BIRLA INSTITUTE OF TECHNOLOGY

NEP-2020 CURRICULUM BOOK
(Effective from Academic Session: Monsoon 2024)

Bachelor of Technology in
Production and Industrial Engineering

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING

Introduced and Approved in Meetings of Board of Studies, Dept. of PIE, dated 29/07/2024

INSTITUTE VISION

To become a Globally Recognized Academic Institution in consonance with the social, economic, and ecological environment, striving continuously for excellence in education, research, and technological service to the National needs.

INSTITUTE MISSION

- To educate students at Undergraduate, Postgraduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and the state-of-the-art research potential of the faculty.
- To build national capabilities in technology, education, and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and the overall academic needs of society.

DEPARTMENT VISION

To become a center of repute in production and industrial engineering, committed to quality education, innovative research, and entrepreneurship skills in consonance with societal, economic, and sustainable needs.

DEPARTMENT MISSION

- To provide quality education at undergraduate, postgraduate, and doctoral levels, preparing students for leadership roles in industry and academia.
- To establish cutting-edge research facilities in the area of production and industrial engineering and promote a culture of innovation, creativity and entrepreneurship.
- To collaborate with industry, academia, and research organizations to offer technological solutions and services that address contemporary challenges.
- To impart state-of-the-art knowledge to students in the domain of manufacturing and industrial engineering by continuous up-gradation of curricula and faculty expertise.
- To provide a comprehensive education that equips the students with sustainable engineering practices, team spirit, and ethical values required to excel in their careers.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

- PEO 1: Developing capability for continuous learning and problem identification in the field of Production and Industrial Engineering.
- PEO 2: To be more explorative in finding state-of-the-art solutions and implementations for complex real-life problems.
- PEO 3: Inculcating managerial aptitude for communication, problem-solving, and decision-making.
- PEO 4: To enhance interpersonal skills, team spirit, and employability while believing in ethical values.
- PEO 5: To develop a strong foundation for building an engineering career with societal and humanitarian responsibility.

PROGRAMME OUTCOMES (POs)

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

PROGRAMME SPECIFIC OUTCOMES (PSOs)

12. PSO 1: To empower with comprehensive knowledge in the wide domain of sciences of manufacturing, technologies for present and future industries, industrial engineering, and operations management while emphasizing professional ethics and societal responsibility to face the evolution in industry.
13. PSO 2: To develop expertise in solving complex technical, industrial engineering, or managerial problems related to industries through innovative solutions using technological skills, analytical aptitude, communication flair, and team spirit.
14. PSO 3: Enable to apply the attained theoretical and practical knowledge to solve industrial and societal problems in the broad areas of production and industrial engineering.

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.

Mapping of PEOs with Department Mission

	M1	M2	M3	M4	M5
PEO 1	3	2	2	3	3
PEO 2	2	3	3	2	2
PEO 3	2	1	2	2	3
PEO 4	2	1	2	1	3
PEO 5	3	2	2	3	3

Mapping of POs and PSOs with PEOs

	PEO 1	PEO 2	PEO 3	PEO 4	PEO 5
PO 1	3	2	1	1	2
PO 2	3	3	2	2	2
PO 3	2	3	2	2	2
PO 4	2	3	2	2	2
PO 5	3	3	2	2	2
PO 6	3	3	2	2	2
PO 7	2	2	3	3	3
PO 8	2	2	3	3	2
PO 9	2	2	3	3	2
PO 10	2	2	3	2	2
PO 11	3	3	2	2	2
PSO 1	3	3	2	2	3
PSO 2	2	3	3	2	2
PSO 3	3	3	2	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Birla Institute of Technology, Mesra, Ranchi

Course Structure for B.Tech. (Production and Industrial Engineering)

Based on NEP-2020, CBCS and OBE, Effective from 2024-2025

Sr. No.	Semester of Study (Recommended)	Category of Course	Course Code	Subjects	Mode of Delivery & Credits *L-Lecture; T-Tutorial; P-Practical*			Total Credits
					L *(Periods/ Week)*	T *(Periods/ Week)*	P *(Periods/ Week)*	
	FIRST	**THEORY**						
I.1		FS	MA24101	Mathematics - I	3	1	0	4
I.2			PH24101	Physics	3	1	0	4
I.3			BE24101	Biological Science for Engineers	2	0	0	2
I.4		GE	CS24101	Programming for Problem Solving	3	1	0	4
I.5			EE24101	Basics of Electrical Engineering	2	1	0	3
		LABORATORIES						
I.6		FS	PH24102	Physics Laboratory	0	0	2	1
I.7		GE	CS24102	Programming for Problem Solving Laboratory	0	0	2	1
I.8			EE24102	Electrical Engineerimg Laboratory	0	0	2	1
I.9		HSS	HS24131	Communication Skill - I	0	0	3	1.5
I.10		MC	MC24 101/102/10 3 /104/105	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA) /Entrepreneurship	0	0	2	1
TOTAL (Theory + Labs)								**22.5**
	SECOND	**THEORY**						
II.1		FS	MA24103	Mathematics - II	3	1	0	4
II.2			CH24101	Chemistry	3	1	0	4
II.3		GE	EC24101	Basic Electronics	2	1	0	3
II.4			ME24101	Basics of Mechanical Engineering	2	1	0	3
II.5		FS	CE24101	Environmental Science	2	0	0	2
		LABORATORIES						
II.6		FS	CH24102	Chemistry Laboratory	0	0	2	1
II.7		GE	EC24102	Basic Electronics Laboratory	0	0	2	1
II.8			ME24102	Engineering Graphics	0	0	4	2
I.9			PE24102	Workshop Practice	0	0	2	1
I.10		MC	MC24 106/107/10 8/109 /110	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA) /Entrepreneurship	0	0	2	1
TOTAL (Theory + Labs)								**22**
GRAND TOTAL FOR FIRST YEAR								**44.5**
Vocational Courses for Exit after 1st Year								
VOC1	**PE24190**	**Welding Technology**			1	0	4	3
VOC2	**ME24104**	**Working with AutoCAD**			1	0	4	3

	THIRD	**THEORY**						
III.1		FS	MA24201	Numerical Methods	2	0	0	2
III.2		PC	PE24201	Introduction to Materials Engineering	3	0	0	3
III.3			PE24203	Operations Research	3	0	0	3
III.4			ME24205	Strength of Materials	3	1	0	4
III.5			ME24221	Thermal and Fluid Engineering	3	0	0	3
III.6		HSS	MT24131	UHV-II: Understanding Harmony	3	0	0	3
		LABORATORIES						
III.7		FS	MA24202	Numerical Methods Laboratory	0	0	2	1
III.8		PC	PE24202	Materials Engineering Lab	0	0	3	1.5
III.9			ME24208	Basic Mechanical Engineering Lab	0	0	2	1
III.10		MC	MC24 201/202/203/204 /205	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA) / Entrepreneurship	0	0	2	1
	TOTAL (Theory + Labs)							**22.5**
	FOURTH	**THEORY**						
IV.1		PC	ME24207	Kinematics and Dynamics of Machines	3	1	0	4
IV.2			PE24205	Foundry, Forming, and Welding Technologies	3	0	0	3
IV.3			PE24207	Metrology & Measurement	3	0	0	3
IV.4			PE24209	Production and Operations Management	4	0	0	4
IV.5		PE		Program Elective - I	3	0	0	3
IV.6		OE	XXXXXXX/MO24201	Open Elective - I / MOOC - I	3	0	0	3
IV.7		MC	HS24211	Indian Knowledge System				0
		LABORATORIES						
IV.8		PC	PE24206	Foundry, Forming, and Welding Lab	0	0	2	1
IV.9			PE24208	Metrology and Measurement Lab	0	0	2	1
IV.10			PE24210	Modeling and Simulation Lab	0	0	2	1
IV.11		MC	MC24205/206/ 207/208/210	Choice of: NCC/NSS/PT & Games/ Creative Arts (CA) / Entrepreneurship	0	0	2	1
TOTAL (Theory + Labs)								**24**
GRAND TOTAL FOR SECOND YEAR								**46.5**
Vocational Courses for Exit after 2nd Year								
VOC3	**PE24290**	**CNC Machining**			1	0	4	3
VOC4	**ME24212**	**Installation, Testing, and Maintenance of Solar Appliances**			1	0	4	3
	FIFTH	**THEORY**						
V.1		PC	PE24301	Machining Science and Machine Tools	3	0	0	3
V.2			PE24303	Design of Machine Elements	3	0	0	3
V.3			PE24305	Statistical Quality Control	3	0	0	3
V.4		PE		Program Elective - II	3	0	0	3
V.5		PE		Program Elective - III	3	0	0	3

V.6		OE	XXXXXX/MO 24301	Open Elective - II / MOOC - II	3	0	0	3
		LABORATORIES						
V.7		PC	HS24133	Communication Skills – II	0	0	3	1.5
V.8			PE24302	Machine Tools Lab	0	0	2	1
V.9			PE24304	Machine Drawing and CAD Lab	0	0	3	1.5
V.10		PC	PE24300	Project - I				2
TOTAL (Theory + Labs)								**24**
	SIXTH	**THEORY**						
VI.1		PC	PE24329	Machine Tool Design	3	0	0	3
VI.2			PE24331	Work System Design	3	0	0	3
VI.3			PE24333	Supply Chain Management	3	0	0	3
VI.4		PE		Program Elective - IV	3	0	0	3
VI.5				Program Elective - V	3	0	0	3
		OE	XXXXXX/MO 24303	Open Elective - III / MOOC - III	3	0	0	3
		LABORATORIES						
VI.6		PC	PE24330	Machine Tool Design Sessional	0	0	2	1
VI.7			PE24332	Work System Design Lab	0	0	2	1
VI.10			PE24350	Project - II				2
TOTAL (Theory + Labs)								**22**
GRAND TOTAL FOR THIRD YEAR								**46**
	SEVENTH	**THEORY**						
VII.1		PC	PE24401	Computer Integrated Manufacturing & Cyber-Physical Systems	3	0	0	3
VII.2			PE24403	Production Economics and Financial Management	3	0	0	3
VII.3			PE24405	Project Engineering	3	0	0	3
VII.4		PE		Program Elective - VI	3	0	0	3
VII.5		OE	XXXXXXX/MO24401	Open Elective - IV / MOOC - IV	3	0	0	3
		HSS	MT24204	Constitution of India	2	0	0	0
		LABORATORIES						
VII.6		PC	PE24402	Manufacturing Automation Lab	0	0	2	1
VII.8		MC	MC24400	Summer Training (Minimum Four Weeks / 160 Hrs)				4
VII.9		PC	PE24400	Project - III				3
TOTAL (Theory + Labs)								**23**
VIII.1	**EIGHTH**	PC	PE24450/ PE24490	Project-IV / Industry Internship				6
VIII.2			PE24498	Comprehensive Viva				2
	TOTAL (Theory + Labs)							**8**
GRAND TOTAL FOR FOURTH YEAR								**31**
GRAND TOTAL FOR B.TECH.								**168**

PROGRAM ELECTIVES (PE)**								
Semester/ Session of Study (Recommended)		Course Code	Name of the PE Courses	Prerequisite Courses	L	T	P	C
FOURTH Spring	PE - I (Any one)	PE24211	Reliability and Maintenance Engineering	None	3	0	0	3
		PE24213	Industrial Statistics	None	3	0	0	3
		PE24215	Quantitative Techniques for Data Analysis	None	3	0	0	3
		PE24217	Discrete-event System Simulation	None	3	0	0	3
FIFTH Monsoon	PE - II (Any one)	PE24307	Advanced Operations Research	Operations Research	3	0	0	3
		PE24309	Competitive Manufacturing Strategies	None	3	0	0	3
		PE24311	Circular Economy- Sustainable Materials Management	None	3	0	0	3
		ME24317	Finite Element Methods	None	3	0	0	3
	PE - III (Any one)	PE24313	Advanced Welding Technology	Introduction to Materials Engineering; Foundry, Forming, and Welding Technologies	3	0	0	3
		PE24315	Rapid Prototyping and Tooling	None	3	0	0	3
		PE24317	Material Deformation Processes	Strength of Materials; Foundry, Forming, and Welding Technologies	3	0	0	3
		ME24323	Mechatronics	None	3	0	0	3
SIXTH Spring	PE - IV (Any one)	PE24335	Surface Engineering and Laser Additive Manufacturing	None	3	0	0	3
		PE24337	Tribology in Engineering	Foundry, Forming, and Welding Technologies	3	0	0	3
		PE24339	Tooling for Manufacturing	Foundry, Forming, and Welding Technologies; Machining Science and Machine Tools	3	0	0	3
		PE24341	Manufacturing Science	Foundry, Forming, and Welding Technologies; Machining Science and Machine Tools	3	0	0	3
	PE - V (Any one)	PE24343	Product Design and Manufacturing	Foundry, Forming, and Welding Technologies	3	0	0	3
		PE24345	Engineering Optimization	None	3	0	0	3
		PE24347	Lean Manufacturing & Six-sigma	None	3	0	0	3
		PE24349	Material Handling Systems	None	3	0	0	3

SEVENTH Monsoon	PE - VI (Any one)	PE24407	Non-conventional Machining Processes	Machining Science and Machine Tools	3	0	0	3
		PE24409	Advanced Manufacturing Processes	Foundry, Forming, and Welding Technologies; Machining Science and Machine Tools	3	0	0	3
		PE24411	Experimental Methods and Measurements	Introduction to Materials Engineering	3	0	0	3
		PE24413	AI and Data Analytics	None	3	0	0	3

****PROGRAM ELECTIVES TO BE OPTED FOR ONLY BY THE B. TECH IN PRODUCTION AND INDUSTRIAL ENGINEERING**

OPEN ELECTIVES (OE)*

Semester / Session of Study (Recommended)	Course Code	Name of the OE Courses	Prerequisites Courses	L	T	P
FOURTH/ Spring	PE24219	Engineering Economy, Costing and Accounting	None	3	0	0
	PE24221	Engineering Materials	None	3	0	0
FIFTH / Monsoon	PE24319	Project Management	None	3	0	0
	PE24321	Work Study & Ergonomics	None	3	0	0
SIXTH / Spring	PE24351	Operations Research with Python	None	3	0	0
	PE24353	Additive Manufacturing	None	3	0	0
SEVENTH / Monsoon	PE24415	Automated Manufacturing Systems	None	3	0	0
	PE24417	Production Management	None	3	0	0

*** OPEN ELECTIVES TO BE OFFERED ONLY TO THE STUDENTS OF OTHER DEPARTMENTS**

IN-DEPTH SPECIALISATION in "Advanced Manufacturing and Production Management"
(OFFERED ONLY TO THE B. TECH IN PRODUCTION AND INDUSTRIAL ENGINEERING STUDENTS)

Students who have registered for DEPARTMENTAL SPECIALISATION (in-depth) in "Advanced Manufacturing and Production Management" should complete 16 credits and shall opt for the courses listed below. The credits shall be over and above the minimum requirement for the degree award.

