of trajectory interpolators, cubic joint trajectories, general design consideration on trajectories 4-3-4 & 3-5-3 trajectories.

**Unit-4: Dynamics of Robotic Manipulators:** Introduction, preliminary definitions, generalized robotic coordinates, Jacobian for a two link manipulator, Euler equations, Lagrangian equations of motion, application of Lagrange-

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	2	1	-	-	-	1	-	-	1	1
<b>CO2</b>	3	2	2	-	-	1	-	-	3	2
<b>CO3</b>	3	2	3	-	-	1	-	-	3	2
<b>CO4</b>	3	2	3	-	-	1	-	-	3	2
<b>CO5</b>	3	2	2	-	-	1	-	-	3	3

**Note:** 1: Low 2: Moderate 3: High



<b>Program:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Refrigeration & Air-Conditioning Lab	<b>Course Code:</b>	SOE-B-ME703
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	25		

**Course Description:**

This lab course introduces students to various refrigeration and air conditioning systems and their performance analysis.

**Course Outcomes:**

After completion of the course students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Identify and explain the components and working principles of basic refrigeration systems.
<b>CO2</b>	Evaluate the performance of vapour compression and vapour absorption refrigeration systems.
<b>CO3</b>	Evaluate the performance of air and water heat pumps under various operating conditions.
<b>CO4</b>	Demonstrate and analyze psychrometric processes using an air conditioning test rig.
<b>CO5</b>	Determine the efficiency of cooling towers.

**List of Experiments:**

(Minimum ten experiments are to be performed by each student)

1. To study domestic refrigerator.
2. To study the Hermetically sealed compressor.
3. To study vapour compression refrigeration system and determine the COP.
4. To study the mechanical heat pump and determine the following:
  - a) Theoretical and actual coefficient of performance
  - b) Theoretical and actual capacity of the plant
5. To study the air and water heat pump and determine the following:
  - a) Theoretical coefficient of performance of the system as a refrigerator and as a heat pump
  - b) Actual coefficient of performance of the system as a refrigerator and as a heat pump
6. To determine the following of air and water heat pump:
  - a) Capacity of the system in tons as a refrigerator
  - b) Capacity of the system in kW as a heat pump under the following conditions of operation:

- i. Water-cooled condenser and water-cooled evaporator
  - ii. Water-cooled condenser and air-cooled evaporator
  - iii. Air-cooled condenser and air-cooled evaporator
  - iv. Air-cooled condenser and water-cooled evaporator
7. To study the sensible heating processes on the air conditioning test rig.
  8. To study the sensible cooling processes on the air conditioning test rig.
  9. To study the sensible cooling/cooling dehumidification processes on the air conditioning test rig.
  10. To study the humidification and cooling processes on the air conditioning test rig.
  11. To find the efficiency of cooling tower test rig.
  12. To study the simple vapor absorption system.

**Equipment/Machines/Instruments/Tools/Software Required:**

1. Domestic Refrigerator
2. Cut Section of Hermitically Sealed Compressor
3. Vapor Compression Refrigeration Test Rig
4. Mechanical Heat Pump Test Rig
5. Air & Water Heat Pump Test Rig
6. Air Conditioning Test Rig
7. Simple Absorption System Test Rig
8. Cooling Tower Test Rig

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	1	-	-	2	-	1	2	1
<b>CO2</b>	3	2	2	-	-	2	-	1	2	2
<b>CO3</b>	3	2	1	2	-	2	-	1	2	2
<b>CO4</b>	2	2	2	-	-	2	-	1	2	2
<b>CO5</b>	3	2	3	-	-	2	-	1	2	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Robotics & Automation Lab	<b>Course Code:</b>	SOE-B-ME704
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	25		

**Course Description:**

This lab introduces the preliminary practical fundamentals of Robotics and Automation to students. The lab focuses on the basic principles of robotic technology, configurations and control of robots. This lab demonstrates the kinematic and dynamic constraints of robotic elements, applications and functions of sensors and transducers, which are intricate parts of any robotic system.

**Course Outcomes:**

After completion of the course students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Classify different robots and identify their different parts and components.
<b>CO2</b>	Write programs for simple operations.
<b>CO3</b>	Use of any robotic simulation software to model the different types of robots and calculate work volume for different robots.
<b>CO4</b>	Understand industrial automation by transfer lines and automated assembly lines.
<b>CO5</b>	Design an automated system.

**List of Experiments:**

(Minimum ten experiments are to be performed by each student)

1. Demonstration of Cartesian/ cylindrical/ spherical robot.
2. Demonstration of articulated/ SCARA robot.
3. Virtual modeling for kinematic and dynamic verification of any one robotic structure using suitable software.
4. Design, modeling, and analysis of two different types of grippers.
5. Study of sensor integration.
6. Two programs for linear and nonlinear paths.
7. Study of robotic system design.
8. To lift the object and place it 100 mm away in various directions.
9. To find the gripper movement from 0 to 50 mm.
10. To determine the 5-axis robotic arm movement and its degree of rotation.

11. To determine the object distance from 30 mm to 300 mm.
12. To detect the objects with an infrared ray detector.
13. To find the horizontal and vertical movement up to 180° on either side.
14. To detect the distance from 100 mm to 800 mm with an infrared object detector.

**List of Equipment**

1. 6–Axis educational robot trainer
2. 5–axis SCORBOT robot
3. Line follower robot
4. Hex crawler robot
5. Tuttlebot4 standard version

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	2	-	3	1	2	3	2
<b>CO2</b>	3	2	2	2	-	2	2	1	2	2
<b>CO3</b>	3	3	3	-	2	3	-	1	3	3
<b>CO4</b>	3	2	2	2	-	3	1	2	3	2
<b>CO5</b>	3	2	2	2	-	2	2	1	2	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Industry Internship	<b>Course Code:</b>	SOE-B-ME705
<b>Credits:</b>	10	<b>No of Hours:</b>	20 hrs. / week
<b>Max Marks:</b>	250		

**Course Description:**

The main objectives of internship training are to expose technical students to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry. It provides exposure to the current technological developments relevant to the subject area of training.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Familiarize with various materials, processes, products, and their applications along with relevant aspects of quality control
<b>CO2</b>	Understand the psychology of the workers and their habits, attitudes, and approach to problem solving.
<b>CO3</b>	Apply the Technical knowledge in real industrial situations.
<b>CO4</b>	Gain experience in writing technical reports/projects
<b>CO5</b>	Expose students to the engineer's responsibilities and ethics

**Internship Guidelines:**

**Step 1:** Request Letter/ Email from the office of the university should go to industry to allot slots of 10-12 weeks during summer vacation as internship periods for the students. Students request letter/profile/ interest areas may be submitted to industries for their willingness for providing the training.

**Step 2:** Industry will confirm the training slots and the number of seats allocated for internships via Confirmation Letter/ Email. In case the students arrange the training themselves the confirmation letter will be submitted by the students in the office of Training & Placement through department. Based on the number of slots agreed to by the Industry, TPO will allocate the students to the Industry. In addition, the internship slots may be conveyed through Telephonic or Written Communication (by Fax, Email, etc.) by the TPO or other members of the T&P cell / Faculty members who are particularly looking after the Final/Summer Internship of the students.

**Step 3:** Students on joining Training at the concerned Industry / Organization, submit the Joining Report/ Letters / Email.

**Step 4:** Students undergo industrial training at the concerned Industry / Organization. In-between Faculty Member(s) evaluate(s) the performance of students once/twice by visiting the Industry/Organization and Evaluation Report of the students is submitted in department office/TPO with the consent of Industry persons/ Trainers.

**Step 5:** Students will submit training report after completion of internship.

**Step 6:** Training Certificate to be obtained from industry.

**Step 7:** List of students who have completed their internship successfully will be issued by Training and Placement Cell

**Evaluation Through Seminar Presentation/Viva-Voce:**

The student will give a seminar based on his training report, before an expert committee constituted by the department as per norms of the institute.

The evaluation will be based on the following criteria:

- Quality of content presented.
- Proper planning for presentation.
- Effectiveness of presentation.
- Depth of knowledge and skills.
- Attendance record, daily diary, departmental reports shall also be analyzed along with the Internship Report.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	1	-	2	1	-	-	3	1
<b>CO2</b>	1	-	-	3	2	2	2	2	2	2
<b>CO3</b>	2	2	3	2	2	2	2	2	3	1
<b>CO4</b>	2	3	1	3	2	3	-	-	3	2
<b>CO5</b>	-	-	-	-	-	2	3	2	2	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Skill Development Course from Coursera: AI for Mechanical Engineers	<b>Course Code:</b>	SOE-B-ME706 (1)
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

AI for Mechanical Engineers is designed to help mechanical engineering professionals. This course explores the integration of Artificial Intelligence (AI) and Machine Learning (ML) in mechanical engineering. Covering fundamental AI concepts, design optimization, autonomous systems, energy efficiency, and biomedical applications, it equips learners with practical AI skills. Through hands-on projects, students will apply AI techniques to optimize designs, enhance robotics, improve energy management, and advance biomedical engineering solutions.

**Course Outcomes:**

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

CO Number	Course Outcome
<b>CO1</b>	Understand the fundamental concepts of artificial intelligence and machine learning.
<b>CO2</b>	Apply machine learning algorithms for design optimization and simulation.
<b>CO3</b>	Develop AI-driven solutions for autonomous systems and robotics.
<b>CO4</b>	Utilize AI techniques to analyze and improve system energy and efficiency.
<b>CO5</b>	Implement AI methodologies for problem-solving in biomedical engineering contexts related to mechanical systems.

**Syllabus:**

**Unit-1: Introduction to AI and Machine Learning for Mechanical Engineers:** Introduction to AI, machine learning 12 792 re W\* n BT /F2 12 Tf 1 0 0 1 72.024 210.86 Tm 0 G [(A)-7(10.48

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109  
Department of Mechanical Engineering



**OPJU**

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Skill Development Course from Coursera: Applied Computational Fluid Dynamics	<b>Course Code:</b>	SOE-B-ME706 (2)
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Skill Development Course from Coursera: Digital Manufacturing & Design Technology	<b>Course Code:</b>	SOE–B–ME706 (3)
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This specialization will equip the students with the essential knowledge of the digital technology revolution in modern factories. The course explores Industry 4.0 and its core elements: digital manufacturing, the digital thread, IoT, and Big Data. The learning culminates in a personalized roadmap project, showcasing expertise and preparation for career advancement in Digital Manufacturing and Design (DM&D).

**Course Outcomes:** After completion of the course students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand the fundamental concepts of Industry 4.0 and its key components.
<b>CO2</b>	Apply digital manufacturing and design principles to optimize manufacturing processes and create innovative product designs.
<b>CO3</b>	Analyze and implement the digital thread concept to enhance data flow and integration throughout the product lifecycle.
<b>CO4</b>	Evaluate and implement advanced manufacturing technologies, including intelligent machining and model-based systems engineering (MBSE).
<b>CO5</b>	Develop strategies for cybersecurity in manufacturing environments and create a personalized roadmap for success in the DM&D field.

**Syllabus:**

**Unit-1: Digital Manufacturing & Design:** Introduction to industry 4.0 and digital manufacturing, digital design and simulation tools, additive manufacturing and advanced materials.

**Digital Thread Components:** Overview of the digital thread concept, data acquisition and sensor technologies, IoT in manufacturing.

**Unit-2: Digital Thread Implementation and Advanced Manufacturing Process Analysis:** Data integration and interoperability, cloud computing and edge computing in manufacturing, big data analytics for process optimization, advanced manufacturing process modeling and simulation, process monitoring and control using digital tools, statistical process control in a digital environment.

**Unit-3: Intelligent Machining and Advanced Manufacturing Enterprise:** Computer Numerical Control (CNC) programming and optimization, adaptive machining and real-time control, predictive maintenance and machine health monitoring, digital twins and virtual factories, enterprise resource planning (ERP) and manufacturing execution systems (MES) integration, supply chain digitalization.

**Unit-4: Cyber Security in Manufacturing:** Cybersecurity threats and vulnerabilities in manufacturing, network security and data protection, risk assessment and management, security standards and compliance, incident response and recovery.

**Unit-5: Model-Based Systems Engineering (MBSE) and Roadmap to Success in Digital Manufacturing & Design:** Introduction to MBSE concepts and methodologies, system modeling and simulation, requirements management and traceability, digital prototyping and validation, career paths in DM&D, developing a personal roadmap for professional growth, portfolio creation.

**Reference:**

1. Course “Digital Manufacturing & Design Technology Specialization” from Coursera offered by The State University of New York.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	2	1	-	-	-	2	-	-	1	1
<b>CO2</b>	3	3	3	-	-	1	-	1	3	3
<b>CO3</b>	3	3	2	-	1	1	-	1	2	2
<b>CO4</b>	3	3	3	-	-	1	-	1	3	3
<b>CO5</b>	2	1	-	-	2	3	1	-	1	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Skill Development Course from Coursera: Modern Robotics – Mechanics, Planning, and Control	<b>Course Code:</b>	SOE-B-ME706 (4)
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This course offers an in-depth study of modern robotics, focusing on the foundational principles and practical applications of robot motion, kinematics, dynamics, control, and manipulation. Students will learn to model, plan, and control robotic systems using mathematical tools and simulation software. The course emphasizes hands-on programming using Python, MATLAB, or Mathematica and employs the V-REP simulator for real-time robot modeling. This specialization prepares students for careers or advanced studies in robotics by combining theoretical understanding with applied problem-solving across six focused modules.

**Course Outcomes:**

After completion of the course students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand and model robot configurations, spatial motions, and C-space topologies.
<b>CO2</b>	Analyze and solve kinematic problems including forward and inverse kinematics of robotic systems.
<b>CO3</b>	Apply dynamic modeling techniques for simulation and control of robotic motion.
<b>CO4</b>	Design motion planning and real-time control strategies for robotic systems in complex environments.
<b>CO5</b>	Integrate robotic subsystems to perform mobile manipulation tasks using simulation and programming tools.

**Syllabus:**

**Unit-1: Foundations of Robot Motion:** Robot configuration and C-space, degrees of freedom, holonomic vs. non-holonomic constraints, representation of spatial velocities and forces (twists and wrenches).

**Unit-2: Robot Kinematics:** Forward kinematics using product-of-exponentials formula, velocity kinematics, statics and inverse kinematics.

**Unit-3: Robot Dynamics:** Forward and inverse dynamics, simulation of robot motion, trajectory generation under dynamic constraints.

**Unit-4: Motion Planning and Control:** C-space obstacles and path planning, graph-based and sampling-based planning methods, motion control and force control strategies, hybrid motion-force control.

**Unit-5: Manipulation, Mobile Robots, and Capstone:** Grasping and manipulation, wheeled mobile robot modeling and control, mobile manipulators, capstone project on mobile manipulation using KUKA youBot.

**Reference:**

1. Course “Modern Robotics: Mechanics, Planning, and Control Specialization” from Coursera offered by Northwestern University.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	-	-	1	-	-	3	2
<b>CO2</b>	3	3	3	-	-	1	-	-	3	3
<b>CO3</b>	3	3	3	-	-	1	-	-	3	3
<b>CO4</b>	3	3	3	-	-	2	-	-	3	3
<b>CO5</b>	3	3	3	2	2	2	-	-	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Skill Development Course from Coursera: Introductions to Robotics: Modeling, Control, and Path Planning	<b>Course Code:</b>	SOE-B-ME706 (5)
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This course provides a comprehensive introduction to foundational robotics concepts, including basic robotic behaviors, odometry, mapping, trajectory generation, path planning, and task execution. Students will model robotic mechanisms, sensors, and actuators in physics-based simulators, and will learn about reactive and discrete controllers. The course emphasizes kinematic computations for both holonomic and non-holonomic mechanisms, as well as feedback control techniques for inverse kinematics. Students will also explore probabilistic representations for dealing with uncertainty and will implement behavior trees for task execution in autonomous systems.

**Course Outcomes:**

After completion of the course students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Model and simulate robotic mechanisms, sensors, and actuators using physics-based simulators.
<b>CO2</b>	Perform forward and inverse kinematics computations for holonomic and non-holonomic robots.
<b>CO3</b>	Apply feedback control techniques to improve robot accuracy and task execution.
<b>CO4</b>	Use planning techniques and behavior trees for optimal path planning and task execution.
<b>CO5</b>	Implement autonomous mobile manipulation behaviors, integrating sensors and control systems for real-world applications.

**Syllabus:**

**Unit-1: Basic Robotic Behaviors and Odometry:** Modeling robotic mechanisms, sensors, and actuators in a physics-based simulator, understanding basic reactive and discrete controllers, performing forward kinematics computations for simple (non-) holonomic mechanisms.

**Unit-2: Robotic Mapping and Trajectory Generation:** Using feedback control techniques for inverse kinematics, applying coordinate transforms to multi-dimensional sensor signals, understanding probabilistic representations for managing uncertainty in measurements.

**Unit-3: Robotic Path Planning and Task Execution:** Using discrete planning techniques to compute optimal trajectories, implementing complex sequences of behaviors using behavior trees, planning and implementing a complex robotic controller for autonomous mobile manipulation.

**Unit-4: Advanced Robotic Control Techniques:** Developing advanced control algorithms for robots, implementing and tuning PID controllers, understanding real-time control strategies in autonomous systems.

**Unit-5: Autonomous Mobile Manipulation:** Developing autonomous mobile manipulation behaviors, integrating vision-based systems for task execution, implementing and testing behavior trees in real-world scenarios.

**Reference:**

1. Course “Introduction to Robotics with Webots Specialization” from Coursera offered by University of Colorado Boulder.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	3	2	-	-	1	-	-	3	3
<b>CO2</b>	3	2	3	-	-	1	-	-	3	2
<b>CO3</b>	3	3	3	-	-	2	-	-	3	3
<b>CO4</b>	3	3	3	-	-	2	-	-	3	3
<b>CO5</b>	3	3	3	2	2	2	-	-	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VII Sem
<b>Name of the Course:</b>	Skill Development Course from Coursera: Introductions to Robotics: Fundamentals of Robotics & Industrial Automation	<b>Course Code:</b>	SOE-B-ME706 (6)
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hrs. / week
<b>Max Marks:</b>	50		

**Course Description:**

This course introduces essential concepts and practical skills in collaborative robotics and industrial automation. Through three comprehensive modules, students will explore sensors and transducers, servo systems, and interfacing techniques in machine tools and robots. Topics include robotic manipulator design, gripper systems, PLC, and mechatronics system design. Students will develop proficiency in integrating mechanical components with digital control circuitry, learning simulation techniques using MATLAB-Simulink. This course caters to undergraduate and postgraduate students in Mechanical & Mechatronics Engineering and practicing engineers aiming to enhance their automation expertise.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand and apply the principles of sensors, transducers, and servo systems in robotic systems and machine tools.
<b>CO2</b>	Design and configure robotic manipulators and grippers for industrial applications.
<b>CO3</b>	Develop and integrate mechatronics systems, troubleshooting and optimizing robotic automation processes.
<b>CO4</b>	Simulate and model robotic systems using MATLAB-Simulink to validate design and performance.
<b>CO5</b>	Apply advanced automation techniques, including PLC and IoT, in real-world industrial settings.

**Syllabus:**

**Unit-1: Introduction to Robotics and Automation:** Overview of collaborative robotics and industrial automation, introduction to sensors, transducers, and servo systems used in machine tools and robots, basics of industrial manufacturing and mechatronics system design.

**Unit-2: Robotic Manipulator Design and Gripper Systems:** Design principles for robotic manipulators and gripper systems, basics of robot programming and interfacing, exploration of PLC systems in robotics and automation.

**Unit-3: Mechatronics System Design and Integration:** Fundamentals of mechatronics system design and optimization, integration of hardware and software in industrial automation, troubleshooting techniques for mechatronic systems.

**Unit-4: Simulation of Robotic Systems:** Use of MATLAB-Simulink for robotic system design and simulation, hands-on practice in simulating robotic movements and systems, validation of system performance through simulation.

**Unit-5: Advanced Robotic Applications and Automation Techniques:** Advanced topics in robotic applications and industrial automation, implementing automation technologies in real-world industrial settings, exploring future trends in collaborative robotics and automation.

**Reference:**

1. Course “Collaborative Robotics in Industry Specialization” from Coursera offered by L&T EduTech.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	-	-	1	-	-	3	2
<b>CO2</b>	3	2	3	-	-	1	-	-	3	2
<b>CO3</b>	3	3	3	1	-	2	-	-	3	3
<b>CO4</b>	3	3	3	-	-	2	-	-	3	3
<b>CO5</b>	3	3	3	-	2	2	-	1	3	3

**Note:** 1: Low 2: Moderate 3: High

**Scheme of Teaching and Examination**  
**B. Tech. in Mechanical Engineering (01UG040)**

**VIII- Semester**

S. No.	Course Code	BOS	Name of the Subject/Course	Periods per week			Scheme of Examination and Marks				Credit L+(T+P)/2
				L	T	P	PRE		ESE	Total	
							MID	TA			
1	SOE-B-ME801	ME	Computer-Aided Design and Manufacturing	3	0	0	30	20	50	100	3
2	SOE-B-ME802	ME	Professional Elective-II (Annexure-II)	3	0	0	30	20	50	100	3
3	SOE-B-ME803	ME	Professional Elective-III (Annexure-III)	3	0	0	30	20	50	100	3
4	SOE-B-ME804	ME	CAD/CAM Lab	0	0	2	0	15	10	25	1
5	HUM-B-SOE801	ME	Professional Development-II	0	0	2	0	15	10	25	1
6	SOE-B-ME805	ME	Major Project	0	0	20	0	150	100	250	10
			<b>TOTAL</b>	<b>09</b>	<b>0</b>	<b>24</b>	<b>90</b>	<b>240</b>	<b>270</b>	<b>600</b>	<b>21</b>

L: Lecture    T: Tutorial    P: Practical    ESE: End Semester Examination    T.A: Teacher's Assessment.    PRE- Progressive Review Examination



**Professional Elective-II (Mech Annexure - II)**

<b>S. No.</b>	<b>Course Code</b>	<b>Board of Study</b>	<b>Name of the Subject/Course</b>
1	SOE-B-ME802 (1)	Mechanical	Subject related to Robotics & Automation through MOOCS
2	SOE-B-ME802 (2)	Mechanical	Subject related to Advanced Manufacturing through MOOCS
3	SOE-B-ME802 (3)	Mechanical	Subject related to Advanced Thermal Engineering through MOOCS
4	SOE-B-ME802 (4)	Mechanical	Product Design and Development
5	SOE-B-ME802 (5)	Mechanical	Composite Materials
6	SOE-B-ME802 (6)	Mechanical	Introduction to Stainless Steel
7	SOE-B-ME802 (7)	Mechanical	Innovation, Entrepreneurship, and Leadership

**Professional Elective-III (Mech Annexure - III)**

<b>S. No.</b>	<b>Course Code</b>	<b>Board of Study</b>	<b>Name of the Subject/Course</b>
<b>1</b>	SOE-B-ME803 (1)	Mechanical	Subject related to Robotics & Automation through MOOCS
<b>2</b>	SOE-B-ME803 (2)	Mechanical	Subject related to Advanced Manufacturing through MOOCS
<b>3</b>	SOE-B-ME803 (3)	Mechanical	Subject related to Advanced Thermal Engineering through MOOCS
<b>4</b>	SOE-B-ME803 (4)	Mechanical	Process Planning and Cost Estimation
<b>5</b>	SOE-B-ME803 (5)	Mechanical	Industrial Engineering and Production Management
<b>6</b>	SOE-B-ME803 (6)	Mechanical	Energy Conservation and Management
<b>7</b>	SOE-B-ME803 (7)	Mechanical	TQM and Reliability Engineering



<b>Program:</b>	B. Tech.	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Computer-Aided Design and Manufacturing	<b>Course Code:</b>	SOE–B–ME801
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

In this course, the student will be familiarized with parametric fundamentals to create and manipulate geometric models using curves, surfaces, and solids. The student will get exposure to CAD tools for use in mechanical engineering design conceptualization, geometric modelling, communication, analysis and optimization. The knowledge is also imparted in recent advances in the computer aided manufacturing.

**Course Outcomes:** After completion of the course students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Recognize various types of curves, surfaces, and solids with their respective applications in geometric modeling.
<b>CO2</b>	Understand the concept of parametric modeling.
<b>CO3</b>	Plan and execute the production activity control on the shop floor.
<b>CO4</b>	Generate and verify tool path and NC programs for milling/drilling processes.
<b>CO5</b>	Skillfully use modern engineering tools and techniques for Mechanical Engineering design, analysis, and application.

**Syllabus:**

**Unit-1: Computer Graphics:** Introduction to computer aided design, computer graphics module, transformations–introduction, formulation, translation, rotation, scaling and reflection, homogeneous representation, concatenated transformation, mapping of geometric models, inverse transformations. projections: orthographic and isometric.

**Unit-2: Modelling:** Curves - introduction, analytic curves - line, circle, ellipse, parabola, hyperbola. synthetic curves -Hermite cubic spline, Bezier curve, B-spline curve, numericals on line, circle, ellipse, and Hermite cubic spline, surfaces–introduction, surface representation, analytic surfaces, synthetic surfaces, Hermite bicubic surface, Bezier surfaces, B-spline surfaces, Coons surface (no analytical treatment), solids: introduction, geometry and topology, solid representation, boundary representation, Euler's equation, constructive solid geometry, Boolean operation for CSG, hybrid modeling, feature based modeling, parametric modeling, constraint based modeling, mass, area, volume calculation.

**Unit-3: Computer Aided Manufacturing:** Introduction to computer aided manufacturing, CNC programming, CNC part programming adaptable to FANUC controller, steps in developing CNC part program, CNC part programming for lathe machine - threading & grooving cycle (canned cycle), CNC part programming for milling machine – linear & circular interpolation, milling cutter, tool length compensation & cutter radius compensation, pocketing, contouring & drilling, subroutine, and do loop using canned cycle.

**Unit-4: Group Technology:** Introduction to group technology, part families, parts classification & coding, three parts classification & coding system, group technology machine cells, benefits and limitations of group technology.

Computer integrated manufacturing (CIM) system, Introduction of computer aided process planning, flexible manufacturing system, types, advantages, limitations.

**Unit-5: Advanced Manufacturing Method:** Introduction to rapid prototyping (RP), classification of RP processes, working principle, models & specification process, application, advantages & disadvantages & case study of stereo lithography apparatus (SLA), laminated object manufacturing (LOM), selective laser sintering (SLS), 3D printing, fused deposition modeling (FDM), rapid tooling and STL format.

**Text Books:**

1. Ibrahim Zeid and Sivasubramanian, CAD/CAM Theory and Practice, TMH.
2. P. N. Rao, CAM/CAD Principle & Applications – TMH.

**Reference Books:**

1. Milkell P. Groover and Emory W. Zimmer, CAD/CAM, Pearson Education.
2. Lalitnarayan, Computer Aided Design & Manufacturing, PHI.
3. N. Krishnamoorthy, Introduction to Computer Graphics, TMH.
4. T. Jeyapooan and Robert Quesada, Computer Numeric Control, Pearson Education.
5. Surendra Kumar and A. K. Jha, CAD/CAM, Dhanpat Rai.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
CO1	3	3	1	2	-	-	2	-	2	2
CO2	3	3	2	2	-	-	2	-	2	2
CO3		2	2	2	2	1	-	1	2	2
CO4	1	3	2	3	1	1	-	-	3	3
CO5	2	3	3	1	-	-	-	-	3	3

**Note:** 1: Low 2: Moderate 3: High



<b>Program:</b>	B. Tech.	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Computer Aided Design and Manufacturing (CAD/CAM) Lab	<b>Course Code:</b>	SOE-B-ME804
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hrs. / week
<b>Max Marks:</b>	25		

**Course Description:**

This course provides hands-on experience in Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM). Students will learn to create 2D drawings and 3D solid models using CAD software, perform geometric transformations and structural analysis. The CAM section focuses on CNC machine operation, part programming for turning, drilling, and milling, NC code generation using CAM software, 3D printing, and demonstrations of advanced CNC machines.

**Course Outcomes:** After completion of the course students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Execute steps required for modeling 3D objects by using protrusion, cut, sweep, and extrude commands.
<b>CO2</b>	Convert 3D solid models into 2D drawings–different views, sections.
<b>CO3</b>	Skills to program and operate CNC machines to machine simple components.
<b>CO4</b>	Use CAM software to generate NC code.
<b>CO5</b>	Ability to develop a product from conceptualization to reality.

**List of Experiments:**

(Minimum ten experiments are to be performed by each student)

**A. CAD Experiments**

1. Line drawing or circle drawing experiment: writing and validation of computer program.
2. Geometric transformation algorithm experiment for translation/rotation /scaling: writing and validation of computer program.
3. Understanding and use of any 3–D modeling software commands.
4. Experiment: solid modeling of a machine component using advanced–modeling software.
5. Structural analysis experiment using FEM software.

**B. CAM Experiments**

1. To study the characteristic features of CNC machine.
2. Part programming (in word address format) experiment for turning operation (including operations such as grooving and threading) and running on CNC machine

3. Part programming (in word address format or ATP) experiment for drilling operation (point to point) and running on CNC machine
4. Part programming (in word address format or ATP) experiment for milling operation (contouring) and running on CNC machine.
5. To study CAM software to generate NC code.
6. Design and fabricate the product using 3D printer.
7. Demonstration of CNC laser cutting machine.
8. Demonstration on 4-axis CNC machine.

### CO, PO, & PSO Correlation

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	3	2	1	-	1	1	1	2	3
<b>CO2</b>	3	3	2	-	-	1	1	1	3	2
<b>CO3</b>	3	3	2	2	-	2	2	2	2	2
<b>CO4</b>	3	3	2	2	-	2	2	2	2	2
<b>CO5</b>	2	3	3	2	2	2	1	1	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Product Design and Development	<b>Course Code:</b>	SOE–B–ME802 (4)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

Product Design and Development is a project-based course that covers modern tools and methods for product design and development. The focus of Product Design and Development is integration of the marketing, design, and manufacturing functions of the firm in creating a new product.

**Course Outcomes:** After completion of the course students will be able to:

CO Number	Course Outcomes
<b>CO1</b>	Describe the characteristics used for product design and development.
<b>CO2</b>	Assess the customer requirements in product design.
<b>CO3</b>	Apply structural approach to concept generation, selection and testing.
<b>CO4</b>	Identify various aspects of design such as industrial design, design for manufacture, assembly, service and quality and product architecture.
<b>CO5</b>	Apply principles of prototyping in product development economics and highlight importance of managing projects.

**Syllabus:**

**Unit-1: Introduction:** Characteristics of successful product development, design and development of products, duration and cost of product development, the challenges of product development.

**Development Processes and Organizations:** A generic development process, concept development: the front-end process, adopting the generic product development process, the AMF development process, product development organizations, the AMF organization.

**Unit-2: Identifying Customer Needs:** Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process.

**Product Specifications:** What are specifications, when are specifications established, establishing target specifications, setting the final specifications.

**Concept Generation:** The activity of concept generation, clarifies the problem, search externally, search internally, explore systematically, reflect on the results and the process.

**Unit-3: Concept Selection:** Overview of methodology, concept screening, and concept scoring, Concept Testing: Define the purpose of concept test, choose a survey population, choose a survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process.

**Unit-4: Industrial design:** Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process, assessing the quality of industrial design.

**Prototyping:** Prototyping basics, principles of prototyping, technologies, planning for prototypes.

**Unit-5: Product Development Economics:** Elements of economic analysis, base case financial mode, Sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis.