<table>
<tr><th rowspan="2">Semester/ Session of Study (Recommended)</th><th rowspan="2">Category of Course</th><th rowspan="2">Course Code</th><th rowspan="2">Course Name</th><th colspan="3">Mode of delivery & credits
L-Lecture; T-Tutorial; P-Practicals</th><th>*Credits*</th></tr>
<tr><th>L
(Periods/ week)</th><th>T
(Periods/ week)</th><th>P
(Periods/ week)</th><th>C</th></tr>
<tr><td rowspan="3">FIFTH / Monsoon</td><td colspan="7">THEORY</td></tr>
<tr><td rowspan="2">PE
(any one)</td><td>PE24323</td><td>Material Characterizations and Non-destructive Testing</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>PE24325</td><td>Sustainable Manufacturing Technologies</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="7">TOTAL</td><td>4</td></tr>
<tr><td rowspan="4">SIXTH / Spring</td><td colspan="7">THEORY</td></tr>
<tr><td rowspan="3">PE
(any one)</td><td>PE24355</td><td>Industrial Robotics</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>PE24357</td><td>Processing of Polymers, Composites and Advanced Materials</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>PE24359</td><td>Manufacturing Management and Cost Optimization</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="7">TOTAL</td><td>4</td></tr>
<tr><td rowspan="5">SEVENTH / Monsoon</td><td colspan="7">THEORY</td></tr>
<tr><td rowspan="2">PE
(any one)</td><td>PE24419</td><td>Finite Elements in Manufacturing Engineering Applications</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>PE24421</td><td>Micro and Nano Manufacturing</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="7">PROJECT</td></tr>
<tr><td>PC</td><td>PE24440</td><td>Applications-based Project</td><td colspan="3"></td><td>4</td></tr>
<tr><td colspan="7">TOTAL</td><td>8</td></tr>
<tr><td colspan="7">GRAND TOTAL</td><td>16</td></tr>
</table>

MINOR in "Production and Industrial Engineering"

(OFFERED ONLY TO STUDENTS OTHER THAN PRODUCTION AND INDUSTRIAL ENGINEERING)

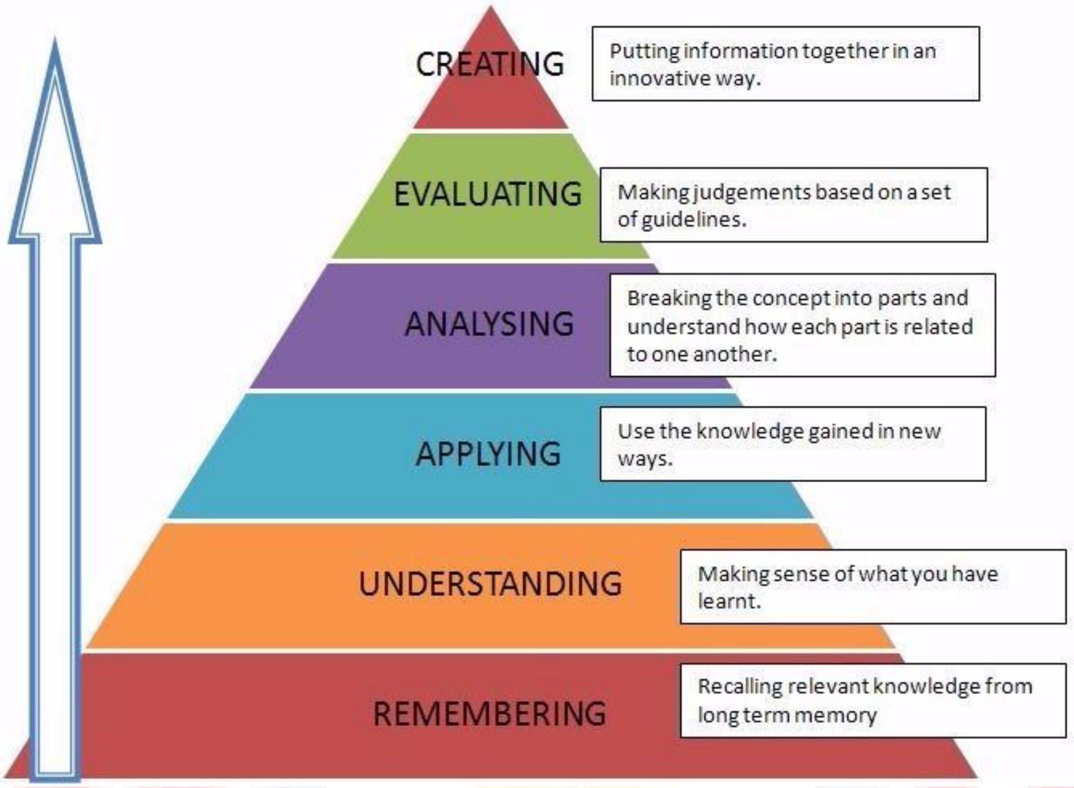
Students who have registered for a Minor in Production and Industrial Engineering should complete 16 credits and shall opt for the courses listed below. The credits shall be over and above the minimum requirement for the degree award.

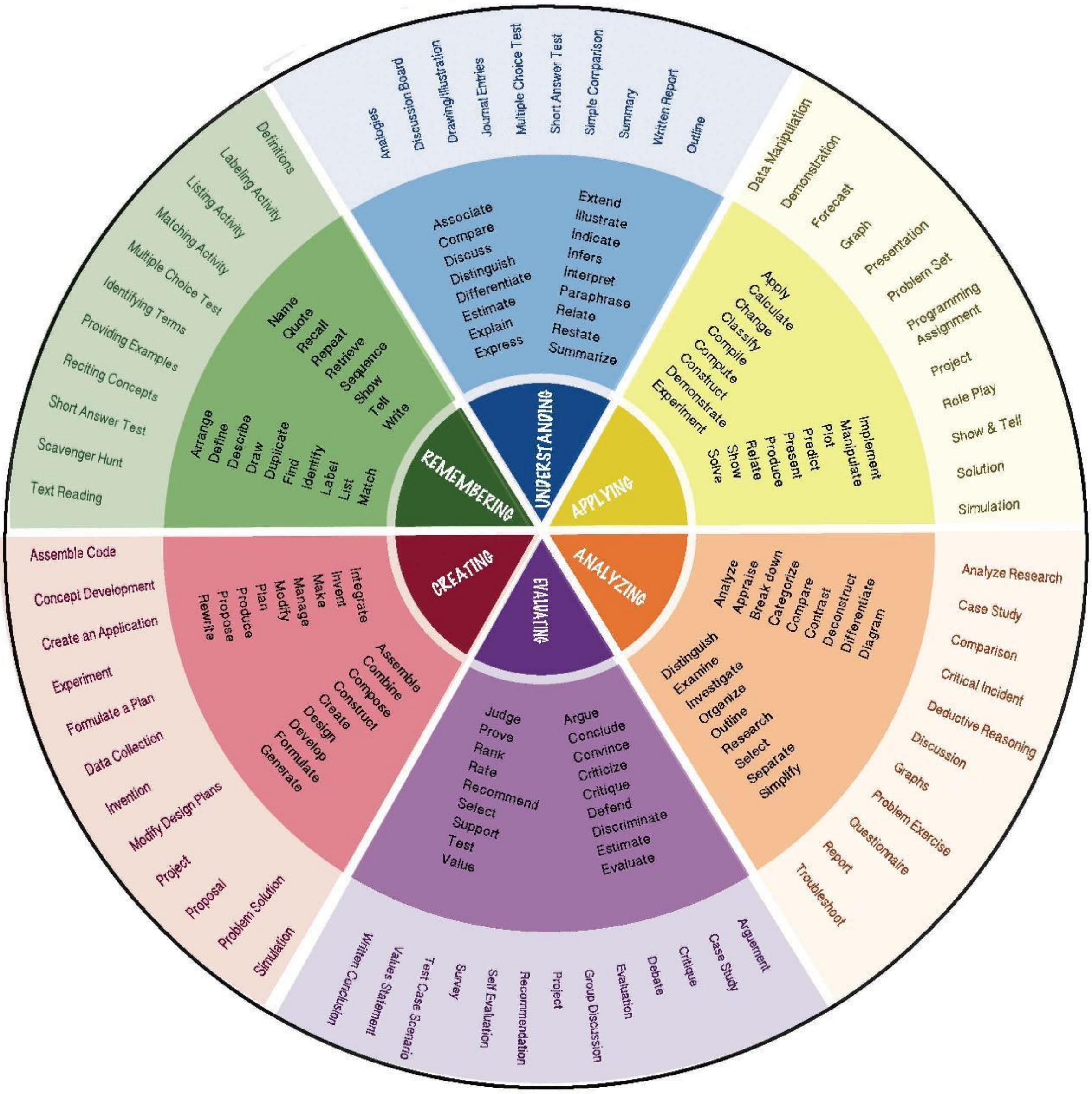
<table>
<tr><th rowspan="2">Semester/ Session of Study (Recommended)</th><th rowspan="2">Category of course</th><th rowspan="2">Course Code</th><th rowspan="2">Course Name</th><th rowspan="2">Prerequisite courses</th><th colspan="3">Mode of delivery & credits
L-Lecture; T-Tutorial; P-Practicals</th><th>*Credits*</th></tr>
<tr><th>L
(Periods/ week)</th><th>T
(Periods/ week)</th><th>P
(Periods/ week)</th><th>C</th></tr>
<tr><td rowspan="6">FIFTH / Monsoon</td><td colspan="8">THEORY</td></tr>
<tr><td rowspan="5">PE (any one)</td><td>PE24223</td><td>Operations Research and Quantitative Techniques</td><td>None</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td rowspan="2">PE24225</td><td rowspan="2">Manufacturing Science and Technologies</td><td>None</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="5">Only for other than Mechanical Engg. Department students</td></tr>
<tr><td rowspan="2">PE24327</td><td rowspan="2">Modern Manufacturing Processes</td><td>Manufacturing Processes</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="5">Only for Mechanical Engg. Department students</td></tr>
<tr><td colspan="8">TOTAL</td><td>4</td></tr>
<tr><td rowspan="2">SIXTH / Spring</td><td colspan="8">THEORY</td></tr>
<tr><td>PC</td><td>PE24361</td><td>Mechanical Measurement & Quality Control</td><td>None</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="8">TOTAL</td><td>4</td></tr>
<tr><td rowspan="5">SEVENTH / Monsoon</td><td colspan="8">THEORY</td></tr>
<tr><td rowspan="2">PE (any one)</td><td>PE24209</td><td>Production and Operations Management</td><td>None</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td>PE24423</td><td>Logistics and Supply Chain Management</td><td>None</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="8">PROJECT</td></tr>
<tr><td>PC</td><td>PE24440</td><td>Applications-based Project</td><td colspan="4"></td><td>4</td></tr>
<tr><td colspan="8">TOTAL</td><td>8</td></tr>
<tr><td colspan="8">GRAND TOTAL</td><td>16</td></tr>
</table>

BLOOM’S TAXONOMY FOR CURRICULUM DESIGN AND ASSESSMENT:

Preamble

The design of curriculum and assessment is based on Bloom’s Taxonomy. A comprehensive guideline for using Bloom’s Taxonomy is given below for reference.




REMEMBERING
Name
Quote
Recall
Repeat
Retrieve
Sequence
Show
Tell
Write
Arrange
Define
Describe
Draw
Duplicate
Find
Identify
Label
List
Match
Definitions
Labeling Activity
Listing Activity
Matching Activity
Multiple Choice Test
Identifying Terms
Providing Examples
Reciting Concepts
Short Answer Test
Scavenger Hunt
Text Reading
UNDERSTANDING
Associate
Compare
Discuss
Distinguish
Differentiate
Estimate
Explain
Express
Extend
Illustrate
Indicate
Infers
Interpret
Paraphrase
Relate
Restate
Summarize
Analogies
Discussion Board
Drawing/Illustration
Journal Entries
Multiple Choice Test
Short Answer Test
Simple Comparison
Summary
Written Report
Outline
APPLYING
Apply
Calculate
Change
Classify
Compile
Compute
Construct
Demonstrate
Experiment
Implement
Manipulate
Plot
Predict
Present
Produce
Relate
Show
Solve
Data Manipulation
Demonstration
Forecast
Graph
Presentation
Problem Set
Programming Assignment
Project
Role Play
Show & Tell
Solution
Simulation
ANALYZING
Analyze
Appraise
Break down
Categorize
Compare
Contrast
Deconstruct
Differentiate
Diagram
Distinguish
Examine
Investigate
Organize
Outline
Research
Select
Separate
Simplify
Analyze Research
Case Study
Comparison
Critical Incident
Deductive Reasoning
Discussion
Graphs
Problem Exercise
Questionnaire
Report
Troubleshoot
EVALUATING
Judge
Prove
Rank
Rate
Recommend
Select
Support
Test
Value
Argue
Conclude
Convince
Criticize
Critique
Defend
Discriminate
Estimate
Evaluate
Arguement
Case Study
Critique
Debate
Evaluation
Group Discussion
Project
Recommendation
Self Evaluation
Survey
Test Case Scenario
Values Statement
Written Conclusion
CREATING
Integrate
Invent
Make
Manage
Modify
Plan
Produce
Propose
Rewrite
Assemble
Combine
Compose
Construct
Create
Design
Develop
Formulate
Generate
Assemble Code
Concept Development
Create an Application
Experiment
Formulate a Plan
Data Collection
Invention
Modify Design Plans
Project
Proposal
Problem Solution
Simulation

<u>**COURSE INFORMATION SHEET**</u>

Course Code:	**MA24101**
Course Title:	**Mathematics-I**
Pre-requisite(s): -	
Co- requisite(s): --	
Credits:	**4 (L: 3 T: 1 P: 0)**
Class schedule per week:	**4**
Class:	**B. Tech.**
Semester / Level:	**FIRST**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	infinite sequences and series
2.	theory of matrices including elementary transformations, rank and its application in consistency of system of linear equations, eigenvalues, eigenvectors etc.
3.	multivariable functions, partial differentiation, properties and applications of partial derivatives.
4.	integrals of multivariable functions viz. double and triple integrals with their applications
5.	properties like gradient, divergence, curl associated with derivatives of vector point functions and integrals of vector point functions

COURSE OUTCOMES (COs)

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

CO1	decide the behavior of sequences and series using appropriate tests.
CO2	handle problems related to the theory of matrices including elementary transformations, rank and its application in consistency of system of linear equations, eigenvalues, eigenvectors etc.
CO3	get an understanding of partial derivatives and their applications in finding maxima - minima problems.
CO4	apply the principles of integrals (multivariable functions viz. double and triple integrals) to solve a variety of practical problems in engineering and sciences.
CO5	get an understanding of gradient, divergence, curl associated with derivatives of vector point functions and integrals of vector point functions and demonstrate a depth of understanding in advanced mathematical topics, enhance and develop the ability of using the language of mathematics in engineering.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
MODULE – I: Sequences and Series Sequences, Convergence of Sequence. Series, Convergence of Series, Tests for Convergence: Comparison tests, Cauchy's Integral test, Ratio test, Cauchy’s root test, Raabe’s test, Gauss test, Alternating series, Leibnitz test, Absolute and Conditional Convergence.	9
MODULE – II: Matrices Rank of a Matrix, elementary transformations. Vectors, Linear Independence and Dependence of Vectors. Consistency of system of linear equations. Eigenvalues, Eigenvectors, Cayley - Hamilton theorem.	9
III: Advance Differential Calculus Function of several variables, Partial derivatives, Euler’s theorem for homogeneous functions, Total derivatives, Chain rules, Jacobians and its properties, Taylor series for function of two variables, Maxima – Minima.	9
MODULE – IV: Advance Integral Calculus Double integrals, double integrals in polar coordinates, Change of order of integration, Triple Integrals, cylindrical and spherical coordinate systems, transformation of coordinates, Applications of double and triple integrals in areas and volumes.	9
MODULE – V: Vector Calculus Scalar and vector point functions, gradient, directional derivative, divergence, curl. Line Integral, Work done, Conservative field, Green’s theorem in a plane, Surface and volume integrals, Gauss – divergence theorem, Stoke ’s theorem.	9

TEXTBOOKS:

1. M. D. Weir, J. Hass and F. R. Giordano: Thomas’ Calculus, 11th edition, Pearson Educations, 2008E.
2. H. Anton, I. Brivens and S. Davis, Calculus, 10th Edition, John Wiley and sons, Singapore Pte. Ltd., 2013.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint,2010.