**Legal and Ethical Issues in ED:** Patents and intellectual property, legal and ethical issues in engineering design, origin of laws, contracts, liability, codes of ethics, ethical conflicts.

**Text Books:**

1. Karl. T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw Hill.
2. Bralla J. G., Handbook of Product Design for Manufacture, McGraw Hill.

**Reference Books**

1. A. C. Chitale and R. C. Gupta, Product Design and Manufacturing, PHI.
2. Tim Jones and Butterworth Heinmann, New Product Development, UCI.
3. Geoffery Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacture and Assembly, CRC Press Inc.
4. N. J. M. Roozenberg, J. Ekels and N. F. M. Roozenberg, Product Design Fundamentals and Methods. John Willey & Sons.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcome								PSO	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	2	1	-	-	-	1	-	-	1	1
<b>CO2</b>	2	2	1	-	-	1	-	1	1	1
<b>CO3</b>	3	2	2	-	1	1	-	-	2	1
<b>CO4</b>	3	1	2	-	-	1	-	1	2	1
<b>CO5</b>	2	1	3	-	2	1	-	-	1	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Composite Materials	<b>Course Code:</b>	SOE–B–ME802 (5)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course is designed for students as an introductory course to composite materials. It introduces the concepts of characterization and classification of composites, methods of composite strengthening and manufacturing, mechanics and mechanical performance of composites under loading, composite laminates, and development in composites.

**Course Outcomes:** After completion of the course students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Identify and explain the types of composite materials and their characteristic features.
<b>CO2</b>	Understand and explain the methods employed in composite fabrication.
<b>CO3</b>	Identify and understand the basic mechanical behaviour of composite materials and make sound prediction on the likely behaviour of new combinations of materials.
<b>CO4</b>	Understand the differences in the strengthening mechanism of composite laminates and its corresponding effect on performance and applications.
<b>CO5</b>	Analyse the micromechanical properties of fiber-reinforced composites.

**Syllabus:**

**Unit-1: Introduction:** Definitions, overview of composite materials, need, reinforcements and matrices, types of reinforcements, types of matrices, types of composites: polymer matrix composites (PMC), metal matrix composites (MMC), ceramic matrix composites (CMC), carbon fibre composites, properties of composites in comparison with standard materials, nano-fillers used in polymer composites, applications of metal, ceramic and polymer matrix composites.

**Unit-2: Manufacturing Methods:** Open and closed molding methods: hand lay-up processes, spray up processes, compression moulding, injection molding, resin injection, filament winding, resin transfer moulding, pultrusion, fibre/matrix interface, mechanical measurement of interface strength. characterization of systems; carbon fibre/epoxy, glass fibre/polyester.

**Unit-3: Mechanics of Composite Materials:** Continuous fibres - iso-stress and iso-strain conditions, discontinuous fibres, nature of stress vs strain curves for different composite materials. mechanical properties: stiffness and strength, geometrical aspects-volume and weight fraction. unidirectional continuous fibre, discontinuous fibers, short fiber systems, woven reinforcements, mechanical testing of composites: determination of stiffness and strengths of unidirectional composites; tension, compression, flexure and shear.

**Unit-4: Composite Laminates:** Plate stiffness and compliance, assumptions, strains, stress resultants, plate stiffness and compliance, computation of stresses, types of laminates, symmetric laminates, antisymmetric laminate, balanced laminate, quasi-isotropic laminates, cross-ply laminate, angle ply laminate. orthotropic laminate, laminate moduli, hydrothermal stresses.

**Unit-5: Recent Developments in Composites:** Self-healing composites, molecular composites, micro and nanocomposites, bio composites, left-handed composites, stiffer than stiff composites, carbon/carbon composites, advantages and limitations of carbon matrix.

**Text books:**

1. K. K. Chawla, Composite materials, Springer.
2. Mein Schwartz, Composite Materials Handbook, McGraw Hill.
3. Autar K. Kaw, Mechanics of Composite Materials, CRC Press.

**Reference Books:**

1. Mathews F. L. and Rawlings R. D., Composite materials: Engineering and Science, Chapman and Hall.
2. A. B. Strong, Fundamentals of Composite Manufacturing, SME.
3. S. C. Sharma, Composite materials, Narosa Publications.
4. P. K. Mallick, Composite Materials Technology: Process and Properties, Hanser.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	1	1	1	1	1	-	2	3	1
<b>CO2</b>	2	3	2	1	1	1	-	2	3	3
<b>CO3</b>	3	3	3	2	2	2	-	3	3	3
<b>CO4</b>	3	2	3	2	1	1	-	3	2	2
<b>CO5</b>	3	3	2	1	1	2	-	2	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Introduction to Stainless Steel	<b>Course Code:</b>	SOE-B-ME802 (6)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Descriptions:**

This course is an industry-linked course. Department used to conduct this course in association with Jindal Stainless Steel (JSL), Hissar, Haryana. This course is relevant to the steel industry practices and lectures being delivered by the eminent Industrial Professionals of JSL, Hissar, Haryana. Students used to gain the knowledge through direct interactions with the steel professionals and also develop their skills in work ethics, communication and management aspects.

**Course Outcomes:** After Completion of the course, Students will be able to

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Distinguish between various stainless steels
<b>CO2</b>	Have an increased level of awareness towards stainless steel and their applications
<b>CO3</b>	Have fundamental understanding of the phase transformations in ferrous alloys.
<b>CO4</b>	Apply their basic understanding in development of alloys with better properties.
<b>CO5</b>	Distinguish between various stainless steels

**Syllabus:**

*This Course is solely designed by the JSL, Hissar, Haryana and delivered accordingly.*

**Unit-1: Stainless Steel (SS) making process:** complete overview, advancements in technology, if any. Family tree of SS, major grades, functions of alloying elements and their impact on mechanical properties of SS, cost implications of alloy addition and using substitutes, phase transformations in Stainless Steel, secondary phase transformations, mechanism of phase transformation and its effect on properties of SS.

**Unit-2: Stainless Steel fabrication:** Hot rolling, cold rolling, shearing, cold roll forming (CRF), process mechanism, tools and equipment, issues faced during fabrication of stainless steel and

their solutions, corrosion in stainless steel, galvanic corrosion, mechanism and prevention, pitting corrosion: mechanism and prevention, PREN, crack propagation mechanisms, inter–granular and trans–granular.

**Unit-3: Welding of Stainless Steel:** Sensitization/Weld decay: causes, mechanisms, remedies, high temperature sensitization, 475 embrittlement,  $\alpha'$  phase transformation, distortion: causes, mechanisms, remedies, effect of alloying elements on weldability of SS, Schaeffler De Long diagram interpretations: Cr, Ni and C equivalent.

**Unit-4: Testing of Stainless Steel:** PMI technique, other NDT methods, handling and storage of stainless steel, recommended procedures for storage.

**Unit-5: Applications of stainless steel in various segments:** current applications of SS grades, conversion of components into SS and reasons for the same.

**Text Books:**

1. Ghosh, Principle & Applications of Secondary Steelmaking, CRC Press.
2. Ahindra Ghosh and Amit Chatterjee, Ironmaking and Steelmaking Theory and Practice, Prentice–Hall of India Private Limited.
3. R H Tupkary, An Introduction to Modern Steel Making, Khanna Publication.

**Reference Books:**

1. Ghosh, Principles of Secondary Processing and Casting of Liquid Steel, Oxford & IBH Publication.
2. E.T. Tukdogan, Fundamentals of steel making.
3. Kurdin, Steel making, Mir Publishers.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcome								PSO	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	-	2	1	–	–	2	–	–	2	–
<b>CO2</b>	1	3	2	–	–	2	–	–	2	2
<b>CO3</b>	1	3	2	–	–	2	–	–	2	2
<b>CO4</b>	1	3	2	–	–	2	–	–	2	2
<b>CO5</b>		2	1	–	–	2	–	–	2	–

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Innovation, Entrepreneurship, and Leadership	<b>Course Code:</b>	SOE–B–ME802 (7)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Descriptions:**

This course aims to provide students with an understanding of the nature of enterprise and entrepreneurship and introduces the role of the entrepreneur, innovation and technology in the entrepreneurial process. It also outlines the theoretical foundations of the concept of Leadership through a thorough review of leadership theories and provides students with the opportunity to understand what it takes to influence and empower others.

**Course Outcomes:** After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Discuss the attitudes, values, characteristics, behaviour, and processes associated with possessing an entrepreneurial mindset and engaging in successful appropriate entrepreneurial behaviour.
<b>CO2</b>	Starting innovative practices in their entrepreneurial activities.
<b>CO3</b>	Developing their skills on the traits that they want to carry forward
<b>CO4</b>	Understand the concept of leadership and leading.
<b>CO5</b>	Develop critical thinking and problem-solving attitude.

**Syllabus**

**Unit-1: Conceptualizing Innovation:** Innovation– an abstract concept; creativity, innovation and imagination; types of innovation –classified According to products, processes or business organizations.

**Unit-2: Entrepreneurial Skills:** Entrepreneurship: who is an entrepreneur? Entrepreneurship– A state of Mind, Emergence of the entrepreneur; Role of Entrepreneur; A Doer, not a Dreamer– Characteristics of an entrepreneur; Factors affecting entrepreneurial growth – Social, cultural, personality factors, psychological and Social Factors. Impact of Entrepreneurship for sustainable development.

**Types of Entrepreneurs:** Difference between entrepreneur and entrepreneurship, Difference between entrepreneur and intrapreneur, Common Entrepreneurial competencies/Traits;

Entrepreneurship stimulants, Obstacles inhibiting Entrepreneurship; Types of entrepreneurs, Functions of an entrepreneur.

**Unit-3: Analyzing Strengths, Weaknesses, Opportunities, and Threats:** Identification of Business Opportunities: Introduction, Sources of Business of Product Ideas, Steps in Identification of Business opportunity and its SWOT Analysis.

**Developing Entrepreneurial project:** Techno–Economic Feasibility of the project: Introduction, Techno–Economic feasibility of the Project, Feasibility Report, Considerations while preparing a Feasibility Report, Proforma of Feasibility Report, Role of Institutions and entrepreneurship.

**Unit-4: Foundations of Leadership:** Introduction to Leadership Studies Overview and approaches to Leadership Studies Theories in leadership Definition and understanding of key terms: leadership, leading, leader, difference between manager and leader, difference between hero and leader.

**Unit-5: Challenges in Leadership:** Issues in Leadership Basic issues in leading like role of emotions and passions, problems in decision making, ethics and values etc. Why good leaders fail? Is ethical leading successful? Contemporary leadership and leaders.

**Text Books:**

1. Bellon & Whittington, Competing through Innovation, Prentice Hall of India.
2. David Oates, A Guide to Entrepreneurship, JAICO Publishing House.
3. Ajith Kumar, Entrepreneurship Management and Development, HPH
4. Manikutty, S. and S.P. Singh, Essence of Leadership: Explorations from Literature, Macmillan.

**Reference Books:**

1. Rober D Hisrich, Peters, Shepherd, Entrepreneurship, TMH
2. Coulter, Entrepreneurship in Action, Prentice Hall of India
3. Mohanty, Fundamentals of entrepreneurship, PHI
4. Jack M Kaplan, Patterns of Entrepreneurship, Wiley, student Edition MS skills.
5. Antonakis, J., A.T. Cianciolo and R.J. Sternberg, The Nature of Leadership, Sage.
6. Bennis, Warren G. –Cambridge, On Becoming a Leader, Perseus,
7. Goleman, D. –Harvard, What Makes a Leader? By Business Review 11 (1998): 93–102.

**CO, PO, & PSO Correlation**

<b>Course Outcomes</b>	<b>Program Outcomes</b>								<b>PSOs</b>	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2		2	2	2	2	3	3	3
<b>CO2</b>	2	2	3	2	3	2	2	2	2	3
<b>CO3</b>	2	2	3	2	-	-	-	-	3	2
<b>CO4</b>	3	2	-	2	2	2	2	2	3	2
<b>CO5</b>	-	3	3	2	2	2	2	2	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Process Planning and Cost Estimation	<b>Course Code:</b>	SOE–B–ME803 (4)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

The course is intended to understand the basic concepts of process planning and estimation and apply different methods of cost estimation in different manufacturing shops and learn the concepts of process planning and cost estimation in competitive manufacturing systems and organizations.

**Course Outcomes:** After completion of the course students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Select the process, equipment and tools for various industrial products.
<b>CO2</b>	Prepare process planning activity chart.
<b>CO3</b>	Explain the concept of cost estimation.
<b>CO4</b>	Compute the job order cost for different type of shop floor.
<b>CO5</b>	Calculate the machining time for various machining operations

**Syllabus**

**Unit-1: Introduction to Process Planning:** Aims and objectives, place of process planning in manufacturing cycle, drawing interpretation, dimensional tolerance vs production processes, study of various process plans for a product from manufacturing industries.

**Unit-2: Process Planning Steps:** Design of a process plan - selection of production processes, tools and process parameters - positioning and work holding devices, selection of inspection devices and tools, documenting the process plan, simple case studies, computer-aided process planning (CAPP) - benefits, architecture and approaches, preparation of process planning sheet for new product design.

**Unit-3: Introduction to Cost Estimation:**

Importance, Types, Purpose, Components, Procedure, Classification of costs, Cost elements, Ladder of cost – Material cost Determination of direct material cost – Labour cost, Determination of direct labour cost– over heads – classification of overhead expenses Depreciation– Methods of depreciation – Allocation of overhead expenses, Break–even analysis. Study on elements of cost in a manufacturing sector and their analysis.

**Unit-4: Production Cost Estimation:** Estimation of production cost for - casting processes, estimation in welding shop - arc welding - gas welding - flame cutting - estimation of metal forming–forging - forging losses - estimation in foundry shop - moulding - pattern making. manufacturing cost estimation of welding processes, - manufacturing cost estimation of foundry processes shop.

**Unit-5: Estimation of Machining Time and Cost:** Estimation of machining time - lathe operations, drilling, milling, shaping and planning, and grinding, cost estimation for machining processes machining time and cost calculation of shaping process, machining time and cost calculation of welding process, machining time and cost calculation of milling process, machining time and cost calculation of drilling process.

**Text Books:**

1. Peter Scalon, Process planning, Design/Manufacture Interface, Elsevier Science Technology Books.

**Reference Books:**

1. P. F. Ostwalal and J. Munez, Manufacturing Processes and systems, John Wiley.
2. R. S. Russell and B. W. Taylor, Operations Management, PHI.
3. A. V. Chitale and R. C. Gupta, Product Design and Manufacturing, PHI.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	2	1	3	2	3	2	2	2	3	3
<b>CO2</b>	2	2	3	3	3	2	-	-	2	3
<b>CO3</b>	3	2	2	3	3	-	-	-	3	2
<b>CO4</b>	2	3	2	3	3	2	-	2	2	2
<b>CO5</b>	2	3	3	3	3	2	-	2	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	B. Tech.	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Industrial Engineering and Production Management	<b>Course Code:</b>	SOE–B–ME803 (5)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Description:**

This course describes the broad scope of areas in which industrial engineers are engaged, including areas that became part of industrial engineering (IE) in recent decades such as work measurement, work design, ergonomics, production and productivity, site selection and plant layout, supply chain management.

**Course Outcomes:** After completion of the course students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Get familiar with the basic aspects of Industrial engineering, production and productivity measurement.
<b>CO2</b>	Understand and apply the concept of Work study and Method study in the industry.
<b>CO3</b>	Understand the plant layout and apply the concept of Time study in the industry.
<b>CO4</b>	Understand and apply the concept of production system and production management.
<b>CO5</b>	Know the recent trends like project management, material requirement planning (MRP I), manufacturing resources planning (MRP II), ERP, and supply chain management.

**Syllabus:**

**Unit-1: Introduction to Industrial Engineering:** Definition, history, and development of industrial engineering, industrial engineering approach, objectives, functions & techniques of industrial engineering, place of the industrial engineering department in the organization, system approach.

**Productivity:** Concept and definition of productivity, production and productivity, benefits from productivity, productivity measures, advantages and limitations of productivity measures, factors influencing productivity, productivity improvement techniques.

**Unit-2: Work–Study:** Introduction, importance & advantages, procedure, work simplifications, human considerations, work study & management, time study on production activities, concept of work content, reasons for excess work content, techniques to reduce work content, work study as a tool to improve productivity.

**Method–Study:** Introduction, objectives, scope of method–study, steps involved in method–study, selection of jobs for method–study, recording techniques, micro motion study, critical examinations, development and selection of new methods, principle of motion economy.

**Unit-3: Plant Location and Layout:** Introduction, need for selecting a suitable location, plant location problems. definition, objectives, principles of plant layout, types of manufacturing systems, types of layouts, tools and techniques of plant layout.

**Work Measurement/Time Study:** Definition, objectives, and techniques of work measurement. time study equipment, performance rating, allowances, computation of standard time, work sampling, synthetic data, predetermined motion time analysis (PMTS).

**Unit-4: Production System:** Introduction, production and production management, objectives, functions and scope of production management, production management framework, relationship of production with other functional areas.

**Demand Forecasting:** Introduction, forecasting and prediction, need of demand forecasting, long-term and short-term forecast, classification of forecasting methods, judgmental techniques, time study analysis, least square methods, moving average method.

**Unit-5: Project Management and MRP:** Introduction, project concept and definition, characteristics of projects, project identifications, sources of projects ideas, project management phases and project appraisal, tools and techniques of project management, material requirement planning (MRP), manufacturing resources planning (MRP II), enterprise resource planning (ERP).

**Logistics:** types and strategies, supply chain management, objectives and decision phases of supply chain, management roles, and development in supply chain management.

**Text Books:**

1. O.P. Khanna, Industrial Engineering and Management – Dhanpat Rai Publications.
2. Hajra and Choudhury, Production Management, M. P. Publishers.
3. Heizer, Operations Management, Pearson.
4. Samuel Eilon, Elements of Production Planning and Control, McMillan.

**Reference Books:**

1. Philip E. Hicks, Industrial Engineering & Management A new perspective, McGraw Hill.
2. H. Koonz and H. Weihrich, Company Essential of Management, McGraw Hill.
3. Sushil, Flexibility in Management, Vikas Publication.
4. Luthans Fred, Human Resource Management, McGraw Hill.
5. Y. K. Bhusan, Fundamentals of Business Organizations and Management, S. Chand.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	2	2	3	2	-	-	-	1	3	1
<b>CO2</b>	2	3	2	-	2	-	2	1	3	2
<b>CO3</b>	3	-	3	-	-	-	-	-	3	1
<b>CO4</b>	2	-	1	3	3	2	-	-	2	3
<b>CO5</b>	2	3	2	-	-	3	-	-	2	2



<b>Program:</b>	B. Tech.	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Energy Conservation and Management	<b>Course Code:</b>	SOE–B–ME803 (6)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hrs. / week
<b>Max Marks:</b>	100		

**Course Descriptions:**

This course provides a comprehensive understanding of energy management, efficiency, and sustainability. It covers energy auditing, financial and project management, and global environmental concerns. Students will explore thermal and electrical energy efficiency, performance assessment of energy systems, and renewable energy applications. Emphasis is placed on waste minimization and conservation strategies to promote sustainable energy solutions.

**Course Outcomes:**

After completion of the course students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand energy management principles, conservation strategies, and auditing techniques for optimizing industrial and commercial energy use.
<b>CO2</b>	Analyze and improve the efficiency of thermal utilities like boilers, furnaces, cogeneration, and waste heat recovery systems.
<b>CO3</b>	Evaluate and implement energy-efficient technologies in electrical systems, motors, HVAC, pumps, and lighting.
<b>CO4</b>	Assess the performance of industrial energy systems and propose optimization strategies for enhanced efficiency.
<b>CO5</b>	Apply financial analysis and renewable energy solutions for sustainable energy management and waste minimization.

**Syllabus**

**Unit-1: Energy Management & Audit:** Energy scenario, basics of energy and its various forms, energy conservation and its importance, energy management and audit, material and energy balance, energy action planning, financial management, project management, global environmental concerns, energy strategy for the future.

**Unit-1: Thermal Energy Efficiency**

Energy efficiency in thermal utilities, fuels and combustion, boilers, steam systems, furnaces, insulation and refractory, FBC boilers, cogeneration, waste heat recovery.

**Unit-3: Electrical Energy Efficiency**

Energy Efficiency in electrical utilities, electrical systems, electric motors compressed air systems, HVAC and refrigeration systems, fans and blowers, pumps, cooling tower, lighting systems, energy efficient technologies in electrical systems.

**Unit-4: Energy Performance Assessment:** Energy performance assessment for equipment and utility systems, boilers, furnaces, cogeneration, turbines (gas, steam), heat exchangers, electric motors and variable speed drives, fans and blowers, water pumps, and compressors.

**Unit-5: Renewable Energy & Sustainability:** HVAC Systems, lighting systems, performing financial analysis, applications of non-conventional and renewable energy sources, waste minimization and conservation.

**Text Books:**

1. Barney L. Capehart, Wayne C. Turner and William J. Kennedy, Guide to Energy Management, The Fairmont Press Inc.
2. Albert Thumann, Handbook of Energy Audits, The Fairmount Press.
3. G. G. Rajan, Optimizing Energy Efficiencies in Industry, Tata McGraw Hill.
4. Wayne C. Turner, Energy Management Hand Book, The Fairmount Press.
5. Charles M. Gottschalk, Industrial Energy Conservation, John Wiley and Sons.
6. Craig B. Smith, Energy Management Principles, Pergamon Press.

**Reference Books**

1. Dale R. Patrick and Stephen W. Fardo, Energy Conservation Guidebook, CRC Press.
2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management and Case Study, Hemisphere Publishers.
3. C. W. Gellings and J. H. Chamberlin, Demand-Side Management Planning, Fairmount Press.
4. Wayne C. Turner, Energy Management Handbook, The Fairmount Press.
5. Bureau of Energy Efficiency Study Material for Energy Managers and Auditors Examination.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	3	3	2	3	2	-	2	3	2
<b>CO2</b>	3	1	2	2	1	1	-	1	2	2
<b>CO3</b>	2	2	3	2	-	-	-	2	2	1
<b>CO4</b>	3	2	-	-	2	2	1	2	1	2
<b>CO5</b>	2	2	2	1	2	3	1	-	1	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program</b>	B. Tech	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	TQM and Reliability Engineering	<b>Course Code:</b>	SOE-B-ME803 (7)
<b>Credits:</b>	3	<b>No of Hours:</b>	3Hr./Week
<b>Max Marks:</b>	100		

**Course Description:**

This course introduces students to the principles and practices of Total Quality Management (TQM) and Reliability Engineering. It emphasizes quality philosophies, quality improvement tools, statistical techniques, and system reliability modeling. The course equips students with the skills to improve manufacturing and service quality, apply reliability concepts in product design, and implement robust quality and reliability management systems in industries.

**Course Outcomes:**

After completion of the course, students will be able to

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Explain the fundamental concepts of TQM and the philosophies behind quality management.
<b>CO2</b>	Apply various quality improvement tools and statistical techniques for quality control.
<b>CO3</b>	Understand and evaluate system reliability and failure analysis methods.
<b>CO4</b>	Analyse and interpret process capability and implement quality planning and cost control.
<b>CO5</b>	Integrate quality and reliability strategies in industrial and engineering problem-solving.

**Syllabus:**

**Unit-1: Introduction to Total Quality Management (TQM):** Definition and Importance of TQM; Evolution and History of Quality. Key Concepts of TQM: Customer focus, Continuous improvement, Employee involvement. Quality Philosophies: Contributions of Deming (14 Points, PDCA), Juran (Quality Trilogy), and Crosby (Zero Defects). Quality Planning, Control, and Improvement frameworks.

**Unit-2: Quality Tools and Techniques:** Seven Basic Quality Tools: Check Sheet, Histogram, Pareto Chart, Cause & Effect Diagram, Control Charts, Scatter Diagram, Flow Charts – interpretation and applications. Advanced Quality Tools: Affinity diagram, Interrelationship

diagram, Tree diagram, Matrix diagram, Arrow diagram, Process decision program chart (PDPC), Activity network diagram. Quality Function Deployment (QFD): House of quality, Voice of customer to engineering characteristics. Six Sigma Methodology: DMAIC and DMADV, Statistical tools in Six Sigma, Project selection and implementation.

**Unit-3: Reliability Engineering Fundamentals:** Definition and Concept of Reliability, Availability, Maintainability (RAM). System Modelling and Analysis: Series, Parallel, Redundant systems. Reliability Metrics: MTBF, MTTR, Hazard Rate, Bathtub Curve. Reliability Block Diagram (RBD) and Fault Tree Analysis (FTA). Failure Data Analysis: Censoring, Probability distributions (Exponential, Weibull, Normal), and Estimation techniques.

**Unit-4: Failure Mode and Effect Analysis (FMEA) and Maintenance Engineering:** FMEA: Purpose, Procedure, Risk Priority Number (RPN), Design and Process FMEA. Failure Modes, Causes, and Effects: Analysis for mechanical components. Root Cause Analysis (RCA): 5-Why Method, Fishbone Diagram. Types of Maintenance: Corrective, Preventive, Predictive, Condition-based. Total Productive Maintenance (TPM): Pillars of TPM, Implementation methodology, OEE (Overall Equipment Effectiveness).

**UNIT-5: Reliability Testing and Risk Assessment:** Accelerated Life Testing (ALT): Types (Step, Constant, Cyclic), test planning. Stress-Strength Analysis: Reliability under variable conditions. Reliability Growth Testing, Reliability Centered Maintenance (RCM). Risk Assessment Techniques: Risk matrix, HAZOP (Hazard and Operability Study), FTA in Risk Assessment. Case Studies: Real-time applications in manufacturing industries, Aerospace, Automotive, and Service sectors.

**Textbooks:**

1. Besterfield, D. H., Total Quality Management, Pearson Education.
2. Mahajan, M., Statistical Quality Control, Dhanpat Rai & Co.
3. Modarres, M., Reliability Engineering and Risk Analysis, CRC Press.

**Reference Books:**

1. Juran, J. M. & Godfrey, A. B., Juran's Quality Handbook, McGraw Hill.
2. Logothetis, N., Managing for Total Quality, Prentice Hall.
3. Kapoor, K. C. & Lamberson, L. R., Reliability in Engineering Design, Wiley.
4. Montgomery, D. C., Introduction to Statistical Quality Control, Wiley.
5. Mitra, A., Fundamentals of Quality Control and Improvement, Pearson.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	1	1	2	3	2	3	2
<b>CO2</b>	3	3	3	2	2	2	2	2	3	3
<b>CO3</b>	3	3	3	1	1	2	2	2	3	3
<b>CO4</b>	3	3	3	2	2	2	3	3	3	3
<b>CO5</b>	3	3	2	2	2	3	3	3	3	3

Note:1: Low 2.: Moderate 3: High

<b>Program</b>	B. Tech	<b>Semester:</b>	VIII Sem
<b>Name of the Course:</b>	Major Project	<b>Course Code:</b>	SOE-B-ME806
<b>Credits:</b>	10	<b>No of Hours:</b>	20 Hr./Week
<b>Max Marks:</b>	250		

**Course Description:**

The project work can be an investigative analysis of a technical problem in the relevant area, planning and/or design project, experimental project or computer application based project on any of the topics. Each project group will submit project synopsis by the end of eighth semester. Project evaluation committee consisting of three or four faculty members specialized in the various fields shall study the feasibility of each project work before giving consent.

**Course Objectives**

1. To develop the capacity of students in correlating theoretical knowledge into practical systems either to perform creative works or to perform analysis and hence to suggest solutions to problems, pertaining to civil engineering domain.
2. Foster collaborative learning skills.
3. Develop self-directed inquiry and life-long skills.
4. To enhance the communication skills of the students by providing opportunities to discuss in groups and to present their observations, findings and report in formal reviews both in oral and written format.

**Course Outcomes:**

After Completion of the course Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Gain in-depth knowledge and use adequate methods in the major subject/field of study.
<b>CO2</b>	Create, analyze and critically evaluate different technical/research solutions
<b>CO3</b>	Clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for these findings
<b>CO4</b>	Identify the issues that must be addressed within the framework of the specific dissertation in order to take into consideration
<b>CO5</b>	Apply principles of ethics and standards, skill of presentation and communication techniques.

### Contents

Project work is of duration of one semesters and is expected to be completed in the eighth semester. Each student group consisting of not more than four members is expected to design and develop a complete system or make an investigative analysis of a technical problem in the relevant area. The project batches are expected to fix their topics, complete preliminary studies like literature survey, field measurements etc. in the seventh semester.

Student shall study the topic of project work and define problem statement. The student shall evolve design and/or do experimental study and/or fabricate engineered device to obtain solution to the identified problem. The student shall prepare a report and shall present a seminar on the basis of work done at the end of semester.

### CO, PO, & PSO Correlation

Course Outcomes	Program Outcomes								PSOs	
	1	2	3	4	5	6	7	8	1	2
<b>CO1</b>	3	2	2	2		2	2	2	3	2
<b>CO2</b>	3	2	1	1	1	1	1	2	2	3
<b>CO3</b>	1	2	1	3	2	-		1	1	3
<b>CO4</b>	1	1	1		1	-	3	2	1	2
<b>CO5</b>	-	1	-	3	2	-	3	1	1	3

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109  
Department of Mechanical Engineering



# **O. P. Jindal University**

## **Raigarh-Chhattisgarh**



*Scheme and Syllabus*

*of*

**M. Tech.**

# **School of Engineering**

**Session- 2025-27**

**M. Tech. (Manufacturing Technology and Automation)**

**Program Code: 01NPG042**

### **Program Outcomes for Engineering Post Graduate Program**

**PO1: Disciplinary knowledge:** Accomplish vertical expertise in the chosen discipline and enhance the ability to function in multidisciplinary domains.

**PO2: Research aptitude:** Ability and aptitude to exercise research intelligence in investigations/innovations and to communicate the findings in a clear, concise manner.

**PO3: Project management:** Develop and apply knowledge of engineering and management principles to manage a project in a multidisciplinary environment.

**PO4: Ethics:** Gain knowledge of ethical principles and commit to professional ethics.

**PO5: Self-directed lifelong learning:** Ability to identify appropriate resources and learn independently for projects, research, etc. using online resources.

### **Program Specific Outcomes for M. Tech. in Manufacturing Technology and Automation**

**PSO 1:** Apply advanced knowledge and skills in the latest manufacturing technologies and automation systems to solve complex engineering problems.

**PSO 2:** Utilize research-based knowledge, including design of experiments, data analysis, interpretation, and modern IT tools, to enhance manufacturing processes and innovations.

**PSO 3:** Design and implement automated mechanical systems or processes that meet functional requirements while considering constraints like safety, health, and manufacturability.

As per NEP Policy, HEIs can offer 3 Designs of PG

**Designs of Postgraduate Program & Components**

- 1. For 2-year PG:** Students entering 2-year PG after a 3-year UG program can choose to do
  - (i) Only coursework in the third and fourth semesters or
  - (ii) Coursework in the third semester and research in the fourth semester or
  - (iii) Only research in the third and fourth semesters.
- 2. For 1-year PG:** Students entering 1-year PG after a 4-year UG program can choose to do
  - (i) Only coursework or
  - (ii) Research or
  - (iii) Coursework and research.
- 3. 5-year Integrated Program (UG+PG):** At the PG level, the curricular component of a 5-year integrated program will be similar to that of the 2-year PG mentioned above.