REFERENCE BOOKS:

1. M. J. Strauss, G. L. Bradley And K. J. Smith, Calculus, 3rd Ed, Dorling. Kindersley (India) Pvt. Ltd. (P Ed), Delhi, 2007.
2. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Ed. Asia, Indian Reprint, 2007.
3. Robert Wrede & Murray R. Spiegel, Advanced Calculus, 3rd Ed., Schaum’s outline series, McGraw-Hill Companies, Inc.,2010.
4. D. G. Zill and W.S. Wright, Advanced Engineering Mathematics, Fourth Edition, 2011.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS) --

POS MET THROUGH GAPS IN THE SYLLABUS --

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN ---

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN --

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination	25
End Sem Examination	50
Quiz	20
Teacher's assessment / Assignment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz	40
Teacher's assessment / Assignment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	√	√	√	√	
Semester End Examination	√	√	√	√	√

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	3	3	2	2	1	0	0	0	0	1	2	1	2	2
CO2	3	3	2	2	2	0	0	0	0	1	2	1	3	3
CO3	3	3	2	2	1	0	0	0	0	1	2	1	3	3
CO4	3	3	3	3	2	1	0	0	0	1	2	1	2	2
CO5	3	3	2	3	2	1	1	1	1	2	2	1	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course Code: **PH24101**
Course Title: **Physics**
Pre-requisite(s): **Intermediate Physics and Intermediate Mathematics**
Co- requisite(s): **Mathematics I**
Credits: **4 (L: 3 T: 1 P: 0)**
Class schedule per week: **4**
Class: **B. Tech.**
Semester / Level: **FIRST**
Branch: **Production and Industrial Engineering**
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students:

1.	The principles of physical optics and basic concept of fiber optics.
2.	Fundamental laws of electromagnetism leading to Maxwell's equations.
3.	The posulates of special theory of relativity, Lorenz transformation equation and their consequences: Einstein energy mass relation and relativistic energy-momentum relation
4.	The limitations of classical physics and basic concepts such as wave-particle duality, and working of quantum mechanics with the help of particles in a box problem
5.	Concepts of stimulated emission and working principle of laser with examples, concepts of nuclear physics and plasma physics

COURSE OUTCOMES (COs)

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

CO1	Analyse the intensity variation of light due to polarization, interference and diffraction.
CO2	Formulate and solve the problems on electromagnetism
CO3	Explain and apply concepts of special theory of relativity and its consequences
CO4	Apply the concepts of quantum mechanics such as wave-particle duality and obtain the solution of simple quantum mechanical problems.
CO5	Explain working principle of lasers and to summarize its applications, describe basic concepts of nuclear and plasma physics

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I: **Physical Optics:** Polarization, Malus' Law, Brewster's Law, Double Refraction, Interference in thin parallel films, Interference in wedge-shaped layers, Newton's rings, Fraunhofer diffraction by single slit and double slit. Elementary ideas of fibre optics and application of fibre optic cables	**8**
Module – II: **Electromagnetic Theory:** Gradient, Divergence and Curl, Statement of Gauss theorem & Stokes theorem, Gauss's law, Applications, Concept of electric potential, Relationship between E and V, Polarization of dielectrics and dielctric constant, Boundary conditions for E & D, Gauss's law in magnetostatics, Ampere's circuital law, Boundary conditions for B & H, Equation of continuity, Displacement current, Maxwell's equations.	**8**
Module – III: **Special Theory of Relativity:** Introduction, Inertial frame of reference, Galilean transformations, Postulates, Lorentz transformations and its conclusions, Length contraction, time dilation, velocity addition, Mass change, Einstein's mass energy relation.	6
Module – IV: **Quantum Mechanics:** Planck's theory of black-body radiation, Compton effect, Wave-particle duality, De Broglie waves, Davisson and Germer's experiment, Uncertainty principle, Brief idea of Wave Packet, Wave Function and its physical interpretation, Schrodinger equation in one-dimension, free particle, particle in an infinite square well	9
Module – V **Modern Physics:** Laser-Spontaneous and stimulated emission, Einstein's A and B coefficients, Population inversion, Light amplification, Basic laser action, Ruby and He-Ne lasers, Properties and applications of laser radiation, Nuclear Physics: Binding Energy Curve, Nuclear Force, Liquid drop model, Introduction to Shell model, Applications of Nuclear Physics, Concept of Plasma Physics and its applications.	9

TEXTBOOKS:

- A. Ghatak, Optics, 4th Edition, Tata Mcgraw Hill, 2009
- Mathew N.O. Sadiku, Elements of Electromagnetics, Oxford University Press, 2001
- Arthur Beiser, Concept of Modern Physics, 6th edition, Tata McGraw- Hill, 2009
- F. F. Chen, Introduction to Plasma Physics and controlled Fusion, Springer, Edition 2016.

REFERENCE BOOKS:

1. Fundamentals of Physics, Halliday, Walker and Resnick

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

POS MET THROUGH GAPS IN THE SYLLABUS

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination	25
End Sem Examination	50
Quiz	20
Teacher's assessment / Assignment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz	40
Teacher's assessment / Assignment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	2	2	0	1	1	0	0	1	0	0	2	1	2	2
CO2	2	2	0	1	1	0	0	1	0	0	2	1	2	2
CO3	2	1	0	1	1	0	0	1	0	0	2	1	1	1
CO4	2	1	0	1	1	0	0	1	0	0	2	1	2	2
CO5	2	1	0	1	1	0	0	1	0	0	2	1	3	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course Code:	**BE24101**
Course Title:	**Biological Science for Engineers**
Pre-requisite(s):	
Co-requisite(s):	
Credits:	**2 (L:2 T: 0 P:0)**
Class schedule per week:	**2**
Class:	**B. Tech.**
Semester / Level:	**First**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Understand fundamental concepts of biology relevant to engineering.
2.	Explore the structure and function of biological molecules and cells.
3.	Learn about genetic principles and molecular biology techniques.
4.	Understand the applications of biological science in various engineering fields considering global challenges and ethical considerations.

COURSE OUTCOMES (COs)

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

CO1	Comprehend and apply the fundamental concepts of biological sciences in the context of engineering.
CO2	Analyze the structure and function of biological molecules and cells and their relevance to engineering solutions.
CO3	Demonstrate understanding of genetic principles and molecular biology techniques and their applications in engineering.
CO4	Apply knowledge of biological sciences to innovate and develop solutions in various engineering domains and critically evaluate the role of biological sciences in addressing global challenges, including ethical and safety considerations.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module I: Introduction to Biological Sciences Overview and importance of biology in engineering, Origin of Life, Cell Theory and Structure.	6
Module II: Molecular Biology and Genetics Central Dogma of Molecular Biology, DNA, RNA and Protein structure and function, Mendelian Genetics, rDNA Technology and Genome Editing.	6
Module III: Biochemistry Cell Metabolism, Enzymes and Catalysis, Cell Communication and Signalling.	6
Module IV: Applications of Biological Sciences in Engineering Biomaterials, Bioinformatics, Biosensors and Bioelectronics (Biological Sensors- Ear & Eye), Synthetic Biology, Nanobiotechnology.	6
Module V: Global Challenges and Ethical Considerations Convergence of AI and Biology, Climate change and food security, Biosafety and Biohazards, Ethical Considerations.	6

TEXTBOOKS:

1. Lehninger A, Principals of Biochemistry
2. Stryer L, Biochemistry
3. K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry.
4. Biology for Engineers" by Arthur T. Johnson

REFERENCE BOOKS:

1. Purves et al, Life: The Science of Biology
2. R. Dulbecco, The Design of Life.
3. Biological Science Edited by Soper, Cambridge low price edition.
4. Synthetic Biology: A Primer" by Paul S. Freemont and Richard I. Kitney
5. "Introduction to Bioinformatics" by Arthur Lesk Genomes" by T.A. Brown

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

POS MET THROUGH GAPS IN THE SYLLABUS

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination	25
End Sem Examination	50
Quiz	20
Teacher's assessment / Assignment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz	40
Teacher's assessment / Assignment	10

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment	√	√	√	√
Semester End Examination	√	√	√	√

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	1	1	2	1	1	1	1	1	2
CO2	3	3	3	3	1	1	1	2	1	1	1	1	2	2
CO3	1	3	3	3	0	1	1	1	0	1	1	1	2	2
CO4	2	2	2	2	0	2	2	2	0	1	1	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course Code:	**CS24101**
Course Title:	**Programming for Problem Solving**
Pre-requisite(s):	**School-level mathematics and Science**
Co- requisite(s):	
Credits:	**4** (L: 3 T: 1 P:0)
Class schedule per week:	**4**
Class:	**B. Tech.**
Semester / Level:	**First**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Develop Programming Skill.
2.	Understand the fundamental Concepts of Coding
3.	Learn how to Debug Programs
4.	Convert Problems to Programs

COURSE OUTCOMES (COs)

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

CO1	Formulate Algorithms for arithmetic and logical problems.
CO2	Translate the algorithms to programs.
CO3	Test and execute the programs and correct syntax and logical errors.
CO4	Apply programmatic skills for solving scientific problems.
CO5	Decompose problems into functions and structured programming.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Representation of an Algorithm: Flowchart/Pseudo code with examples. From algorithms to programs: source code, variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.	**6**
Module – II Structure of a C program, variables and data types, Operators – precedence and associativity, Evaluating expressions, Basic I/O – use of printf, scanf, getchar etc. and format specifiers, Conditional Branching statements – If, If - else, If-else- if, switch case, Writing nested conditional statements.	**8**
Module – III Iterative programming structures – for loops, while loops, do while loops. Understanding break and continue and their usage. Writing Nested loops, Arrays – creation and usage, Strings and string handling.	**8**
Module – IV Functions (including using built in libraries), Parameter passing in functions, call by value, Recursion, as a different way of solving problems, Nested function calls. Understanding scope and lifetime of a variable.	**8**
Module – V Structures - Defining structures, Accessing structures elements, Creating an array of Structures, Nested structures. Some advanced concepts – typedef, enum, macros. An introduction to pointers – understanding, creating pointers and accessing variables using pointers. Passing arrays to functions: idea of call by reference, passing parameters to main.	**10**

TEXTBOOKS:

1. Let us C, Yashwant Kanetkar, 18th Edition, BPB Publications
2. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
3. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
4. R.G.Dromey, How to Solve it by Computer, Pearson Education

REFERENCE BOOKS:

1. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

- The syllabus focused on the concepts and basics of Program writing skills.
- Industry often requires debugging of their existing programs/software compare to the new program, which is a knowledge beyond the basics, including real-world software (collection of programs) experience.
- More memory management practices, file handling and library functions

POS MET THROUGH GAPS IN THE SYLLABUS: YES [PO1-PO5 & PO10-PO12]

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

File Handling with memory management, preprocessor directives, Graphics, Data Arrangement, Task scheduling, and assembly level programs.

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: YES [PO1-PO5]

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	2	0	1	2	2	2	1	3	2
CO2	3	3	3	3	3	2	0	1	2	2	2	1	3	2
CO3	3	3	3	3	3	2	0	1	2	2	2	1	3	2
CO4	3	3	3	3	3	2	0	1	2	2	2	1	3	3
CO5	3	3	3	3	3	2	0	1	2	2	2	1	3	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD3, CD5
CO3	CD3, CD5, CD7
CO4	CD2, CD3, CD4, CD6, CD7
CO5	CD1, CD3, CD5, CD7

COURSE INFORMATION SHEET

Course Code:	**EE24101**
Course Title:	**Basics of Electrical Engineering**
Pre-requisite(s):	**Basic Sciences**
Co- requisite(s):	
Credits:	**3 (L:2 T: 1 P: 0)**
Class schedule per week:	**3**
Class:	**B. Tech.**
Semester / Level:	**FIRST**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Realize the electrical signals, elements, and their properties.
2.	Understand the mathematical representation of AC, DC signals and theorems/laws for solving electrical circuits with variations of voltage and frequency.
3.	Perceive the 3-phase AC signal representation and 3-phase circuit analysis for balanced and unbalanced condition.
4.	Understand the characteristics of magnetic material and analysis of magnetic circuits.

COURSE OUTCOMES (COs)

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

CO1	Explain the voltage, current signals and their characteristics in electrical circuit elements.
CO2	Apply the theorems/laws for electrical circuit analysis.
CO3	Solve the electrical circuits for variable voltage and frequency to observe the resonance, power and power factor in the electric circuit.
CO4	Analyze the 1-phase and 3-phase AC balanced and unbalanced circuits
CO5	Apply the concept of magnetic circuits for magnetic circuit analysis.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Introduction:** Importance of Electrical Engineering in day-to-day life, Electrical elements, properties (linear, non-linear, unilateral, bilateral, lumped and distributed, etc.) and their classification, Ideal and Real Sources, Source Conversion, Star-Delta conversion, KCL and KVL, Mesh current and Nodal voltage method.	**8**
Module – II **D.C. Circuits**: Steady state analysis with independent and dependent sources; Series and Parallel circuits. **Circuit Theorems:** Superposition, Thevenin's, Norton's, and Maximum Power Transfer theorems for Independent and Dependent Sources applied to DC circuits.	**8**
Module – III **Single-phase AC Circuits:** Common signals and their waveforms, RMS and Average value. Form factor & Peak factor of a sinusoidal waveform. **Series Circuits:** Impedance of Series circuits. Phasor diagram. Active Power. Power factor. Power triangle. **Parallel Circuits:** Admittance method, Phasor diagram, Power and Power factor Power triangle, Series-parallel Circuit, Power factor improvement, Circuit Theorems applied to AC circuits. **Series and Parallel Resonance**: Resonance curve, Q–factor, Dynamic Impedance, and Bandwidth.	**12**
Module – IV **Three-Phase AC Circuits:** Importance and use of a 3-phase network, types of 3-phase connections- Star and Delta, Line and Phase relations for Star and Delta connection, Phasor diagrams, Power relations, analysis of balanced and unbalanced 3-phase circuits, Measurement of Power in 3-phase star and delta network.	**6**
Module – V **Magnetic Circuits:** Introduction, Series-parallel magnetic circuits, Analysis of Linear and Non-linear magnetic circuits, Energy storage, A.C. excitation, Eddy currents and Hysteresis losses. **Coupled Circuits:** Dot rule, Self and mutual inductances, Coefficient of coupling, working of transformer.	**6**

TEXTBOOKS:

1. W. H. Hayt, Jr J. E. Kemmerly and S. M. Durbin, Engineering Circuit Analysis, 7th Edition TMH, 2010.
2. Hughes, Electrical Technology, Revised by McKenzie Smith, Pearson.
3. Fitzgerald and Higginbotham, Basic Electrical Engineering, McGraw Hill Inc, 1981

REFERENCE BOOKS:

1. D. P. Kothari and I. J. Nagrath, Basic Electrical Engineering, 3rd Edition, TMH, New Delhi, 2009.
2. Electrical Engineering Fundamental, Vincent Del Toro, Prentice Hall, New Delhi.
3. Rajendra Prasad, Fundamentals of Electrical Engineering, 2nd Edition, PHI, New Delhi, 2011.
4. Raymond A. DeCarlo, Prn-Min Lin, Linear Circuit Analysis Time Domain, Phasor and Laplace Transform Approaches, 2nd Edition, Oxford University, 2001

5. Abhijit Chakrabarti, Sudipta Nath, Chandan Kumar Chanda, Basic Electrical Engineering, Tata McGraw Hill Publication, 2009.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

1. Application of principles of magnetic circuits to electrical machines like transformers, generators and motors.
2. Field applications of three phase equipment and circuits in power system.
3. Applications of circuit theorems in electrical and electronics engineering

POS MET THROUGH GAPS IN THE SYLLABUS: 6, 4, 11

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

1. Concepts of electric, magnetic and electromagnetic fields.
2. 3 - Φ power generation, transmission, and distribution.
3. Power factor improvement for three phase systems.
4. Utility of reactive power for creation of electric and magnetic fields.

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: 3, 4, 6.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Continuous Internal Assessment	% Distribution
Mid Semester Examination	25
Quiz, Assignment	10 + 10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	√	√	√	√	√
Semester End Examination	√	√	√	√	√

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Self- learning such as use of NPTEL materials and internets
CD8	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	3	2	3	1	1	2	3	1	2	1	2	2
CO2	3	1	3	3	3	1	1	2	3	1	2	1	2	2
CO3	3	2	3	3	3	1	2	1	3	1	2	1	2	2
CO4	3	2	3	3	3	2	2	1	3	1	2	1	2	2
CO5	3	2	1	1	3	1	2	1	3	1	2	1	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD5
CO2	CD1, CD2, CD4, CD5, CD7
CO3	CD1, CD2, CD5, CD7, CD8
CO4	CD1, CD2, CD5, CD7, CD8
CO5	CD1, CD2, CD4, CD5, CD7, CD8

<u>**COURSE INFORMATION SHEET**</u>

Course Code:	**PH24102**
Course Title:	**Physics Lab**
Pre-requisite(s):	**Intermediate Physics**
Co-requisite(s):	
Credits:	**1** L: 0 T: 0 P: 2
Class schedule per week:	**2**
Class:	**B. Tech.**
Semester / Level:	**FIRST**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course enables the students to:

1.	Understand the fundamentals of physical measurements and learn to account for inevitable errors in physical measurements.
2.	Understand and verify the basic principles of physics by hands-on experiments and making suitable measurements.
3.	Make electrical connections reliably to form functional circuits for measuring electrical quantities such as voltage, current, resistance, and resistivity
4.	Learn to set up different types of oscillating systems to study their characteristics, viz -a-viz resonant frequency, frequency response, phase relationship, bandwidth, and quality factor
5.	Develop an understanding of optical phenomena like dispersion, interference and diffraction and make measurements on the patterns produced to obtain physical quantities such as wavelength of light and refractive index of transparent materials.

COURSE OUTCOMES (COs)

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

CO1	Make reliable measurements and report results along with errors.
CO2	Wire simple electrical circuits for experimentally determining measurable electrical quantities.
CO3	Build electral and mechanical oscillating systems, characterize them, and make measurements over them.
CO4	Construct setups to produce interference and diffraction patterns and make measurements for determining physical quantities.