**Credit Distribution**

**a) For 1-year PG**

Choice	Curricular Components	PG Programme (one year) for 4-yr UG (Hons/Hons. with Research)			
		Minimum Credits			
		Course Level	Coursework	Research Thesis/Project/Patent	Total Credits
1	Coursework + Research	500	20	20	40
2	Coursework	500	40	-	40
3	Research	-	-	40	40

**b) For 2-year PG**

Choice	Curricular Components	Two-Year PG Programme (Generic and Professional)				
		Minimum Credits				
		Course Level	Coursework	Research Thesis/Project/Patent	Total Credits	
1_1 <sup>st</sup> Y	PG Diploma	400	40	-	40	
2_1 <sup>st</sup> Y	1st Year (1st & 2nd Semester)	400 500	24 16	-	40	
Students who exit at the end of 1st year shall be awarded a <b>Postgraduate Diploma</b>						
1_2 <sup>nd</sup> Y	2nd Year (3rd & 4th Semester)	Coursework + Research	500	20	20	40
2_2 <sup>nd</sup> Y		Coursework	500	40	-	40
3_2 <sup>nd</sup> Y		Research	-	-	40	40

**All the above designs are for the PG courses such as M.A., M.Com., M.Sc., etc. The entry criteria for the M.Tech PG Course are given in Table 1 of the OPJU Ordinance.**

**Table – 1**  
**Qualification Type and Credit Requirements**

978 (36)

छत्तीसगढ़ राजपत्र, दिनांक 3 सितम्बर 2024

<b>NHEQF levels</b>	<b>Qualification title/nomenclature</b>	<b>Credit Requirements (Minimum)</b>
Level 4.5	Undergraduate Certificate (in the field of learning/discipline) for those who exit after the first year (2 semesters) of the undergraduate programme. (Programme duration: First year or 2 semesters of the undergraduate programme)	40 credits
Level 5	Undergraduate Diploma (in the field of learning/discipline) for those who exit after the first two years (4 semesters) of the undergraduate programme (Programme duration: First two years or 4 semesters of the undergraduate programme)	80 credits
Level 5.5	Bachelor's Degree (examples: Bachelor of Arts; Bachelor of Science; Bachelor of Commerce; Bachelor of Business Administration, etc.(Programme duration: Three years or 6 semesters).	120 credits
Level 5.5	Bachelor of Vocation (B.Voc). (Programme duration: 3 years or 6 semesters).	120 credits
Level 6	Bachelor of Engineering (B.E.); Bachelor of Technology (B.Tech.) (Programme duration: Four years or	160 credits
Level 6	B.A., B.Ed.; B.Sc., B.Ed.; B.Com., B.Ed. (4-year dual-degree Integrated Teacher Education Programme)	160 credits)
Level 6	Bachelor's Degree (Honours/ Honours with Research). (Programme duration: Four years or 8 Semesters).	160 credits
Level 6	Post-Graduate Diploma. For those who exit after successful completion of the first year or two semesters of the 2-year master's programme). (Programme duration: One year or 2 semesters).	40 credits
Level 6.5	Master's degree. (e.g. M.A.; M.Com., M.Sc.; etc.) (Programme duration: Two years or four semesters after obtaining a 3-year Bachelor's degree).	80 credits
Level 6.5	Master's degree (e.g. M.A.; M.Com., M.Sc.; etc.) (Programme duration: One year or 2 semesters after obtaining a 4- year Bachelor's degree (Honours/ Honours with Research)	40 credits
<b>Level 7</b>	<b>Master's degree (e.g. ME; M.Tech. etc.) (Programme duration: Two years or four semesters after obtaining a Bachelor's degree (e.g. B.E., B.Tech.etc.).</b>	<b>80 credits</b>
Level 8	Doctoral Degree	Credits for course work and, a thesis and published work

Source: Approved NEP-based ordinance no. 32\_September 2024\_OPJU

### Curriculum and Credit Framework for Postgraduate Program (M.Tech)

Semester	Core Courses	Professional Elective	Common Course	Industrial Training / Research Internship	Dissertation	Total Credits
<b>I</b>	16	3	1			<b>20</b>
<b>II</b>	13	3	4			<b>20</b>
<i>Exit Point: For those who join 2-year PG programs, there shall only be one exit point. Students who exit at the end of 1<sup>st</sup> year shall be awarded a Postgraduate Diploma.</i>						
<b>III</b>				8	12	<b>20</b>
<b>IV</b>					20	<b>20</b>
						<b>80</b>
<i>Students on exit shall be awarded a Master of Technology (in the Field of Study/ Discipline) after securing the requisite 80 credits on completion of Semester IV.</i>						

**M. Tech. in (Manufacturing Technology and Automation)**

<b>FIRST SEMESTER (NHEQF Level: 6)</b>										
S. No.	Subject Code	Subject	Periods per Week			Scheme of Examination			Total Marks	Credit L+(T+P)/2
						Theory / Practical				
			PRE		ESE					
			L	T		P	MID	TA		
1	ME25-M-PPE101	Computational Methods and Optimization Techniques	3	0	0	15	15	70	100	3
2	ME25-M-MTA101	Advanced Manufacturing Processes	3	0	0	15	15	70	100	3
3	ME25-M-MTA102	Advanced Materials and Processing	3	0	0	15	15	70	100	3
4	ME25-M-MTA103	Industrial Automation and Robotics	3	0	0	15	15	70	100	3
5	ME25-M-MTA104 (1-5)	Program Elective I (Annexure -I)	3	0	0	15	15	70	100	3
6	ME25-M-PPE106	Computational Methods and Optimization Techniques Lab	0	0	4	-	15	35	50	2
7	ME25-M-MTA105	Advanced Manufacturing Lab	0	0	4	-	15	35	50	2
8	ME25-M-MTA106	Introduction to Intellectual Property	0	0	2	-	15	35	50	1
<b>Total</b>			<b>15</b>	<b>0</b>	<b>10</b>	<b>75</b>	<b>120</b>	<b>455</b>	<b>650</b>	<b>20</b>

**Program Elective I (Annexure - I)**

S. No.	Subject Code	Name of the Courses
1	ME25-M-MTA104 (1)	Micro and Nano Machining
2	ME25-M-MTA104 (2)	Design and Metallurgy of Welded Joint
3	ME25-M-MTA104 (3)	AI in Manufacturing
4	ME25-M-MTA104 (4)	Quantitative Decision Making
5	ME25-M-MTA104 (5)	Finite Element Analysis in Manufacturing

**M. Tech. in (Manufacturing Technology and Automation)**

SECOND SEMESTER (NHEQF Level: 6)										
S. No.	Subject Code	Subject	Periods per Week			Scheme of Examination			Total Marks	Credit L+(T+P)/2
						Theory / Practical				
			PRE		ESE					
			L	T		P	MID	TA		
1	ME25-M-MTA107	Industrial Instrumentation and Control	3	0	0	15	15	70	100	3
2	ME25-M-MTA108	Research Methodology	3	0	0	15	15	70	100	3
3	ME25-M-MTA109	Digital Manufacturing	3	0	0	15	15	70	100	3
4	ME25-M-MTA110	Quality Engineering in Manufacturing	3	0	0	15	15	70	100	3
5	ME25-M-MTA111 (1-5)	Program Elective II (Annexure -II)	3	0	0	15	15	70	100	3
6	ME25-M-MTA112	Advanced Welding Lab	0	0	4	-	15	35	50	2
7	ME25-M-MTA113	CAD/CAM/CIM Lab	0	0	4	-	15	35	50	2
8	ME25-M-MTA114	Scientific Paper Writing	0	0	2	-	15	35	50	1
<b>Total</b>			<b>15</b>	<b>0</b>	<b>10</b>	<b>75</b>	<b>120</b>	<b>455</b>	<b>650</b>	<b>20</b>

**Program Elective -II (Annexure - II)**

S. No.	Subject Code	Name of the Courses
1	ME25-M-MTA111 (1)	Product Design and Development
2	ME25-M-MTA111 (2)	Digital Twin
3	ME25-M-MTA111 (3)	Product Analysis and Cost Optimization
4	ME25-M-MTA111 (4)	Industry 4.0
5	ME25-M-MTA111 (5)	Lean Manufacturing

**M. Tech. in (Manufacturing Technology and Automation)**

<b>THIRD SEMESTER (NHEQF Level: 7)</b>										
S. No.	Subject Code	Subject	Periods per Week			Scheme of Examination			Total Marks	Credit L+(T+P)/2
						Theory / Practical				
			PRE		ESE					
			L	T		P	MID	TA		
1	ME25-M-MTA201	Industrial / Research Internship	0	0	16	-	60	140	200	8
2	ME25-M-MTA202	Dissertation-I	0	0	24	-	90	210	300	12
<b>Total</b>			<b>0</b>	<b>0</b>	<b>40</b>	<b>-</b>	<b>150</b>	<b>350</b>	<b>500</b>	<b>20</b>

<b>FOURTH SEMESTER (NHEQF Level: 7)</b>										
S. No.	Subject Code	Subject	Periods per Week			Scheme of Examination			Total Marks	Credit L+(T+P)/2
						Theory / Practical				
			PRE		ESE					
			L	T		P	MID	TA		
1	ME25-M-MTA203	Dissertation-II	0	0	40	-	150	350	500	20
<b>Total</b>			<b>0</b>	<b>0</b>	<b>40</b>	<b>-</b>	<b>150</b>	<b>350</b>	<b>500</b>	<b>20</b>

**L-** Lecture      **ESE-** End Semester Exam      **P-** Practical      **TA-** Teacher's Assessment

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Computational Methods and Optimization Techniques	<b>Course Code:</b>	ME25-M-PPE101
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

Computational methods are powerful problem-solving tools capable of handling large systems of equations, nonlinear systems, and complex problems—common challenges in engineering practice that often cannot be solved analytically. This course focuses on computational solutions to nonlinear equations, with special attention given to standard finite element equations. Additionally, the course covers modern optimization techniques for achieving optimal solutions.

**Course Outcomes:**

After completion of the course, students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Solve linear and nonlinear algebraic equations and systems of nonlinear equations using numerical techniques.
<b>CO2</b>	Use regression and interpolation methods for curve fitting.
<b>CO3</b>	Apply and analyze the finite difference and finite volume schemes for the numerical solution of systems of equations in one and two dimensions.
<b>CO4</b>	Apply fuzzy logic tools to inference systems.
<b>CO5</b>	Apply modern optimization techniques to engineering problems.

**Syllabus:**

**Unit-1: Linear and Non-Linear Equations:** Introduction, Bisection method, False Position Method, Method of iteration: Newton-Raphson method, Secant method, Gauss Elimination Method, Gauss Jordan method, Gauss-Seidel method, Convergence of iterative methods.

**Unit-2: Interpolation:** Newton’s forward and backward interpolation, Lagrange’s interpolation, Newton’s divided difference interpolation, Inverse interpolation.

**Unit-3: Linear and Non-Linear Programming:** Definition, Classification of Optimization Problem, Simplex Method, Duality, Sensitivity Methods, Non-Linear Programming: Newton’s Method, GRG Method, Penalty Function Method, Augmented Lagrange Multiplier Method.

**Unit-4: Fuzzy Logic:** Basic concepts Fuzzy Logic (FL), Fuzzy sets, and their operations. Fuzzy memberships and relations, Fuzzification, and defuzzification methods, Numerical problems on FL, Fuzzy rule generation, Applications of FL in optimization.

**Unit-5: Introduction to Optimization:** Engineering application of Optimization, Statement of an Optimization problem, Optimal Problem formulation, Classification of optimization problem.

**Modern methods of Optimization:** Genetic Algorithms, Ant Colony Optimization, Neural-Network based Optimization Applications, Firefly Algorithm, Use of MATLAB to solve optimization problems.

**Text Books:**

1. S. Rajasekaran, G. A. Vijayalakshmi Pai, Neural Networks, fuzzy logic, and genetic algorithms: synthesis and applications, PHI Learning Private Limited
2. S.S. Rao, Engineering Optimization: Theory and Practice, New Age International Pvt Ltd Publishers
3. Dilip Kumar Pratihar, Soft Computing: Fundamentals and Applications, Narosa Publishing House Pvt. Ltd. - New Delhi

**References Books:**

1. S.S. Sastry, Introductory Method of Numerical Analysis, Prentice Hall India Learning Private Limited
2. S.C. Chapra, Applied Numerical Methods with MATLAB, McGraw Hill Education
3. David G. Luenberger, Linear and Nonlinear Programming, Springer, India, Private Ltd
4. Joe D. Hoffman, Steven Frankel, Numerical Methods for Engineers and Scientists, CRC Press
5. E. Kreyszig, Advance Engineering Mathematics, John Wiley & Sons Inc

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
<b>CO1</b>	2	1	-	-	2	1	-	1
<b>CO2</b>	2	1	-	-	2	1	-	1
<b>CO3</b>	2	1	-	-	2	3	-	2
<b>CO4</b>	3	3	1	-	3	2	1	3
<b>CO5</b>	3	3	1	-	3	2	1	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Advanced Manufacturing Processes	<b>Course Code:</b>	ME25-M-MTA101
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course aims to provide students with a comprehensive understanding of advanced and non-conventional manufacturing techniques used for machining and shaping complex and high-precision components. The focus is on processes where traditional methods fall short due to limitations in geometry, material hardness, or required accuracy. The course explores mechanical, chemical, electrochemical, thermoelectrical, hybrid, and additive manufacturing technologies. It also introduces modern forming and microfabrication processes to prepare students for future advancements in manufacturing, including applications in aerospace, biomedical, and high-performance engineering systems.

**Course Outcomes:** After completion of the course, students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Explain the principles, classification, and applications of mechanical non-traditional machining processes.
<b>CO2</b>	Analyze chemical and electrochemical machining methods and evaluate their suitability for precision machining applications.
<b>CO3</b>	Understand the working principles and application domains of thermoelectrical machining processes.
<b>CO4</b>	Describe the fundamentals and types of additive manufacturing technologies and compare them with traditional manufacturing systems.
<b>CO5</b>	Discuss the working, advantages, and applications of high velocity forming and hybrid machining processes in modern manufacturing scenarios.

**Syllabus:**

**Unit 1: Introduction** - Classification and capability based on materials.

**Mechanical machining:** Ultrasonic machining (USM), Abrasive Jet Machining (AJM), Abrasive Flow Machining (AFM), Water Jet Machining (WJM) –Principle, analysis and applications.

**Unit 2: Chemical Machining:** Introduction, principle of material removal, types of chemical machining Maskants, Etchants, Advantages and limitations and applications.

**Electrochemical Machining:** Electro chemical machining (ECM), Classification of ECM process, principle of material removal, determination of the metal removal rate, advantages, disadvantages and applications, Electro Chemical Grinding.

**Unit 3: Thermoelectrical machining:** Electrical discharge machining (EDM), Electrical discharge wire cutting (EDWC), Electron beam machining (EBM), Plasma Arc Machining (PAM), Ion Beam Machining (IBM), Laser beam machining (LBM) – Working Principle, analysis and applications.

**Unit 4: Additive Manufacturing: Introduction:** Introduction to Prototyping, Traditional Manufacturing Vs. Additive Manufacturing, Need for time compression in product development.  
**Types of AM Processes** – Stereolithography, Fused Deposition Modelling, Selective Laser Sintering. 3D Printing Process: Laminated Object Manufacturing, Electron Beam Melting Process – Operation, Advantages, Disadvantages and Applications.

**Unit 5: High Velocity Forming Process:** Explosive forming processes, Electrohydraulic forming, Electromagnetic forming, Pneumatic/mechanical forming, Formability criteria.

**Hybrid Machining:** Introduction, Hybrid chemical and electrochemical processes, Hybrid thermal machining

**Text Books:**

1. Benedict G.F., Non-Traditional Manufacturing Processes, Marcel Dekker
2. Ghosh, A., Mallik, A. K. (1986). Manufacturing Science. United Kingdom: Ellis Horwood.
3. New technology Institution of Engineers - Bhattacharya -India
4. Production Technology - HMT - Tata McGraw Hill.
5. Modern Machining Process - P.C Pandy& H.S. Shan - Tata McGraw Hill.

**References Books:**

1. Metals Handbook - ASM -Vol-3.
2. Modern Manufacturing Method - Adithan- New Age International (p) Limited.
3. Modern Machining Processes - P.K. Mishra - Narosa Publishing House, New Delhi -1997.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	2	2	-	-	3	3	2
<b>CO2</b>	3	3	2	-	-	3	3	3
<b>CO3</b>	3	3	3	-	-	3	3	3
<b>CO4</b>	3	2	2	-	-	3	3	2
<b>CO5</b>	3	2	2	-	-	3	3	3

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Advanced Materials and Processing	<b>Course Code:</b>	ME25-M-MTA102
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides the classification, structure, properties, and applications of metals, polymers, ceramics, and composites. It covers crystalline structures, strengthening mechanisms, phase transformations, and material processing techniques. Emphasis is placed on ferrous and non-ferrous alloys, heat treatment, polymer and ceramic properties, and advanced composite materials for engineering applications.

**Course Outcomes:**

After completion of the course, students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Understand the classification, structure, and characteristics of metals, ceramics, polymers, and composites.
<b>CO2</b>	Interpret iron-carbon diagrams, heat treatment, and transformation hardening in steels.
<b>CO3</b>	Evaluate composition, properties and heat treatment of non-ferrous alloys.
<b>CO4</b>	Differentiate and analyze polymers, ceramics, and their processing methods.
<b>CO5</b>	Classify and assess composites, reinforcements, and processing techniques.

**Syllabus:**

**Unit 1: Modern Materials and Structural Considerations:** Introduction to modern materials in engineering: smart materials, biomaterials, nanomaterials, and functionally graded materials. Crystal structures and defects in advanced materials. Bonding and microstructural features influencing properties. Grain refinement, texture, and anisotropy in materials. Advanced strengthening mechanisms: nanostructuring, surface hardening, and thermomechanical treatments.

**Unit 2: Processing of Engineering Materials:** Powder metallurgy: compaction, sintering, and hot isostatic pressing (HIP). Solid-state processing: friction stir processing (FSP), severe plastic deformation (SPD) techniques (e.g., ECAP, HPT). Additive Manufacturing (AM): processes for metals (SLM, DED), materials used, and limitations. Directional solidification and rapid solidification processing.

**Unit 3: Surface Engineering and Thermal Processing:** Surface treatment techniques: carburizing, nitriding, chromizing, and boriding. Coating technologies: PVD, CVD, plasma spraying, and laser cladding. Thermal processing of materials: annealing, normalizing, quenching, tempering – case studies. Diffusion bonding, hot pressing, and hot rolling. Microstructure evolution during thermal processing.

**Unit 4: Polymers and Ceramics:** Structure and properties of thermoplastics and thermosets; engineering applications; property modifications. Mechanical and thermal behaviour of polymers; polymer processing methods (injection moulding, extrusion, blow moulding). Nature and structure of ceramics; refractory abrasives, glasses, and glass ceramics. Advanced ceramics processing: slip casting, tape casting, hot pressing, and sintering.

**Unit 5: Composites and Their Processing:** Classification of composite materials; matrix and reinforcement types. Fabrication methods: hand lay-up, pultrusion, filament winding, resin transfer moulding, powder-infiltration for MMCs. Properties and applications of FRPs, MMCs, and CMCs. Surface and tribological engineering: thermal spraying, ion beam machining, diamond coating techniques.

**Text Books:**

1. Callister, W.D. & Rethwisch, D.G. Materials Science and Engineering: An Introduction, Wiley.
2. Askeland, D.R. & Phulé, P.P. The Science and Engineering of Materials, Cengage Learning.
3. Kalpakjian, S. & Schmid, S. Manufacturing Processes for Engineering Materials, Pearson.
4. Raymond Aurelius Higgins, Engineering Metallurgy, Butterworth-Heinemann.
5. James F. Shackelford, Introduction to Materials Science for Engineers, Pearson.

**References Books:**

1. K. K. Chawla, Composite Materials - Science and Engineering, Springer.
2. L. H. Van Vlack, Elements of Material Science and Engineering, Addison Wesley.
3. P. K. Rohagti, Cast Metal Matrix Composites, ASM Metals Handbook.

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
<b>CO1</b>	2	2	-	-	-	2	2	2
<b>CO2</b>	1	2	2	2	-	1	2	2
<b>CO3</b>	3	1	-	-	-	1	2	1
<b>CO4</b>	3	3	3	-	-	2	2	1
<b>CO5</b>	3	3	3	-	2	3	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Industrial Automation and Robotics	<b>Course Code:</b>	ME25-M-MTA103
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides an in-depth understanding of automation principles, strategies, and their economic and societal impacts. It covers fluid power systems, including hydraulic and pneumatic circuits, and their applications in industrial automation. The course explores automation components such as drives, servo systems, PLCs, and electronic controls. Material handling automation and robotic systems, including their design, performance, and industrial applications, are also discussed.

**Course Outcomes:** After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Explain automation principles, economic aspects, and socio-economic impacts of automation on manufacturing systems.
<b>CO2</b>	Design basic hydraulic and pneumatic circuits for automation applications.
<b>CO3</b>	Analyze drive systems, PLCs, and electronic controls used in automation.
<b>CO4</b>	Evaluate automated material handling and storage systems for industrial applications.
<b>CO5</b>	Classify and assess robotic systems, their programming, and industrial applications.

**Syllabus:**

**Unit 1: Introduction:** Basic Concepts & Need for Automation in Production System, Principles and Strategies, Advanced Functions, Levels of Automation, Socio-economic impacts of automation, Low-Cost Automation.

**Automated Production Economics:** Methods of Evaluating Investment Alternatives, Costs in Manufacturing, Break Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process.

**Unit 2: Hydraulic and Pneumatic Circuits:** Fluid power control elements, Standard graphical symbols, Fluid power generators, Hydraulic and pneumatic Cylinders - construction, design and mounting; Hydraulic and pneumatic Valves for pressure, flow and direction control.

**Basic hydraulic and pneumatic circuits:** Direct and Indirect Control of Single/Double Acting Cylinders, designing logic circuits for a given time displacement diagram & sequence of

operations, Hydraulic & Pneumatic Circuits using Time Delay Valve & Quick Exhaust Valve, Memory Circuit & Speed Control of a Cylinder, Troubleshooting and Causes & Effects of Malfunctions, Basics of Control Chain, Circuit Layouts, Designation of specific Elements in a Circuit.

**Unit 3: Drives:** Stepper AC/ DC motors and servo drives - Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines and transfer systems.

**Electrical and Electronic Controls:** Basics of Programmable logic controllers (PLC), Architecture & Components of PLC, Ladder Logic Diagrams.

**Unit 4: Automation in Material Handling:** Function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. Automated Storage Systems: Storage System Performance, Automated Storage/Retrieval Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing.

**Unit 5: Robotics:** Introduction, Classification based on geometry, control and path movement, Robot Specifications, Robot Performance Parameters, Robot Programming, Machine Vision, Teach pendants, Industrial Applications of Robots

**Text Books:**

1. Krishna Kant, “Computer Based Industrial Control”, EEE-PHI, 2<sup>nd</sup> Edition, 2010.
2. Tiess Chiu Chang & Richard A. Wysk, “An Introduction to Automated Process Planning Systems”. Prentice-Hall, 1985.
3. S. R Majumdar, Pneumatic Control, McGraw Hill.

**Reference Books:**

1. Anthony Esposito, Fluid Power with applications, Pearson
2. Viswanandham N & Narahari Y, Performance Modeling of Automated Manufacturing Systems, PHI, 1<sup>st</sup> Edition, 2009.
3. S. R Deb, Robotic Technology and Flexible Automation, Tata Mc Hill
4. Saeed B. Niku Introduction to Robotics, Wiley India
5. Ashitava Ghosal, Robotics, Oxford
6. Frank Lamb, “Industrial Automation Hands-on” The McGraw-Hill, 2013
7. Anthony Esposito, “Fluid Power with Applications”, PHI / Pearson Education, 2005

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
CO1	3	1	2	1	-	3	1	-
CO2	3	3	3	1	-	3	3	1
CO3	3	3	3	2	2	3	3	1
CO4	2	2	2	1	-	2	1	-
CO5	2	3	2	1	-	2	3	-

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Computational Methods and Optimization Techniques Lab	<b>Course Code:</b>	ME25-M-PPE106
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hours/week
<b>Max Marks:</b>	50		

**Course Description:**

This course aims to teach a suite of algorithms and concepts related to fitting data to models, as well as various numerical techniques to solve mathematical problems encountered in engineering, physical sciences, and real-life applications. It begins with fundamental topics in linear algebra and computational methods, and gradually introduces more advanced concepts, including soft computing and optimization techniques.

**Course Outcomes:**

After Completion of the course Students will be able to:

CO Number	Course Outcome
CO1	Write the program for solving non-linear equations.
CO2	Write a Program non-conventional method for solving system of linear equations
CO3	Interpret of data using fuzzy logic toolbox
CO4	Solve optimization Problem using genetic algorithms
CO5	Train and test data using neural networks

**Syllabus**

**LIST OF EXPERIMENTS:**

1. Write and execute a program for the Bi-Section Method to find roots using soft computing tools.
2. Write and execute a program for the Regula-Falsi Method to find roots using soft computing tools.
3. Write and execute a program for the Newton-Raphson Method to find roots using soft computing tools.
4. Write and execute a program to solve a system of linear equations using the Gauss Elimination Method with soft computing tools.
5. Write and execute a program for Newton's Forward and Backward Interpolation Methods using soft computing tools.

6. Write and execute a program for Lagrange's Interpolation Method using soft computing tools.
7. Implement of fuzzy logic in an optimization problem.
8. Interpret data using the fuzzy logic toolbox.
9. Solve optimization problems using genetic algorithms.
10. Train and test data using neural networks.

**CO, PO, & PSO Correlation**

<b>Course Outcome</b>	<b>Program Outcome</b>					<b>PSOs</b>		
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>1</b>	<b>2</b>	<b>3</b>
<b>CO1</b>	2	1				1		1
<b>CO2</b>	2	1						1
<b>CO3</b>	3	1	2		2		1	1
<b>CO4</b>	3	3	2			3	1	2
<b>CO5</b>	3	3	2		2	3	1	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Advanced Manufacturing Lab	<b>Course Code:</b>	ME25-M-MTA105
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hours/week
<b>Max Marks:</b>	50		

**Course Description:**

The Advanced Manufacturing Processes laboratory provides state-of-the-art facilities for experimenting with advanced manufacturing techniques. This lab provides a multipurpose and interdisciplinary environment for both training and research related machining. The focus of the lab is on the development of efficient non-traditional processes as well as system-level manufacturing solutions.

**Course Outcomes:** at the end of the course the students will be able to

CO Number	Course Outcome
<b>CO1</b>	Analyse and optimize process parameters (pulse on/off time, wire feed) for precision machining using CNC Wire Cut EDM.
<b>CO2</b>	Perform and evaluate CNC turning operations and multi-pass machining to assess dimensional accuracy and tool wear.
<b>CO3</b>	Investigate the effect of laser parameters on engraving quality and cutting efficiency across different materials.
<b>CO4</b>	Model engineering components for additive manufacturing and analyse how slicing parameters affect build time and part quality.
<b>CO5</b>	Apply and compare additive and subtractive manufacturing processes for a mechanical component, evaluating surface finish and dimensional accuracy.

**Syllabus:**

**LIST OF EXPERIMENTS (Minimum 10 to be performed)**

1. Study the effect of process parameters (pulse on time, pulse off time, wire feed) on performance characteristics on CNC Wire Cut EDM.
2. Generate intricate 2D profiles on electrically conductive materials on CNC Wire Cut EDM.
3. Perform turning operations (facing, contouring, threading) using G-code and M-code on CNC lathe.
4. Investigate the impact of multiple cutting passes on dimensional accuracy of workpiece and tool wear on CNC lathe.

5. Perform laser engraving on different materials and analyze the effect of power, speed, and number of passes on quality of engraving.
6. Analyze the effect of speed and laser power on cutting depth and edge quality.
7. Modeling of Engineering component and conversion of STL format.
8. Slicing of STL files and study of effect of process parameters like layer thickness, Orientation and infill on build time using software.
9. Evaluate the impact of layer thickness and infill percentage on the strength and weight of a 3D-printed part.
10. Perform 2D and 3D milling operations on various materials (wood, acrylic, aluminum) using a CNC router.
11. Manufacturing a mechanical component using a hybrid approach—first, 3D print a base structure, then use CNC machining to achieve precision finishing and tolerance control. Compare dimensional accuracy and surface roughness between additive and subtractive processes.

**CO, PO, & PSO Correlation**

<b>Course Outcome</b>	<b>Program Outcome</b>					<b>PSOs</b>		
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>1</b>	<b>2</b>	<b>3</b>
<b>CO1</b>	3	3	2	2	2	3	3	3
<b>CO2</b>	3	3	3	2	2	3	3	3
<b>CO3</b>	3	2	2	1	2	2	2	2
<b>CO4</b>	3	3	3	2	2	3	3	2
<b>CO5</b>	3	3	3	2	3	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M.Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Intellectual Property Rights	<b>Course Code:</b>	ME25-M-MTA106
<b>Credits:</b>	1	<b>No of Hours:</b>	2
<b>Max Marks:</b>	50		

**Course Description:**

This course offers lectures and case studies to impart teaching and learning. It is designed to provide a detailed knowledge of Intellectual Property Rights, Copyright, Trademarks, Industrial Designs, and recent trends in IPR. This course covers IPR in detail.

**Course Outcomes:**

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand Intellectual Property Rights in detail, Patents and its types.
<b>CO2</b>	Understand Copyright Infringement and Fair Use.
<b>CO3</b>	Understand the Trademarks and its Registration and Protection of Trademarks.
<b>CO4</b>	Understand the Concept, Importance and Registration, Protection of Industrial Designs
<b>CO5</b>	Understand IPR and Research & Development.

**Syllabus:**

**Unit-1: Introduction to Intellectual Property Rights:** Definition, Nature, Scope, and Types of Intellectual Property (IP), Importance of IPR in Technology and Innovation, International Framework.

**Patents:** Definition and Scope, Patent Filing Procedure (National & International), Patentability Criteria.

**Unit-2: Copyrights:** Definition, Rights of Copyright Holder, Copyright in Digital Era (Software, Multimedia), Copyright Infringement and Fair Use.

**Unit-3: Trademarks:** Definition, Importance, and Types; Registration and Protection of Trademarks, Trademark Infringement, and Passing off.

**Unit-4: Industrial Designs:** Concept and Importance, Registration and Protection. Trade Secrets and Confidential Information, Importance in Industries, Legal Aspects of Trade Secrets.

**Unit-5: IPR Research & Development:** Role of IPR in Scientific and Technological Developments, Technology Transfer and Licensing, Case Studies on Patent & Copyright Issues.