SYLLABUS (List of experiments)

1. Error analysis in Physics Laboratory (CO: 1)
2. To determine the frequency of AC mains with the help of a sonometer. (CO:1, 2, 3)
3. To determine the resistance per unit length of a Carey Foster's bridge wire and resistivity of unknown wire. (CO:1, 2)
4. Measurement of electrical equivalent of heat (CO:1, 2)
5. To determine the wavelength of sodium lines by Newton's rings method (CO:1, 4)
6. To determine the frequency of tuning fork using Melde's Experiment (CO:1,3)
7. Measurement of voltage and frequency of a given signal using CRO (CO: 1,2, 3)
8. To determine the emf of a cell using stretched wire potentiometer (CO:1, 2)
9. Determination of refractive index of the material of a prism using spectrometer and sodium light (CO:1, 4)
10. To study the frequency response of a series LCR circuit (CO:1, 2, 3)
11. To study Lorentz force using Current balance (CO:1,2)
12. To study electromagnetic induction and verification of Faraday's laws. (CO:1,2,3)
13. To measure the wavelength of prominent spectral lines of mercury light by a plane transmission grating. (CO:1, 4)
14. To determine the Planck's constant using photocell and optical wavelength filters. (CO:1, 2)

REFERENCE MATERIALS:

1. Lab manuals (available on department website)

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

POS MET THROUGH GAPS IN THE SYLLABUS

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Lab Journal	30
Lab quizzes	20
Progressive viva	20
End Sem Examination	30

Continuous Internal Assessment	% Distribution
Lab Journal	30
Lab quiz	10
Progressive viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	Y
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. **Student Feedback on Course Outcome**

COURSE DELIVERY METHODS

CD1	Introductory lecture by use of boards/LCD projectors
CD2	Laboratory experiments/ teaching aid
CD3	Self- learning such as use of NPTEL materials and internets

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	2	1	0	1	2	0	0	2	0	0	2	2	2	2
CO2	2	1	0	1	2	0	0	2	0	0	2	1	2	2
CO3	2	1	0	1	2	0	0	2	0	0	2	1	2	2
CO4	2	1	0	1	2	0	0	2	0	0	2	1	2	2
CO5	2	1	0	1	2	0	0	2	0	0	2	2	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course Code: **CS24102**
Course Title: **Programming for Problem Solving Lab**
Pre-requisite(s): **School-level Mathematics and Science**
Co-requisite(s): **Programming for Problem Solving**
Credits: **1 (L: 0 T: 0 P:2)**
Class schedule per week: **2**
Class: **B. Tech.**
Semester / Level: **First**
Branch: **Production and Industrial Engineering**
Name of Teacher:

COURSE OBJECTIVES

This course enables the students to:

1.	The basics of computer programming.
2	Ideas about converting problem statements to programs.
3	Ideas about handling data at scale.
4	Knowledge about accessing the memory of a computer using code.
5	The basics of computer programming.

COURSE OUTCOMES (COs)

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

CO1	Write basic programs using fundamental control structures.
CO2	Demonstrate the accessing of arrays.
CO3	Write simple functions to modularize programs.
CO4	Work with user-defined data types.
CO5	Access memory using pointers and manipulate data using them.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I 1. Programming using basic control structures including sequential programs, selection logic including nested selection logic switch structures.	3
Module – II 1. Write programs using basic iterative structures, nested iterations, programs using looping with selections, controlled loop exit, Manipulating n-dimensional arrays.	3
Module – III 1. Modularize programs using functions, functions calling functions, elementary string handling programs, recursive programs.	3
Module – IV 1. Programs using user-defined data types, arrays of user-defined data types, basic usage of pointers, functions, and pointers.	3
Module – V 1. Advanced usage of pointers, string handling using pointers, parameterizing main, and manipulating arrays using pointers.	3

TEXTBOOKS:
1. Programming in C, Yashwant Kanetkar, BPB Publications.

REFERENCE BOOKS:

1. C Programming, Byron Gottfried, Addison Wesley Press

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)
Elementary file handling

POS MET THROUGH GAPS IN THE SYLLABUS: YES [PO1-PO5 & PO10-PO12]

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
End Semester Examination	40

Continuous Internal Assessment	% Distribution
Day-to-day performance & Lab files	30
Quiz	10
Viva	20

End Semester Examination	% Distribution
Examination Experiment Performance	30
Quiz	10

INDIRECT ASSESSMENT

1. **Student Feedback on Course Outcome**

COURSE DELIVERY METHODS

CD1	Demonstration by use of smart boards/LCD projectors
CD2	Assignments
CD3	Viva-Voce/Quiz (s)
CD4	Software and Hardware
CD5	Laboratory experiments/Coding

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	1	2	0	0	3	1	0	0	1	3	2
CO2	3	3	2	1	2	0	0	3	1	0	0	1	3	2
CO3	3	3	2	1	2	0	0	3	1	0	0	1	3	2
CO4	3	3	2	1	2	0	0	3	0	0	0	1	3	2
CO5	3	2	2	1	2	0	0	1	0	0	0	1	3	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD3, CD5
CO3	CD3, CD5
CO4	CD2, CD3, CD4
CO5	CD1, CD3, CD5

COURSE INFORMATION SHEET

Course Code:	**EE24102**
Course Title:	**Electrical Engineering Laboratory**
Pre-requisite(s):	**Physics, Fundamentals of Mathematics and Electrical Engineering**
Co-requisite(s):	
Credits:	**1** (L:0 T: 0 P: 2)
Class schedule per week:	**2**
Class:	**B. Tech.**
Semester / Level:	**FIRST**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	To describe students' practical knowledge of active and passive elements and operation of measuring instruments
2.	To demonstrate electrical circuit fundamentals and their equivalent circuit models for both 1-φ and 3-φ circuits and use circuit theorems
3.	To establish voltage & current relationships with the help of phasors and correlate them to experimental results
4.	1. To conclude performance of 1 – Φ AC series circuits by resonance phenomena 2. To evaluate different power measurement for both 1-φ and 3- φ circuits

COURSE OUTCOMES (COs)

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

CO1	classify active and passive elements, explain working and use of electrical components, different types of measuring instruments;
CO2	illustrate fundamentals of operation of DC circuits, 1-φ and 3- φ circuits and also correlate the principles of DC, AC 1-φ and 3- φ circuits to rotating machines like Induction motor and D.C machine
CO3	measure voltage, current, power, for DC and AC circuits and also represent them in phasor notations;
CO4	analyze response of a circuit and calculate unknown circuit parameters;
CO5	recommend and justify power factor improvement method in order to save electrical

SYLLABUS
LIST OF EXPERIMENTS ***(The experiment list may vary to accommodate recent development in the field)***

EXPERIMENT – 1

Name: - Measurement of low and high resistance of a DC shunt motor

Aim: - (i) To measure low resistance of armature winding of DC shunt motor.

(ii) To measure high resistance of field winding of DC shunt motor.

EXPERIMENT – 2

Name: - AC RLC series circuit

Aim: - To obtain current and voltage distribution in AC RLC series circuit and draw the phasor diagram of voltage distribution.

EXPERIMENT – 3

Name: - Single phase power factor measurement by three voltmeter method

Aim: - To obtain power and power factor of the single-phase load using three voltmeter method and draw the phasor diagram.

EXPERIMENT – 4

Name: - AC RLC parallel circuit

Aim: - To obtain current and voltage distribution in a AC RLC parallel circuit and draw the current phasor diagram.

EXPERIMENT – 5

Name: - Single phase power factor measurement by three Ammeter method

Aim: -To obtain power and power factor of single-phase load using three ammeter method and draw the phasor diagram.

EXPERIMENT – 6

Name: -Study of resonance in a RLC series circuit

Aim: - To obtain the resonance condition in AC RLC series circuit and draw the phasor diagram.

EXPERIMENT – 7

Name: -Three phase Delta connection

Aim: - To obtain the relation between line and phase quantities in a three-phase Delta connected load and obtain the phasor diagram.

EXPERIMENT – 8

Name: - Three phase Star connection

Aim: -To obtain the relation between line and phase quantities in a three-phase Star connected load and draw the phasor diagram.

EXPERIMENT – 9

Name: - Measurement of three phase power by two wattmeter method.

Aim: - To measure the power input to a three-phase induction motor by two-wattmeter method and draw the phasor diagram.

EXPERIMENT – 10

Name: - Verification of superposition and Thevenin's Theorems.

Aim: - (i) To verify Thevenin's Theorem for a given circuit.

(ii) To verify Superposition Theorem for a given circuit.

Gaps in the syllabus (to meet Industry/Profession requirements)

1. Application of principles of magnetic circuits to electrical machines like transformers, generators and motors.
2. Visualize Phase sequence.

POs met through Gaps in the Syllabus: 1, 2, 4, 6.

Topics beyond syllabus/Advanced topics/Design

1. Assignment: Simulation of electrical circuits with dependent/independent sources by various techniques (Mesh current/Node Voltage/Thevenin's theorem/Norton's theorem/Maximum power transfer theorem etc.) using MATLAB/PSIM/C++ software.
2. Active/reactive power calculation for 3 – Φ circuits

POs met through Topics beyond syllabus/Advanced topics/Design: 3, 4, 5, 6.

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Lab Journal	30
Lab quizzes	20
Progressive viva	20
End Sem Examination	30

Continuous Internal Assessment	% Distribution
Lab Journal	30
Lab quiz	10
Progressive viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	Y
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

Course Delivery methods	
CD1	Laboratory experiments/teaching aids
CD2	Mini projects/Projects
CD3	Tutorials/Assignments
CD4	Self- learning, such as the use of NPTEL materials and the internet

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	1	2	3	3	1	2	2	1	1
CO2	3	2	3	2	3	1	2	3	3	1	2	1	2	1
CO3	3	2	3	2	3	1	2	3	3	1	2	1	2	1
CO4	3	2	3	2	3	1	2	3	3	1	2	1	2	1
CO5	3	2	3	2	3	2	2	3	3	1	2	1	2	1

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

COURSE INFORMATION SHEET

Course Code:	**HS24131**
Course Title:	**Communication Skills I**
Pre-requisite(s):	
Co- requisite(s):	
Credits:	**1.5** (L:0 T:0 P: 3)
Class schedule per week:	**3**
Class:	**B. Tech.**
Semester / Level:	**FIRST**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	**Develop Language Proficiency and communicative competence**: Improve students' ability to read, write, speak, and listen effectively in English. In addition, students will also learn and improve politeness strategies in communicative contexts.
2.	**Enhance Verbal and Non-Verbal Communication**: Train students in both spoken and body language communication for personal and professional interactions.
3.	**Enhance Reading Ability:** Equip students with the ability to strategically comprehend and interpret visual and textual information.
4.	**Enhancing Writing Proficiency**: Enable students to write structured reports, emails, resumes, and other professional documents.
5.	**Developing Presentation and Public Speaking Skills:** Self-assurance during talks, presentations and speeches.

COURSE OUTCOMES (COs)

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

CO1	In a variety of pragmatic and communicative contexts, students will be able to confidently and fluently articulate their ideas.
CO2	This will enable learners to accurately interpret messages for effective interaction by comprehending audio texts and listening selectively.
CO3	Learners will be able to examine texts for particular and intricate details, draw inferences, and provide interpretations.
CO4	Learners will be capable of creating organized written pieces, including paragraphs, essays, and narratives, and will also be able to summarize, paraphrase, and create précis of ideas effectively.
CO5	Learners will be capable of confidently using verbal and non-verbal communication during speeches and presentations.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Theory** **Principles of Fundamental Communication.** Communication theory, various types and methods of communication, communication flow (upward, downward, and horizontal), characteristics of successful communication, obstacles, and approaches, verbal and non-verbal communication, and social context communication—requests, refusals, compliments, and providing constructive feedback. **Practice** **Communication:** Study relevant materials or case studies on effective communication, obstacles, strategies, and both verbal and non-verbal aspects. Understand and contextualize the influence of culture and society on communication in both writing and speaking. **Role plays:** Engage in scenario-based questions focusing on communication, body language, and courtesy. **Dialogue writing:** Presenting viewpoints based on various situations or scenarios—including requests, refusals, compliments, and criticism—in both writing and speaking.	**6**
Module – II **Theory** **Communicating, Depicting, and Hearing:** Salutations, Presenting oneself/others, Descriptive communication for locations, objects, scenarios, challenges, etc. Proficient listening abilities and the various aspects of listening, including types such as intensive, responsive, selective and extensive. A brief introduction to Varieties of English Accents (neutral accent) through audio and video examples. **Practice tasks** **Introducing people/Describing people:** - Introducing oneself and others - Characterizing an individual, image, circumstance - Discussing traits (positive/negative/critical) about a person, object, scenario, or image. **Listening skills:** - Engaging in attentive listening activities - Listening selectively to complete the blanks - Hearing a passage and rephrasing the precise information in your own words (listening comprehension) - Listening to a discussion on a topic and responding critically. - Attending to informal workplace interactions and dialogues.	**6**
Module – III **Theory** **Enhancing Vocabulary and Grammar** Lexicon (Affixes- Inflections-Derivations), Registers, Idiomatic Expressions and Phrasal Verbs, vocabulary in context. Opposites, similar words, and one-word alternatives. Sentence constructions (word order like SVO, etc.), Paragraphs (Thesis statement, main idea, topic sentences), Generating ideas for paragraph composition. W. S Allen (Book) **Practice** **Vocabulary Building:** **-** Students utilize specific vocabulary related to various registers to construct paragraphs, narratives, and more. - Students incorporate phrasal verbs to create a coherent paragraph. - Exercises involving antonyms, synonyms, and word substitution can be conducted using	**6**

worksheets. - Engage graphic organizers such as word associations and concept mapping for vocabulary enhancement activities. Identify suffixes, prefixes, idioms, and phrasal verbs: - Analyze texts to find suffixes and prefixes along with their definitions. - Word association and spider diagrams can be utilized to uncover suffixes and prefixes. **Paragraph writing:** **-** Generate ideas about a topic/concept/idea and prompt students to compose a detailed paragraph.	
Module – IV **Theory** **Elements of Reading and Writing** Present the sub-skills involved in reading and writing, including the different types of reading such as close reading and intensive reading. Techniques like mind mapping and note-taking. Generating ideas through brainstorming, structuring thoughts, and creating coherent written pieces consisting of an introduction, body, and conclusion. Writing letters, summaries, précis, resumes, essays, narratives, biographies, and news articles. **Practice** **Reading:** **-** Encourage students to distinguish between factual and inferential information from a text. - Read a passage and create a mind map outlining the main and supporting ideas of the content. - Read the text and take notes. - Read and interpret the author's perspective. - Read and conduct a critical analysis of the text. - Read a passage and provide constructive feedback. (speaking/writing modality) **Writing:** **-** Compose a summary. - Write a précis. - Create a resume. - Develop an essay. - Write a narrative account, whether personal or about others. - Produce a news column.	**6**
Module – V **Theory** **Public speaking and presentation abilities** Public speaking and presentation techniques Public speaking, objectives of a speech – to inform, entertain, persuade, or commemorate/celebrate. Methods of persuasion in speeches – ethos, logos, and pathos. Speech preparation – researching background information, organizing content, crafting an introduction, developing main points, and concluding effectively. Showcasing structured speeches – welcome addresses, farewell remarks, expressions of gratitude (examples may be provided in written scripts, videos, or audio recordings). Presentation etiquette, verbal presentations, poster displays, and delivering speeches. **Practice** **Public speaking:** **-** Deliver an opening speech (during the Annual day, General meeting, sports day, cultural events) - Present a farewell address - Express gratitude through a vote of thanks - Make a persuasive speech (given a specific scenario) - Engage in an extempore speech	**6**

Presentations: - Conduct a role play - Prepare a PowerPoint presentation - Create a poster presentation	

TEXTBOOKS:
1) Communication Skills (2015) 2nd edition, Sanjay Kumar & Pushp Lata, Oxford University Press
2) Business Correspondence and Report Writing (2017), R.C.Sharma, Krishna Mohan. McGraw Hill

REFERENCE BOOKS:
1) Basic Business Communication-(2004). Lesikar I Flatley, McGraw Hill
2) Business Communication Today, (2017), Bovee, Thill and Chatterjee, Pearson
3) Krishnan, M, & Jha, S.(2024). *Focus: A course in Communication Skills*. Cambridge University Press
4) Suparna Dutta, 2013 Business Communication, PHI Learning Pvt Ltd, New Delhi

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

POS MET THROUGH GAPS IN THE SYLLABUS

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	60
End Semester exams	40

Continuous Internal Assessment	% Distribution
Day-to-day performance & assignments	30
Quiz 1	10
Viva- Voce	20

End Semester Examination	% Distribution
Examination: Submission of reports	30
Viva- Voce	10

Assessment Components	**CO1**	**CO2**	**CO 3**	**CO 4**	**CO 5**
Continuous Internal Assessment	✓	✓	✓	✓	✓
Examination: Submission of reports	✓	✓	✓	✓	✓

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning, such as the use of NPTEL materials and the internet
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	0	1	0	0	2	3	3	2	2	3	2
CO2	1	0	0	1	1	0	0	1	2	2	1	2	3	2
CO3	2	3	1	2	2	0	0	1	2	2	1	2	3	2
CO4	2	2	2	1	2	0	0	2	2	3	2	2	3	2
CO5	1	1	1	0	2	1	1	2	3	3	2	2	3	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD2, CD3
CO2	CD 3, CD 6
CO3	CD 1, CD 2
CO4	CD 3, CD6
CO5	CD 2, CD3, CD6

Course Code:	**MA24103**
Course Title:	**Mathematics II**
Pre-requisite(s):	**Mathematics - I**
Co-requisite(s):	
Credits:	**4(L: 3 T: 1 P: 0)**
Class schedule per week:	**4**
Class:	**B.Tech.**
Semester / Level:	**Second**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

6.	various methods to solve linear differential equations of second and higher order
7.	special functions viz. Legendre's and Bessel's and different properties associated with them
8.	diverse mathematical techniques for solving partial differential equations of first order, along with their applications in wave and heat equations using Fourier series
9.	the theory of functions of a complex variable, complex differentiation and integration
10.	about random variables and elementary probability distribution

COURSE OUTCOMES (COs)

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

CO1	investigate the occurrence of ordinary differential equations in real-life problems and identify the suitable methods available for their solutions.
CO2	develop skills to solve and implement various forms of differential equations and special functions in diverse domains.
CO3	learn to solve various forms of partial differential equations arising in real-world.
CO4	gain an understanding of complex variable functions and their properties in science and engineering.
CO5	comprehend and apply the concept of probability distributions in solving problems related to uncertainty.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Ordinary Differential Equations – I Linear differential equations, Wronskian, Linear independence and dependence of solutions, Linear differential equations of 2nd and higher order with constant coefficients, Operator method, Euler – Cauchy's form of linear differential equation, Method of variation of parameters.	**9**
Module – II Ordinary Differential Equations – II Ordinary and singular points of differential equation, Power and Frobenius' series solutions (root differ by non integer and equal roots). Bessel's differential equation, Bessel function of first kind and its important properties. Legendre's differential equation, Legendre's polynomial and its important properties.	**9**
Module – III Fourier series and Partial Differential Equations Fourier series: Euler formulae for Fourier series, Half range Fourier series. Partial Differential Equations: Method of separation of variables and its application in solving one dimensional wave and heat equations.	**9**
Module – IV Complex Variable-Differentiation & Integration Function of a complex variable, Analyticity, Analytic functions, Cauchy – Riemann equations. Cauchy's theorem, Cauchy's Integral formula, Taylor and Laurent series expansions. Singularities and its types, Residues, Residue theorem.	**9**
Module – V Applied Probability Discrete and continuous random variables, cumulative distribution function, probability mass and density functions, expectation, variance. Introduction to Binomial, Poisson and Normal Distribution.	**9**

TEXTBOOKS:

1. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. D. G. Zill and W.S. Wright, Advanced Engineering Mathematics, Fourth Edition, 2011.
3. J. W. Brown and R. V. Churchill, Complex Variables and Applications, 7th Ed., McGraw Hill, 2004.
4. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing, 3rd Ed, 2009.
5. R. A. Johnson, I. Miller and J. Freund: Probability and Statistics for Engineers, PHI
6. S. C. Gupta and V. K. Kapoor: Fundamental of Mathematical Statistics, Sultan Chand and Sons

REFERENCE BOOKS:

1. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, 9th Edition, Wiley India, 2009.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
3. E. A. Coddington, An Introduction to Ordinary Differential Equations, Prentice Hall India, 1995.
4. G. F. Simmons, Differential Equations with Applications and Historical Notes, TMH, 2nd ed., 2003.
5. P. L. Meyer: Introductory Probability and Statistical Applications, Oxford & IBH.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS) --

POS MET THROUGH GAPS IN THE SYLLABUS --

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN ---

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN --

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	3	2	3	2	1	0	0	0	1	2	2	3	3
CO2	3	3	2	3	2	1	0	0	1	1	2	2	3	3
CO3	3	3	2	3	2	1	0	0	1	1	2	2	3	3
CO4	3	2	2	2	2	1	0	0	1	1	2	2	2	2
CO5	3	3	2	2	2	1	1	1	1	2	3	2	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course Code:	**CH24101**
Course Title:	**Chemistry**
Pre-requisite(s):	**Intermediate level chemistry**
Co-requisite(s):	
Credits:	**4** L:3 T:1 P: 0
Class schedule per week:	**4**
Class:	**B. Tech.**
Semester / Level:	**SECOND**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students:

11.	To create concept of chemical bonding in coordination chemistry
12.	To understand the basics of stereochemistry, aromaticity and reaction mechanism of organic molecules
13.	To understand the reaction dynamics and to know different types of catalysis
14.	To apprehend the basic principles and the application of vibrational, electronic and NMR spectroscopy
15.	To develop knowledge on the physical state and electrochemistry of molecules

COURSE OUTCOMES (COs) (3 COs to 6 COs depending upon the course)

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

CO1	Able to explain the bonding in a coordination complex
CO2	Able to explain the 3D structure, aromaticity and stereochemistry of organic molecules
CO3	Able to predict the rate, molecularity and mechanism of a simple as well as catalytic reaction
CO4	Able to explain the UV-vis, IR and NMR spectra of unknown molecules
CO5	Able to interpret the phase diagram of simple one and two component heterogeneous systems in equilibrium and the electrochemical behavior of the molecules

SYLLABUS

MODULE	**(NO. OF LECTURE HOURS)**
Module – I: Bonding in Coordination Complex Introduction to Chemical Bonding, Werner's Theory, Bonding in coordination complexes, Crystal Field Theory, Octahedral, Tetrahedral and Square planar complexes, CFSE, Jahn-Teller theorem, Spectral, electronic and magnetic properties of coordination complexes.	**8**
Module – II: Organic Structure and Reactivity Aromaticity, Geometrical isomerism: cis–trans, E/Z, and syn-anti isomerism; Optical isomerism & Chirality; Wedge, Fischer, Newmann and Sawhorse projection formulae and interconversions; D/L, R/S nomenclature system; Conformational studies of n-butane. Addition, Elimination, Substitution and Rearrangement reaction.	**8**
Module – III: Kinetics and Catalysis Kinetics of Chain, Parallel/Competing/Side, Consecutive reactions; Fast reactions; Outline of Catalysis, Acid-base catalysis, Enzyme catalysis (Michaelis-Menten equation), Important catalysts in industrial processes: Hydrogenation using Wilkinsons catalyst, Phase transfer catalyst.	8
Module – IV: Spectroscopic Techniques Absorption Spectroscopy, Lambert-Beers law, Principles and applications of UV-Visible spectroscopy, Principles and applications of Vibrational spectroscopy; Introduction of NMR spectroscopy.	8
Module – V: Phase and Chemical Equilibrium Phase rule: terms involved, Phase diagram of one component (Water) & two component (Pb/Ag) system & their applications; Gibbs Free energy, Van't Hoff equation and Chemical Equilibrium; Nernst Equation, Standard electrode potential, EMF measurement and its application, Batteries and Fuel Cells.	8

TEXTBOOKS:

- Huheey, J. E., Inorganic Chemistry: Principles of Structure and Reactivity, 4 th edition, Pearson.

2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Seventh Edition, Pearson
3. Atkins, P. W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.

REFERENCE BOOKS:

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier (2009).
3. William Kemp, Organic Spectroscopy, 3 rd Ed., 2008 Macmillan.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

Limited exposure to computational tools, industrial case studies, and skill-based training needed for industry readiness.

POS MET THROUGH GAPS IN THE SYLLABUS

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	**10**

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	0	0	0	0	1	0	2	2	1	1
CO2	3	3	2	1	0	0	0	0	1	0	2	2	1	1
CO3	3	3	3	2	1	1	0	0	1	0	3	2	2	1
CO4	3	2	1	3	3	0	0	0	2	0	2	2	1	1
CO5	3	3	2	2	1	2	0	0	1	0	3	2	2	1

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6
CO5	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course Code:	**EC24101**
Course Title:	**Basic Electronics**
Pre-requisite(s):	
Co-requisite(s):	
Credits:	**3** (L:2 T:1 P:0)
Class schedule per week:	**3**
Class:	**B. Tech.**
Semester / Level:	**SECOND**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To understand PN Junction, diodes and their applications.
2.	To comprehend BJT and the bias configurations.
3.	To understand the operating principles of FETs
4.	To understand the op amp and its applications.
5.	To apprehend the number system, Logic Gates, and Boolean algebra.

Course Outcomes

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

CO1	Understand the characteristics of electronic devices like PN-diode, BJT, JFET and MOSFET
CO2	Classify and analyze the various circuit configurations of BJTs and MOSFETs.
CO3	Analyze the characteristics of an operational amplifier.
CO4	Design electronic circuits using diodes, transistors, op-amps, and logic gates for analog and digital applications.
CO5	Solve day-to-day life problems using electronic circuits.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Diodes and Applications:** Introduction to semiconductor materials, PN junction diode, barrier potential, depletion layer width, junction capacitance, diode current equation, I-V plot, diode resistance, temperature dependence, breakdown mechanisms, Zener diode – operation and applications, Diode as a Rectifier: Half Wave and Full Wave Rectifiers with and without C-Filters.	**8**
Module – II **Bipolar Junction Transistors (BJT):** Basic operation of PNP and NPN Transistors, Input and Output Characteristics of CB, CE, and CC Configurations.Transistor biasing: operating point, Fixed bias, emitter bias, voltage divider bias, stability factor, small signal analysis (h-parameter model) of CE configuration.	**8**
Module – III **Field Effect Transistors:** JFET: Principle of operation, transfer characteristics, MOSFET: Operation of N-MOS, P-MOS, enhancement and depletion type, transfer characteristics, CS biasing of JFET and MOSFET.	**8**
Module – IV **Operational Amplifiers:** Introduction of Operational Amplifier, Characteristics of Operational Amplifier, Differential Amplifier, CMRR, Slew Rate, input and output offset voltages, Inverting and non-inverting amplifiers, Summing Amplifier, Difference amplifier, Differentiator and Integrator.	**8**
Module – V **Boolean Algebra and Logic Gates:** Boolean Algebra, Boolean operators, Truth table of different digital logic gates (AND, OR, NOT, NAND, NOR, EXOR, EX-NOR), application of diode for design of logic gates, realization of logic gates using universal gates, adder, subtractor.	**8**

Textbooks:

1. Millman J., Halkias C.C. "Integrated Electronics: Analog and Digital Circuits and Systems", Tata McGraw-Hill.
2. Boylstead R.L., Nashelsky L., "Electronic Devices and Circuit Theory", Pearson Education, Inc, 11/e.
3. Mano M.M., Michael D. Ciletti, "Digital Design", Pearson Education, Inc, 5/e, 2011.

Reference books:

1. Millman J., Halkias C.C., Parikh Chetan, "Integrated Electronics: Analog and Digital Circuits and Systems", Tata McGraw-Hill, 2/e.
2. Millman J., Halkias C.C., Satyabrata Jit, "Millman's Electronic Devices and Circuits", Tata McGraw-Hill, 3/e.
3. Albert Paul, Malvino, David J. Bates, "Electronic principles", McGraw-Hill, 8/e, 2015.

Gaps in the syllabus (to meet Industry/Profession requirements): NA

POs met through Gaps in the Syllabus: 3, 11, 12

Topics beyond syllabus/Advanced topics/Design: NA

POs met through Topics beyond syllabus/Advanced topics/Design: 2, 3, 11, 12

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
First Quiz	10
Mid Semester Examination	25
Assignment	10
Teacher's Assessment	5
End Semester Examination	50

Indirect Assessment

1. Students' Feedback on Course Outcome.

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	3	1	2	2	3	2	2	1	1	1
CO2	3	3	1	2	3	1	2	2	3	2	2	1	2	1
CO3	3	3	1	2	3	1	2	2	3	2	2	1	2	1
CO4	3	3	1	2	3	1	2	2	3	2	2	1	2	1
CO5	3	3	1	2	3	1	2	2	3	2	2	1	2	1

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between COs and Course Delivery (CD) methods

CD Code	Course Delivery Methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of Boards/LCD Projectors	CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD3, CD8
CD3	Seminars	CO3	CD1, CD2, CD3, CD8
CD4	Mini Projects/Projects	CO4	CD1, CD2, CD3, CD8
CD5	Laboratory Experiments/Teaching Aids	CO5	CD1, CD2, CD3, CD8
CD6	Industrial/Guest Lectures		
CD7	Industrial Visits/In-plant Training		
CD8	Self-learning such as the use of NPTEL Materials and the Internet		
CD9	Simulation		

COURSE INFORMATION SHEET

Course Code: **ME24101**
Course Title: **Basics of Mechanical Engineering**
Pre-requisite(s): **NIL**
Co-requisite(s): **NIL**
Credits: **3** (L: 2 T:1 P: 0)
Class schedule per week: **3**
Class: **B. Tech**
Semester / Level: **SECOND**
Branch: **Production and Industrial Engineering**
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Introduce system of forces, and write equation of equilibrium.
2.	Analyse motion of particle and rigid body subjected to force.
3.	Grasp the importance of internal and external combustion engines.
4.	Apprehend the fundamentals of friction.
5.	Understand the different sources of energy.

COURSE OUTCOMES (COs)

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

CO1	Explain the basics of Mechanical Engineering.
CO2	Apply various laws of mechanics on static and dynamic elements and bodies.
CO3	Analyse various mechanics problems related to static and dynamic bodies.
CO4	Evaluate the real life problem related to mechanics and energy for its probable solution.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **System of Forces and Structure Mechanics;** Addition of Forces, Moment of a Force, Couple, Varignon's theorem, Free Body Diagram, Equilibrium in Two and Three Dimensions, Equivalent Forces and Moment. Types of Plane Trusses, Analysis of Plane Trusses by: Method of Joints and Method of Sections. Hooke's Law of elasticity, Stress and Strain, Relation between elastic constants.	**8**
Module – II **Kinematics & Kinetics of rigid bodies:** Types of rigid body motion– translation, rotation about fixed axis, equations defining the rotation of a rigid body about a fixed axis, plane motion, absolute and relative velocity in plane motion, instantaneous center of rotation. Equation of motion and D'Alembert's principle.	**8**
Module – III **Friction :** Interfacial Friction (a) Laws of dry friction, static & kinetic co-efficient of friction, Analysis of static, kinetic and rolling friction. (b) Analysis of frictional forces in inclined planes, wedges, screw jacks and belt drives.	**8**
Module – IV **Boilers and Internal Combustion Engine;** Classification of Boilers, Fire tube and Water Tube boilers. Boiler Mountings and Accessories. Boiler efficiency. Classification of I C Engines. Basic components and terminology of IC engines, working principle of four stroke and two stroke - petrol and diesel engine.	**6**
Module – V **Non-Conventional Energy Sources** Renewable and Non-renewable Energy Resources, Advantages and Disadvantages of Renewable Resources, Renewable Energy Forms and Conversion- Solar Energy, Wind Energy, Hydro Energy.	**5**

TEXTBOOKS:

1. Engineering Mechanics, Irving H. Shames, P H I. ltd, 2011.
2. Boiler operator, Wayne Smith, LSA Publishers, 2013.
3. Internal Combustion Engines, M. L. Sharma and R. P. Mathur, Dhanpat Rai Publications, 2014.
   Fundamentals of Renewable Energy Processes, Aldo Vieira Da Rosa, Elsevier publication, 2012.