**Text Books:**

1. Deborah E. Bouchoux, Intellectual Property Rights, Cengage Learning.
2. Dr. B. L. Wadehra, Law Relating to Intellectual Property, Universal Law Publishing.
3. R. Radhakrishnan & S. Balasubramanian, Intellectual Property Rights: Text and Cases, Excel Books
4. V.K. Ahuja, Intellectual Property Rights in India, LexisNexis.
5. Robert P. Merges & John F. Duffy, Patent Law and Policy, Wolters Kluwer

**References Books:**

1. Siva Prasad, The Law of Intellectual Property Rights, Asia Law House,
2. William M. Landes & Richard A. Posner, Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, Harvard University Press.
3. W.R. Cornish & David Llewelyn, Intellectual Property Rights: A Global Perspective, Cambridge University Press.
4. V. Sople, Managing Intellectual Property, PHI Learning Pvt. Ltd.
5. Rajkumar S. Dukki, Fundamentals of Intellectual Property Rights: For Engineers, Scientists, and Entrepreneurs, Springer

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	-	1	3	1	1	3	2
<b>CO2</b>	3	2	-	3	2	1	2	3
<b>CO3</b>	2	2	-	3	1	1	3	2
<b>CO4</b>	3	-	-	2	2	1	3	2
<b>CO5</b>	3	2	-	3	2	1	2	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Micro and Nano Machining	<b>Course Code:</b>	ME25-M-MTA104 (1)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course offers the concepts related to the advancement of technology and the rapid pace of miniaturization of equipment. This includes the introduction to the technologies used for manufacturing products at micro and Nano scale. It provides awareness of different techniques used in micro and nano machining/manufacturing and facilitates in-depth idea of the conventional techniques used in micro machining/manufacturing.

**Course Outcomes:**

After completion of the course, students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Understand molecular dynamics simulation and its role in nanoscale material removal and ductile cutting of brittle materials.
<b>CO2</b>	Explain micro-turning, drilling, milling, and grinding processes with a focus on precision and surface quality.
<b>CO3</b>	Describe laser-based micromachining techniques and assess subsurface damage using evaluation methods.
<b>CO4</b>	Analyze advanced nano-finishing techniques for achieving ultra-smooth surfaces in micro components.
<b>CO5</b>	Understand micro joining methods and their industrial applications in electronics and precision engineering.

**Syllabus:**

**Unit 1: Introduction:** Basic elements of molecular dynamics modelling, Design and requirements for state-of-the-art MD cutting process simulations, Capabilities of MD for nanoscale material removal process analysis, Advances and recent developments in material removal process simulation, Summary.

**Ductile Mode Cutting of Brittle Materials:** The mechanism of ductile mode cutting of brittle materials, the chip formation in cutting of brittle materials, Machined surfaces in relation to chip formation mode.

**Diamond Tools in Micromachining:** Diamond technology, Preparation of substrate, Modified HFCVD process, Nucleation and diamond growth, Deposition on complex substrates, Diamond micromachining.

**Unit 2: Conventional Processes:** Micro-turning, Micro-drilling and Micro-milling-Introduction, Product quality in micromachining

**Micro-grinding and Ultra-precision Processes:** Introduction, Micro and nano grinding, Nano grinding tools.

**Unit 3: Non-Conventional Processes:** Laser Micromachining: Introduction, Fundamentals of lasers, Laser microfabrication, Laser nanofabrication.

**Evaluation of Subsurface Damage in Nano and Micromachining:** Destructive evaluation technologies, Non-destructive evaluation technologies

**Unit 4: Micro and Nano Finishing Processes:** Need for Nano finishing, Magnetic abrasive Finishing, Magnetorheological Finish, Elastic Emission Finishing, Magnetic Float Polishing, Ion Beam finishing

**Unit 5: Micro Joining:** Challenges, Micro Resistance welding, Ultrasonic welding, Micro TIG, Applications.

**Applications of Nano and Micromachining in Industry:** Typical machining methods, Applications in optical manufacturing, Semiconductor and electronics related applications.

#### **Text Books:**

1. J. Paulo Davim, Mark J. Jackson Nano and Micro machining, John Wiley & Sons, 2013.
2. Mark. J. Jackson, Micro and Nano-manufacturing, Springer, 2006
3. Mark. J. Jackson, Micro-fabrication and Nano-manufacturing - Pulsed water drop micromachining CRC Press 2006.

#### **References Books**

1. Nitai gour Prem chand Mahalik, Micro-manufacturing and Nanotechnology, 2006
2. V. K. Jain, Micro-manufacturing Processes, CRC Press, 2012
3. Yi Qin, Micro-manufacturing Engineering and Technology, William Andrew, 2015
4. Kapil Gupta, Micro and Precision Manufacturing, Springer, 2017

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
CO1	2	2	2	1	2	1	2	3
CO2	2	2	1	-	2	1	1	2
CO3	1	2	2	1	2	2	1	3
CO4	3	2	1	3	1	-	2	3
CO5	2	2	3	1	3	2	1	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Design and Metallurgy of Welded Joint	<b>Course Code:</b>	ME25-M-MTA104 (2)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course is aimed at familiarizing the students with the fundamentals weld joint design, metallurgical aspects in welding of steel, and assessing the quality and suitability of weld joints. Topics related to the weldability of metals shall also be covered to equip the student's technological input for handling the problems in welding of selected metals and alloys.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the concept of static design of joints.
<b>CO2</b>	Design of welded joints and static and dynamic loading.
<b>CO3</b>	Evaluate the metallurgical and thermal aspects of welding joints of metals acquire
<b>CO4</b>	Knowledge about the cooling transformation curves of welded joints
<b>CO5</b>	Acquire knowledge about destructive and non-destructive tests of weldments

**Syllabus:**

**Unit 1: Introduction:** Welded joints, symbols, welded defects; Design considerations; Joint efficiency; Factor of safety, Types of loading; Permissible stress; Computation of stress in welds; Weld size calculation; Code requirement for statically loaded welded structures

**Unit 2: Dynamic Behavior of Welded Joints and Failure Theories:** Design for fluctuating and impact loading; Dynamic behavior of welded joints; Stress Concentrations; Fatigue analysis; Fatigue improvement techniques; Permissible stress- life prediction; Concept of stress intensity factors - LEFM and EPFM concepts; Brittle fracture; Transition temperature approach, Application of fracture mechanics to fatigue.

**Unit 3: Welding Metallurgy:** Thermal effect of welding on parent metal; Structure of fusion welds; Effect of cooling rate; Weld metal solidification and heat affected zone; Heat flow - temperature distribution cooling rates; Influence of heat input; Joint geometry; Plate thickness; Preheat; Significance of thermal severity number; Epitaxial growth - weld metal solidification - columnar structures and growth morphology effect of welding parameters; Absorption of gases - gas/metal and slag/metal reactions.

**Unit 4: Phase Transformations:** Weld CCT diagrams - carbon equivalent-preheating and post heating weldability of low alloy steels; Welding of stainless steels use of Schaffler and Delong diagrams.

**Unit 5: Weldability testing:** Types of weldability test, Vareststraint test, Cast pin tear test, hot ductility test, Strain to fracture test, reheat cracking test, tests for Hydrogen induced cracking.

**Text Books:**

1. Design of Weldments; W. B. Omer; James. F. Lincoln; Arc Welding Foundation; 1991.
2. Deformation and Fracture of Mechanics of Engineering Materials; R. W. Hertzberg; John Wiley;1996.
3. Welding Metallurgy; Volume I and II; 4th Edition; G. E. Linnert; AWS; 1994.
4. The Metallurgy of Welding, 6th Edition, Lancaster, William Andrew Publishing, NY.

**References Books**

1. Rational Welding Design; T. G. E. Gray; Butterworths; 1982.
2. Mechanical Metallurgy; G. Dieter; Tata McGraw Hill; 1988.
3. Weldment Design; M. Bhattacharya; Association of Engineers;1991.
4. Fundamentals of Welding Metallurgy; H. Granjon; Jaico Publishing House; 1994.
5. Introduction to Physical Metallurgy of Welding; 2nd Edition; Easterling Kenneth; Butterworth Heinmann; 1992.

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	3	1	-	1	3	3	2
<b>CO2</b>	3	3	2	-	1	3	3	3
<b>CO3</b>	3	3	2	-	-	3	3	3
<b>CO4</b>	3	3	1	-	2	3	3	2
<b>CO5</b>	3	3	1	-	2	3	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	AI in Manufacturing	<b>Course Code:</b>	ME25-M-MTA104 (3)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course introduces the fundamental principles and techniques of Artificial Intelligence (AI) and their applications in modern manufacturing environments. It covers expert systems, AI languages, neural networks, fuzzy logic, genetic algorithms, and their integration into intelligent manufacturing systems. Emphasis is placed on real-world applications such as robotics, CAD/CAM integration, process planning, fault diagnosis, and smart manufacturing.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the fundamentals of AI and its relevance to manufacturing.
<b>CO2</b>	Apply expert systems and knowledge-based tools for intelligent decision-making in manufacturing.
<b>CO3</b>	Use AI programming languages (e.g., PROLOG, CLIPS) to simulate manufacturing tasks.
<b>CO4</b>	Implement neural networks, fuzzy logic, and genetic algorithms in manufacturing scenarios.
<b>CO5</b>	Analyze AI-based case studies in manufacturing, including fault diagnosis and tool/process selection.

**Syllabus:**

**Unit 1: Introduction to Artificial Intelligence:** Definitions of intelligence and artificial intelligence. Human cognitive functions: association, pattern recognition, reasoning. Components, scope, and applications of AI in manufacturing. AI in Industry 4.0: Smart factories, Cyber-Physical Systems (CPS), and IoT integration.

**Unit 2: AI Languages & Programming:** Introduction to AI programming languages: PROLOG and CLIPS. Basic syntax and logic programming in PROLOG. Developing knowledge bases and inference engines. Hands-on exercises and simulations using AI tools

**Unit 3: Expert Systems in Manufacturing:** Expert systems: structure, characteristics, and benefits. Knowledge acquisition and representation. Inference techniques: forward and backward chaining. Case studies in CAD, CAM, and adaptive control.

**Unit 4: Neural Networks, Fuzzy Logic, and Genetic Algorithms:** Artificial neural networks: perceptron, backpropagation, training methods. Fuzzy logic: membership functions, fuzzy sets, rules, and inference. Genetic algorithms: selection, crossover, mutation, fitness functions. Application in predictive maintenance, scheduling, and optimization.

**Unit 5: AI Applications in Manufacturing Systems:** AI in production planning, inventory control, and process optimization. AI for fault diagnosis, quality control, and robotic control systems. AI in flexible manufacturing and smart assembly systems. Integration of AI in digital twins and simulation tools.

**Text Books:**

1. W.F. Clocksin & C.S. Mellish, Programming in PROLOG, Narosa Publishing
2. J.C. Giarratano & G.D. Riley, Expert Systems: Principles and Programming, Cengage

**References Books**

1. Kevin Warwick, Artificial Intelligence: The Basics, Routledge
2. S.N. Sivanandam & S.N. Deepa, Principles of Soft Computing, Wiley
3. Rajiv Tiwari, AI in Manufacturing: Real-World Applications, Springer

**CO, POs & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	3	2	1	3	3	3	3
<b>CO2</b>	3	3	2	-	3	3	3	2
<b>CO3</b>	3	3	3	1	3	3	3	2
<b>CO4</b>	3	3	3	-	2	3	3	3
<b>CO5</b>	3	3	3	1	3	3	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Quantitative Decision Making	<b>Course Code:</b>	ME25-M-MTA104 (4)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

### Course Description

This course introduces students to the foundational and advanced concepts of optimization techniques applied in engineering and decision-making problems. Beginning with classical optimization methods for single and multivariable problems, the course progresses through linear and integer programming, sensitivity analysis, and simulation-based decision support tools. Students will also explore cutting-edge non-traditional optimization techniques such as Genetic Algorithms, Simulated Annealing, Particle Swarm Optimization, and Machine Learning-based approaches. Emphasis is placed on formulating real-world problems, selecting appropriate optimization strategies, and implementing solutions in complex engineering and industrial systems.

### Course Outcomes:

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	To understand the role of optimization in various engineering applications
<b>CO2</b>	To formulate the real-life problem in optimization problem
<b>CO3</b>	To solve single and multivariable optimization problem
<b>CO4</b>	To solve integer programming problems
<b>CO5</b>	To apply the recent optimization tools to solve real-life problems

### Syllabus:

**Unit-1:** Introduction to Optimization Techniques and Single Variable Non-Linear Unconstrained Optimization, Optimality criteria, Classical optimization techniques, Kuhn-Tucker (KT) optimality conditions, Interior and exterior penalty function method.

**Unit-2:** Multi variable non-linear unconstrained optimization, Direct search methods – Univariate method, Pattern search methods – Powell’s, Hook-Jeeves, Rosenbrock search methods.

**Unit-3:** Linear Programming – Formulation, Simplex method & Artificial variable optimization techniques - Big M & Two-phase methods. Sensitivity analysis – Changes in the objective coefficients, constants & coefficients of the constraints. Addition of variables, constraints.

Simulation – Introduction, Types, steps, applications. Inventory & queuing – Advantages and disadvantages.

**Unit-4:** Integer Programming – Introduction, mathematical formulation, Geometry cutting plane algorithm, Zero or one algorithm, branch and bound method.

**Unit-5:** Non-Traditional Optimization Algorithms: Modern Methods in Optimization – Genetic Algorithm, Simulated Annealing, Particle Swarm Optimization, Neural Network based optimization, Optimization of Fuzzy systems, multi-Objective optimization, Design of experiment-based optimization, Data Analytics and optimization using Machine learning approach.

**Text Books:**

1. Optimization for Engineering Design by Kalyanmoy Deb, PHI
2. Operation Research by H. A. Taha, TMH

**Reference Books:**

- 1 Engineering Optimization Theory and Practice, by Rao, S. S, New Age International, 2013.
- 2 Introduction to Optimum Design, by J. S. Arora, Academic press.
- 3 Manufacturing Optimization through Intelligent Techniques by Saravanan. R., Taylor & Francis, CRC Press.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	2	1	-	-	2	3	3	2
<b>CO2</b>	1	2	-	-	2	3	2	2
<b>CO3</b>	2	2	2	-	1	1	2	1
<b>CO4</b>	2	2	1	-	1	1	2	1
<b>CO5</b>	2	3	2	-	3	3	2	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I Sem
<b>Name of the Course:</b>	Finite Element Analysis in Manufacturing	<b>Course Code:</b>	ME25-M-MTA104 (5)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course offers a comprehensive study of nonlinear finite element analysis (FEA) with applications in production design and manufacturing. It begins with the fundamentals of nonlinear systems, element formulation, and coordinate systems, then progresses into advanced concepts such as geometric and material nonlinearities. The course also addresses contact nonlinearity, computational strategies for solving nonlinear problems, and the integration of FEA into design optimization workflows. Emphasis is placed on real-world manufacturing applications including metal forming, casting, welding, and automotive components, with a focus on interpreting FEA results and improving design accuracy and efficiency through simulation.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Apply foundational finite element concepts, including element formulation and discretization, to solve linear and nonlinear problems in manufacturing.
<b>CO2</b>	Analyze and model geometric and material nonlinearities in manufacturing processes, utilizing appropriate constitutive models and incremental solution techniques.
<b>CO3</b>	Formulate and solve contact nonlinearity problems in manufacturing, and apply appropriate solution strategies for nonlinear FEA, including convergence and post-processing.
<b>CO4</b>	Integrate FEA with CAD for production design optimization and apply FEA to improve product performance and minimize design cycles in manufacturing.
<b>CO5</b>	Apply FEA to analyze and optimize manufacturing processes such as metal casting, forming, and welding, and evaluate FEA results for automotive and other industrial applications.

**Syllabus:**

**Unit 1: Fundamentals of Nonlinear FEA and Element Formulation:** Introduction to linear and nonlinear problems; FEM elements and coordinate systems; Interpolation polynomials; Element and global matrices; Local and natural coordinate systems; Discretization, element selection, nodes, and degrees of freedom.

**Unit 2: Geometric and Material Nonlinearities:** Geometric nonlinearity: Linear buckling, pre-stress, stress stiffening, nonlinear buckling, imperfections, incremental equilibrium, nonlinear strain-displacement, tangent-stiffness, strain measures; Material nonlinearity: Plasticity, yield criteria, flow rules, hardening rules, tangent stiffness, finite strain, rate equations, incremental equations, elasto-plastic formulation.

**Unit 3: Contact Nonlinearity and Solution Strategies:** Contact nonlinearity: Contact applications, contact kinematics, contact algorithms, FEA contact issues; Issues in nonlinear FEA: Solution methods, convergence, stop criteria, post-processing, troubleshooting.

**Unit 4: FEA in Production Design and Optimization:** FEA in production design: Minimizing design cycles via CAD-FEA interfacing; FEA of maximum fatigue life and minimum weight; Vehicle aerodynamics studies; Design optimization; Fundamentals of Applied finite element analysis - hardware requirements for doing FEA.

**Unit 5: Manufacturing Applications of FEA:** Applications in metal casting, cutting, metal forming, and welding; FEA in moulds and dies; FEA in automotive industries: Models, results, and discussions; Preprocessing, executing the model, and post processing

**Text Books:**

1. Concepts and applications of finite element analysis by R. D. Cook, John Wiley & Sons, 2007.
2. Finite-Element Plasticity and Metalforming Analysis by G. W. Rowe, C. E. N. Sturgess, P. Hartley, Cambridge University Press, 2005.
3. Advances in Numerical Methods by Nikos Mastorakis, John Sakellaris, Springer, 2008.
4. Advances in Production Technology by Christian Becher, Springer, 2014.
5. Finite Element Method in Manufacturing Processes by J. Paulo Davim (Editor), John Wiley & Sons, 2011.
6. An Introduction to Nonlinear Finite Element Analysis by J. N. Reddy, McGraw Hill Education, Oxford University Press, 2014.

**CO, PO, & PSO Mapping**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	1	1	-	1	3	1	1
<b>CO2</b>	3	2	1	-	2	3	2	1
<b>CO3</b>	3	2	1	-	2	3	2	1
<b>CO4</b>	3	2	2	-	2	3	2	2
<b>CO5</b>	3	2	2	-	2	3	2	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Industrial Instrumentation and Control	<b>Course Code:</b>	ME25-M-MTA107
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

### Course Description

This course is designed to familiarize students with the functions and instrumentation used in modern power generation plants. It covers the fundamentals of industrial instrumentation, with emphasis on electrical, electronic, and process measurement systems. The course also introduces concepts of mathematical modeling, feedback control, and stability analysis in both time and frequency domains, providing a foundation for control system design and performance evaluation in industrial applications.

### Course Outcomes

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand about different instruments that are used for measurement purpose.
<b>CO2</b>	Analyze the Performance characteristics of each instrument, analyses the data and generate report.
<b>CO3</b>	Understand how waveforms can be analyzed using wave analyzers, MATLAB and Simulink
<b>CO4</b>	Determine transfer function models of electrical, mechanical and electromechanical systems.
<b>CO5</b>	Determine stability/relative stability from characteristic equation.

### Syllabus:

**Unit-1: Basics of Measurement Systems:** Static and dynamic characteristics of measurement systems. Measurement errors: Gross error, systematic error, absolute error and relative error, accuracy, precision, resolution and significant figures, Measurement error combination, basics of statistical analysis. Statistical analysis of data and curve fitting.

**Unit-2: Electrical and Electronic Measurements:** Bridges and potentiometers, measurement of R, L and C. Measurements of voltage, current, power, power factor and energy. AC & DC current probes. Extension of instrument ranges. Q-meter and waveform analyzer. Digital voltmeter and multi-meter. Time, phase and frequency measurements. Cathode ray oscilloscope. Serial and parallel communication. Shielding and groundings.

**Unit-3: Transducers, Mechanical Measurement and Industrial Instrumentation:** Resistive, Capacitive, Inductive and piezoelectric transducers and their signal conditioning. Measurement of displacement, velocity and acceleration (translational and rotational), force, torque, vibration and shock. Measurement of pressure, flow, temperature and liquid level. Measurement of pH, conductivity, viscosity and humidity.

**Unit-4: Control Systems:** Open loop and closed loop control systems, Feedback characteristics of control systems, Mathematical representation of physical systems, electrical, mechanical, hydraulic, thermal systems, Block diagram, algebra and signal flow graphs, Mason's gain formula. Time Domain Analysis, standard test signals, time response of first, second and higher order systems, performance indices. Error analysis, static and dynamic error coefficients. Stability, concept of stability, asymptotic and conditional stability, Routh Hurwitz criterion,

**Unit-5: Process Control:** Root locus technique (Concept and construction) Frequency Response Analysis Correlation between time and frequency response, Polar and inverse polar plots, NY Quist stability criterion, Bode plots, Time delay systems. Phase and gain margin. Mechanical, hydraulic and pneumatic system components. Synchro pair, servo and step motors. On-off, cascade, P, P-I, P-I-D, feed forward and derivative controller, Fuzzy controller.

**Text Books:**

1. Doebelin, E.O., Measurement systems, Applications and Design, McGraw–Hill (1982).
2. Nakra, B. C. and Chaudhry, K. K., Instrumentation Measurement and Analysis, Tata McGraw–Hill (2003).
3. Ogata, K., Modern Control Engineering, Prentice–Hall of India Private Limited (2001)
4. Nagrath, I.J. and Gopal, M., Control System Engineering, New Age International (P) Limited, Publishers (2003).
5. Gopal, M., Digital Control System, Wiley Eastern (1986).

**Reference Books:**

1. W Bolton- Instrumentation and control systems, Elsevier (2004).
2. Murthy, D.V.S., Transducers and Instrumentation, Prentice–Hall of India Private Limited (2003).
3. Sawhney, A.K., A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Co. (P) Ltd. (2007).
4. Kuo, B.C., Automatic Control System, Prentice–Hall of India Private Limited (2002).
5. Sinha, N.K., Control System, New Age International (P) Limited, Publishers (2002).

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
CO1	3	-	-	-	-	2	2	1
CO2	2	2	2	-	1	1	1	3
CO3	3	1	2	1	2	1	2	3
CO4	3	-	1	1	1	2	1	1
CO5	2	2	3	2	2	1	2	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Research Methodology	<b>Course Code:</b>	ME25-M-MTA108
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides an in-depth understanding of research methodology, equipping students with essential skills to conduct scientific research. It covers various research approaches, research design and data collection methods. Emphasis is placed on developing critical thinking skills for hypothesis formulation and data interpretation. The course also introduces students to ethical research practices and referencing techniques, enabling them to effectively communicate research findings through reports and synopsis.

**Course Outcomes:**

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Explain the fundamental concepts, types, and methodologies of scientific research.
<b>CO2</b>	Develop appropriate research designs, hypotheses, and sampling strategies for effective data collection.
<b>CO3</b>	Apply data collection techniques, analyze research data, and utilize statistical tools for interpretation.
<b>CO4</b>	Draft well-structured research reports and present findings effectively through seminars and papers.
<b>CO5</b>	Demonstrate awareness of publication ethics, plagiarism detection, and integrity in research writing.

**Syllabus**

**Unit 1: Introduction to Research:** Aims and Objectives of Research, Types of Research, Research Approaches, Characteristics of Scientific Research, Steps in Scientific Research, Methods of Scientific Research, research methods vs research methodology, Criteria of Good Research. Review of Literature.

**Unit 2: Research Design and Sampling:** Hypothesis – Qualities of a good Hypothesis, Hypothesis Testing – Logic & Important Features of a good research design; Concept and Importance of Research Design: –Experimental Design: Concept of Independent & Dependent variables. Qualitative and Quantitative Research.

**Unit 3: Data Collection, Methods, and Preparation:** Types of data, Projective Techniques, Collection of Secondary Data, Case Study, Pilot Study and Pre-Testing, Questionnaire Checking, Editing and Coding of Data, Sampling: Concepts of Statistical Population, Sample Size, Sampling Error, Probability, Practical considerations in sampling and sample size

**Data analysis and Visualization:** Classification, Tabulation, Graphical Visualization, Types of Analysis, Statistics in Research.

**Unit 4: Report Drafting and Presentation:** Structure and components of research report, Seminars and paper presentations, drafting research papers, Essential components for report drafting and scientific editing tools.

**Unit 5: Publication Ethics:** Importance of ethics in research, Ethical issues related to publishing: Plagiarism and Self-Plagiarism, Plagiarism detection tools, originality and novelty in research, conflict of interest.

**Text Books:**

1. Donald Cooper & Pamela Schindler, Business Research Methods, TMGH.
2. Alan Bryman & Emma Bell, Business Research Methods, Oxford University Press.
3. C. R. Kothari, Research Methodology, New Age Publication.
4. Rudolf J. Freund William J. Wilson, Statistical Methods, Academic Press, London.

**Reference Books:**

1. Chawla and Sondhi, Research Methodology, Vikas
2. Paneersevam, Research Methodology, PHI.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	3	2	-	2	2	2	1
<b>CO2</b>	2	3	2	-	3	1	2	2
<b>CO3</b>	2	3	2	-	3	2	1	3
<b>CO4</b>	3	3	2	-	2	2	2	2
<b>CO5</b>	2	2	1	1	2	1	1	3

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Digital Manufacturing	<b>Course Code:</b>	ME25-M-MTA109
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive overview of modern product design and development methodologies, emphasizing the integration of digital technologies such as CAD, CAE, additive manufacturing, and reverse engineering. Students will explore the design process from concept generation through embodiment and learn how to communicate design ideas through sketching and 3D modeling. It also includes exposure to additive manufacturing technologies and design for 3D printability, along with reverse engineering processes that support redesign and product innovation. Practical applications and case studies help students connect theoretical knowledge with real-world engineering product development.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the processes and methodologies involved in product conception and development, including 2D sketching and the role of CAD/CAM/CAE in PLM.
<b>CO2</b>	Apply 3D solid modeling and parametric design principles in CAD to visualize and render product assemblies and components.
<b>CO3</b>	Analyze and validate functional performance of products using CAE tools such as Finite Element Analysis (FEA) and perform topology optimization.
<b>CO4</b>	Explain the working principles, technologies, and design considerations involved in Additive Manufacturing and apply DFAM principles.
<b>CO5</b>	Apply reverse engineering processes using digitizing technologies, point cloud processing, and CAD modeling to recreate physical products.

**Syllabus:**

**Unit 1: Conception and development of products:** Design processes and methods, CAD/CAM/CAE technologies and product lifecycle management (PLM), Concepts generation and embodiment, Expression of product design ideas using 2D sketches.

**Unit-2: Computer-Aided Design (CAD):** Introduction to Computer Aided Design (CAD), Advantages of CAD, 3D Solid Modelling, Parametric design, Assembly Modelling, Drawing module. Render the appearance of a product.

**Unit-3: Computer-Aided Engineering (CAE):** Finite Element Analysis (FEA) to validate functional performance: general stages of the process, solid and FEA models, materials definition, loading (loads, displacements constraints, etc.), post-processing, results, and verifications. Topology optimization in Computer-Aided Engineering.

**Unit-4: Additive manufacturing:** General methodology, stages, and components of the process, Main technologies, principles and applications. Strengths, weaknesses, challenges, and limitations of additive manufacturing technologies. Main brands and suppliers available. Design for Additive Manufacturing (DFAM). Design for functionality and 3D printability, Planning and slicing additive manufacturing software.

**Unit-5: Reverse engineering:** General methodology: point clouds, meshes (.stl), NURBS surface models, and parametric CAD models, Digitizing methods and main technologies: applications and selection of reverse engineering systems. Hardware and software involved. Reverse engineering and additive manufacturing.

**Text Books:**

1. K. T. Ulrich and S. D. Eppinger, Product Design and Development, 6th Ed., McGraw-Hill Education, 2015.
2. Parametric Technology Corporation (PTC), Simulation using Creo Parametric user guides.
3. V. Raja and K. J. Fernandes (eds.), Reverse Engineering. An Industrial Perspective, 1st Ed., Springer-Verlag London, 2008.
4. N. Hopkinson, R. J. M. Hague and P. M. Dickens (eds.), Rapid Manufacturing: An Industrial Revolution for the Digital Age, 1st Ed., John Wiley & Sons, 2005.

**References Books:**

1. K. Otto and K. Wood, Product Design: Techniques in Reverse Engineering and New Product Development, 1st Ed., Prentice Hall, 2000.
2. Z. Zhou, S. Xie, and D. Chen, Fundamentals of Digital Manufacturing Science, 1st Ed., Springer-Verlag London, 2012.
3. I. Gibson, D. W. Rosen, and B. Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing. Springer-Verlag Boston, 2010.
4. C. K. Chua, K. F. Leong, and C. S. Lim, Rapid Prototyping: Principles and Applications, 3rd Ed., World Scientific, 2010.

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
CO1	2	2	2	1	2	1	2	3
CO2	2	2	1	-	2	1	1	2
CO3	1	2	2	1	2	2	1	3
CO4	3	2	1	3	1	-	2	3
CO5	2	2	3	1	3	2	1	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Quality Engineering in Manufacturing	<b>Course Code:</b>	ME25-M-MTA110
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course introduces key concepts of quality control and management, covering statistical tools, control charts, process capability, and acceptance sampling. It also explores advanced techniques like Taguchi methods, TQM, and ISO standards, along with quality improvement tools such as Six Sigma and benchmarking, to enhance product and process quality in industrial settings.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the fundamentals of quality control, statistical concepts, and control charts for process monitoring.
<b>CO2</b>	Analyze process capability and apply acceptance sampling techniques for quality assessment.
<b>CO3</b>	Apply Taguchi methods and design of experiments to optimize product and process quality.
<b>CO4</b>	Evaluate modern quality management initiatives like TQM, 5S, Kaizen, and Quality Function Deployment through industrial case studies.
<b>CO5</b>	Interpret and implement quality standards such as ISO 9000, Six Sigma, and business excellence models for organizational improvement

**Syllabus:**

**Unit 1: Quality Control:** Introduction to quality control and the quality system, Some philosophies and their impact on quality, Cost of quality, Quality audit.

**Statistical Concepts and Data Analysis:** Fundamentals of statistical concepts and techniques in quality control and improvement, Data analysis and sampling.

**Control Charts:** Statistical Process Control using control charts, Control charts for attributes and variables.

**Unit 2: Process capability analysis:** Concepts and procedures of Process capability.

**Acceptance Sampling:** Acceptance sampling for attributes and variables.

**Unit 3: Taguchi Methods:** Quality loss function, Taguchi method, Design of experiments using orthogonal array, Data analysis from Taguchi and Multi level factor design.

**Unit 4: New Quality Concepts and initiatives:** Total Quality Management (TQM) and its techniques, New Seven Management Tools, and Industrial Case studies on Costs of Quality, Five S, Kaizen, Quality Circles, Quality Function Deployment (QFD).

**Unit 5: Quality Standards and Business Excellence Models:** Quality System Standards, ISO 9000, ISO 14000, various Quality Awards and case studies. 6.-sigma, Bench marking, Quality circles, Brainstorming, Fishbone diagram, problem analysis.

**Text Books:**

1. Mitra Amitava, Fundamentals of Quality Control and Improvement, 2nd Ed., Prentice Hall of India, 2011
2. Kanishka Bedi, Quality Management, Oxford University Press.
3. M. Mahajan, Statistical Quality Control, Dhanpat Rai & Co. (P) Ltd.

**References Books:**

1. Phillip J. Ross, Taguchi Techniques for Quality Engineering, McGraw Hill, Intl. II Edition, 1995.
2. I G. Taguchi, A. Elsayed et al., Quality Engineering in Production systems, Mc. Graw Hill Intl. Edition, 1989.
3. Papan P. BagchiI, Taguchi Methods explained: Practical steps to Robust Design, Prentice Hall MD Pvt. Ltd., New Delhi.
4. Ranjit K. Roy, Design of Experiments using the Taguchi Approach, John Wiley & sons. Inc. 2001.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
<b>CO1</b>	2	2	3	2	-	3	1	-
<b>CO2</b>	2	3	2	-	2	3	2	-
<b>CO3</b>	3	-	3	-	-	3	1	-
<b>CO4</b>	2	-	1	3	3	2	3	2
<b>CO5</b>	2	3	2	-	-	2	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Advanced Welding Lab	<b>Course Code:</b>	ME25-M-MTA112
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hours/week
<b>Max Marks:</b>	50		

### Course Description

This practical course equips students with hands-on skills in multiple welding processes including Oxy-Fuel Cutting, SMAW, GMAW, GTAW, and Robotic Welding. Emphasis is placed on joint preparation, position-based welding techniques, and the application of modern technologies like Cold Metal Transfer (CMT) and robotic automation in welding.