REFERENCE BOOKS:

1. Engineering Mechanics : statics, James L. Meriam, L. G. Kraige, Wiley, 7th Edition, 2011.
2. Engineering Mechanics, S. Rajasekaran & G. Sankarasubramaniam, Vikash publishing house, 2018.
3. An Introduction to Steam Boilers, David Allan Low, Copper Press Publisher, 2012.
4. Internal Combustion Engines – V Ganesan, McGraw hill, 2017.
5. Non Conventional Energy Resources, B. H. Khan, McGraw Hill Education Publisher, 2017.
6. Principles of Mechanical Engineering, R. P. Sharma & Chilkesh Ranjan, Global Academic Publishers, 2016.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS) : NIL

POS MET THROUGH GAPS IN THE SYLLABUS: NA

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NIL

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NA

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Continuous Internal Assessment	% Distribution
Mid Semester Examination	25
Quiz, Assignment	10 + 10
Teacher’s Assessment	5

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment	√	√	√	√
Semester End Examination	√	√	√	√

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	0	2	1	1	0	2	3	2	2
CO2	3	3	2	2	2	1	1	2	1	1	2	3	3	2
CO3	3	3	3	3	2	1	1	2	2	2	2	3	3	2
CO4	2	3	3	3	3	2	2	2	2	2	3	2	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course Code:	**CE24101**
Course Title:	**Environmental Science**
Pre-requisite(s):	**NIL**
Co- requisite(s):	
Credits:	**2** L: 2 T: 0 P:0
Class schedule per week:	**2**
Class:	**B. Tech.**
Semester / Level:	**SECOND**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course enables the students to:

1.	To develop basic knowledge of ecological principles and their applications in environment.
2.	To identify the structure and composition of the spheres of the earth, the only planet sustaining life.
3.	To analyze how the environment is getting contaminated and probable control mechanisms for them.
4.	To generate awareness and become a sensitive citizen towards the changing environment.

COURSE OUTCOMES (COs)

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

CO1	Able to explain the structure and function of ecosystems and their importance in the holistic environment.
CO2	Able to identify the sources, causes, impacts and control of air pollution
CO3	Able to distinguish the various types of water pollution happening in the environment and understand about their effects and potential control mechanisms.
CO4	Able to judge the importance of soil, causes of contamination and need of solid waste management.
CO5	Able to know the impacts of noise pollution and its management.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I: Ecosystem and Environment Concepts of Ecology and Environmental Science, ecosystem: structure, function and services, Biogeochemical cycles, energy and nutrient flow, ecosystem management. Concept of Biodiversity.	6
Module – II: Air Pollution Structure and composition of unpolluted atmosphere, classification of air pollution sources, types of air pollutants, effects of air pollution, monitoring of air pollution, Air pollution control and management.	6
Module – III: Water Pollution Water Resource; Water Pollution: types and Sources of Pollutants; effects of water pollution; Water quality monitoring, Water quality index, water and wastewater treatment: primary, secondary and tertiary.	6
Module – IV: Soil Pollution and Solid Waste Management Soil profile, soil properties, soil pollution, and Municipal solid waste management. MSW – Functional elements of MSW.	6
Module – V: Noise Pollution Noise pollution: introduction, sources, outdoor and indoor noise propagation, Effects of noise on health, criteria noise standards and limit values, Noise measurement techniques, prevention and control of noise pollution.	6

TEXTBOOKS:

1. A, K. De. (3rd Ed). 2008. Environmental Chemistry. New Age Publications India Ltd.
2. R. Rajagopalan. 2016. Environmental Studies: From Crisis to Future by, 3rd edition, Oxford University Press.
3. Eugene P. Odum. 1971. Fundamentals of Ecology (3rd ed.) -. WB Sunders Company, Philadelphia.
4. C. N. Sawyer, P. L. McCarty and G. F. Parkin. 2002. Chemistry for Environmental Engineering and Science. John Henry Press.
5. S.C. Santra. 2011. Environmental Science. New Central Book Agency.

REFERENCE BOOKS:

1. D.W. Conell. Basic Concepts of Environmental Chemistry, CRC Press.
2. Peavy, H.S, Rowe, D.R, Tchobanoglous, G. Environmental Engineering, Mc-Graw - Hill International
3. G.M. Masters & Wendell Ela. 1991. Introduction to Environmental Engineering and Science, PHI Publishers.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS): NA

POS MET THROUGH GAPS IN THE SYLLABUS: NA

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NA

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NA

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination	25
End Sem Examination	50
Quiz	10
Assignment	10
Teacher's assessment	05

Continuous Internal Assessment	% Distribution
Mid Sem Examination	50
Quiz and assignment	40
Teacher's assessment	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lectures by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Self- learning such as use of NPTEL materials and internet

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	0	1	1	0	0	1	0	0	0	0	0	2	1	2
CO2	0	1	1	0	0	1	0	0	0	0	0	2	2	2
CO3	0	1	1	0	0	1	0	0	0	0	0	2	2	2
CO4	0	1	1	0	0	1	0	0	0	0	0	2	2	2
CO5	0	1	1	0	0	1	0	0	0	0	0	1	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2
CO4	CD1, CD2
CO5	CD1, CD2

COURSE INFORMATION SHEET

Course Code:	**CH24102**
Course Title:	**Chemistry Lab**
Pre-requisite(s):	**Intermediate level Chemistry**
Co-requisite(s):	
Credits:	**1 (L:0 T:0 P:2)**
Class schedule per week:	**2**
Class:	**B. Tech.**
Semester / Level:	**SECOND**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course enables the students to:

1	To gain an understanding of the synthesis of organic and inorganic compounds.
2	To interpret and analyze spectroscopic data effectively.
3	To develop a strong concept of potentiometric and pH-metric titrations of acids and bases.
4	To understand and calculate the rate constant of chemical reactions.
5	To acquire knowledge of determining melting points and estimating eutectic and transition temperatures.

COURSE OUTCOMES (COs)

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

CO1	Able to perform the synthesis of organic and inorganic compounds.
CO2	Able to interpret and analyze spectroscopic data.
CO3	Able to carry out potentiometric and pH-metric titrations of acids and bases.
CO4	Able to determine the rate constant of chemical reactions.
CO5	Able to measure melting points and estimate eutectic and transition temperatures.

SYLLABUS (List of experiments)

1. Gravimetric estimation of Nickel using Dimethylglyoxime.

2. Determination of total Hardness of a given water Sample (Complexometric Titration).

3. Verification of Beer's Law using Fe^{3+} solution by spectrophotometer/colorimeter, and determination of the concentration of an unknown Fe^{3+} solution.

4. Preparation of Diazoamino Benzene and reporting of its melting point and yield.

5. Construction of a melting point–mass percent composition diagram for a two-component mixture and determination of its eutectic temperature.

6. Study of the kinetics of acid-catalyzed hydrolysis of ethyl acetate and evaluation of the rate constant.

7. Determination of the strength of a strong acid using potentiometric titration with a strong base.

8. Determination of the transition temperature of a given salt hydrate.

9. Separation of binary organic mixture by acid-base extraction and analysis using given FTIR and NMR spectrum.

10.Construction of a pH-titration curve for a strong acid versus a strong base

REFERENCE MATERIALS:

2. https://bitmesra.ac.in/edudepartment/content/1/140/553 (link of Lab Manual)
3. **Experimental Physical Chemistry** – B. Viswanathan, P. S. Raghavan, Narosa Publishing House (1997).
4. **Vogel's Textbook of Practical Organic Chemistry**
5. **Experiments in General Chemistry** – C. N. R. Rao, U. C. Agarwal.
6. **Experimental Organic Chemistry, Vol. 1 & 2** – P. R. Singh, D. S. Gupta, K. S. Bajpai, Tata McGraw-Hill

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS)

POS MET THROUGH GAPS IN THE SYLLABUS

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Lab Journal	30
Lab quizzes	20
Progressive viva	20
End Sem Examination	30

Continuous Internal Assessment	% Distribution
Lab Journal	30
Lab quiz	10
Progressive viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	Y	Y	Y	Y	Y
Semester End Examination	Y	Y	Y	Y	Y

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Introductory lecture by use of boards/LCD projectors
CD2	Laboratory experiments/ teaching aid
CD3	Self- learning such as use of NPTEL materials and internets
CD4	Seminars (discussion of experimental results and error analysis).
CD5	Group discussions/problem-solving sessions (to analyze experimental data and calculations).
CD6	Industrial/guest lectures (applications of chemical analysis techniques in industry).
CD7	Industrial visits (exposure to real chemical laboratories and processes).

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2	PSO3
CO1	3	2	3	2	2	2	3	1	1	2	2	2	2	1
CO2	3	2	2	3	3	2	1	1	3	2	3	2	2	1
CO3	3	3	1	3	3	1	2	1	2	2	2	2	2	1
CO4	3	3	1	3	2	1	1	1	1	2	3	2	2	1
CO5	3	2	1	2	2	2	1	1	1	1	3	2	2	1

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3
CO5	CD1, CD2, CD3

<u>**COURSE INFORMATION SHEET**</u>

Course Code:	**EC24102**
Course Title:	**Basic Electronics Lab**
Pre-requisite(s):	
Co-requisite(s):	
Credits:	**1** L:0 T:0 P: 2
Class schedule per week:	**2**
Class:	**B. Tech.**
Semester / Level:	**SECOND**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

Course Objectives

This course enables the students:

1.	To measure magnitude, time-period, frequency, phase of signals using CRO
2.	To know PN junction characteristics and its applications
3.	To understand the working of transistor amplifier
4.	To understand the working of operational amplifier and circuits
5.	To realize logic gates and implement simple Boolean expression

Course Outcomes

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

CO1	Familiarize with electronics components like diode, transistors, ICs
CO2	Make use of measuring instruments and function generators
CO3	Verify characteristics of diodes, transistors and op-amp
CO4	Design electronic circuits using diodes, transistors, op-amp for analog applications
CO5	Design electronic circuits using logic gates for digital applications

List of Experiments

Experiment No.	Name of the Experiments
	(A) HARDWARE BASED EXPERIMENTS
1.	**MEASURMENTS USING CRO** AIM-1: To understand the Measurement of voltage, time-period and frequency of different signals on CRO. AIM-2: To measure the frequency and phase of two different signals using Lissajous pattern.
2.	**HALF-WAVE AND FULL WAVE RECTIFIER CIRCUITS** AIM-1: To understand the basic operation principle of Half-wave rectifier circuit and measurement of rectification efficiency and ripple factor with and without C-Filter. AIM-2:To understand the basic operation principle of Full-wave rectifier circuit and measurement of rectification efficiency and ripple factor with and without C-Filter.
3.	**COMMON EMITTER (CE) TRANSISTOR AMPLIFIER** AIM-1: To understand the basic operation principle of CE transistor amplifier circuit and finding its frequency response. AIM-2: To determine the gain bandwidth product of CE transistor amplifier from its frequency response.
4.	**INVERTING OPERATIONAL AMPLIFIER (OP-AMP)** AIM: To design the inverting operational amplifier using IC741 OP-AMP and find its Gain and Frequency Response.
5.	**DIFFERENTIAL AMPLIFIER** AIM-1: To design common mode and differential mode circuit using IC741 OP-AMP AIM-2:To obtain common mode gain and differential mode gain and calculate CMRR.
6.	**REALIZATION OF LOGIC GATES** AIM-1: To understand basic Boolean logic functions (NOT, AND, OR). AIM-2: To realize the basic logic gates (AND, OR, NOT) using NAND Gate (IC-7400).
	(B) SOFTWARE BASED EXPERIMENTS
1.	**PN JUNCTION CHARACTERISTICS** AIM-1: To determine the forward bias V-I characteristics of PN junction diode and finding itsforward cut-in voltage. AIM-2: To determine the reverse bias V-I characteristics of PN junction diode and finding its reverse breakdown voltage.
2.	**ZENER DIODECHARACTERISTICS** AIM-1: To design a basic voltage regulator circuit using Zener diode. AIM-2: To determine the reverse bias V-I characteristics of Zener diode and finding its reverse breakdown voltage.
3.	**FIELD EFFECT TRANSISTOR CHARACTERISTICS** AIM-1: To determine the output and transfer characteristics of JFET. AIM-2: To measure the voltage,gain of JFET.
4.	**NON-INVERTING OPERATIONAL AMPLIFIER (OP-AMP)** AIM:To design the non-inverting operational amplifier using IC741 OP-AMP and find its Gain and Frequency Response.
5.	**DIFFERENTIATOR AND INTEGRATOR CIRCUITS USING OP-AMP** AIM-1: To design differentiator circuit using IC741 OP-AMP and observe waveforms. AIM-2:To design integrator circuit using IC741 OP-AMP and observe waveforms.
6.	**IMPLEMENTATION OF BOOLEAN FUNCTION** AIM-1: To understand the AND Gate IC (IC 7408) and OR Gate IC (IC 7432) AIM-2: To implement a given Boolean expression using logic gate ICs.

Text Books:

1. Millman J., Halkias C.C., Parikh Chetan, "Integrated Electronics: Analog and Digital Circuits and Systems", Tata McGraw-Hill, 2/e.
2. Mano M.M., "Digital Logic and Computer Design", Pearson Education, Inc, Thirteenth Impression, 2011.

Reference Book:

1.Boylstead R.L., Nashelsky L., "Electronic Devices and Circuit Theory", Pearson Education, Inc, 10/e.

Gaps in the syllabus (to meet Industry/Profession requirements): NA

POs met through Gaps in the Syllabus: N/A.

Topics beyond syllabus/Advanced topics/Design: N/A

POs met through Topics beyond syllabus/Advanced topics/Design: N

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	**(60)**
Attendance Marks	**12**
Day-to-day performance Marks	**06**
Lab Viva marks	**20**
Lab file Marks	**12**
Lab Quiz-I Marks	**10**
End SEM Evaluation	**(40)**
Lab Quiz-II Marks	**10**
Lab performance Marks	**30**

Indirect Assessment –

1. Student Feedback on Course Outcome

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	1	2	3	1	1	2	2	2	2	2	1	1
CO2	3	3	1	2	3	1	1	2	2	2	2	2	2	1
CO3	3	2	1	2	3	1	1	2	2	2	2	2	2	1
CO4	3	3	1	2	3	1	1	2	2	2	2	2	2	1
CO5	3	2	1	2	3	1	1	2	2	2	2	2	2	1

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between COs and Course Delivery (CD) methods:

CD Code	Course Delivery Methods	Course Outcome	Course Delivery Method Used
CD1	Lecture by use of Boards/LCD Projectors	CO1	CD1, CD5, CD9
CD2	Tutorials/Assignments	CO2	CD1, CD5, CD9
CD3	Seminars/ Quiz (s)	CO3	CD1, CD5, CD9
CD4	Mini Projects/Projects	CO4	CD1, CD5, CD9
CD5	Laboratory Experiments/Teaching Aids	CO5	CD1, CD5, CD9
CD6	Industrial/Guest Lectures		
CD7	Industrial Visits/In-plant Training		
CD8	Self- learning such as use of NPTEL Materials and Internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course Code:	**ME24102**
Course Title:	**Engineering Graphics**
Pre-requisite(s):	**NIL**
Co-requisite(s):	**NIL**
Credits:2	(L:0 T: 0 P:4)
Class schedule per week:	**4**
Class:	**B. Tech.**
Semester / Level:	**SECOND**
Branch:	**Production and Industrial Engineering**
Name of Teacher:	

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Understand the basic principles of Engineering Graphics, which include projections of 1D, 2D and 3D objects.
2.	Visualize a solid object (including sectioned) and convert it into drawing.
3.	Visualize different views of any object.
4.	Develop skill to draw objects using AutoCAD software.
5.	Inculcate the imagination and mental visualization capabilities for interpreting the geometrical details of common engineering objects.

COURSE OUTCOMES (COs)

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

CO1	Explain the fundamentals of Engineering Graphics and projection and acquire visualization skills.
CO2	Demonstrate the concept of projections of points and lines for various engineering applications.
CO3	Apply the concept of projections to construct planes and solids, and its orthographic projections which are positioned in various configurations.
CO4	Demonstrate the understanding of AutoCAD software commands to draw projections of points, lines, planes and solids.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Introduction to Engineering Graphics, dimensioning and projections, orthographic projections, Fundamentals of First and Third Angle projection, Orthographic projections of points.	9
Module – II Orthographic projections of straight lines: lines parallel to HP and VP, lines inclined to HP and Parallel to VP, line inclined to VP and parallel to HP, line inclined to both reference planes. Orthographic projections of planes/lamina: lamina perpendicular to both HP and VP, lamina parallel to HP and perpendicular to VP (and vice versa), lamina inclined to HP and perpendicular to VP, lamina inclined to VP and perpendicular to HP, lamina inclined to both reference planes.	9
Module – III Projections of solids (cube, prism, pyramid, tetrahedron) - axis perpendicular to HP and inclined to VP and inclined to one or both planes. Section of solids: sectional plane perpendicular to one plane and parallel/inclined to another plane.	9
Module – IV Working with AutoCAD Commands, Cartesian Workspace, Basic Drawing & Editing Commands, Drawing: Lines, Rectangles, Circles, Arcs, Polylines, Polygons, Ellipses, Creating Fillets and Chamfers, Creating Arrays of Objects, Working with Annotations, Adding Text to a Drawing, Hatching, Adding Dimensions, Dimensioning Concepts, Adding Linear Dimensions, Adding Radial & Angular Dimensions, Editing the Dimensions.	9
Module – V Create views of points, lines, planes, and various types of solids (cube, prism, pyramid, tetrahedron, etc.) using AutoCAD software.	9

TEXTBOOKS:

1. Engineering Drawing by N. D. Bhatt, Charotar Publishing House Pvt.Ltd., 53rd, Edition, 2014.
2. Engineering Drawing and Graphics + AutoCAD by K. Venugopal, New Age International (P) Limited, 4th Reprint: June, 2017.