### Course Outcomes

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Perform basic Oxy-Fuel gas cutting operations including straight-line and bevel cuts.
<b>CO2</b>	Demonstrate proficiency in welding techniques using SMAW, GMAW, and GTAW across various joint configurations and positions.
<b>CO3</b>	Prepare and execute butt and “T” joint welds with proper technique and safety in multiple positions.
<b>CO4</b>	Analyze and apply suitable welding processes based on material, position, and application requirements.
<b>CO5</b>	Operate robotic welding systems and perform automated welding using advanced technologies such as CMT.

### Syllabus:

Any 12 exercises of the following are to be performed.

1. To perform Straight Line Cut using Oxy-Fuel gas cutting.
2. To perform Bevel Cut using Oxy-Fuel gas cutting.
3. Prepare a straight-line weld bead using filler wire.
4. Prepare a square butt joint welding.
5. Practice plate to plate welding in 2F, 3F & 4F and positions in GMAW Process.
6. Practice plate to plate welding in 1G, 2G and 3G positions in GMAW Process.
7. Practice plate to plate welding in 2F and 3F positions in GTAW Process.

8. Practice plate to plate welding in 1G and 2G positions in GTAW Process.
9. Practice plate to plate welding in 2F and 3F positions in SMAW Process.
10. Practice plate to plate welding in 1G and 2G positions in SMAW Process.
11. Prepare a “T” joint using SMAW in 2F, 3F and 4F positions.
12. Prepare a “T” joint using GMAW in 3F, 4F, 3G and 4G positions.
13. Practice straight weld bead using GTAW process.
14. To study operational functioning of robotic welding system
15. Practice straight weld bead by robotic welding using CMT technology.
16. Practice Friction Stir Welding.

**List of Equipment available:**

1. TransPocket-180/EF (MMAW)
2. AccuPocket-150/230V/Set/EF(MMAW-Portable)
3. Trans Steel 2200C-4R/FSC Synergic (MMAW/TIG/MIG)
4. TPS 400i (MMAW/TIG/MIG)
5. TransTig 230i EF (MMAW/TIG/MIG)
6. Virtual Welder-Stand up-Terminal Basic (2.O)
7. Miscellaneous- (Teachware set, Fazor, Hand gloves, Leather jackets)
8. Robotic Welding Machine

**Resources**

1. Little R. L. – ‘Welding and Welding Technology’ – Tata McGraw Hill Publishing Company Limited, New Delhi – 1989
2. Grong O. – ‘Metallurgical Modelling of Welding’ – The Institute of Materials – 1997 – 2nd Edition
3. Kou S. – ‘Welding Metallurgy’ – John Wiley Publications, New York – 2003 – 2nd Edition.

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	3	2	-	2	3	3	3
<b>CO2</b>	3	3	2	-	2	3	3	3
<b>CO3</b>	3	3	2	-	2	3	3	3
<b>CO4</b>	3	3	2	-	2	3	3	3
<b>CO5</b>	3	3	2	-	3	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	CAD/CAM/CIM Lab	<b>Course Code:</b>	ME25-M-MTA113
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hours/week
<b>Max Marks:</b>	50		

**Course Description:**

This course provides hands-on experience in computer-aided design, CNC programming, and rapid prototyping technologies. Students will learn part modeling, assembly, and engineering drawing creation using CAD software. They will also write CNC programs, practice turning operations on CNC machines, and explore the application of rapid prototyping (RP) and reverse engineering techniques to convert physical models into digital formats.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Create part and assembly models using CAD software and apply appropriate constraints for effective design.
<b>CO2</b>	Generate engineering drawings with annotations and automated Bill of Materials (BOM), including tolerance specifications.
<b>CO3</b>	Develop CNC programs for creating contours, pockets, and perform turning operations on CNC machines.
<b>CO4</b>	Demonstrate rapid prototyping by generating STL files, slicing, and sending toolpath data to an RP machine for production.
<b>CO5</b>	Apply reverse engineering techniques to convert physical models into digital formats and utilize rapid tooling for manufacturing.

**List of Experiments:**

1. Part modeling of simple and complex components by using various features of the software
2. Assembly modeling of components using different constraints
3. Creation of Engineering drawing details and adding various annotations and generation of automated BOM.
4. Specifying tolerances for part and assembly Drawings
5. Writing of CNC programming for creation of Contours and Pockets
6. Surface Roughing of Crane Hook

7. Manufacturing Bottle Die
8. Taper Turning and Multiple Turning on CNC Lathe Machine.
9. Introduction to RP machine, Machine Specifications, Materials, Stl file generation
10. Slicing of stl files and obtaining the tool path data and sending it to RP machine
11. Demonstration of rapid tooling using fused deposition modeling.
12. Conversion of physical model to digital data format to demonstrate Reverse Engineering

**Note:** Out of the above 12 experiments, 10 experiments have to be carried out.

**Suggested Reading:**

1. Solidworks Essentials, “Solidworks” By Dassault Systems
2. EdgeCAM 11.0: For Engineers & Manufacturers, Sham Tickoo, DreamTech Pub.

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	3	2	1	-	2	3	1
<b>CO2</b>	3	3	2	-	-	3	2	1
<b>CO3</b>	3	3	2	2	-	2	2	2
<b>CO4</b>	3	3	2	2	-	2	2	2
<b>CO5</b>	2	3	3	2	2	3	2	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Scientific Paper Writing	<b>Course Code:</b>	ME25-M-MTA114
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hours/week
<b>Max Marks:</b>	50		

### Course Description

This subject is related to the techniques of scientific study and understanding related research mobility and how to express it in a scientific framework. The area of the subject may be a particular topic/subject/area/live project/case study and identifies the key areas and express in a paper mode for the scientific audiences.

### Course Outcomes

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the research methods
<b>CO2</b>	Acquire the perfection in journal reading
<b>CO3</b>	Develop skills for research publication/write-up.
<b>CO4</b>	Effectively present research findings.
<b>CO5</b>	Make use of new and recent tools for creating technical reports.

### Syllabus:

In this course, students will develop their scientific and technical reading and writing skills that they need to understand and construct research articles. A term paper requires a student to obtain information from a variety of sources (i.e., Journals, dictionaries, reference books) and then place it in logically developed ideas.

The work involves the following steps:

1. Selecting a subject, narrowing the subject into a topic
2. Stating an objective.
3. Collecting the relevant bibliography (at least 15 journal papers)
4. Preparing a working outline.
5. Studying the papers, understanding the author's contributions, and critically analyzing each paper.
6. Preparing a working outline

7. Linking the papers and preparing a draft of the paper.
8. Preparing conclusions based on the reading of all the papers.
9. Writing the Final Paper and giving the final Presentation

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	1	3	1	1	-	2	1	3
<b>CO2</b>	2	2	-	1	2	2	1	-
<b>CO3</b>	-	2	2	-	1	2	1	1
<b>CO4</b>	-	-	2	1	2	2	1	2
<b>CO5</b>	-	-	2	1	2	-	-	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Product Design and Development	<b>Course Code:</b>	ME25-M-MTA111 (1)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course focuses on the product development process, from concept generation to managing the entire life cycle of product design and manufacturing. Students will learn to identify customer needs, develop product specifications, and select and test design concepts. The course also covers industrial design, design for manufacturing, prototyping, and project management, equipping students with the tools to effectively manage product development from initial planning to final evaluation.

**Course Outcomes:**

After Completion of the course Students will be able to:

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Understand the characteristics of successful product development and the challenges associated with product planning and development processes.
<b>CO2</b>	Identify customer needs and generate product specifications, applying methods to prioritize and establish target specifications.
<b>CO3</b>	Apply concept generation and selection techniques and evaluate design concepts through concept testing.
<b>CO4</b>	Integrate industrial design and design for manufacturing (DFM) principles to reduce costs and improve product functionality.
<b>CO5</b>	Conduct economic analysis and manage product development projects, including planning, execution, and post-project evaluation.

**Syllabus:**

**Unit 1: Introduction:** Characteristics of successful product development, Design and development of products, duration and cost of product development, the challenges of product development.

**Development Processes and Organizations:** A generic development process, concept development: the front-end process, adopting the generic product development process, the AMF development process, product development organizations, the AMF organization.

**Product Planning:** The product planning process, identify opportunities. Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and the process.

**Unit 2: Identifying Customer Needs:** Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process.

**Product Specifications:** What are specifications, when are specifications established, establishing target specifications, setting the final specifications.

**Concept Generation:** The activity of concept generation clarifies the problem, search externally, search internally, explore systematically, reflect on the results and the process.

**Unit 3: Concept Selection:** Overview of methodology, concept screening, and concept scoring, Concept Testing: Define the purpose of concept test, choose a survey population, choose a survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process.

**Product Architecture:** What is product architecture, implications of architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues.

**Unit 4: Industrial design:** Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process, assessing the quality of industrial design.

**Design for Manufacturing:** Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors.

**Prototyping:** Prototyping basics, principles of prototyping, technologies, planning for prototypes.

**Unit 5: Product Development Economics:** Elements of economic analysis, base case financial mode, Sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis.

**Managing Projects:** Understanding and representing task, baseline project planning, accelerating projects, project execution, postmortem project evaluation.

**Text Books:**

1. Karl.T. Ulrich, Steven D Eppinger, Product Design and Development, Tata McGrawHill - 2003.
2. Bralla J G, Handbook of Product Design for Manufacture, McGrawhill NewYork.

**Reference Books**

1. Product Design and Manufacturing - A C Chitale and R C Gupta, PH1, - 3rd Edition, 2003.
2. New Product Development - Timjones. Butterworth Heinmann -Oxford. UCI -1997.
3. Product Design for Manufacture and Assembly –GeofferyBoothroyd, Peter Dewhurst and Winston Knight – 2002.

4. N J M Roozenberg, J Ekels, N F M Roozenberg, Product Design Fundamentals and Methods.  
 John Willey & Sons, 1995.

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	3	3	2	3	3	2	2
<b>CO2</b>	3	1	-	2	-	2	2	2
<b>CO3</b>	2	2	3	2	-	2	1	-
<b>CO4</b>	3	2	-	-	2	2	2	1
<b>CO5</b>	2	-	2	-	2	1	2	1

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Digital Twin	<b>Course Code:</b>	ME25-M-MTA111 (2)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course focuses on Industry 4.0 and the transformative role of Digital Twins in modern manufacturing and business operations. Students will gain in-depth knowledge of the fundamental concepts of Digital Twins, enabling technologies, and their application in product development, manufacturing, logistics, and more. Students will also explore the future of Digital Twin technology, its business impact, and career opportunities in the field.

**Course Outcomes:**

After Completion of the course Students will be able to:

CO Number	Course Outcomes
<b>CO1</b>	Understand the key concepts of Industry 4.0 and the role of Digital Twin in accelerating the adoption of Industry 4.0 technologies.
<b>CO2</b>	Gain knowledge of the enabling technologies for Digital Twin, including AI, ML, IoT, VR, AR, and others, and understand how to build and implement Digital Twin systems.
<b>CO3</b>	Apply Digital Twin technology to real-world use cases in product development, manufacturing, predictive maintenance, and other industries.
<b>CO4</b>	Integrate Digital Twin technology with Product Life Cycle Management (PLM), ERP, CRM, and other business systems for enhanced operational efficiency.
<b>CO5</b>	Develop business and revenue models for Digital Twin applications, evaluate its benefits and challenges, and explore future research opportunities and career paths in the Digital Twin domain.

**Syllabus:**

**Unit 1: Industry 4.0:** Introduction to industry 4.0, Technologies drivers & enablers of industry 4.0 like sensors, computing power, speed of data, connectivity, accessibility, advanced analytics. Evolution of Digital Twins, Introduction to Digital twin, Basic concepts of Digital twins, Growth drivers for digital twin, Product & Process digital twins, Digital Model, Digital Shadow, Digital twin Prototype (DTP), Digital Twin Instance (DTI), Digital Twin Aggregate (DTA), Partial digital twin, Clone digital twin, augmented digital twin, Smart & Connected design, accelerating industry 4.0 using Digital Twin

**Unit 2: Enabling technologies for Digital Twin** like Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Big Data Analytics, Internet of Things (IOT), Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), Cloud Computing Services (CCS) etc.

How to build a digital Twin, Steps in building digital twin, integration of IOT & CAD, integration of IOT, BIM data & machine Learning, Hardware & Software related to digital twin, working of a digital twin, Digital Twin Platforms Concurrent engineering & digital twin, digital twin as a smart service to industries

**Unit 3:** Use cases of Digital Twin in Product development, Logistics Manufacturing, Simulation, Predictive Maintenance, Asset Maintenance, Construction industry, Facility Management Architecture, Electrical engineering, digital twin driven power transformer service, Health Care & etc.

**Unit 4:** Integration of Digital Twin with Product Life Cycle Management (PLM), Big Data Analytics, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM), Supplier Relationship Management (SRM), Manufacturing Execution Systems (MES) etc

**Unit 5:** Building New business/Revenue models, developing maturity model of digital twin, Benefits of Digital Twins, Challenges in applying & implementing digital twins Future research areas of digital twin, Careers in Digital twin, Digital Twin Engineer

**Textbooks:**

1. Digital Twin: Possibilities of the new Digital twin technology, Anand Iyer, 2017.
2. Digital Twin Development & Deployment on the Cloud, 1st edition, Nassim Khaled Bibin Pattel Affan Siddiqu. ELSEVIER.
3. Digital Twin Technologies & Smart Cities, Maryam Farsi, Alireza Danesh khah, Amin Hosseinian-Far, Hamid Jahankahani, Springer.

**Reference Books**

1. Digital Twin Driven Smart Design by Fei Tao, Ang Liu, Tianliang Hu, A.Y.C. Nee, Elsevier,
2. Handbook of Digital Enterprise Systems: Digital Twins, Simulation and Ai, by Wolfgang Kühn, world scientific publishing co.,
3. Digital Twin Complete Self-Assesment Guide, Gerardus Blokdyk, Create Space Independent Publishing Platform, 2017.
4. Digital Twin Driven Smart Manufacturing, By Fei Tao, Meng Zhang, A.Y.C. Nee,
5. Advances in Computers, The Digital Twin Paradigm for Smarter Systems and Environments: The Industry, Pethuraj & Preetha Evanjaline, ELSEVIER.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
CO1	2	3	3	2	-	3	1	2
CO2	3	3	2	3	3	2	1	2
CO3	2	2	3	-	3	3	1	-
CO4	2	3	1	3	2	2	3	-
CO5	2	1	2	1	2	2	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Product Analysis and Cost Optimization	<b>Course Code:</b>	ME25-M-MTA111 (3)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive understanding of product analysis techniques and cost optimization strategies to enhance business profitability and efficiency. Students will explore methods for evaluating product performance, market competitiveness, and cost structures while learning to identify opportunities for cost reduction without compromising quality or value.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Understand new products and strategies.
<b>CO2</b>	Understand and implement the Value Analysis and Cost Accounting in the manufacturing system.
<b>CO3</b>	Understand and implement the types of costs involved in product design and manufacturing.
<b>CO4</b>	Understand and implement types of Variance Analysis in the manufacturing system.
<b>CO5</b>	Do Cost Calculation & Cost Accounting of the manufacturing system.

**Syllabus:**

**Unit 1: Introduction:** New products, new product strategy -market definition Idea generation introduction to the design process -forecasting sales potential -product engineering and markets, monopoly competitive.

**Manufacturing Planning:** Selection of optimum process, standardization. Break even analysis, application and area of use -problems -multi - product analysis.

**Unit 2: Value Analysis:** Steps in selection, analysis and implementation, Selection of cutting speed for optimum cost -problems.

**Cost Accounting:** Cost estimation -difference -types -steps involved in cost estimation.

**Unit 3: Types of Cost:** Cost Centers, Direct –indirect, material cost -direct indirect material cost Overhead cost, Elements in overheads: Preparation of cost sheet, machine hour rate, apportioning methods

**Unit 4: Variance Analysis** – Labor variance, Material variance and Overhead variance, Activity based costing - Introduction to target costing.

**Unit 5: Cost Calculation:** Cost calculation for machined components, welding, casting and forged components illustrations -calculation of sales cost.

**Cost Optimization Techniques:** Analytical, Graphical and Incremental Methods Learning curves.

**Text Books:**

1. Design and Marketing of New Products - Glen L Urban - John R Hauser- Prentice Hall. New Jersey, 1980.
2. Production and Costing - Narang CBS & Kumar V - Khanna Publishers- 2001.

**Reference Books:**

1. Cost management in the New Manufacturing Age -Yasuhiro Monden, Productivity Press, 1992.
2. Technique for Value Analysis and Engineering - Miles Lawrence. D- McGraw Hill, New york-1972.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	2	1	3	2	3	3	1	2
<b>CO2</b>	2	2	1	2	3	2	3	1
<b>CO3</b>	3	2	2	1	3	3	2	1
<b>CO4</b>	2	3	2	1	3	2	2	2
<b>CO5</b>	2	1		1	3	2	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Industry 4.0	<b>Course Code:</b>	ME25-M-MTA111 (4)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course exposes the students to understand the various industrial revolutions, the enabling technologies for industry 4.0, the power of data analytics, the importance of Connectivity, interdisciplinary concept & technology convergence, New business and Revenue models considering industry 4.0

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the basic concepts of Industry 4.0 and the other related fields
<b>CO2</b>	Identify various enabling technologies of Industry 4.0.
<b>CO3</b>	Apply the Industrial 4.0 concepts in a manufacturing plant to improve productivity and profits
<b>CO4</b>	Develop small applications using various technologies of Industry 4.0.
<b>CO5</b>	Implement Industry 4.0 to solve engineering problems.

**Syllabus:**

**Unit 1: Introduction to Industry 4.0:** Evolution of industry 4.0, Technology drivers & enablers of industry 4.0 like sensors, computing power, speed of data, connectivity, accessibility, advanced analytics & enabling technologies of industry 4.0. Relevance of industry 4.0 to Mechanical engineering.

**Unit 2: Introduction to Augmented Reality:** Basics of AR, Mixed Reality, enabling technologies of AR, Marker-based & Markerless AR. Software & Hardware of AR, Creating AR experience, Applications of AR in Mechanical engineering, Challenges.

**Introduction to Virtual Reality:** Basics of VR, Software & Hardware of VR, Challenges, Applications in Mechanical, Robotic automation & Collaborative robots (COBOTS).

**Unit 3: Introduction to Industrial Internet of Things (IIOT):** Sensors, IOT Protocols, IOT Platforms, Selection of sensors & IOT Platform, enabling technologies, micro controller, micro processor, Arduino board, Raspberry Pi, Sending Analog Data on Cloud Server, Smart Product Development, Smart Cities, Smart Manufacturing, Smart Logistics etc.

**Unit 4: Introduction to Big Data Analytics:** Evolution of big data, big data tools, 6V of big data, Basics of big data, HADOOP Ecosystem, HDFS data storage, data processing, RDBMS & NOSQL database management, Challenges of big data, Sentiment Analytics, Predictive Analytics, Graph Analytics etc.

**Unit 5: Introduction to Cloud Computing:** Cloud Computing basics, Cloud deployment models like Software as a Service (SAAS), Platform as a Service (PAAS), Infrastructure as a Service (IAAS), Mobile Computing Virtualization, Technology providers vs. Cloud providers vs. Cloud vendors, Cyber Security Business Issues in industry4.0, Opportunities, Challenges, Skillsets, Strategies.

**Text Books:**

1. Industry 4.0: Managing The Digital Transformation Book by Alp Ustundag and Emre Cevikcan, Publisher: Springer International Publishing.
2. Shaping the Fourth Industrial Revolution A Guide to Building a Better World, by Klaus Schwab, Nicholas Davis, Publisher: Penguin Books Limited.
3. Dieter Uckelmann et.al, “Architecting the Internet of Things”, Springer, 2011
4. Data Analytics: The Complete Beginner's Guide - Step By Step Instructions (The Black Book) Kindle Edition, by Byron Francis
5. The Enterprise Cloud: Best Practices for Transforming Legacy IT, by James Bond
6. Augmented Reality: Principles & Practice Paperback, by Schmalstieg/Hollerer
7. Learning Virtual Reality: Developing Immersive Experiences and Applications for Desktop, Web, and Mobile, by Tony Parisi, Publisher: O'Reilly Media.

**Reference Books:**

1. Charalampos Doukas, “Building Internet of Things with the Arduino”, Create space, April 2002.
2. Big Data and Analytics 1st Edition, Kindle Edition, by Subhashini Chellappan Seema Acharya.
3. Cloud Computing: Concepts, Technology & Architecture, by Richardo Puttini, Thomas Erl, and Zaigham Mahmood.
4. Handbook of Augmented Reality, by Borko Furht, Publisher: Springer New York.

**CO, PO & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
CO1	3	3	1	-	-	3	3	2
CO2	3	3	1	-	-	3	3	2
CO3	3	3	2	-	1	3	3	3
CO4	3	3	1	-	1	3	3	2
CO5	3	3	1	-	-	3	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Lean Manufacturing	<b>Course Code:</b>	ME25-M-MTA111 (5)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive overview of Lean Manufacturing, Total Quality Management (TQM), Total Productive Maintenance (TPM), Six Sigma, and Design of Experiments (DOE). The primary focus is on improving operational efficiency, reducing waste, and enhancing product quality across manufacturing and service sectors. Students will explore the key concepts, tools, and methodologies that enable organizations to achieve higher levels of productivity, quality, and continuous improvement. The course also covers essential techniques like benchmarking, failure mode analysis, and the use of quality circles to foster a culture of quality within organizations.

**Course Outcomes:**

After completion of the course, students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Understand the principles of Lean Manufacturing and apply the primary and secondary tools (5S, JIT, Kanban, SMED, etc.) to enhance workplace organization and efficiency.
<b>CO2</b>	Develop the ability to apply TQM tools and techniques, including Six Sigma, FMEA, benchmarking, and quality circles, to improve quality and performance in manufacturing and service sectors.
<b>CO3</b>	Gain an understanding of Total Productive Maintenance (TPM), its objectives, tools, and applications, to optimize maintenance operations and system effectiveness.
<b>CO4</b>	Apply the principles of Design of Experiments (DOE), with an emphasis on Taguchi's approach, to design and improve processes for better quality and performance.
<b>CO5</b>	Understand Six Sigma methodology and apply the DMAIC and DMADV models to solve problems, improve processes, and build a culture of continuous improvement within an organization

**Syllabus:**

**Unit-1: Introduction Lean Manufacturing:** Introduction, Definitions of Lean manufacturing, explaining basic concepts. Overview of historical development. Management theory.

**Primary Tools of Lean manufacturing:** 5-S, Workplace organization, Total Productive Maintenance, Process mapping/ Value stream mapping, Work cell.

**Secondary Tools of Lean manufacturing:** Objective and benefits of Secondary lean tool, Cause and Effect diagram, Pareto chart, Spider chart, Poka yoke, Kanban, Automation, Single minute exchange of die (SMED), Design for manufacturing and assembly, Just in time (JIT), Visual workplace, Overall equipment Efficiency (OEE).

**Unit-2: TQM Tools and Techniques:** The seven traditional tools of quality, New management tools, and Six sigma: Concepts, methodology, applications to manufacturing, service sector including IT, Bench marking, Reason to benchmark, Bench marking process, FMEA, Stages, and Types. Quality circles, Quality Function Deployment (QFD), Taguchi quality loss function, TPM, Concepts, improvement needs, Cost of Quality, Performance measures

**Unit-3: Total Productive Maintenance:** Objectives and functions, Reliability Centered Maintenance (RCM), maintainability prediction, availability and system effectiveness, maintenance costs, maintenance organization. Minimal repair, maintenance types, balancing PM and breakdown maintenance, Primary and secondary tool for TPM, Case studies related to TPM.

**Unit-4: Design of Experiments:** Introduction, Methods, Taguchi approach, steps in experimental design Designing for Quality: Introduction to Concurrent Engineering, Quality Function Deployment (QFD) and Failure Mode and Effect Analysis (FMEA).

**Unit-5: Six Sigma:** Meaning of six sigma, Why six sigma, Six sigma improvement model, DMAIC and DMADV principle, building six sigma organization and culture, Six sigma application, case studies. **Quality Circle:** Quality Circle structure, its operation, Characteristics of Quality Circle, developing quality circle in organization, Basic problem solving techniques.

**Text Books:**

1. Mitra A., Fundamentals of Quality Control and Improvement, PHI, 2nd Ed., 1998.
2. J Evans and W Linsay, The Management and Control of Quality, 6'th Edition, Thomson, 2005
3. Besterfield, D H et al., Total Quality Management, 3rd Edition, Pearson Education, 2008.
4. D. C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons, 6th Edition, 2004

**Reference Books:**

1. Dale H. Besterfield, Total Quality Management, Pearson Education Asia.
2. Poornima Charantimath, Total Quality Management, Pearson Education Asia
3. Tapan Bose, Total Quality Management, Pearson Education.
4. K C Jain and A K Chitale, Quality Assurance and Total Quality Management (ISO 9000, QS 9000 ISO 14000), Khanna Publishers.

5. B. L. Hanson & P. M. Ghare, Quality Control & Application, Prentice Hall of India.
6. Lonnie Wilson, How to Implement Lean Manufacturing, McGraw-Hill Professional; 1 edition, 2009.
7. Ronald G. Askin and Jeffrey B. Goldberg, Design and Analysis of Lean Production Systems, John Wiley and Sons, 2003.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	2	-	3	-	2	2	2	-
<b>CO2</b>	3	1	-	2	2	1	1	2
<b>CO3</b>	2	-	-	-	1	2	2	-
<b>CO4</b>	3	2	1	2	-	2	1	2
<b>CO5</b>	2	-	1	-	2	2	1	-

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Industrial/Research Internship	<b>Course Code:</b>	ME25-M-MTA201
<b>Credits:</b>	8	<b>No of Hours:</b>	16 hours/week
<b>Max Marks:</b>	200		

**Course Description:**

The Industrial Training/Research Internship course for M.Tech students specializing in Manufacturing Technology and Automation provides an opportunity for hands-on experience in industrial automation, manufacturing processes, and optimization. Students will engage in industry-driven projects or research, focusing on automation technologies, manufacturing process optimization, robotics, and advanced manufacturing systems. The course aims to enhance technical, analytical, and project management skills, culminating in a detailed report, presentation, and defense of their findings.

**Course Outcomes:**

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Demonstrate hands-on knowledge of advanced manufacturing systems, automation technologies, and their applications in real-world industrial settings.
<b>CO2</b>	Apply process optimization techniques and automation strategies to improve manufacturing efficiency and productivity.
<b>CO3</b>	Analyze data from industrial/academic research using appropriate methodologies, software tools, and automation techniques.
<b>CO4</b>	Develop a structured technical report and communicate findings with clarity and precision to both technical and non-technical audiences.
<b>CO5</b>	Present and defend their work effectively to industry professionals and academic researchers in the field of manufacturing technology and automation.

**Course Content:**

1. Industrial safety, regulations, and ethics
2. Overview of advanced manufacturing technologies (CNC, additive manufacturing, robotics)
3. Industrial automation and control systems
4. Process optimization and lean manufacturing techniques
5. Robotics and automation in production systems
6. Smart manufacturing and Industry 4.0 technologies
7. Data collection, analysis, and performance evaluation in manufacturing systems

8. Software tools for simulation, modeling, and optimization of manufacturing processes
9. Technical report writing and documentation
10. Presentation of industrial/academic research findings

**CO, PO, & PSO Correlation**

<b>Course Outcome</b>	<b>Program Outcome</b>					<b>PSOs</b>		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	2	2	1	2	3	3	2
<b>CO2</b>	3	3	2	1	3	3	3	2
<b>CO3</b>	2	3	2	-	3	2	3	3
<b>CO4</b>	2	3	2	1	2	2	2	3
<b>CO5</b>	1	2	2	1	2	2	1	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	III Sem
<b>Name of the Course:</b>	Dissertation-I	<b>Course Code:</b>	ME25-M-MTA202
<b>Credits:</b>	12	<b>No of Hours:</b>	24 hours/week
<b>Max Marks:</b>	300		

**Course Description:**

Dissertation I aims to develop research aptitude among M.Tech. students in Manufacturing Technology & Automation. The course guides students through identifying research problems, reviewing relevant literature, formulating research methodologies, and initiating preliminary experimental or simulation-based investigations. Emphasis is placed on addressing contemporary challenges in manufacturing systems, automation technologies, process optimization, and Industry 4.0 applications. This foundational phase prepares students for their final dissertation work in the subsequent semester.

**Objectives:**

1. To enable students to conduct an extensive literature review and identify gaps relevant to their prospective area of research.
2. To formulate well-defined research objectives and design an appropriate methodology for their study.
3. To initiate preliminary experimental work, simulations, or data analysis relevant to the research problem.
4. To develop technical writing and documentation skills for preparing an interim research report.
5. To enhance presentation and communication skills by effectively conveying research findings through oral and written formats.

**Course Outcomes:**

After completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Identify relevant and impactful research problems in the field of Manufacturing Technology and Automation.
<b>CO2</b>	Conduct comprehensive literature reviews to understand the research landscape and knowledge gaps.
<b>CO3</b>	Formulate appropriate research methodologies, including experimental or simulation-based approaches.
<b>CO4</b>	Initiate and perform preliminary investigations and data collection.
<b>CO5</b>	Prepare a research proposal and communicate initial findings effectively through technical documentation and presentations.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	3	2	-	2	3	2	2
<b>CO2</b>	2	3	2	-	3	3	3	2
<b>CO3</b>	3	3	3	-	2	1	3	3
<b>CO4</b>	1	3	2	2	3	2	2	1
<b>CO5</b>	2	3	2	1	3	2	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	IV Sem
<b>Name of the Course:</b>	Dissertation-II	<b>Course Code:</b>	ME25-M-MTA203
<b>Credits:</b>	20	<b>No of Hours:</b>	40 hours/week
<b>Max Marks:</b>	500		

**Course Description:**

Dissertation II is a continuation of Dissertation I, focusing on the execution of the research plan in the domain of Manufacturing Technology & Automation. In this phase, students conduct detailed experiments, simulations, or case studies, analyze results, and derive conclusions. The course emphasizes refining methodologies, validating outcomes, and preparing a structured dissertation. It also develops students' skills in independent research, critical thinking, and professional presentation.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Plan an independent and sustained critical investigation and evaluation of a chosen research topic relevant to the environment and society.
<b>CO2</b>	Systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques, and draw appropriate conclusions.
<b>CO3</b>	Engage in systematic discovery and critical review of appropriate and relevant information sources.
<b>CO4</b>	Understand and apply ethical standards of conduct in the collection and evaluation of data and other resources.
<b>CO5</b>	Communicate research concepts and contexts clearly and effectively both in writing and orally.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
CO1	3	3	2	1	1	2	3	1
CO2	2	2	3	1	2	2	1	1
CO3	1	2	2	-	2	2	2	2
CO4	-	2	2	3	-	-	2	2
CO5	1	2	3	1	2	-	-	2

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109  
Department of Mechanical Engineering



**O. P. Jindal University**  
**Raigarh-Chhattisgarh**



*Scheme and Syllabus*  
*of*  
M.Tech  
**School of Engineering**  
Session- 2025-27

**M.Tech**  
**(Power Plant Engineering and Energy Management)**

**Program Code: 01NPG041**

### **Program Outcomes for the Engineering Post Graduate Program**

**PO1: Disciplinary knowledge:** Accomplish vertical expertise in the chosen discipline and enhance the ability to function in multidisciplinary domains.