REFERENCE BOOKS:

1. Engineering Graphics with Autocad by J. D. Bethune, Prentice Hall, 2007.

GAPS IN THE SYLLABUS (TO MEET INDUSTRY/PROFESSION REQUIREMENTS) : NIL

POS MET THROUGH GAPS IN THE SYLLABUS: NA

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NIL

POS MET THROUGH TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: NA

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	60
End Semester Test	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Lab Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Lab Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment	√	√	√	√
Semester End Examination	√	√	√	√

INDIRECT ASSESSMENT

1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	0	2	0	0	0	2	0	2	3	2	2
CO2	3	3	2	0	2	0	0	0	2	0	2	3	2	2
CO3	3	3	3	2	2	0	0	2	2	0	2	3	2	2
CO4	2	2	2	2	3	0	0	2	3	2	2	3	3	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD3
CO2	CD3
CO3	CD3
CO4	CD3

<u>**COURSE INFORMATION SHEET**</u>

Course Code: **PE24102**
Course Title: **Workshop Practice**
Pre-requisite(s): **None**
Co-requisite(s): **None**
Credits: **1 (L:0 T:0 P: 2)**
Class schedule per week: **2**
Class: **B.Tech.**
Semester / Level: **SECOND**
Branch: **Production and Industrial Engineering**
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Familiarize with the basics of manufacturing processes.
2	Impart knowledge and skill to use tools, machines, equipment, and measuring instruments.
3	Practice on manufacturing of components using workshop trades.
4	Educate students on the safe handling of machines and tools.
5	Exercise individual as well as group activity with hands-on training in different workshop trades.

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

CO1	Be conversant with the basic manufacturing processes.
CO2	Identify and apply suitable tools and instruments for carpentry, foundry, welding, fitting, and conventional and modern machining.
CO3	Manufacture different components using various workshop trades.
CO4	Take safety and precautionary measures for self and machines during operations.
CO5	Develop skills to work as an individual or in a team during trade practices.

<u>**SYLLABUS**</u>

LIST OF EXPERIMENTS	**(NO. OF PRACTICAL HOURS)**
1. **CARPENTRY SHOP** **EXPERIMENT-I: Carpentry Tools and Instruments** **Objective**: To study the various tools, instruments, and equipment used in carpentry practice.	**2**
2. **CARPENTRY SHOP** **EXPERIMENT-II: Carpentry Practice** **Objective:** To perform the carpentry work by making a wooden job using different tools.	**2**
3. **FOUNDRY SHOP** **EXPERIMENT-I: Green Sand Moulding** **Objective:** To get acquainted with various tools and equipment used in making green sand mould (to practice green sand mould making with single-piece patterns).	**2**
4. **FOUNDRY SHOP** **EXPERIMENT-II: Aluminium Casting** **Objective:** To get acquainted with melting and pouring metal in a mould (given two-piece patterns of handle) and to make aluminium casting.	**2**

5. **WELDING SHOP** **EXPERIMENT-I: Manual Metal Arc Welding** **Objective:** To study arc welding processes including arc welding machines (AC & DC), electrodes and equipment. To join two pieces of given metal by the arc welding process.	**2**
6. **WELDING SHOP** **EXPERIMENT-II: Gas Welding** **Objective:** To study gas welding processes, including types of flames produced, filler metals and fluxes, etc. To join two pieces of given metal by the gas welding process.	**2**
7. **FITTING SHOP** **EXPERIMENT-I: Fitting Tools and Measuring Instruments** **Objective**: To study the various tools used in the fitting shop and perform fitting operations (like marking, chipping, hack-sawing, filing, drilling, etc.)	**2**
8. **FITTING SHOP** **EXPERIMENT-II: Fitting Assembly Practice** **Objective:** To make a job clamping plate as per the given drawing by fitting operations and to check for its assembly with a given component.	**2**
9. **MACHINE SHOP** **EXPERIMENT – I: Centre Lathe Machine** **Objective**: To study lathe machine and to machine a given job on the center lathe as per drawing.	**2**
10. **MACHINE SHOP** **EXPERIMENT-II: Shaper Machine** **Objective:** To study the Shaper machine and to machine a given job on the shaper as per drawing.	**2**
11. **MODERN MACHINE SHOP** **EXPERIMENT – I: CNC Lathe Machine** **Objective**: To provide an introduction to the functionality and operation of the CNC Lathe Machine through practical demonstration.	**2**
12. **MODERN MACHINE SHOP** **EXPERIMENT-II: CNC Surface Grinding Machine** **Objective:** To provide an introduction to the functionality and operation of the CNC Surface Grinding Machine through practical demonstration	**2**

Books recommended:

TEXT BOOK

1. S K Hajra Choudhury, A K. Hajra, "Elements of Workshop Technology: Vol- I and Vol -II", Media Promotors Pvt Ltd. **(T1)**
2. B S Raghuwanshi, "A course in Workshop Technology", Dhanpat Rai Publications. **(T2)**

REFERENCE BOOK

1. P.N. Rao, "Manufacturing Technology Vol-1and Vol-II", Tata McGraw Hill. **(R1)**
2. Kalpakjian, "Manufacturing Engineering and Technology", Pearson. **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	√

Course Evaluation:

Direct Assessment-

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	**% Distribution**				
Day to day performance & Lab files	30				
Quiz 1	10				
Viva-voce	20				
End Semester Examination	**% Distribution**				
Examination: Experiment Performance	30				
Quiz 2	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	1	0	1	1	1	1	1	1	2	3	2	2
CO2	2	3	2	1	3	1	1	1	2	2	2	3	2	3
CO3	2	2	3	2	3	1	1	2	2	2	2	2	2	3
CO4	1	1	2	1	2	2	3	1	1	1	2	1	1	2
CO5	1	1	2	0	1	0	1	3	3	3	2	2	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD3, CD6
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD1, CD3
CO5	CD3

COURSE INFORMATION SHEET

Course code: MA 24201
Course title: NUMERICAL METHODS
Pre-requisite(s): None
Co- requisite(s): NUMERICAL METHODS LAB
Credits: 2 L: 2 T:0
Class schedule per week: 2
Class: B. Tech
Semester / Level: III / Second
Branch: All
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Comprehend suitable numerical methods to solve algebraic and transcendental equations.
2	Learn proper numerical methods to solve linear system of equations.
3	Approximate a function using various interpolation techniques.
4	Evaluation of derivatives and integrals using interpolating polynomials.

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

CO1	Solve algebraic and transcendental equations using numerical methods for real-world problem solving.
CO2	Apply numerical techniques to solve linear system of equations in scientific and engineering computations.
CO3	Use interpolation methods to approximate functions in data analysis and modelling.
CO4	Compute derivatives and integrals for complex mathematical and physical problems.
CO5	Solve ordinary differential equations numerically for dynamic system modeling and Simulations.

SYLLABUS

Module 1: Errors and Nonlinear Equations **[5]**
Types and sources of errors, Propagation of errors. Bisection method, Regula-Falsi method, Secant method, Newton-Raphson method and its
variants, General Iterative method.

Module 2: System of Linear Equations **[5]**
Gaussian Elimination, Gauss-Jordan, LU Decomposition (Crout's method), Gauss-Jacobi and Gauss-Siedel methods to solve linear system of equations.

Module 3: Interpolation **[5]**
Lagrange's interpolation, Newton's divided differences interpolation formulas, Interpolating polynomial using Newton forward and backward differences.

Module 4: Differentiation and Integration **[5]**
Differentiation using interpolation formulas, Integration using Newton-Cotes formulas: Trapezoidal rule, Simpson's one-third and three-eighth rules.

Module 5: Solution of Ordinary Differential Equations **[5]**
Euler's method, modified Euler's method, Runge-Kutta Methods of second and fourth order to solve initial value problems.

Text books:

1. Jain M.K, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age Publications, 2004. (**T1**)
2. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI. .(**T2**)
3. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006. (**T3**)

Reference books:

1. S.C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw Hill, 1985. (**R1**)
2. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Seventh Edition, 2003. (**R2**)
3. R. W. Hamming: Numerical Methods for Scientists and Engineers, Second Edition, Dover (**R3**)

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
End Semester Examination	√	√	√	√	√
Quiz / Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program-Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	2	2	2	0	0	0	1	1	2	1	2	2
CO2	3	3	2	2	2	0	0	0	1	1	2	1	2	2
CO3	3	2	2	2	3	0	0	0	1	1	2	1	2	2
CO4	3	2	2	2	3	0	0	0	1	1	2	1	2	2
CO5	3	3	2	3	3	0	0	0	1	1	2	1	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6
CO5	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course code: MA 24202
Course title: NUMERICAL METHODS LAB
Pre-requisite(s): None
Co- requisite(s): NUMERICAL METHODS
Credits: 1 L:0 T:0 P: 2
Class schedule per week: 2
Class: B.Tech.
Semester / Level: III / Second
Branch: All
Name of Teacher:

COURSE OBJECTIVES

This course envisions to impart to students to:

1.	Execute appropriate numerical methods to solve algebraic and transcendental equations correctly up to a certain level of significance.
2.	Solve the linear system of equations using direct and iterative methods.
3.	Approximate a function by a polynomial using various interpolation techniques, along with the computation of derivatives and integrals.
4.	Compute numerical solutions of initial value problems.
5.	Handle numerical problems efficiently through programming languages like C, C++, etc., on a computer.

COURSE OUTCOMES (COs)

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

CO1	Employ numerical techniques to solve algebraic and transcendental equations
CO2	Analyze and implement numerical methods for solving systems of linear equations
CO3	Construct numerical approximations of functions using interpolation techniques
CO4	Compute derivatives and definite integrals using numerical differentiation and integration methods
CO5	Develop solutions of ordinary differential equations using appropriate numerical schemes

SYLLABUS

LIST OF EXPERIMENT:

1. ASSIGNMENT – 1
Objective: Find a simple root of f(x)=0 using the Bisection method. Read the endpoints of the interval in which the root lies, the maximum number of iterations, and the error tolerance eps.

2. ASSIGNMENT – 2
Objective: Find a simple root of f(x)=0 using the Regula-Falsi method. Read the endpoints of the interval in which the root lies, the maximum number of iterations, and the error tolerance eps.

3. ASSIGNMENT – 3
Objective: Find a simple root of f(x)=0 using the Secant method. Read the endpoints of the interval in which the root lies, the maximum number of iterations, and the error tolerance eps.

4. ASSIGNMENT – 4
Objective: Find a simple root of f(x)=0 using Newton Raphson method. Read any initial approximation, maximum number of iterations and error tolerance eps.

5. ASSIGNMENT – 5
Objective: Find the solution of a system of linear equations using the Gauss elimination method.

6. ASSIGNMENT – 6
Objective: Find the solution of a system of linear equations using the Gauss-Jordan method.

7. ASSIGNMENT – 7
Objective: Find the solution of a system of linear equations using the Jacobi method.

8. ASSIGNMENT – 8
Objective: Find the solution of a system of linear equations using the Gauss-Seidel method.

9. ASSIGNMENT – 9
Objective: Approximate the function using the Lagrange interpolation formula

10. ASSIGNMENT – 10
Objective: Approximate the function using the Newton divided difference formula

11. ASSIGNMENT – 11
Objective: Approximate the function using Newton's forward and backward interpolation formulae.

12. ASSIGNMENT – 12
Objective: Evaluate the integral using the Trapezoidal rule

13. ASSIGNMENT – 13
Objective: Evaluate the integral using Simpson's one-third and three-eighth rules.

14. ASSIGNMENT – 14
Objective: Solve an IVP, $\frac{dy}{dx} = f(x, y), y(x_0) = y_0$ using the Euler method

15. ASSIGNMENT – 15
Objective: Solve an IVP, $\frac{dy}{dx} = f(x, y), y(x_0) = y_0$ using the classical Runge-Kutta fourth-order method.

Text books:

1. Jain M.K, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age Publications, 2004. (**T1**)
2. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI. .(**T2**)
3. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006. (**T3**)

Reference books:

1. S.C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw Hill, 1985. (**R1**)
2. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Seventh Edition, 2003. (**R2**)
3. R. W. Hamming: Numerical Methods for Scientists and Engineers, Second Edition, Dover (**R3**)

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>

<u>POs met through Gaps in the Syllabus:</u>

<u>Topics beyond syllabus/Advanced topics/Design:</u>

<u>POs met through Topics beyond syllabus/Advanced topics/Design:</u>

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Day to day performance & Lab files	√	√	√	√	√
Quiz 1	√	√			
Quiz 2			√	√	√
Viva-voce	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

INDIRECT ASSESSMENT

1.Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	2	3	0	0	1	1	1	2	1	2	2
CO2	3	3	2	2	3	0	0	1	1	1	2	1	2	2
CO3	3	2	2	2	3	0	0	1	1	1	2	1	2	2
CO4	3	2	2	2	3	0	0	1	1	1	2	1	2	2
CO5	3	3	2	3	3	0	0	1	1	2	3	1	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD2, CD3
CO2	CD2, CD3
CO3	CD2, CD3
CO4	CD2, CD3
CO5	CD2, CD3

COURSE INFORMATION SHEET

Course code: MT 24131
Course title: UHV2: UNDERSTANDING HARMONY
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: III / First
Branch: All
Name of Teacher:

Course Objectives

1	Development of a holistic perspective based on self- exploration about themselves (human being), family, society and nature/existence.
2	Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3	Strengthening of self-reflection
4	Development of commitment and courage to act

Course Outcomes

CO1	By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems

SYLLABUS

Module 1: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education

1. Purpose and motivation for the course, recapitulation from Universal Human Values-I.
2. Self-Exploration–what is it? - Its content and process; 'Natural Acceptance' and Experiential Validation- as the process for self-exploration.
3. Continuous Happiness and Prosperity- A look at basic Human Aspirations.
4. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority.
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking.

Module 2: Understanding Harmony in the Human Being - Harmony in Myself!

1. Understanding human being as a co-existence of the sentient 'I' and the material 'Body'.
2. Understanding the needs of Self ('I') and 'Body' - happiness and physical facility.
3. Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer).
4. Understanding the characteristics and activities of 'I' and harmony in 'I'.
5. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail.
6. Programs to ensure Sanyam and Health.

Include practice sessions to discuss the role others have played in making material goods available tome. Identifying from one's own life.
Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease

Module 3: Understanding Harmony in the Family and Society- Harmony in Human- Human Relationship

1. Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship
2. Understanding the meaning of Trust; Difference between intention and competence
3. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship
4. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals
5. Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives.

Module 4: Understanding Harmony in the Nature and Existence - Whole existence as Coexistence

1. Understanding the harmony in the Nature
2. Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self-regulation in nature.
3. Understanding Existence as Co-existence of mutually interacting units in all- pervasive space.
4. Holistic perception of harmony at all levels of existence.
5. Include practice sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.

Module 5: Implications of the above Holistic Understanding of Harmony on Professional Ethics

1. Natural acceptance of human values
2. Definitiveness of Ethical Human Conduct
3. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
4. Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems.
5. Case studies of typical holistic technologies, management models and production systems
6. Strategy for transition from the present state to Universal Human Order:
   a) At the level of individual: as socially and ecologically responsible engineers, technologists and managers
   b) At the level of society: as mutually enriching institutions and organizations
7. Sum up.

Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions
e.g. to discuss the conduct as an engineer or scientist etc.

Text books:

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 2010

Reference books:

1. Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi.
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj - PanditSunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
11. India Wins Freedom - Maulana Abdul Kalam Azad
12. Vivekananda - Romain Rolland (English)

13. Gandhi - Romain Rolland (English)

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:
While analysing and discussing the topic, the faculty mentor's role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.
In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one's own self and do self- observation, self-reflection and self- exploration.
Scenarios may be used to initiate discussion. The student is encouraged to take up "ordinary" situations rather than" extra-ordinary" situations.
Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.
Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values.
It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

Course Evaluation:
DIRECT ASSESSMENT

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Continuous Internal Assessment	% Distribution
Assessment by faculty mentor	10
Self-assessment	10
Assessment by peers	10
Socially relevant project/Group ctivities/Assignments	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	√	√	√	√	√
Semester End Examination	√	√	√	√	√

INDIRECT ASSESSMENT
1. Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	0	0	2	1	1	3	3	3	2	2	3	1	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course code: PE 24201
Course title: INTRODUCTION TO MATERIALS ENGINEERING
Pre-requisite(s): None
Co- requisite(s): MATERIALS ENGINEERING LAB
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: B.Tech
Semester / Level: III/ Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Examine the properties and structures of materials and get acquainted with metallographic principles and material characterization techniques.
2	Understand the thermodynamics of solids and invariant transformations involved in phase diagrams, comprehend the construction of iron carbon phase diagram and appreciate the effects of alloying elements in steel
3	Analyze the kinetics of phase transformation of steel, understand heat treatment operations associated with steels and introduced to concept of hardenability
4	Acknowledge important non-ferrous alloys, polymers and understand their properties, microstructure, and applications
5	Introduced to various material testing methods related to its mechanical and functional properties.