**PO2: Research aptitude:** Ability and aptitude to exercise research intelligence in investigations/innovations and to communicate the findings in a clear, concise manner.

**PO3: Project management:** Develop and apply knowledge of engineering and management principles to manage a project in a multidisciplinary environment.

**PO4: Ethics:** Gain knowledge of ethical principles and commit to professional ethics

**PO5: Self-directed lifelong learning:** Ability to identify appropriate resources and learn independently for projects, research, etc., using online resources.

### **Program Specific Outcomes for M. Tech in Power Plant Engineering and Energy Management**

**PSO 1:** Use engineering knowledge to design and analyse energy systems for different energy sources; suggest measures for energy conservation and management in industry and research organizations.

**PSO 2:** Apply the knowledge of science and engineering to develop efficient, clean, and sustainable ways to supply energy for social and industrial needs.

**PSO 3:** Practice as professionals by applying state-of-the-art research tools & techniques to analyse real-life industry problems.

**As per NEP Policy, HEIs can offer 3 Designs of PG**

**Designs of Postgraduate Program & Components**

- 1. For 2-year PG:** Students entering 2-year PG after a 3-year UG program can choose to do
  - (i) Only coursework in the third and fourth semesters or
  - (ii) Coursework in the third semester and research in the fourth semester or
  - (iii) Only research in the third and fourth semesters.
  
- 2. For 1-year PG:** Students entering 1-year PG after a 4-year UG program can choose to do
  - (i) Only coursework or
  - (ii) Research or
  - (iii) Coursework and research.
  
- 3. 5-year Integrated Program (UG+PG):** At the PG level, the curricular component of a 5-year integrated program will be similar to that of the 2-year PG mentioned above.

**Credit Distribution**

**a) For 1-year PG**

Choice	Curricular Components	PG Programme (one year) for 4-yr UG (Hons/Hons. with Research)			
		Minimum Credits			
		Course Level	Coursework	Research Thesis/Project/Patent	Total Credits
1	Coursework + Research	500	20	20	40
2	Coursework	500	40	-	40
3	Research	-	-	40	40

**b) For 2-year PG**

Choice	Curricular Components	Two-Year PG Programme (Generic and Professional)				
		Minimum Credits				
		Course Level	Coursework	Research Thesis/Project/Patent	Total Credits	
1_1 <sup>st</sup> Y	PG Diploma	400	40	-	40	
2_1 <sup>st</sup> Y	1st Year (1st & 2nd Semester)	400 500	24 16	-	40	
Students who exit at the end of 1st year shall be awarded a <b>Postgraduate Diploma</b>						
1_2 <sup>nd</sup> Y	2nd Year (3rd & 4th Semester)	Coursework + Research	500	20	20	40
2_2 <sup>nd</sup> Y		Coursework	500	40	-	40
3_2 <sup>nd</sup> Y		Research	-	-	40	40

**All the above designs are for the PG courses such as M.A., M.Com., M.Sc., etc. The entry criteria for the M.Tech PG Course are given in Table 1 of the OPJU Ordinance.**

**Table – 1**  
**Qualification Type and Credit Requirements**

978 (36)

छत्तीसगढ़ राजपत्र, दिनांक 3 सितम्बर 2024

NHEQF levels	Qualification title/nomenclature	Credit Requirements (Minimum)
Level 4.5	Undergraduate Certificate (in the field of learning/discipline) for those who exit after the first year (2 semesters) of the undergraduate programme. (Programme duration: First year or 2 semesters of the undergraduate programme)	40 credits
Level 5	Undergraduate Diploma (in the field of learning/discipline) for those who exit after the first two years (4 semesters) of the undergraduate programme (Programme duration: First two years or 4 semesters of the undergraduate programme)	80 credits
Level 5.5	Bachelor's Degree (examples: Bachelor of Arts; Bachelor of Science; Bachelor of Commerce; Bachelor of Business Administration, etc.(Programme duration: Three years or 6 semesters).	120 credits
Level 5.5	Bachelor of Vocation (B.Voc). (Programme duration: 3 years or 6 semesters).	120 credits
Level 6	Bachelor of Engineering (B.E.); Bachelor of Technology (B.Tech.) (Programme duration: Four years or	160 credits
Level 6	B.A., B.Ed.; B.Sc., B.Ed.; B.Com., B.Ed. (4-year dual-degree Integrated Teacher Education Programme)	160 credits
Level 6	Bachelor's Degree (Honours/ Honours with Research). (Programme duration: Four years or 8 Semesters).	160 credits
Level 6	Post-Graduate Diploma. For those who exit after successful completion of the first year or two semesters of the 2-year master's programme). (Programme duration: One year or 2 semesters).	40 credits
Level 6.5	Master's degree. (e.g. M.A.; M.Com., M.Sc.; etc.) (Programme duration: Two years)	160 credits

**Source: Approved NEP based ordinance no. 32\_September 2024\_OPJU**

**Curriculum and Credit Framework for Postgraduate Program (M.Tech)**

Semester	Core Courses	Professional Elective	Common Course	Industrial Training / Research Internship	Dissertation	Total Credits
<b>I</b>	16	3	1			<b>20</b>
<b>II</b>	13	3	4			<b>20</b>
<i>Exit Point: For those who join 2-year PG programs, there shall only be one exit point. Students who exit at the end of 1<sup>st</sup> year shall be awarded a Postgraduate Diploma.</i>						
<b>III</b>				8	12	<b>20</b>
<b>IV</b>					20	<b>20</b>
						<b>80</b>
<i>Students on exit shall be awarded a Master of Technology (in the Field of Study/ Discipline) after securing the requisite 80 credits on completion of Semester IV.</i>						

<b>FIRST SEMESTER (NHEQF Level: 6)</b>										
<b>S. No.</b>	<b>Subject Code</b>	<b>Subject</b>	<b>Periods per Week</b>			<b>Scheme of Examination (Theory / Practical)</b>			<b>Total Marks</b>	<b>Credit L+(T+P)/2</b>
						<b>PRE</b>		<b>ESE</b>		
			<b>L</b>	<b>T</b>	<b>P</b>	<b>MID</b>	<b>TA</b>			
1	ME25-M-PPE101	Computational Methods and Optimization Techniques	3	0	0	15	15	70	100	3
2	ME25-M-PPE102	Advanced Power Plant Engineering	3	0	0	15	15	70	100	3
3	ME25-M-PPE103	Power Plant Machines	3	0	0	15	15	70	100	3
4	ME25-M-PPE104	Advanced Thermodynamics and Combustion	3	0	0	15	15	70	100	3
5	ME25-M-PPE105 (1-5)	Program Elective I (Annexure -I)	3	0	0	15	15	70	100	3
6	ME25-M-PPE106	Computational Methods and Optimization Techniques Lab	0	0	4	-	15	35	50	2
7	ME25-M-PPE107	Advanced Power Plant Engineering Lab	0	0	4	-	15	35	50	2
8	ME25-M-MTA106	Intellectual Property Rights	0	0	2	-	15	35	50	1
<b>Total</b>			<b>15</b>	<b>0</b>	<b>10</b>	<b>75</b>	<b>120</b>	<b>455</b>	<b>650</b>	<b>20</b>

**Program Elective I (Annexure - I)**

<b>S. No.</b>	<b>Subject Code</b>	<b>Name of the Courses</b>
1	ME25-M-PPE105 (1)	Design of Advanced Thermal Power Plant Equipment
2	ME25-M-PPE105 (2)	Advanced Heat Transfer
3	ME25-M-PPE105 (3)	Sustainable and Renewable Energy Technology
4	ME25-M-PPE105 (4)	Energy Storage Systems
5	ME25-M-PPE105 (5)	Industrial Automation

<b>SECOND SEMESTER (NHEQF Level: 6)</b>										
<b>S. No.</b>	<b>Subject Code</b>	<b>Subject</b>	<b>Periods per Week</b>			<b>Scheme of Examination (Theory / Practical)</b>			<b>Total Marks</b>	<b>Credit L+(T+P)/2</b>
						<b>PRE</b>		<b>ESE</b>		
			<b>L</b>	<b>T</b>	<b>P</b>	<b>MID</b>	<b>TA</b>			
1	ME25-M-MTA107	Industrial Instrumentation and Control	3	0	0	15	15	70	100	3
2	ME25-M-MTA108	Research Methodology	3	0	0	15	15	70	100	3
3	ME25-M-PPE108	Design of Heat Exchangers	3	0	0	15	15	70	100	3
4	ME25-M-PPE109	Computational Fluid Dynamics	3	0	0	15	15	70	100	3
5	ME25-M-PPE110 (1-5)	Program Elective II (Annexure -II)	3	0	0	15	15	70	100	3
6	ME25-M-PPE111	Heat Exchangers Lab	0	0	4	-	15	35	50	2
7	ME25-M-PPE112	Computational Fluid Dynamics Lab	0	0	4	-	15	35	50	2
8	ME25-M-MTA114	Scientific Paper Writing	0	0	2	-	15	35	50	1
<b>Total</b>			<b>15</b>	<b>0</b>	<b>10</b>	<b>75</b>	<b>120</b>	<b>455</b>	<b>650</b>	<b>20</b>

**Program Elective -II (Annexure - II)**

<b>S. No.</b>	<b>Subject Code</b>	<b>Name of the Courses</b>
1	ME25-M-PPE110 (1)	Energy Management & Audit
2	ME25-M-PPE110 (2)	Advanced Solar Thermal Energy Systems
3	ME25-M-PPE110 (3)	Artificial Intelligence in Power Systems
4	ME25-M-PPE110 (4)	Energy Conservation by Waste Heat Recovery
5	ME25-M-PPE110 (5)	Advanced Steam & Gas Turbine Engineering

<b>THIRD SEMESTER (NHEQF Level: 7)</b>										
<b>S No.</b>	<b>Subject Code</b>	<b>Subject</b>	<b>Periods per Week</b>			<b>Scheme of Examination (Theory / Practical)</b>			<b>Total Marks</b>	<b>Credit L+(T+P)/2</b>
						<b>PRE</b>		<b>ESE</b>		
			<b>L</b>	<b>T</b>	<b>P</b>	<b>MID</b>	<b>TA</b>			
1	ME25-M-PPE201	Industrial/Research Internship	0	0	16	-	60	140	200	08
2	ME25-M-PPE202	Dissertation-I	0	0	24	-	90	210	300	12
<b>Total</b>			<b>0</b>	<b>0</b>	<b>40</b>	<b>-</b>	<b>150</b>	<b>350</b>	<b>500</b>	<b>20</b>

<b>FOURTH SEMESTER (NHEQF Level: 7)</b>										
<b>S. No.</b>	<b>Subject Code</b>	<b>Subject</b>	<b>Periods per Week</b>			<b>Scheme of Examination</b>			<b>Total Marks</b>	<b>Credit L+(T+P)/2</b>
						<b>Theory / Practical</b>				
			<b>PRE</b>		<b>ESE</b>					
<b>L</b>	<b>T</b>	<b>P</b>	<b>MID</b>	<b>TA</b>						
1	ME25-M-PPE203	Dissertation-II	0	0	40	-	150	350	500	20
<b>Total</b>			<b>0</b>	<b>0</b>	<b>40</b>	<b>-</b>	<b>150</b>	<b>350</b>	<b>500</b>	<b>20</b>

**L-** Lecture      **ESE-** End Semester Exam      **P-** Practical      **T.A.-** Teacher's Assessment

<b>FIRST SEMESTER (NHEQF Level: 6)</b>										
<b>S. No.</b>	<b>Subject Code</b>	<b>Subject</b>	<b>Periods per Week</b>			<b>Scheme of Examination (Theory / Practical)</b>			<b>Total Marks</b>	<b>Credit L+(T+P)/2</b>
						<b>PRE</b>		<b>ESE</b>		
			<b>L</b>	<b>T</b>	<b>P</b>	<b>MID</b>	<b>TA</b>			
1	ME25-M-PPE101	Computational Methods and Optimization Techniques	3	0	0	15	15	70	100	3
2	ME25-M-PPE102	Advanced Power Plant Engineering	3	0	0	15	15	70	100	3
3	ME25-M-PPE103	Power Plant Machines	3	0	0	15	15	70	100	3
4	ME25-M-PPE104	Advanced Thermodynamics and Combustion	3	0	0	15	15	70	100	3
5	ME25-M-PPE105 (1-5)	Program Elective I (Annexure -I)	3	0	0	15	15	70	100	3
6	ME25-M-PPE106	Computational Methods and Optimization Techniques Lab	0	0	4	-	15	35	50	2
7	ME25-M-PPE107	Advanced Power Plant Engineering Lab	0	0	4	-	15	35	50	2
8	ME25-M-MTA106	Intellectual Property Rights	0	0	2	-	15	35	50	1
<b>Total</b>			<b>15</b>	<b>0</b>	<b>10</b>	<b>75</b>	<b>120</b>	<b>455</b>	<b>650</b>	<b>20</b>

**Program Elective I (Annexure - I)**

<b>S. No.</b>	<b>Subject Code</b>	<b>Name of the Courses</b>
1	ME25-M-PPE105 (1)	Design of Advanced Thermal Power Plant Equipment
2	ME25-M-PPE105 (2)	Advanced Heat Transfer
3	ME25-M-PPE105 (3)	Sustainable and Renewable Energy Technology
4	ME25-M-PPE105 (4)	Energy Storage Systems
5	ME25-M-PPE105 (5)	Industrial Automation

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Computational Methods and Optimization Techniques	<b>Course Code:</b>	ME25-M-PPE101
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

Computational methods are powerful problem-solving tools capable of handling large systems of equations, nonlinear systems, and complex problems, common challenges in engineering practice that often cannot be solved analytically. This course focuses on computational solutions to nonlinear equations, with special attention given to standard finite element equations. Additionally, the course covers modern optimization techniques for achieving optimal solutions.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Solve linear and nonlinear algebraic equations and systems of nonlinear equations using numerical techniques.
<b>CO2</b>	Use of regression and interpolation methods for curve fitting.
<b>CO3</b>	Apply and analyze the finite difference and finite volume schemes for the numerical solution of system equations in one and two dimensions.
<b>CO4</b>	Apply fuzzy logic tools to inference systems
<b>CO5</b>	Apply modern optimization techniques to engineering problems.

**Syllabus:**

**Unit-1: Linear and Non-Linear Equations:** Introduction, Bisection method, False Position Method, Method of iteration: Newton-Raphson method, Secant method, Gauss Elimination Method, Gauss Jordan method, Gauss-Seidel method, Convergence of iterative methods.

**Unit-2: Interpolation:** Newton’s forward and backward interpolation, Lagrange’s interpolation, Newton’s divided difference interpolation, Inverse interpolation.

**Unit-3: Linear and Non-Linear Programming:** Definition, Classification of Optimization Problem, Simplex Method, Duality, Sensitivity Methods, Non-Linear Programming: Newton’s Method, GRG Method, Penalty Function Method, Augmented Lagrange Multiplier Method.

**Unit-4: Fuzzy Logic:** Basic concepts Fuzzy Logic (FL), Fuzzy sets, and their operations. Fuzzy memberships and relations, Fuzzification, and defuzzification methods, Numerical problems on FL, Fuzzy rule generation, Applications of FL in optimization.

**Unit-5: Introduction to Optimization:** Engineering application of Optimization, Statement of an Optimization problem, Optimal Problem formulation, Classification of optimization problem.

**Modern methods of Optimization:** Genetic Algorithms, Ant Colony Optimization, Neural-Network based Optimization Applications, Firefly Algorithm, Use of MATLAB to solve optimization problems.

**Text Books:**

1. S. Rajasekaran, G. A. Vijayalakshmi Pai, “Neural Networks, fuzzy logic, and genetic algorithms: synthesis and applications, PHI Learning Private Limited
2. S.S. Rao, “Engineering Optimization: Theory and Practice”, New Age International Pvt Ltd Publishers
3. Dilip Kumar Pratihar, “Soft Computing: Fundamentals and Applications”, Narosa Publishing House Pvt. Ltd. - New Delhi

**References Books**

1. S.S. Sastry, “Introductory Method of Numerical Analysis,” Prentice Hall India Learning Private Limited
2. S.C. Chapra, “Applied Numerical Methods with MATLAB”, McGraw Hill Education
3. David G. Luenberger, “Linear and Nonlinear Programming”, Springer, India, Private Ltd
4. Joe D. Hoffman, “Steven Frankel, Numerical Methods for Engineers and Scientists”, CRC Press
5. E. Kreyszig, “Advanced Engineering Mathematics”, John Wiley & Sons Inc

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
<b>CO1</b>	2	1	-	-	2	1	-	1
<b>CO2</b>	2	1	-	-	2	1	-	1
<b>CO3</b>	2	1	-	-	2	3	-	2
<b>CO4</b>	3	3	1	-	3	2	1	3
<b>CO5</b>	3	3	1	-	3	2	1	3

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	M.Tech	<b>Semester:</b>	I
<b>Name of the Course:</b>	Advanced Power Plant Engineering	<b>Course Code:</b>	ME25-M-PPE102
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course offers lectures and laboratory classes to impart teaching and learning. The course is designed to provide detailed knowledge of advanced power plant technologies to the learners. This course covers the concepts, numerical problems, and working principles of the various power plant technologies. The subject deals with conventional as well as non-conventional energy resources of power generation.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand various energy sources and thermal power plant components, layout, advantages, and limitations.
<b>CO2</b>	Explain hydro, wind, and solar power generation principles, site selection, and system components.
<b>CO3</b>	Describe diesel and nuclear power plants, their layouts, working principles, and fuel types.
<b>CO4</b>	Understand the gas turbine operation, classifications, cycles, performance characteristics, and efficiency considerations.
<b>CO5</b>	Explore different energy storage systems and their principles, types, and applications in power systems.

**Syllabus:**

**Unit-1: Introduction:** Conventional & Non-Conventional Sources of Energy and their availability in India, Different Types of Power Plants, Choice of Type of Power Generation, Power Plants scenario in India.

**Thermal Power Generation:** Operating Principle, Site selection, Coal to Electricity, General Layout of Thermal Power Plant, Brief description of different parts/systems and their functions, Advantages, and Limitations.

**Unit-2: Hydro Power:** Hydrology, Hydrographs, Principle of working, Classification, Site selection, Different components & their functions, Types of Dams, Pumped Storage Power Plants, Advantages of Hydroelectric Power Plants.

**Wind Power:** Basic principles of wind energy conversion, wind energy estimation, site selection consideration, basic components of a wind energy conversion system,

**Solar Power:** Photovoltaic effect, efficiency of solar cells, solar photovoltaic system.

**Unit-3: Diesel & Nuclear Power Generation:** Applications of Diesel Engine, Advantages & disadvantages, Types of Diesel Plants, General Layout, Performance Characteristics, Turbocharging, Supercharging, Layout of a Diesel Engine Power plant, Principle of Nuclear Energy, Nuclear Power Plant Components & their Functions, types; Nuclear Fuels, Radioactivity, Nuclear Fission and Fusion.

**Unit-4: Gas Turbine Power Generation:** Operating Principle; Classification, Open Cycle, Closed Cycle, Combined Cycle, Fuels for Gas Turbine Power Plants, Different Components and their functions, Gas Turbine Characteristics, Cycle Efficiency, Operational Aspects, Advantages and Limitations.

**Unit-5: Energy Storage:** Pumped hydro, Compressed Air Energy Storage (CAES), Flywheel energy storage, Electrochemical Energy Storage, Thermal Energy Storage, Magnetic Energy Storage, Chemical Energy Storage, Hydrogen Energy storage.

**Text Books:**

1. P. C. Sharma, A Textbook of Power Plant Engineering, S.K. Kataria & Sons.
2. Domkundwar and Arora Domkundwar, Power Plant Engineering, Dhanpat Rai & Co. (P) Limited.
3. Rajput, A Text Book of Power Plant Engineering, Laxmi Publications.
4. Birol Kılıkış and Sadık Kakaç, Energy Storage Systems, Springer Publications

**References Books:**

1. P. K. Nag, Power Plant Engineering, The McGraw Hill Companies.
2. G.D. Rai, An Introduction to Power Plant Technology, Khanna Publishers.
3. C. Elanchezhian, L. Saravanakumar, B. Vijaya Ramnath, Power Plant Engineering, TechSar Pvt. Ltd.
4. K. K. Ramalingam, Power Plant Engineering, Scitech Publications (India) Pvt Ltd.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
CO1	2	1	-	-	1	2	2	-
CO2	2	1	-	-	1	2	1	-
CO3	2	1	-	-	2	1	-	1
CO4	2	1	-	-	1	2	2	-
CO5	3	2	-	-	2	2	2	1

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	M. Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Power Plant Machines	<b>Course Code:</b>	ME25-M-PPE103
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive overview of essential power plant systems and operations. It begins with coal and ash handling, covering fuel processing and waste management. Students will then learn about draught systems, including natural and forced draught, and fan power requirements. The course explores power plant fans and pumps, focusing on their types, performance evaluation, and energy efficiency. High-pressure boilers and their accessories, including superheaters and economizers, will be analyzed, with a focus on corrosion prevention. Finally, the course covers AC power generation and grid synchronization, including generator design, cooling systems, and excitation methods. This course equips students with a thorough understanding of power plant fundamentals.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Evaluate coal and ash-handling systems in power plants.
<b>CO2</b>	Analyse power plant draught system performance.
<b>CO3</b>	Assess power plant fan and pump operation and control.
<b>CO4</b>	Analyse high-pressure boiler systems and accessories.
<b>CO5</b>	Evaluate AC generator design and grid synchronization.

**Syllabus:**

**Unit-1: Coal & Ash Handling Systems:** Coal handling and storage, Types of stokers and their working, Pulverized fuel handling systems, Pulverized mills, Pulverized coal and Oil burners, Ash handling systems, Dust collection and disposal.

**Unit-2: Draught System:** Natural draught- estimation of height of the chimney, Maximum discharge, Condition, Forced, Induced, and balanced draught, Power requirement by fans, Primary and Secondary air fans, Capacity control methods-VFD and Magnetic drives.

**Unit-3: Power Plant Fans and Pumps:** Types, Principle, constructional aspects, operation of fans used in power plant. Fan laws, Performance evaluation, efficient system operation, Flow control strategies and energy conservation opportunities.

**Pumps and Pumping System:** Types of pumps used in power plants, Performance evaluation, efficient system operation, Flow control strategies, and energy conservation opportunities.

**Unit-4: High-Pressure Boilers & Accessories:** Unique features and advantages of high-pressure boilers, critical and supercritical, Supercharged and fluidized bed combustion boilers (AFBC, CFBC, PFBC). Different types of superheaters, reheaters, economizers, Air preheaters, Methods of superheat control, Corrosion in boilers, and its prevention.

**Unit 5: AC power Generation and Grid Synchronization:** Introduction, Types, Rotating armature & rotating field generators, Polyphase generators, Generator cooling systems, Design & Construction, Stator and windings, Rotors: Salient pole, cylindrical rotor, Excitation systems, Grid synchronization.

**Text Books:**

1. Arora & Domkundwar, Power Plant Engineering, Dhanpat Rai & Co. Delhi.
2. R.K. Rajput, A Textbook of Power Plant Engineering, Laxmi Publication, Delhi
3. A.K. Raja, Power Plant Engineering, New Age International, Delhi
4. Dr. P.C. Sharma, A textbook of Power Plant Engineering, S.K. Kataria & Sons, Delhi

**References Books:**

1. P.K. Nag, Power Plant Engineering, Tata McGraw-Hill Co., Delhi
2. G.R. Nagpal, Power Plant Engineering, Khanna Publishers, Delhi.
3. C. Elanchazhian, Power Plant Engineering, I.K. International, Delhi.
4. Practical Power Plant Engineering: A Guide for Early Career Engineers, Zark Bedalov, John Wiley & Sons, Inc

**CO, PO & PSO Correlation**

Course Outcomes	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	2	2	-	2	3	1	2
<b>CO2</b>	3	2	2	-	2	3	1	2
<b>CO3</b>	3	2	2	-	2	3	1	2
<b>CO4</b>	3	2	2	-	2	3	1	2
<b>CO5</b>	3	2	2	-	2	3	1	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M.Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Advanced Thermodynamics & Combustion	<b>Course Code:</b>	ME25-M-PPE104
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

In this course, the students are introduced to the advanced concepts in thermodynamics. It is an extension of the basic energy analysis with a strong emphasis on the concepts of entropy, exergy, and irreversibility concerning thermodynamic systems. The course also introduces the concepts of combustion and reactive systems. The course emphasizes the application of thermodynamic principles to solve complex engineering problems relevant to energy conversion and chemical reactions.

**Course Outcomes:**

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

CO Number	Course Outcome
<b>CO1</b>	Apply the principles of entropy and the second law of thermodynamics to analyze various thermodynamic processes.
<b>CO2</b>	Analyze thermodynamic systems using the concept of available energy (exergy).
<b>CO3</b>	Apply equations of state to analyze the behavior of gases and utilize property diagrams to analyze the properties of pure substances.
<b>CO4</b>	Understand the importance of thermodynamic property relations and develop various property relations.
<b>CO5</b>	Analyze reactive systems, including combustion processes, using the first and second laws of thermodynamics.

**Syllabus:**

**Unit-1: Entropy:** First and second law review, Clausius theorem - property of entropy, inequality of Clausius, entropy change in an irreversible process, entropy principle, applications of entropy principle, entropy transfer with heat flow, entropy generation in a closed system, entropy generation in an open system.

**Unit-2: Available Energy/Exergy:** Available energy referred to a cycle, available energy from a finite energy source, maximum work in a reversible process, availability in a steady flow process, and availability in a non-flow process.

**Unit-3: Properties of Gases:** Equations of state, Vander Waal’s equation, law of corresponding states, Beattie- Bridgeman equation, Redlich-Kwong equation. Gas Mixtures: Dalton’s law of partial pressures, enthalpy, and entropy of gas mixtures.

**Properties of Pure Substance:** P-v, T-s, and h-s diagram for a pure substance.

**Unit- 4: Thermodynamic Relations:** Maxwell’s equations, TdS equations, difference in heat capacities, ratio of heat capacities, Energy equation, Joule-Kelvin effect, Clausius-Clapeyron equation.

**Unit-5: Reactive Systems:** Reactive Systems, degree of reaction, reaction equilibrium, law of mass action, heat of reaction, temperature dependence of the heat of reaction, temperature dependence of the equilibrium constant, change in Gibbs function, Fugacity and activity.

**Chemical Reactions:** Combustion, theoretical and actual combustion processes, enthalpy of formation, enthalpy of combustion, First Law analysis of reacting systems, adiabatic flame temperature, entropy change of reacting mixtures – Second Law analysis of reacting systems.

**Text Books:**

1. P. K. Nag, Engineering Thermodynamics, Tata McGraw Hill.
2. J. P. Holman, Thermodynamics, Tata McGraw Hill.
3. S. S. Thipse, Advanced Thermodynamics, Narosa Publishing House.

**References Books:**

1. Y. A. Cengel and M. A. Boles, Thermodynamics – An Engineering Approach, Tata McGraw Hill.
2. Sonntag & Van Wylen, Thermodynamics, John Wiley & Sons.
3. Doolittle Messe, Thermodynamics for Engineers, John Wiley & Sons.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	1	-	-	1	2	1	2
<b>CO2</b>	3	2	-	-	1	2	1	2
<b>CO3</b>	3	1	-	-	1	1	-	-
<b>CO4</b>	3	1	-	-	1	2	-	-
<b>CO5</b>	3	3	-	-	1	2	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Computational Methods and Optimization Techniques Lab	<b>Course Code:</b>	ME25-M-PPE106
<b>Credits:</b>	2	<b>No. of Hours:</b>	4 hours/week
<b>Max Marks:</b>	50		

### Course Description:

This course aims to teach a suite of algorithms and concepts related to fitting data to models, as well as various numerical techniques to solve mathematical problems encountered in engineering, physical sciences, and real-life applications. It begins with fundamental topics in linear algebra and computational methods and gradually introduces advanced concepts, including soft computing and optimization techniques.

### Course Outcomes:

After Completion of the course, Students will be able to:

CO Number	Course Outcome
CO1	Write a program for solving nonlinear equations.
CO2	Write a program of non-conventional methods for solving a system of linear equations
CO3	Interpret data using the fuzzy logic toolbox
CO4	Solve optimization problems using genetic algorithms
CO5	Train and test data using neural networks

### List of Experiments:

1. Write and execute a program for the Bi-Section Method to find roots using soft computing tools.
2. Write and execute a program for the Regula-Falsi Method to find roots using soft computing tools.
3. Write and execute a program for the Newton-Raphson Method to find roots using soft computing tools.
4. Write and execute a program to solve a system of linear equations using the Gauss Elimination Method with soft computing tools.
5. Write and execute a program for Newton's Forward and Backward Interpolation Methods using soft computing tools.
6. Write and execute a program for Lagrange's Interpolation Method using soft computing tools.
7. Implementation of fuzzy logic in an optimization problem.
8. Interpret data using the fuzzy logic toolbox.

- 9. Solve optimization problems using genetic algorithms.
- 10. Train and test data using neural networks.

**Equipment/Machines/Instruments/Tools/Software Required:**

- 1. MATLAB

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
CO1	2	1	-	-	-	1	-	1
CO2	2	1	-	-	-	-	-	1
CO3	3	1	2	-	2	-	1	1
CO4	3	3	2	-	-	3	1	2
CO5	3	3	2	-	2	3	1	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M.Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Advanced Power Plant Engineering	<b>Course Code:</b>	ME25-M-PPE107
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hours/week
<b>Max Marks:</b>	50		

**Course Description:**

This Lab course offers experimentation to impart teaching and learning. In this course, learners will study and perform experiments on power plant major and minor components such as the deaerator, feedwater pump, L. P. & H. P. heater, ESP, turbine rotor, cooling towers, solar panels, and compressors. Learners will get insight into various boilers and their accessories & mountings. This course covers the study of important thermal power plant components and experimentation on some of them.

**Course Outcomes:**

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand various plant equipment such as deaerator, feedwater pump, L. P & H. P. heater, ESP, and turbine rotor.
<b>CO2</b>	Experiment with axial and reciprocating air compressors and examine their performance.
<b>CO3</b>	Classify and explain the boilers and determine the calorific value of fuel.
<b>CO4</b>	Experiment with cooling towers and examine their performance.
<b>CO5</b>	Experiment with solar power plants and examine their performance characteristics.

**List of Experiments (minimum ten experiments):**

1. To obtain performance characteristics of an Axial Flow air compressor.
2. To obtain the performance characteristics of a Reciprocating air compressor.
3. To determine the calorific value of the given sample fuel by Bomb Calorimeter.
4. To obtain the Flash point and Fire point of an oil.
5. To study the boiler working and its mountings and accessories.
6. To perform testing on the Solar PV training kit to study I-V characteristics.
7. To perform testing on the Solar PV training kit for parallel connection.
8. To perform testing on the Solar PV training kit for series connection.

9. Study of working of a Muffle furnace.
10. To study boiler feed pumps and air heaters of thermal power plants.
11. To evaluate the cooling efficiency of the cooling tower.
12. To study the deaerator system for a thermal power plant.
13. To study the role of an Electrostatic precipitator in fly ash control.
14. To study the L.P. & H.P. heater of a thermal power plant.
15. To study the construction details of a thermal power plant turbine rotor.

**Equipment/Machines/Instruments/Tools/Software Required:**

1. Axial Flow Compressor
2. Drop-wise and Film wise condensation apparatus
3. Flash and fire point apparatus
4. Solar Radiation Meters
5. Solar PV Training Kit
6. Model of La Mont boiler
7. Boiler models

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
CO1	2	2	-	-	1	2	3	2
CO2	2	2	-	-	2	1	2	2
CO3	2	1	-	-	2	2	3	1
CO4	2	2	-	-	2	2	2	2
CO5	2	2	-	-	2	1	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M.Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Intellectual Property Rights	<b>Course Code:</b>	ME25-M-MTA106
<b>Credits:</b>	1	<b>No of Hours:</b>	2
<b>Max Marks:</b>	50		

**Course Description:**

This course offers lectures and case studies to impart teaching and learning. It is designed to provide a detailed knowledge of Intellectual Property Rights, Copyright, Trademarks, Industrial Designs, and recent trends in IPR. This course covers IPR in detail.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand Intellectual Property Rights in detail, Patents, and their types.
<b>CO2</b>	Understand Copyright Infringement and Fair Use.
<b>CO3</b>	Understand the Trademarks and their Registration and Protection of Trademarks.
<b>CO4</b>	Understand the Concept, Importance and Registration, and Protection of Industrial Designs
<b>CO5</b>	Understand IPR and Research & Development.

**Syllabus:**

**Unit-1: Introduction to Intellectual Property Rights:** Definition, Nature, Scope, and Types of Intellectual Property (IP), Importance of IPR in Technology and Innovation, International Framework.

**Patents:** Definition and Scope, Patent Filing Procedure (National & International), Patentability Criteria.

**Unit-2: Copyrights:** Definition, Rights of Copyright Holder, Copyright in Digital Era (Software, Multimedia), Copyright Infringement and Fair Use.

**Unit-3: Trademarks:** Definition, Importance, and Types; Registration and Protection of Trademarks, Trademark Infringement, and Passing off.

**Unit-4: Industrial Designs:** Concept and Importance, Registration and Protection. Trade Secrets and Confidential Information, Importance in Industries, Legal Aspects of Trade Secrets.

**Unit-5: IPR Research & Development:** Role of IPR in Scientific and Technological Developments, Technology Transfer and Licensing, Case Studies on Patent & Copyright Issues.

**Text Books:**

1. Deborah E. Bouchoux, Intellectual Property Rights, Cengage Learning.
2. Dr. B. L. Wadehra, Law Relating to Intellectual Property, Universal Law Publishing.
3. R. Radhakrishnan & S. Balasubramanian, Intellectual Property Rights: Text and Cases, Excel Books
4. V.K. Ahuja, Intellectual Property Rights in India, LexisNexis.
5. Robert P. Merges & John F. Duffy, Patent Law and Policy, Wolters Kluwer

**References Books:**

1. Siva Prasad, The Law of Intellectual Property Rights, Asia Law House,
2. William M. Landes & Richard A. Posner, Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets, Harvard University Press.
3. W.R. Cornish & David Llewelyn, Intellectual Property Rights: A Global Perspective, Cambridge University Press.
4. V. Sople, Managing Intellectual Property, PHI Learning Pvt. Ltd.
5. Rajkumar S. Dukki, Fundamentals of Intellectual Property Rights: For Engineers, Scientists, and Entrepreneurs, Springer

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	-	1	3	1	1	3	2
<b>CO2</b>	3	2	-	3	2	1	2	3
<b>CO3</b>	2	2	-	3	1	1	3	2
<b>CO4</b>	3	-	-	2	2	1	3	2
<b>CO5</b>	3	2	-	3	2	1	2	1

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	M. Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Design of Advanced Thermal Power Plant Equipment	<b>Course Code:</b>	ME25-M-PPE105 (1)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course is aimed at illustrating the principles and applications of turbomachinery, with a focus on gas turbines. It begins with fundamental gas dynamics and energy transfer in turbomachines, progressing to the design and performance analysis of centrifugal and axial flow compressors. Students will explore gas turbine combustion systems, including factors affecting design, fuels, and emissions. The course then examines axial and radial flow turbines, covering thermodynamics, design, and performance. Finally, students will learn to predict the off-design performance of simple gas turbines, including component characteristics and equilibrium running conditions, equipping them with the knowledge to analyze and optimize gas turbine systems.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand the basics of Energy transfer in Turbo-Machines and Flow dynamics.
<b>CO2</b>	Understand the performance parameters of a centrifugal and axial flow compressor.
<b>CO3</b>	Understand the basics of combustion chambers of Gas Turbine plants.
<b>CO4</b>	Understand the basic and advanced concepts of a gas turbine-based power plant
<b>CO5</b>	Predict the performance of simple gas turbines

**Syllabus:**

**Unit-1: Turbo-Machines and Gas Dynamics:** Introduction, Types of Turbomachines, applications of Turbomachines, Performance Characteristics, Methods of Analysis, Energy Transfer in Turbo Machines, efficiency, static and stagnant conditions, Mach Number, Area Velocity relations, Dynamic pressures, normal shock relations for perfect gas.

**Unit-2: Centrifugal and Axial Flow Compressors:** Classification, Performance Parameters and Characteristics, Change of Performance, Polytropic Efficiency, Preliminary Design of Centrifugal Compressors. Axial Flow Compressors, Introduction. Basic Theory, Preliminary

Design of Compressor Stage, Determination of Stage Efficiency, Axial Flow Compressor Performance, Surge and Stall in Compressor, and the Remedies.

**Unit-3: Gas turbine combustion System:** Introduction, Types of Combustion System, Factors affecting combustor design, fuels, combustion chamber performance, Existing combustion technologies, Flameless oxidation, Continuous air staging, pressure loss in the combustion chamber, combustion efficiency and its effect on Gas turbine cycle, Gas turbine Emissions.

**Unit-4: Gas Turbines:** Introduction, Thermodynamics of Axial Flow Turbine, Degree of Reaction, Preliminary Design Procedure for Turbine Stage, Determination of Turbine Stage Efficiency, Axial Flow Turbine Performance, Turbine Matching, Radial Inflow Gas Turbine, Thermodynamic Processes in Radial Inflow Gas Turbine.

**Unit-5: Performance Prediction for Simple Gas Turbines:** Component characteristics, off-design operation of the single shaft turbine, Equilibrium running of a gas generator, off-design operation of a free turbine engine, Off-design operation of the jet engine, Methods of displacing the equilibrium running line, incorporation of variable losses.

**Text Books:**

1. Yahya, S. M. (2011). Turbine compressors and fans. Tata Mcgraw Hill Pvt. Ltd., New Delhi.
2. H. I. H. Saravanamuttoo, Henry Cohen, G. F. C. Rogers, Gas Turbine Theory, Pearson.

**References Books:**

1. Philip Hill and Carl Peterson, Mechanics and thermodynamics of Propulsion, Prentice Hall.
2. Stepanoff A.J., Centrifugal and axial flow pumps, John Wiley, 1962.
3. D. G. Shepherd, Principles of Turbo Machinery, The Macmillan Company.
4. Horlack, Axial flow turbines, H.H., Butter worth, London, 1973.
5. Ganesan, Gas Turbines, V., 3rd Edition, Tata McGraw Hill, 2010.

**CO-PO & PSO Correlation**

CO Number	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	2	1	-	2	3	1	2
<b>CO2</b>	3	3	2	-	3	3	1	3
<b>CO3</b>	3	2	1	-	2	3	1	2
<b>CO4</b>	3	3	2	-	3	3	-	3
<b>CO5</b>	3	3	2	-	3	3	1	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Advanced Heat Transfer	<b>Course Code:</b>	ME25-M-PPE105(2)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

The course will deepen the fundamentals of heat transfer. Particular focus will be put on radiative and convective heat transfer, and computational approaches to solve complex, coupled heat transfer problems.

**Course Outcomes:** At the end of the course, the students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Apply the principles of conduction heat transfer to solve steady-state and transient problems in various geometries.
<b>CO2</b>	Analyze and solve forced convection problems, including external and internal flows, using appropriate equations and correlations.
<b>CO3</b>	Evaluate and calculate heat transfer rates in natural convection scenarios for different geometries and enclosures.
<b>CO4</b>	Design and analyze heat exchangers using the LMTD and effectiveness-NTU methods, and explain the mechanisms of boiling and condensation.
<b>CO5</b>	Calculate radiation heat exchange between black and gray surfaces using shape factors and relevant radiation principles.

**Syllabus:**

**Unit-1: Introduction to Conduction:** Fundamentals of heat transfer, Review of conduction heat transfer, General heat conduction equation-initial and boundary conditions, multi-dimensional conduction, and Transient heat conduction.

**Unit-2: Introduction to Forced Convection:** Basics principles of convection, A review of mass, momentum and energy equations.

**External Forced Convection:** Laminar boundary layer over a plane wall, turbulent boundary layer over a plane wall, Forced convection in other external flows.

**Internal Forced Convection:** Hydrodynamic and thermal considerations, Laminar forced convection in pipes and ducts, Forced convection in turbulent flow

**Unit-3: Introduction to Natural Convection:** Free convection in laminar flow over a vertical wall, Empirical correlation in external free convection flows, inclined walls, long horizontal cylinder and spheres, Free convection in enclosures, annular space between horizontal cylinders and annular space between concentric spheres.

**Unit-4: Heat Exchangers:** Classification of heat exchangers, Overall heat transfer coefficient, Basic design methodologies - the log-mean temperature difference (LMTD) and effectiveness-NTU methods, Correlations for heat transfer coefficient and friction factor.

**Convection with Change of Phase:** Boiling heat transfer, forced convection boiling, Pool boiling, Condensation heat transfer, Film condensation, dropwise condensation.

**Unit-5: Introduction to Radiation:** Fundamental concepts of radiation, Radiation exchange between black surfaces, Shape factor, Radiation exchange between gray surfaces.

**Text Books:**

1. Adrian Bejan, Heat Transfer, Wiley.
2. Incropera and Dewitt, Fundamentals of Heat and Mass Transfer, Wiley.
3. Yunus A. Cengel, Heat and Mass Transfer, McGraw Hill.
4. M. N. Ozisik, Heat Transfer - A Basic Approach, McGraw Hill.

**Reference Books:**

1. Mills and Ganeshan, Mechanics Heat Transfer, Pearson.
2. J. P. Holman, Heat Transfer, McGraw Hill.
3. Kakac, Yener and Pramuanjaroenkji, Convective Heat Transfer, CRC Press.
4. D. Q. Kern, Process Heat Transfer, McGraw Hill.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	2	1	-	1	3	2	2
<b>CO2</b>	3	2	1	-	1	3	3	2
<b>CO3</b>	3	2	1	-	1	3	3	2
<b>CO4</b>	3	1	3	-	1	2	3	2
<b>CO5</b>	3	2	1	-	1	2	2	2

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	M. Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Sustainable and Renewable Energy Technology	<b>Course Code:</b>	ME25-M-PPE105 (3)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course explores the critical intersection of renewable energy and sustainable development. Students will analyze global green energy trends, delve into machine learning applications for optimizing renewable systems, and evaluate principles for creating sustainable eco-cities. The course covers carbon capture and storage technologies, examining their environmental and economic impacts. Additionally, it addresses CO<sub>2</sub> emission mitigation strategies, including circular economy concepts and advanced technologies like supercritical CO<sub>2</sub> cycles. Through this comprehensive study, students will gain insights into the latest advancements and challenges in transitioning towards a sustainable energy future.

**Course Outcomes:**

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

CO Number	Course Outcome
CO1	Analyse global green energy trends and climate policies.
CO2	Apply machine learning to optimize renewable energy systems.
CO3	Evaluate principles for sustainable eco-cities and villages.
CO4	Assess carbon capture and geological storage technologies.
CO5	Examine CO <sub>2</sub> emission mitigation and circular economy concepts.

**Syllabus:**

**Unit-1: Green and Clean Energy-Current Global Scenario:** Introduction, Growth of Solar Energy Worldwide, Current Status of Solar Photovoltaic Capacity, International Climate Policies, International Efforts for Mitigating Climate Change, International Solar Alliance, Status of Power System Transformation, Environmental Stewardship, Static and Dynamic Load, Flexible Power Generation, Renewable Energy and AI for Sustainable Development

**Unit-2 Machine Learning for Renewable Energy Applications:** Introduction , Overview of Machine Learning, Necessity for Prediction, Implementation of Machine Learning in Renewable Energy Sources, Groupings of Machine Learning, Supervised Learning, Unsupervised Learning, Semi-Supervised Learning, Reinforcement Learning, Deep Learning and Neural Networks, Basic Concepts of Neural Networks, Data Pre-Processing, Data Required for Machine Learning, Feature

Selection in Machine Learning, Energy, Power Quality Disturbances, Fault Diagnosis in Renewable Energy, Performance Metrics, Challenges in Implementation of Various Models.

**Unit-3: Eco-Friendly Cities and Villages with Sustainability: Futuristic Perspectives**

Introduction, Brief History of Eco-Friendly Cities and Villages, Definition of Eco-Friendly Cities and Villages, Sustainability for 21st-Century Dwellers, Principles of Building Eco-Friendly Urban Settlements, Challenges of Building Sustainable Eco-Friendly Cities and Villages, Principles (1 to 15) with Measures.

**Unit-4: Carbon capture and storage:** Introduction and Fundamentals, Carbon Capture Technologies: Post-Combustion Capture, Pre-Combustion Capture, Oxy-Fuel Combustion, Direct Air Capture (DAC), CO<sub>2</sub> Transport and Injection, Geological Storage, Environmental, Economic, and Regulatory Aspects, Advanced Topics and Research Trends

**Unit 5: CO<sub>2</sub> Emissions and Mitigation:** Carbon emissions: Global trends, Emission drivers, Earth's natural CO<sub>2</sub> cycle, Tracing carbon trail, Single layer atmospheric model and GHG, Circular CO<sub>2</sub> economy, CO<sub>2</sub> based water desalination, Fossil free fuels, Supercritical CO<sub>2</sub> cycle: Basic introduction, need, supercritical cycle for thermal power generation, applications, Allam cycle.

**Text Books:**

1. Sailesh Iyer, Anand Nayyar, Mohd Naved, Renewable Energy and AI for Sustainable Development, CRC Press.
2. Rackley, S. A. Carbon Capture and Storage. Butterworth-Heinemann.
3. Geoffery A. Ozin, Mireille F. Ghossoub, The story of Carbon dioxide: Big ideas for small molecule

**References Books:**

1. MacKay, D. J. . Sustainable Energy- Without the hot air. Bloomsbury Publishing.
2. Twidell, J., Renewable energy resources. Routledge.
3. Botkin, D. B., & Keller, E. A., Environmental science: Earth as a living planet. Wiley Global Education.
4. Benyoussef, A., The limits to growth: by Donella H. Meadows, Dennis L. Meadows, Jorgen Randers and William W. Behrens III. Earth Island, London.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	2	2	2	3	2	3	1
<b>CO2</b>	3	3	1	1	3	3	3	3
<b>CO3</b>	3	2	2	-	3	2	3	1
<b>CO4</b>	3	2	2	2	2	3	2	2
<b>CO5</b>	3	2	2	2	2	2	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Energy Storage Systems	<b>Course Code:</b>	ME25-M-PPE105 (4)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

### Course Description:

This course provides a comprehensive overview of energy storage systems, covering diverse technologies and their applications. Students will explore thermal, chemical, electromagnetic, and electrochemical storage methods, with a focus on batteries, supercapacitors, and fuel cells. The course examines the design, performance, and management of energy storage systems, particularly for electric vehicles, including charging optimization, thermal management, and recycling. Students will analyze the scope, needs, and opportunities in energy storage, gaining insights into the latest advancements and future prospects of these critical technologies.

### Course Outcomes:

After completion of the course students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Evaluate energy storage technologies and applications.
<b>CO2</b>	Analyse chemical energy storage systems.
<b>CO3</b>	Describe electromagnetic energy storage principles.
<b>CO4</b>	Compare electrochemical storage devices.
<b>CO5</b>	Apply battery design and management for EVs.

### Syllabus:

**Unit-1: Energy storage systems basics and overview:** Scope of energy storage, needs and opportunities in energy storage, Technology overview and key disciplines, comparison of time scale of storages and applications, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles, Current electric vehicle market. Thermal storage system-heat pumps, hot water storage tank, solar thermal collector, application of phase change materials for heat storage-organic and inorganic materials, efficiencies, and economic evaluation of thermal energy storage systems.

**Unit-2: Chemical storage:** Chemical storage system- hydrogen, methane etc., concept of chemical storage of solar energy, application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems.

**Unit-3: Electromagnetic Storage:** Electromagnetic storage systems - double layer capacitors with electrostatically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems

**Unit-4: Electrochemical storage systems:** Batteries-Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery& Metal hydride battery vs lead-acid battery. Supercapacitors-Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors, Fuel cell: basics and hybrid fuel cell-supercapacitor systems.

**Unit-5: Battery storage fundamentals and applications:** Battery design for transportation, Mechanical Design and Packaging of Battery Packs for Electric Vehicles, Advanced Battery-Assisted Quick Charger for Electric Vehicles, Charging Optimization Methods for Lithium-Ion Batteries, Thermal run-away for battery systems, Thermal management of battery systems, State of Charge and State of Health Estimation Over the Battery Lifespan, Recycling of Batteries from Electric Vehicles

**Text Books:**

1. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press.
2. Ralph Zito, Energy storage: A new approach, Wiley & Sons.

**References Books:**

1. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing.
2. Robert A. Huggins, Energy storage, Springer Science & Business Media

**CO, PO, & PSO Correlation**

CO Number	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	2	1	-	2	3	2	2
<b>CO2</b>	3	2	1	-	2	3	2	2
<b>CO3</b>	3	2	1	-	2	3	1	2
<b>CO4</b>	3	3	1	-	2	3	2	3
<b>CO5</b>	3	3	2	-	3	3	2	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M.Tech.	<b>Semester:</b>	I
<b>Name of the Course:</b>	Industrial Automation	<b>Course Code:</b>	ME25-M-PPE105 (5)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

### Course Description:

The Course Learning Objective is to introduce the importance of automation techniques in manufacturing and process industries. To impart the role of PLC in industry automation. To expose to various control techniques employed in process automation. To develop an automation system for manufacturing and process industries.

### Course Outcomes:

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Explain the principles, strategies, and levels of automation in modern manufacturing systems
<b>CO2</b>	Analyze different material handling and identify technologies for efficient production flow
<b>CO3</b>	Illustrate automation techniques in process industries using DCS, SCADA, and digital control
<b>CO4</b>	Develop PLC-based control strategies, including safety automation and networking applications
<b>CO5</b>	Evaluate DCS architecture, communication protocols, and real-time data analytics for process optimization

### Syllabus

**Unit 1: Automation in Manufacturing Industries:** Introduction- Automation in production system, Principles and strategies of automation, Basic elements of an automated system, Advanced automation functions, Levels of automation, Automated flow lines and transfer mechanisms, Analysis of transfer lines without storage, Automated flow lines with storage buffers.

**Unit 2: Material handling and identification technologies:** Overview of material handling systems, Types of material handling equipment, Design of the system, Conveyor system, Automated guided vehicle system, Automated storage systems, Interfacing handling and storage with manufacturing, Overview of Automatic Identification Methods.

**Unit 3: Automation in Process Industries:** Introduction to computer-based industrial automation- Direct Digital Control (DDC), Distributed Control System (DCS) and supervisory control and data acquisition (SCADA) based architectures. SCADA for process industries includes understanding of RTUs, Pumping stations, Evacuation processes, Mass Flow Meters and other flow meters, Leak-flow studies of pipelines, Transport Automation.

**Unit 4: Programmable Logic Controller (PLC):** Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks, Networking of PLC, Overview of safety of PLC with case studies. Process Safety Automation: Levels of process safety through the use of PLCs, Integrating Process safety PLC and DCS, Application of international standards in process safety control.

**Unit 5: Distributed Control System:** Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS. Introduction to communication protocols- Profibus, Field bus, HART protocols. Data gathering, Data analytics, Real-time analysis of data stream from DCS, Historian build, Integration of business inputs with process data, Leveraging RTU (as different from PLCs and DCS).

#### **Text Books**

1. M.P. Groover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education.
2. John W. Webb and Ronald A. Reis, Programmable Logic Controllers: Principles and Applications, Prentice Hall Inc.
3. Krishna Kant, Computer - Based Industrial Control, Prentice Hall.
4. Frank D. Petruzella, Programmable Logic Controllers, McGraw- Hill.

#### **Reference Books**

1. Curtis D. Johnson, Process Control Instrumentation Technology, Pearson New International.
2. Lukas M.P, Distributed Control Systems, Van Nostrand Reinhold Co.
3. N. Viswanandham, Y. Narahari, Performance Modeling of Automated Manufacturing Systems, Prentice-Hall.
4. <https://nptel.ac.in/syllabus/108108098/>

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
CO1	3	2	1	-	2	3	2	1
CO2	3	3	2	-	2	3	3	2
CO3	2	3	3	1	2	3	3	3
CO4	3	2	3	1	2	3	2	3
CO5	2	3	2	-	3	3	3	3

**Note:** 1: Low 2: Moderate 3: High

<b>SECOND SEMESTER (NHEQF Level: 6)</b>										
<b>S. No.</b>	<b>Subject Code</b>	<b>Subject</b>	<b>Periods per Week</b>			<b>Scheme of Examination (Theory / Practical)</b>			<b>Total Marks</b>	<b>Credit L+(T+P)/2</b>
						<b>PRE</b>		<b>ESE</b>		
			<b>L</b>	<b>T</b>	<b>P</b>	<b>MID</b>	<b>TA</b>			
1	ME25-M-MTA107	Industrial Instrumentation and Control	3	0	0	15	15	70	100	3
2	ME25-M-MTA108	Research Methodology	3	0	0	15	15	70	100	3
3	ME25-M-PPE108	Design of Heat Exchangers	3	0	0	15	15	70	100	3
4	ME25-M-PPE109	Computational Fluid Dynamics	3	0	0	15	15	70	100	3
5	ME25-M-PPE110 (1-5)	Program Elective II (Annexure -II)	3	0	0	15	15	70	100	3
6	ME25-M-PPE111	Heat Exchangers Lab	0	0	4	-	15	35	50	2
7	ME25-M-PPE112	Computational Fluid Dynamics Lab	0	0	4	-	15	35	50	2
8	ME25-M-MTA114	Scientific Paper Writing	0	0	2	-	15	35	50	1
<b>Total</b>			<b>15</b>	<b>0</b>	<b>10</b>	<b>75</b>	<b>120</b>	<b>455</b>	<b>650</b>	<b>20</b>

**Program Elective -II (Annexure - II)**

<b>S. No.</b>	<b>Subject Code</b>	<b>Name of the Courses</b>
1	ME25-M-PPE110 (1)	Energy Management & Audit
2	ME25-M-PPE110 (2)	Advanced Solar Thermal Energy Systems
3	ME25-M-PPE110 (3)	Artificial Intelligence in Power Systems
4	ME25-M-PPE110 (4)	Energy Conservation by Waste Heat Recovery
5	ME25-M-PPE110 (5)	Advanced Steam & Gas Turbine Engineering

<b>Program:</b>	M.Tech.	<b>Semester:</b>	II Sem
<b>Name of the Course:</b>	Industrial Instrumentation and Control	<b>Course Code:</b>	ME25-M-MTA107
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

The course is designed to familiarize the student with the functions and instrumentation available in a modern industry. This course covers the fundamentals of instrumentation used in the industry. Emphasis is on electric, electronic, and other instruments. Students also learn the concepts of mathematical modeling, feedback control, and stability analysis in the Time and Frequency domains.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Explain the static and dynamic characteristics of measurement systems and analyze measurement errors using statistical methods.
<b>CO2</b>	Apply principles of electrical and electronic measurement to evaluate circuit parameters and analyze signals using measurement instruments.
<b>CO3</b>	Demonstrate the working principles of transducers and industrial instrumentation for mechanical and environmental parameter measurement.
<b>CO4</b>	Analyze control system characteristics, mathematical modeling, stability criteria, and error analysis for various engineering applications.
<b>CO5</b>	Implement process control techniques using root locus, frequency response, and various control strategies for industrial automation.

**Syllabus**

**Unit 1: Basics of Measurement Systems:** Static and dynamic characteristics of measurement systems. Measurement errors: Gross error, systematic error, absolute error and relative error, accuracy, precision, resolution and significant figures, Measurement error combination, basics of statistical analysis. Statistical analysis of data and curve fitting.

**Unit 2: Electrical and Electronic Measurements:** Bridges and potentiometers, measurement of R, L, and C. Measurements of voltage, current, power, power factor, and energy. AC & DC probes. Extension of instrument ranges. Q-meter and waveform analyzer. Digital voltmeter and

multimeter. Time, phase, and frequency measurements. Cathode ray oscilloscope. Serial and parallel communication. Shielding and groundings.

**Unit 3: Transducers, Mechanical Measurement and Industrial Instrumentation:** Resistive, Capacitive, Inductive and piezoelectric transducers and their signal conditioning. Measurement of displacement, velocity and acceleration (translational and rotational), force, torque, vibration, and shock. Measurement of pressure, flow, temperature, and liquid level. Measurement of pH, conductivity, viscosity, and humidity.

**Unit 4: Control Systems:** Open loop and closed loop control systems, Feedback characteristics of control systems, Mathematical representation of physical systems, electrical, mechanical, hydraulic, thermal systems, Block diagram, algebra and signal flow graphs, Mason's gain formula. Time Domain Analysis, standard test signals, time response of first, second and higher order systems, performance indices. Error analysis, static and dynamic error coefficients. Stability, concept of stability, asymptotic and conditional stability, Routh Hurwitz criterion,

**Unit 5: Process Control:** Root locus technique (Concept and construction) Frequency Response Analysis Correlation between time and frequency response, Polar and inverse polar plots, NY Quist stability criterion, Bode plots, Time delay systems. Phase and gain margin. Mechanical, hydraulic, and pneumatic system components. Synchro pair, servo, and step motors. On-off, cascade, P, P-I, P-I-D, feed forward and derivative controller, and Fuzzy controller.

**Text Books:**

1. Doebelin, E.O., Measurement systems, Applications and Design, McGraw–Hill.
2. Nakra, B. C. and Chaudhry, K. K., Instrumentation Measurement and Analysis, Tata McGraw–Hill.
3. Ogata, K., Modern Control Engineering, Prentice–Hall of India Private Limited.
4. Nagrath, I.J. and Gopal, M., Control System Engineering, New Age International (P) Limited, Publishers.
5. Gopal, M., Digital Control System, Wiley Eastern.

**Reference Books:**

1. W Bolton- Instrumentation and control systems, Elsevier.
2. Murthy, D.V.S., Transducers and Instrumentation, Prentice–Hall of India Private Limited.
3. Sawhney, A.K., A Course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Co. (P) Ltd..
4. Kuo, B.C., Automatic Control System, Prentice–Hall of India Private Limited.
5. Sinha, N.K., Control System, New Age International (P) Limited, Publishers.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
CO1	3	-	-	-	-	2	2	1
CO2	2	2	2	-	1	1	1	3
CO3	3	1	2	1	2	1	2	3
CO4	3	-	1	1	1	2	1	1
CO5	2	2	3	2	2	1	2	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M.Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Research Methodology	<b>Course Code:</b>	ME25-M-MTA108
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

### Course Description:

This course provides an in-depth understanding of research methodology, equipping students with essential skills to conduct scientific research. It covers various research approaches, research design and data collection methods. Emphasis is placed on developing critical thinking skills for hypothesis formulation and data interpretation. The course also introduces students to ethical research practices and referencing techniques, enabling them to effectively communicate research findings through reports and synopses.

### Course Outcomes:

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Explain the fundamental concepts, types, and methodologies of scientific research.
<b>CO2</b>	Develop appropriate research designs, hypotheses, and sampling strategies for effective data collection.
<b>CO3</b>	Apply data collection techniques, analyze research data, and utilize statistical tools for interpretation.
<b>CO4</b>	Draft well-structured research reports and present findings effectively through seminars and papers.
<b>CO5</b>	Demonstrate awareness of publication ethics, plagiarism detection, and integrity in research writing.

### Syllabus

**Unit 1: Introduction to Research:** Aims and Objectives of Research, Types of Research, Research Approaches, Characteristics of Scientific Research, Steps in Scientific Research, Methods of Scientific Research, research methods vs research methodology, Criteria of Good Research. Review of Literature.

**Unit 2: Research Design and Sampling:** Hypothesis – Qualities of a good Hypothesis, Hypothesis Testing – Logic & Important Features of a good research design; Concept and

Importance of Research Design: Experimental Design: Concept of Independent & Dependent variables. Qualitative and Quantitative Research.

**Unit 3: Data Collection, Methods, and Preparation:** Types of data, Projective Techniques, Collection of Secondary Data, Case Study, Pilot Study and Pre-Testing, Questionnaire Checking, Editing and Coding of Data, Sampling: Concepts of Statistical Population, Sample Size, Sampling Error, Probability, Practical considerations in sampling and sample size  
 Data analysis and Visualization: Classification, Tabulation, Graphical Visualization, Types of Analysis, Statistics in Research.

**Unit 4: Report Drafting and Presentation:** Structure and components of research report, Seminars and paper presentations, drafting research papers, Essential components for report drafting and scientific editing tools.

**Unit 5: Publication Ethics:** Importance of ethics in research, Ethical issues related to publishing: Plagiarism and Self-Plagiarism, Plagiarism detection tools, originality and novelty in research, conflict of interest.

**Text Books:**

1. Donald Cooper & Pamela Schindler, Business Research Methods, TMGH.
2. Alan Bryman & Emma Bell, Business Research Methods, Oxford University Press.
3. C. R. Kothari, Research Methodology, New Age Publication.
4. Rudolf J. Freund William J. Wilson, Statistical Methods, Academic Press, London.

**Reference Books:**

1. Chawla and Sondhi, Research Methodology, Vikas
2. Paneersevam, Research Methodology, PHI.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSO		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	3	2	-	2	2	2	1
<b>CO2</b>	2	3	2	-	3	1	2	2
<b>CO3</b>	2	3	2	-	3	2	1	3
<b>CO4</b>	3	3	2	-	2	2	2	2
<b>CO5</b>	2	2	1	1	2	1	1	3

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	M. Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Design of Heat Exchangers	<b>Course Code:</b>	ME25-M-PPE108
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive study of heat exchanger design and analysis. Students will explore fundamental heat transfer principles, including temperature distribution, overall heat transfer coefficients, and fouling effects. The course covers the design of condensers and boilers, focusing on condensation and boiling phenomena. Thermal design calculations using LMTD and other methods are emphasized, along with the analysis of pressure drop and pumping power. Students will also examine advanced heat exchanger types, such as recuperators, plate, and micro heat exchangers, and their practical applications. This course equips students with the skills to design, analyze, and optimize heat exchanger systems for various industrial applications.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Analyze heat exchanger fundamentals and fouling.
<b>CO2</b>	Apply condensation and boiling principles to condenser/boiler design.
<b>CO3</b>	Perform heat exchanger thermal design calculations.
<b>CO4</b>	Calculate heat exchanger pressure drop and pumping power.
<b>CO5</b>	Evaluate advanced heat exchanger types and applications.

**O. P. JINDAL UNIVERSITY**  
O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109  
Department of Mechanical Engineering



<b>Program:</b>	M. Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Computational Fluid		

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Heat Exchanger Lab	<b>Course Code:</b>	ME25-M-PPE111
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This lab course provides hands-on experience with heat transfer equipment. Students will test shell and tube, double-pipe, and plate heat exchangers, analyze condensation and cooling towers, and determine fuel calorific value. Experiments also cover solar stills, PVT systems, heat pipes, electronic cooling, HVAC heat exchangers, and gland steam condensers, bridging theory with practical application.

**Course Outcomes:**

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

CO Number	Course Outcome
<b>CO1</b>	Evaluate heat exchanger performance through testing.
<b>CO2</b>	Analyze condensation and cooling tower operation.
<b>CO3</b>	Determine fuel energy and solar still efficiency.
<b>CO4</b>	Investigate specialized heat transfer systems.
<b>CO5</b>	Apply heat transfer principles to industrial and building systems.

**List of Experiments (minimum 10 experiments):**

1. To perform a test on the shell and tube surface condenser setup.
2. To perform a test on film and drop-wise condensation apparatus.
3. To perform a test on a double-pipe heat exchanger setup
4. To perform a test on plate-type heat exchanger setup
5. To evaluate the range and approach for cooling tower setup
6. To determine the calorific value of gaseous fuel by using Junker's gas Calorimeter
7. To determine the instantaneous thermal efficiency and hourly yield for a solar still.
8. Study of PVT systems
9. To study heat pipes, heat exchanger
10. To study electronic and automobile cooling systems using compact heat exchangers.
11. Study of heat exchangers used in HVAC systems
12. To study the gland steam condenser for a thermal power plant turbine.

**Equipment/Machines/Instruments/Tools/Software Required**

1. Surface condenser setup
2. Film and drop wise condensation apparatus
3. Double pipe heat exchanger setup
4. Plate-type heat exchanger setup
5. To evaluate the range and approach for cooling tower setup
6. Solar still.
7. Photo-Voltaic Thermal (PVT) System
8. Heat pipe test setup
9. Electronic cooling fins, automobile radiator
10. HVAC components (Condenser and evaporator)

**CO, PO, & PSO Correlation**

CO Outcomes	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	3	2	-	2	3	-	3
<b>CO2</b>	3	3	2	-	2	3	-	3
<b>CO3</b>	3	3	2	-	2	3	3	3
<b>CO4</b>	3	2	1	-	3	3	-	2
<b>CO5</b>	3	2	2	-	2	3	-	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Computational Fluid Dynamics Lab	<b>Course Code:</b>	ME25-M-PPE112
<b>Credits:</b>	2	<b>No of Hours:</b>	4 hours/week
<b>Max Marks:</b>	50		

**Course Description:**

This Lab course offers computer simulations of real-world problems to impart teaching and learning. In this course learners will study and do hands-on practice on simulation software. The course will make students familiar with different CAD/CAM design as well as analysis software, which will help the students for research work.

**Course Outcomes:** At the end of the course, the students will be able to

<b>CO Number</b>	<b>Course Outcomes</b>
<b>CO1</b>	Demonstrate flow system modeling and analysis in ANSYS Design Modeler and Fluent.
<b>CO2</b>	Solve problems of heat transfer in a composite slab and unsteady state heat conduction in a rectangular slab.
<b>CO3</b>	Analyze heat transfer from 1D and 2D walls in steady-state conditions.
<b>CO4</b>	Solve problems of laminar and turbulent flow past a cylinder & Sphere.
<b>CO5</b>	Analyze the laminar flow of air in a convergent-divergent nozzle for velocity and pressure distribution.

**List of Experiments (minimum ten experiments):**

1. To obtain a solution for the 1-D heat conduction equation using the explicit method, using the finite difference method (Code Development).
2. To perform a simulation of 1-D laminar flow in a pipe using a commercial software package.
3. To perform a simulation of 1-D steady-state heat transfer in a composite wall using a commercial software package.
4. To perform a simulation of 2-D steady state heat transfer in a composite wall with radiation effect using a commercial software package.
5. To perform a numerical simulation of flow over a sphere using a commercial software package.
6. To perform a numerical simulation of laminar flow of air in convergent-divergent nozzles using commercial software packages.

7. To perform a numerical simulation of the flat plate boundary layer using a commercial software package.
8. To perform a numerical simulation of unsteady heat transfer in a cylinder using a commercial software package.
9. To perform a numerical simulation of flow past the cylinder using a commercial software package.
10. Generation of the algebraic grid (Code Development).
11. Generation of the elliptic grid (Code Development).

**Equipment/Machines/Instruments/Tools/Software Required:**

1. Ansys and MATLAB Software.
2. High-end computers for smooth working.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	2	-	2	-	1	2	-	2
<b>CO2</b>	-	1	-	2	1	1	-	3
<b>CO3</b>	2	2	-	-	2	1	2	-
<b>CO4</b>	2	2	2	-	1	2	-	2
<b>CO5</b>	2	-	1	2	2	1	2	-

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M.Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Scientific Paper Writing	<b>Course Code:</b>	ME25-M-MTA114
<b>Credits:</b>	1	<b>No of Hours:</b>	2 hours/week
<b>Max Marks:</b>	50		

### Course Description

This subject is related to the techniques of scientific study and understanding related research mobility, and how to express it in a scientific framework. The area of the subject may be a particular topic/subject/area/live project/case study, and identifies the key areas and expresses in a paper format for the scientific audience.

### Course Outcomes

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the research methods
<b>CO2</b>	Acquire perfection in journal reading
<b>CO3</b>	Develop skills for research publication/write-up.
<b>CO4</b>	Effectively present research findings.
<b>CO5</b>	Make use of new and recent tools for creating technical reports.

### Syllabus:

In this course, students will develop their scientific and technical reading and writing skills that they need to understand and construct research articles. A term paper requires a student to obtain information from a variety of sources (i.e., Journals, dictionaries, reference books) and then place it in logically developed ideas.

### The work involves the following steps:

1. Selecting a subject, narrowing the subject into a topic
2. Stating an objective.
3. Collecting the relevant bibliography (at least 15 journal papers)
4. Preparing a working outline.
5. Studying the papers, understanding the author's contributions, and critically analyzing each paper.
6. Preparing a working outline
7. Linking the papers and preparing a draft of the paper.

8. Preparing conclusions based on the reading of all the papers.
9. Writing the Final Paper and giving the final Presentation

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
CO1	1	3	1	1	-	2	1	3
CO2	2	2	-	1	2	2	1	-
CO3	-	2	2	-	1	2	1	1
CO4	-	-	2	1	2	2	1	2
CO5	-	-	2	1	2	-	-	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Energy Management and Audit	<b>Course Code:</b>	ME25-M-PPE110 (1)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

The course is designed to enable the students to understand the concept of energy management and energy management opportunities. It covers different methods of energy management and demonstrates the energy auditing procedure. This course also covers the basics of energy economics and efficiency assessment of various thermal systems.

**Course Outcomes:**

After completion of the course, students will be able to

CO Number	Course Outcomes
<b>CO1</b>	Understand the importance of energy and related policies and Acts.
<b>CO2</b>	Understand the need and concept of energy management in energy-related issues.
<b>CO3</b>	Understand and apply the energy audit procedure for the technical audit
<b>CO4</b>	Understand the energy economics, pricing, and incentives for energy conservation.
<b>CO5</b>	Evaluate the energy efficiency of various thermal systems

**Syllabus**

**Unit-1: Introduction:** Energy and Sources of energy, Energy consumption, Costs of exploration and utilization of resources, Energy pricing, Energy demand and supply, National energy plan, Need for Energy Policy, National and State level Energy Policies. Basic concepts of Energy Conservation and its importance, Energy Strategy for the Future, The Energy Conservation Act. and its Features.

**Unit-2: Energy Management:** History of Energy Management, Definition and Objective of Energy Management and its importance. Need for energy management, General Principles of Energy Management, Energy Management Skills, and Energy Management Strategy. Energy Management Approach. Understanding Energy Costs, Benchmarking, Energy performance, Organizing, Initiating, and managing an energy management program. Roles, responsibilities, and accountability of Energy Managers.

**Unit-3: Energy Audit:** Energy audit concepts, Definition, Need, and Types of energy audit, Energy Audit Approach and Methodology, Systematic procedure for technical audit. Understanding energy audit costs, Benchmarking and Energy Performance. Energy audit based on First law and Second law of thermodynamics, Mass and Energy balances, Availability analysis, Evaluation of energy conserving opportunities, Economic analysis, and life cycle costing, Duties, and responsibilities of energy auditors, Energy audit instruments and their usage for auditing. Report-writing, preparations, and presentations of energy audit reports.

**Unit-4: Energy Economics:** Cost of electrical energy, Selection of type of generation and generation equipment, Performance and operating characteristics of power plants, Economic scheduling principle, Load curves, Effect of load on power plant design, Load forecasting, Electric tariffs, Peak load pricing.

**Unit-5: Energy Efficiency of Thermal Systems:** Energy Efficiency in Thermal Utilities Like Boilers, Furnaces, Heat Exchangers, Fans and Blowers, Pumps, Compressors, Cogeneration, and Waste Heat Recovery Systems.

**Text Books:**

1. Amlan Chakrabarti, Energy Engineering and Management, PHI, Eastern Economy Edition.
2. W.R. Murphy, G. Mckay, Energy Management, Butterworths
3. C.B. Smith Energy Management Principles, Pergamon Press
4. A.V. Desai, Energy Economics, Wileley Eastern
5. Deshpande, M.V., Power Plant Engineering, Tata McGraw Hill

**References Books:**

1. Munasinghe, Mohan Desai, Ashok V, Energy Demand: Analysis, Management and Conservation, Wiley Eastern Ltd., New Delhi.
2. L. C. Witte, P. S. Schmidt and D. R. Brown, Industrial Energy Management and Utilization, Hemisphere Publications, Washington
3. Archie, W Culp, Principles of Energy Conservation, McGraw Hill

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	2	2	2	1	2	1	2	3
<b>CO2</b>	2	2	1	-	2	1	1	2
<b>CO3</b>	1	2	2	1	2	2	1	3
<b>CO4</b>	3	2	1	3	1	-	2	3
<b>CO5</b>	2	2	3	1	3	2	1	3

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	M. Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Advanced Solar Thermal Energy Systems	<b>Course Code:</b>	ME25-M-PPE110 (2)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course provides a comprehensive exploration of solar thermal energy applications. Students will examine the design and performance of various solar collectors, including flat plates, evacuated tubes, and concentrated systems. The course delves into solar water heating and desalination technologies, as well as solar space conditioning for heating, cooling, and drying. Students will explore diverse solar applications in cooking, architecture, and net-zero buildings. Finally, the course emphasizes the economic analysis of solar systems, focusing on feasibility assessments and cost requirements for various applications, equipping students to evaluate and implement effective solar energy solutions.

**Course Outcomes:**

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

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Analyze the construction and performance of various solar thermal collectors.
<b>CO2</b>	Evaluate solar water heating and desalination systems, including advancements and challenges.
<b>CO3</b>	Assess solar space conditioning systems for heating, cooling, and drying applications.
<b>CO4</b>	Explore diverse solar applications in cooking, architecture, and net-zero buildings.
<b>CO5</b>	Apply economic methods to evaluate the feasibility of solar energy systems.

**Syllabus:**

**Unit-1: Solar Thermal Collectors:** Flat plate, Evacuated tube, Concentrated, Pool and Air collectors Construction, Function, Suitability, Comparison, Storage Tank, Solar Fluids. Advancements: FPC, FPC-CPC, PVT collectors, PVT-CPC, Thermal efficiency, and performance parameters.

**Unit-2: Chemical Storage Solar Water Heating and Desalination Systems:** Integral Collector Storage System, Thermosyphon System, Open Loop, Drain Down, Drain Back, Antifreeze Systems, Refrigerant Solar Water Heaters, Solar Heated Pools, Solar Heated Hot Tubs and Spas.  
**Solar Stills:** Classification and Types, Active and passive, yield characteristics, advancements, Thermal collector integrated systems. Challenges and status.

**Unit-3: Solar Space Conditioning Systems:** Liquid Type Solar Heating System With / Without Storage, Heat Storage Configurations, Heat Delivery Methods, Air-type solar Heating Systems, Solar Refrigeration and Air Conditioning, Solar dryers for food processing, Preservation and value addition.

**Unit-4: Other Solar Energy Applications:** Solar Cooking, Solar Ponds, Solar Passive Architecture, BIPVT, Solar Chimney, Trombe wall, wind catcher, green buildings using Solar PV and thermal systems, Net zero buildings.

**Unit-5: Solar Economics:** Economic analysis, Net energy analysis, Cost requirements for active and passive heating & cooling, Electric power generation for industrial process heating.

**Text Books:**

1. G. N. Tiwari, Solar Energy: Fundamentals, Design, Modelling and Applications, Narosa Publication.
2. Sukhatme and Nayak, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill.

**References Books:**

1. H. P. Garg, M Dayal, G Furlan, Physics and Technology of Solar Energy- Volume I: Solar Thermal Applications, Springer, 2007.
2. Bob Ramlow & Benjamin Nusz, Solar Water Heating, New Society Publishing, 2006.
3. John Canavan, Solar Thermal Energy, Sunny Future Press - 2003.
4. Charles Christopher Newton - Concentrated Solar Thermal Energy- Published by VDM Verlag, 2008.
5. H.P. Garg, S.C. Mullick, A.K. Bhargava, D. Reidal, Solar Thermal Energy Storage Springer, 2005.

**CO, PO, & PSO Correlation**

CO Outcomes	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
CO1	3	2	1	-	2	3	3	2
CO2	3	2	1	-	2	3	3	2
CO3	3	2	-	-	2	3	3	2
CO4	3	2	1	-	3	3	3	-
CO5	3	2	2	-	2	3	3	2

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M. Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Artificial Intelligence in Power Systems	<b>Course Code:</b>	ME25-M-PPE110 (3)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course introduces Artificial Intelligence (AI) and its engineering applications. It covers problem-solving methods, searching techniques, and knowledge representation. Fuzzy logic concepts, membership functions, and defuzzification techniques are explored. Artificial Neural Networks (ANNs), including feedforward networks, backpropagation, and radial basis functions, are discussed. Evolutionary techniques like genetic algorithms and evolutionary programming are introduced. The course also covers hybrid AI systems, such as neuro-fuzzy and neuro-genetic models, with applications in power systems, including load forecasting, load flow analysis, economic load dispatch, and motor control.

**Course Outcomes:**

After Completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Understand the basic concepts of expert systems and their applications
<b>CO2</b>	Understand the concepts of artificial intelligence systems and their applications.
<b>CO3</b>	Master the programming in Artificial Neural Networks
<b>CO4</b>	Able to use and analyze Artificial intelligence concepts for Power System problems
<b>CO5</b>	Able to program and troubleshoot neural network-based problems

**Syllabus:**

**Unit-1: Artificial Intelligence:** Definition, problem-solving methods, searching techniques, knowledge representation, reasoning methods, predicate logic, predicate calculus, and multivalued logic.

**Unit-2: Fuzzy Logic:** Concepts, fuzzy relations, membership functions, matrix representation, defuzzification methods.

**Unit-3: Artificial Neural Network:** Introduction, multi-layer feed forward networks, back propagation algorithms, radial basis function and recurrent networks.

**Unit-4: Evolutionary Techniques:** Introduction and concepts of genetic algorithms and evolutionary programming.

**Unit-5: Hybrid Systems:** Introduction and Algorithms for Neuro-Fuzzy, Neuro-Genetic, Genetic-Fuzzy Systems Application of AI Techniques, Load forecasting, load flow studies, economic load dispatch, load frequency control, reactive power control, speed control of DC and AC motors.

**Text Books:**

1. N. P. Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press.
2. Rajasekaran S. and Pai G. A. V., Neural Networks, Fuzzy Logic and Genetic Algorithm Synthesis and applications, PHI New Delhi.
3. Lin C. and Lee G., Neural Fuzzy Systems, Prentice Hall International Inc.

**References Books**

1. D. E. Goldberg, Genetic Algorithms in Search Optimization & Machine Learning, Addison Wesley.
2. B. Kosko, Neural Networks & Fuzzy Systems: A dynamical systems approach to machine intelligence, Prentice Hall.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
CO1	2	1	-	-	1	2	1	3
CO2	2	1	-	-	1	2	1	3
CO3	-	2	2	-	2	1	-	3
CO4	1	2	3	-	2	2	2	3
CO5	1	1	1	-	3	1	1	3

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M.Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Energy Conservation by Waste-Heat Recovery	<b>Course Code:</b>	ME25-M-PPE110 (4)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

The proposed course introduces the various methods of Waste Heat Recovery that have been employed by the industry to harness the energy stored in waste heat and use it for the generation of additional electric power.

**Course Outcomes:**

After completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Explain heat losses, waste heat sources, and energy conservation methods in industrial systems
<b>CO2</b>	Analyze exergy utilization and evaluate heat recovery systems like recuperators and regenerators
<b>CO3</b>	Discuss waste heat boilers, heat pipes, and fluidized bed heat recovery systems
<b>CO4</b>	Apply waste heat recovery techniques in HVAC, thermoelectric, and incineration systems
<b>CO5</b>	Perform waste heat recovery calculations and pinch analysis, and assess thermo-economic viability

**Syllabus:**

**Unit-1: Introduction:** Heat losses, its quality and quantity, potential for energy conservation. Waste heat sources: steam, compressed air, refrigeration, flue gases, furnace/air stream exhaust, high grade heat, low grade heat. Optimal utilization of fossil fuels, Total energy approach; Coupled cycles and combined plants; Cogeneration systems.

**Unit-2: Exergy Analysis:** Utilization of industrial waste heat; Properties of exhaust gas; Gas-to-gas, gas-to-liquid heat recovery systems, Recuperator and regenerators; Shell and tube heat exchangers; Spiral tube and plate heat exchangers.

**Unit-3: Waste Heat Recovery Boiler:** Boiler types and design aspects. Heat pipes: theory and applications in waste heat recovery. Fluidized bed heat recovery systems.

**Unit-4: Utilization of Waste Heat:** Waste heat utilization in refrigeration, heating, ventilation, and air conditioning systems; Thermoelectric system to recover waste heat; Heat pump for energy recovery; Heat recovery from incineration plants

**Unit-5: Waste Heat Recovery Calculations:** Quantifying available heat, Pinch analysis, typical energy costs/construction costs, pay back analysis, thermo-economic viability.

**Text Books:**

1. Hewitt, G. F., Shires, G. L., and T. R. Bott, Process Heat Transfer, CRC Press.
2. David Anthony Reay, Heat Recovery System, Spon Press.
3. Chirla Chandra Sekhara Reddy and Gade Pandu Rangaiah, Waste Heat Recovery Principles and Industrial Applications, World Scientific

**References Books**

1. Goswami, D. Y., and Kreith, F., Energy Conversion, CRC Press.
2. Harlock J. H., Combined Heat and Power, Pergaman Press.
3. Kreith F. and West R. E., Handbook of Energy Efficiency, CRC Press.
4. Kays W. M. and London A. Ia., Compact Heat Exchangers, Third Edition, McGraw Hill.
5. Ramesh K. Sash and Dusan P. Sekulic, Fundamental of Heat Exchanger Design, Wiley.
6. D. M. Rowe, Thermoelectric Handbook, CRC Press.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	-	-	-	1	2	-	-
<b>CO2</b>	2	1	-	-	-	2	-	-
<b>CO3</b>	3	3	3	1	2	3	3	1
<b>CO4</b>	2	2	2	2	3	3	3	3
<b>CO5</b>	2	3	1	2	2	2	1	-

**Note:** 1: Low 2: Moderate 3: High

<b>Program:</b>	M.Tech.	<b>Semester:</b>	II
<b>Name of the Course:</b>	Advanced Steam & Gas Turbine Engineering	<b>Course Code:</b>	ME25-M-PPE110 (5)
<b>Credits:</b>	3	<b>No of Hours:</b>	3 hours/week
<b>Max Marks:</b>	100		

**Course Description:**

This course offers lectures and laboratory classes to impart teaching and learning. The course is designed to provide a detailed knowledge of advanced steam and gas turbine systems to the learners. This course covers the working principle of elements, numerical problems, design, and development of components of the various power plant technologies.

**Course Outcomes:**

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Understand the working of steam turbines and various losses.
<b>CO2</b>	Explain the working principle and operations of the different auxiliary units of a steam turbine.
<b>CO3</b>	Understand the working of the gas turbine cycle and the various elements of it.
<b>CO4</b>	Explain the working principle and operations of the different auxiliary units of the gas turbine.
<b>CO5</b>	Understand the working of combined and cogeneration cycle power plants.

**Syllabus:**

**Unit-1: Steam cycle and steam turbine:** Working Cycle of steam turbine plants, principle of operation of steam turbine, classification of steam turbine, impulse turbine, compounding of steam turbine, velocity diagram for impulse turbine, force on the blade and work done, blade or diagram efficiency, axial thrust, gross stage efficiency, energy losses in steam turbines, governing of steam turbines.

**Unit-2: Steam turbine auxiliary systems:** Steam turbine auxiliary systems, turbine protective devices, tripping devices, unloading gears, lubricating systems, glands and sealing systems, construction, operation, and maintenance of steam turbines.

**Unit-3: Gas cycle and gas turbine:** Gas Turbine shaft power cycle, cycles with intercooling, reheating and recuperation, turbine blade cooling, blade materials, Combustion chambers, requirements, types, factors affecting the performance of Combustion Chambers.

**Unit-4: Gas turbine auxiliary systems:** Gas Turbine auxiliary systems, operation and maintenance, starting and ignition systems, lubrication systems, Fuel system and controls, operation, maintenance, and troubleshooting.

**Unit-5: Combined and cogeneration cycle power plants:**

Introduction, classification of combined gas/steam, combined cycle power plants in India, various configurations of combined cycle power plants, thermodynamic analysis of ideal combined cycle and cogeneration plants, advantages of combined cycle power generation, other types of combined cycles, numerical problems on combined cycle

**Text Books:**

1. R. Yadav, Steam & Gas Turbines and Power Plant Engineering, Central Pub House-Allahabad.
2. H. Cohen, G.F.C. Rogers, Paul Straznicky, Gas Turbine Theory, Pearson.
3. Lee, J.F., Theory and Design of Steam and Gas Turbines. McGraw-Hill Book Company Inc.

**References Books:**

1. William Johnston Kearton, Steam Turbine Theory and Practice, CBS Publishers.
2. Gerogeous lucaus and Murari singh, Blade Design and analysis for steam turbines, Mc GrawHill.
3. Design Alexndar Leyzerovich, Large Power steam turbines, Pennwell Books.
4. P. Shlyakhin, Steam Turbine: Theory and Design, University Press of the Pacific.
5. Heck, Robert Culbertson, The Steam Engine and Turbine, Forgotten Books.

**CO, PO, & PSO Correlation**

Course Outcomes	Program Outcomes					PSOs		
	1	2	3	4	5	1	2	3
<b>CO1</b>	3	2	2	-	3	2	1	1
<b>CO2</b>	3	-	1	-	2	1	2	1
<b>CO3</b>	3	2	2	-	3	1	1	2
<b>CO4</b>	3	-	1	-	2	2	1	2
<b>CO5</b>	3	2	2	-	3	1	2	1

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>THIRD SEMESTER (NHEQF Level: 7)</b>										
<b>S No.</b>	<b>Subject Code</b>	<b>Subject</b>	<b>Periods per Week</b>			<b>Scheme of Examination (Theory / Practical)</b>			<b>Total Marks</b>	<b>Credit L+(T+P)/2</b>
						<b>PRE</b>		<b>ESE</b>		
			<b>L</b>	<b>T</b>	<b>P</b>	<b>MID</b>	<b>TA</b>			
1	ME25-M-PPE201	Industrial/Research Internship	0	0	16	-	60	140	200	08
2	ME25-M-PPE202	Dissertation-I	0	0	24	-	90	210	300	12
<b>Total</b>			<b>0</b>	<b>0</b>	<b>40</b>	<b>-</b>	<b>150</b>	<b>350</b>	<b>500</b>	<b>20</b>

<b>Program:</b>	M.Tech.	<b>Semester:</b>	III
<b>Name of the Course:</b>	Industrial Training/ Research Internship	<b>Course Code:</b>	ME25-M-PPE201
<b>Credits:</b>	8	<b>No of Hours:</b>	16 hours/week
<b>Max Marks:</b>	200		

### Course Description:

The Industrial Training/Research Internship course provides M.Tech students in Power Plant Engineering & Energy Management with hands-on experience in power generation, energy efficiency, and sustainability. Students engage in industry-driven projects or research, focusing on plant operations, optimization, and emission control. The course enhances technical, analytical, and project management skills, culminating in a detailed report, presentation, and defense of their findings.

### Course Outcomes:

After Completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Demonstrate hands-on knowledge of power plant operations and energy management practices.
<b>CO2</b>	Apply energy efficiency techniques and performance evaluation methods in industrial settings.
<b>CO3</b>	Analyze industrial/academic research data using appropriate methodologies and software tools.
<b>CO4</b>	Develop a structured report and communicate findings with technical clarity.
<b>CO5</b>	Present and defend their work effectively to industry/academic research professionals.

### Course Content:

1. Industrial safety, regulations, and ethics
2. Power plant operations and optimization
3. Energy efficiency and conservation techniques
4. Renewable energy integration and smart grid management
5. Emission control and sustainability practices
6. Research methodologies and experimental design
7. Data collection, analysis, and performance evaluation

8. Software tools for energy modeling and simulation
9. Technical report writing and documentation
10. Presentation of industrial/academic research findings

**CO, PO, & PSO Correlation**

<b>Course Outcome</b>	<b>Program Outcome</b>					<b>PSOs</b>		
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>1</b>	<b>2</b>	<b>3</b>
<b>CO1</b>	3	2	2	1	2	3	3	2
<b>CO2</b>	3	3	2	1	3	3	3	2
<b>CO3</b>	2	3	2	-	3	2	3	3
<b>CO4</b>	2	3	2	1	2	2	2	3
<b>CO5</b>	1	2	2	1	2	2	1	3

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>Program:</b>	M.Tech.	<b>Semester:</b>	III
<b>Name of the Course:</b>	Dissertation I	<b>Course Code:</b>	ME25-M-PPE202
<b>Credits:</b>	12	<b>No of Hours:</b>	24 hours/week
<b>Max Marks:</b>	300		

**Course Description:**

Dissertation I outcomes and objectives are designed to equip M.Tech. students with research skills in the domain of Power Plant Engineering and Energy Management. This course focuses on problem identification, literature review, research methodology formulation, and preliminary experimental/simulation work. Students will explore contemporary challenges in power generation, energy efficiency, and sustainable management, setting the foundation for their final dissertation.

**Objectives:**

1. To enable students to conduct an extensive literature review and identify gaps relevant to their prospective area of research.
2. To formulate well-defined research objectives and design an appropriate methodology for their study.
3. To initiate preliminary experimental work, simulations, or data analysis relevant to the research problem.
4. To develop technical writing and documentation skills for preparing an interim research report.
5. To enhance presentation and communication skills by effectively conveying research findings through oral and written formats.

**Course Outcomes:**

After completion of the course, Students will be able to:

<b>CO Number</b>	<b>Course Outcome</b>
<b>CO1</b>	Conduct a comprehensive literature review to identify research gaps in power plant engineering and energy management.
<b>CO2</b>	Formulate clear research objectives and methodology aligned with the identified problem
<b>CO3</b>	Perform preliminary experiments, simulations, or data analysis to validate the research approach
<b>CO4</b>	Develop an interim dissertation report with structured documentation of research progress
<b>CO5</b>	Present and defend initial research findings effectively through oral and written communication

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
CO1	3	3	2	-	2	3	2	2
CO2	2	3	2	-	3	3	3	2
CO3	3	3	3	-	2	1	3	3
CO4	1	3	2	2	3	2	2	1
CO5	2	3	2	1	3	2	2	3

**Note:** 1: Low 2: Moderate 3: High

**O. P. JINDAL UNIVERSITY**  
**O. P. Jindal Knowledge Park, Punjipathra, Raigarh-496109**  
**Department of Mechanical Engineering**



<b>FOURTH SEMESTER (NHEQF Level: 7)</b>										
<b>S. No.</b>	<b>Subject Code</b>	<b>Subject</b>	<b>Periods per Week</b>			<b>Scheme of Examination</b>			<b>Total Marks</b>	<b>Credit L+(T+P)/2</b>
						<b>(Theory / Practical)</b>		<b>ESE</b>		
			<b>L</b>	<b>T</b>	<b>P</b>	<b>PRE</b>	<b>TA</b>			
1	ME25-M-PPE203	Dissertation-II	0	0	40	-	150	350	500	20
<b>Total</b>			<b>0</b>	<b>0</b>	<b>40</b>	<b>-</b>	<b>150</b>	<b>350</b>	<b>500</b>	<b>20</b>

**L-** Lecture      **ESE-** End Semester Exam      **P-** Practical      **T.A.-** Teacher's Assessment

<b>Program:</b>	M.Tech.	<b>Semester:</b>	IV
<b>Name of the Course:</b>	Dissertation II	<b>Course Code:</b>	ME25-M-PPE203
<b>Credits:</b>	20	<b>No of Hours:</b>	40
<b>Max Marks:</b>	500		

### Course Description:

Dissertation II outcomes and objectives are aligned in continuation with Dissertation I, where students will focus on executing their proposed research plan in their respective field. This phase involves conducting detailed experiments, simulations, or case studies, analyzing results, and deriving meaningful inferences & conclusions. Students will refine their methodologies, validate findings, and document their research in a structured dissertation report. The course emphasizes independent research, critical analysis, and professional presentation skills.

### Objectives:

1. Execute Research Plan: Implement the proposed research methodology to achieve the defined research objectives.
2. Data Collection & Analysis: Perform rigorous data collection, simulations, and experiments to derive valid results.
3. Interpret Results & Develop Solutions: Critically analyze findings, compare them with existing literature, and propose innovative solutions.
4. Technical Documentation & Report Writing: Compile research findings in a structured and well-documented dissertation.
5. Presentation & Defense: Effectively communicate research outcomes through presentations and viva voce.

### Course Outcomes:

After completion of the course, Students will be able to:

CO Number	Course Outcome
<b>CO1</b>	Implement the proposed research methodology effectively to achieve the identified research objectives.
<b>CO2</b>	Collect and analyze experimental/simulated data to derive meaningful conclusions.
<b>CO3</b>	Compare research findings with existing studies and suggest improvements or novel solutions.
<b>CO4</b>	Prepare a well-structured dissertation report with technical clarity and coherence.
<b>CO5</b>	Present and defend the research work confidently in front of an academic/research panel.

**CO, PO, & PSO Correlation**

Course Outcome	Program Outcome					PSOs		
	1	2	3	4	5	1	2	3
CO1	3	3	2	-	2	3	3	2
CO2	2	3	2	-	2	3	2	3
CO3	3	3	1	-	2	2	3	3
CO4	1	3	2	2	3	2	2	2
CO5	2	3	-	2	3	1	2	3

**Note:** 1: Low 2: Moderate 3: High