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

CO1.	Analyze and select various engineering materials for various purposes and describe the various material characterization techniques
CO2.	Explain the thermodynamics of solids, elucidate iron carbon diagram and identify the effects of alloying elements on steel
CO3.	Describe the kinetics involved with steel transformation and understand the application of various heat treatment operations
CO4.	Identify the different types of non-ferrous alloys and explain its properties
CO5.	Apply and explain various methods of material testing procedures

SYLLABUS

Module 1: Introduction to Material Science and Metallurgy [8]
Definition, scope and classification of engineering solids; Properties of engineering solids and their applications; Structure of solids – crystalline and non-crystalline; Basics of crystallography – point/space lattice, unit cell, crystal system, crystal lattice, and crystal structure; Structure of elemental and compound crystal structures with examples; Crystallographic indexing of directions and planes, Influence of crystal structure on properties; Defects in crystalline solids – definition, classification and examples of dimension-wise crystal defects; Macroscopic symmetry elements; Influence of crystal defects on engineering properties; Solid solutions; Synthesis of solids by different routes – from vapour, melt or solids; Solidification of pure and alloyed systems; Evolution and concept of macrostructure – mono and polycrystalline aggregates; Principles of metallography – sample selection, preparation and examination; Optical or light microscopy; Interpretation of optical microstructure; Standard techniques of material characterization – structural examination; Standard techniques of material characterization – compositional analysis.

Module 2: Phase Diagrams and Fe-C equilibrium Diagram [10]
Thermodynamics of solids: component, phase, thermodynamic system - single and multicomponent, specific heat, enthalpy, entropy, Free energy concept - Gibbs and Helmholz energy; Condensed and uncondensed systems; Gibbs phase rule and degree of freedom – examples and application; Phase equilibrium and phase transformations; Invariant and non-invariant phase changes; Binary phase diagrams – miscible, immiscible and partially miscible systems; Isomorphous system; Utility of phase diagram; Phase diagrams with invariant transformations involving a liquid phase– peritectic, eutectic, syntactic, monotectic and metatectic; Phase diagrams showing solid state phase

invariant transformations; Interpretation of microstructural evolution in binary systems using phase diagrams – effect on properties; Iron-carbon and iron-cementite equilibrium diagram; Definition and microstructure of steel and cast iron; Important phase transformations in steel; Classification of plain carbon steel and cast iron, Properties and utility of steel and cast iron; Effect of alloying elements on steel; Alloy steel – main classes and application; Important non-ferrous alloys and applications – aluminium and copper based alloys; Distinction from steel and ferrous alloys; Strengthening mechanisms of ferrous and non-ferrous alloys

Module 3: Transformation curve and Heat Treatment Methods [10]
Kinetics of phase transformation – mechanism of solute transport; Diffusion; Shear; Isothermal decomposition of austenite in steel (TTT diagram); Non-isothermal decomposition of austenite in steel (CCT diagram); Homogeneous and Heterogeneous Nucleation Mechanism and Growth – Thermodynamics and kinetics; Heat treatments of steel – annealing, normalizing, hardening and tempering; Special heat treatments of steel (TMT, Austempering, Martempering, etc.); Concept of hardenability of steel, Jominy hardenability test; Mechanism of hardening of steel; Cold working and hot working; Strain hardening; Annealing of cold worked alloys - recovery, recrystallization and grain growth; Surface hardening, case hardening and surface engineering of steel; Heat treatment furnaces – types, uses and special features, Ovens, Heating elements, Temperature controllers and principles; Quenching and quanchants – process, stages and equipment, Heat treatment defects – types, causes, effects, precaution and remedies, Inspection and control

Module 4: Types of Alloys and applications [6]
Types and application of plain and alloyed cast iron – grey, spheroidal graphitic, white and malleable cast iron; Heat treatment and microstructure; Important non-ferrous alloys – Al, Cu, Pb, Zn, Ti, Mg and Ni based alloys; Heat treatments, Important properties and applications; Composition, microstructure, properties and classification of various grades of stainless steel, maraging steel and superalloys, Heat treatments, Applications; Engineering ceramics – classification, fabrication, structure and properties; Important ceramics – refractory, glass, clay, cutting tools and functional ceramics; Engineering polymers: synthesis, structure and classification; Engineering properties; Applications

Module 5: Material Testing methods [6]
Testing of mechanical properties I: Surface (hardness, friction) and bulk (under tension and compression) mechanical properties, Definition and types of wear, Classification of mechanical properties – definition and units; Testing of mechanical properties II: Fatigue, impact, creep – definition, types and significance, Various combinations of important mechanical properties and testing, Review of failures; Functional properties: Thermal conductivity, Electrical conductivity, Emission – photo and thermoelectric, Magnetism, Topography, Colour, Reflection, Surface energy, Wetting, Catalysis, Adhesion/cohesion; Corrosion and oxidation properties and testing, Types, Conditions, Laws, Thermodynamics and kinetics, Prevention; Case studies of engineering failures due to stress, wear, erosion, fatigue cycles, thermal cycles, corrosion, oxidation, creep, etc.

Text Books:

1. V. Raghvan, Material Science and Engineering, Prentice Hall India **(T1)**
2. William D. Callister Jr., Materials Science and Engineering, Wiley Publication **(T2)**
3. Y. Lakhtin, Physical Metallurgy **(T3)**
4. J. F. Shackelford – Introduction to Materials Science and Engineering – **(T4)**
5. R. E. Reedhill – Physical Metallurgy Principles – **(T5)**

Reference

1. George Dieter, Physical Metallurgy, McGraw Hill Education **(R1)**
2. B.D. Cullity, Elements of X Ray Diffraction, Pearson Education **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Study of Advanced Materials, Nano Materials, Non-Destructive Testing methods

POs met through Gaps in the Syllabus:
PO 1-5

Topics beyond syllabus/Advanced topics/Design:
Electrical, Optical, Thermal, Magnetic and Electrical properties of materials. Composites, Degradation of Materials, Environmental and Societal Considerations in Material Science. Powder Metallurgy, Plastic Technology.

POs met through Topics beyond syllabus/Advanced topics/Design:
PO 1-5, 11-12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	**% Contribution during CO Assessment**
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	**% Distribution**
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	3	0	0	0	3	1	0	3	3	3	3
CO2	3	3	3	3	1	2	0	0	2	0	3	3	2	3
CO3	3	3	2	3	1	1	0	2	0	0	3	3	2	3
CO4	3	3	2	3	2	3	1	2	0	2	2	2	3	3
CO5	3	3	2	3	3	1	0	2	2	0	2	2	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6
CO5	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course code: PE 24202
Course title: MATERIALS ENGINEERING LAB
Pre-requisite(s): None
Co-requisite(s): INTRODUCTION TO MATERIALS ENGINEERING
Credits: 1.5 L:0 T:0 P:3
Class schedule per week: 3
Class: B.Tech
Semester / Level: III/ Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Get acquainted with basics of process metallurgy
2	Impart knowledge and skill to utilize tools, equipment, and measuring instruments related to metallographic study
3	Analyze microstructure of metals/alloys (ferrous/non-ferrous)
4	Conduct heat treatment processes and analyze various factors related to those processes
5	Get introduced to modern metallographic testing method

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

CO1	Learn how to prepare samples for metallographic study
CO2	Utilize tools, equipment, and measuring instruments related to metallographic study
CO3	Analyze microstructure of metals, alloys (ferrous/non-ferrous) and composites
CO4	Apply heat treatment processes and analyze various factors related to those processes
CO5	Understand mechanisms and working principles of modern material property analysis techniques

SYLLABUS

LIST OF EXPERIMENT:

Experiment 1: Study of Equipment and Processes in Metallurgy Laboratory
Objective: To study the working principle of optical microscope, techniques of sample preparation for metallography and demonstration of heat treatment furnaces

Experiment 2: Sample preparation of ferrous alloys for metallography
Objective: To prepare the sample for microstructure study of metallic specimens

Experiment 3: Study of microstructure of steel specimens in as-received condition
Objective: To investigate the microstructure of steel specimens in the as-received condition through optical microscope

Experiment 4: Study the hardness of materials by various testing methods
Objective: Demonstration, study of working principle and measurement of hardness of materials by various testing methods

Experiment 5: Study the effect of quenching media on microstructure and hardness of steel specimens
Objective: To study the effect of quenching media on the microstructure and hardness of steel specimens

(a) Heat treatment and cooling in different quenching media viz. furnace cooling, air cooling, water cooling and oil cooling
(b) Observation of the microstructure through metallurgical microscope
(c) Measurement of hardness of heat-treated steel specimens

Experiment 6: Effect of time of heat treatment on microstructure and property of steel specimens
Objective: To study the effect of soaking time of heat treatment on the microstructure and hardness of steel specimens

(a) Heat treatment by varying the soaking time at fixed temperature and cooling in furnace/air
(b) Observation of the microstructure through metallurgical microscope
(c) Determination of hardness of the heat-treated steel specimens

Experiment 7: Effect of temperature of heat treatment on microstructure and property of steel specimens
Objective: To study the effect of temperature of heat treatment on the microstructure and hardness of steel specimens

(a) Heat treatment at different temperatures with fixed soaking time and cooling in air
(b) Observation of the microstructure through metallurgical microscope
(c) Determination of hardness of the heat-treated steel specimens

Experiment 8: Study the hardenability of steel specimens
Objective: To conduct Jominy End Quench test to study the hardenability of steel specimens.

Experiment 9: Study of non-ferrous alloy sample preparation
Objective: To prepare the sample for study of microstructure of aluminum alloy.

Experiment 10: Study of non-ferrous alloy microstructure study
Objective: To observe the microstructure of aluminum alloy through metallurgical microscope.

Experiment 11: Study of microstructure and hardness of composite specimens
Objective: To study the microstructure and hardness of composite specimens

(a) Observation of the microstructure through metallurgical microscope
(b) Measurement of hardness of composite specimens

Experiment 12: Demonstration of recent methods for microstructure and materials property analysis
Objective: To demonstrate the basic mechanism and working principle of modern testing methods

Books recommended:

TEXT BOOK

1. V. Raghvan, Material Science and Engineering, Prentice Hall India **(T1)**
2. William Callister, Materials Science and Engineering, Wiley Publication **(T2)**
3. Physical Metallurgy, Y. Lakhtin, CBS Publishers India **(T3)**
4. Vijendra Singh, Physical Metallurgy, Standard Publishers **(T4)**

REFERENCE BOOK

1. George Dieter, Physical Metallurgy, McGraw Hill Education **(R1)**
2. B.D. Cullity, Elements of X Ray Diffraction, Pearson Education **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Metallurgy Laboratory experiments are majorly demonstration of different processes. Scope for individual practices is limited.

POs met through Gaps in the Syllabus:
PO 9, PO 10

Topics beyond syllabus/Advanced topics/Design:
Heat Treatment for non-ferrous metals/alloys, Latest techniques in destructive/non- destructive testing of materials

POs met through Topics beyond syllabus/Advanced topics/Design:
PO 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and the internets	
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	**% Distribution**				
Day to day performance & Lab files	30				
Quiz 1	10				
Viva-voce	20				
End Semester Examination	**% Distribution**				
Examination: Experiment Performance	30				
Quiz 2	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Day to day performance & Lab files	√	√	√	√	√
Quiz 1	√	√			
Quiz 2			√	√	√
Viva-voce	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	1	1	0	3	1	1	1	2	2	2	1	2	2
CO2	0	2	0	0	3	1	0	2	2	0	0	2	1	2
CO3	1	2	1	2	2	0	0	2	3	0	2	2	2	2
CO4	2	3	2	3	3	1	0	2	2	0	2	3	3	3
CO5	2	0	0	3	3	0	0	0	2	0	2	2	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (Cos) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD1, CD3

COURSE INFORMATION SHEET

Course code: PE 24203
Course title: OPERATIONS RESEARCH
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:
0 **Class schedule per week:** 3
Class: B. Tech
Semester / Level: III / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1	Apply the techniques of operations research in industrial engineering problems.
2	Formulate a real-world industrial problem as a mathematical programming model
3	Understand the simplex method for linear programming and perform iterations of it by hand
4	Solve specialized linear programming problems like transportation and assignment problems
5	Operations research helps in solving problems in different environments that need decisions, such as sequencing, queuing, and games theory.

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

CO1	Formulate a mathematical model of a real-world word problem and solve it using the graphical method.
CO2	Formulate and solve engineering and managerial scenarios such as linear programming problems (LPP).
CO3	Formulate and solve engineering and managerial situations as transportation and assignment
CO4	Apply sequencing and queuing theory for performance evaluation of engineering and management systems.
CO5	Solve engineering and managerial decision problems using game theory.

SYLLABUS

Module 1: Introduction: **[8]**
Importance of Operation Research, Methodology, Characteristics, Scope, Application and Limitation of Operations Research
Requirement of LP, Basic Assumptions, Mathematical formulation of the of LP, Graphical solution; numerical problems based on these methods.

Module 2: Linear Programming: **[8]**
Analytical Methods Simplex method, Big-M method, concept of duality; numerical problems based on these methods (preferably industrial engineering-based problems)

Module 3: Transportation & Assignment Model **[10]**
Basic feasible solution by different methods (North west corner method, least cost method, Vogel's approximation method), finding optimal solutions (MODI method), unbalanced transportation problems; numerical problems based on these methods (preferably industrial engineering-based problems)
Balanced and unbalanced assignments, travelling sales man Problem; numerical problems based on these methods (preferably industrial engineering-based problems)

Module 4: Sequencing and Queuing Model **[8]**
Processing of ***n*** jobs through two machines, processing ***n*** jobs through three machines; Processing of 2 jobs through ***m*** machines –graphical method, numerical problems based on these methods
Basis of Queuing theory, elements of queuing theory, Kendall's Notation, Operating characteristics of a queuing system, Classification of Queuing models, Queuing system and their characteristics of M/M/1/FIFO/ Queuing system

Module 5: Games Theory **[6]**

Game theory: Introduction, Characteristics of game theory, Rules for game theory: pure strategy, dominance theory, mixed strategies (2x2, mx2) (algebraic, graphical and sub-game methods).

Text books:

1. Operations Research, (Revised Edition), D.S. Hira, P.K. Gupta, S. Chand & Company Ltd, 2014 **[T1]**
2. Quantitative Techniques Vol I and Vol II, L. C. Jhamb, Everest Publishing House **[T2]**
3. Operations Research, - Kanti Swarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons **[T3]**

Reference books:

1. Operations Research an Introduction –Hamady A. Taha, Prentice Hall. **[R1]**
2. Introduction to Operations Research, 9e, Frederick S. Hillier, Gerald J. Lieberman, Bodhibrata Nag and Preetam Basu, McGraw Hill **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Revised Simplex, Integer programming, other queuing models, Decision theory, Goal programming, Dynamic programming, Non-linear programming and Simulation. These topics are to be covered in an advanced course.

POs met through Gaps in the Syllabus:

POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:

Advanced Operation Research

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1, 3, 5, 7, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program-Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	2	1	0	1	2	1	3	3	3	3	3
CO2	3	3	3	2	1	0	1	2	1	3	3	3	3	3
CO3	3	3	3	2	1	0	1	2	1	3	3	3	2	3
CO4	3	3	3	2	1	0	1	2	1	3	3	3	3	3
CO5	3	3	3	2	1	0	1	3	1	3	3	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: ME 24205
Course title: STRENGTH OF MATERIALS
Pre-requisite(s): None
Co-requisite(s): None
Credits: 4 L: 3, T:1, P:0
Class schedule per week: 4
Class: B. Tech
Semester / Level: III / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1	Understand state of stress at a material point under plane stress and strain conditions.
2	Evaluate shear force and bending moment and corresponding stresses at a beam cross-section.
3	Determine deflection of beams using different methods.
4	Apply energy methods in structural problems.
5	Derive stress-strain behavior of thin and thick cylindrical shells.

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

CO1	Understand the stress-strain behavior of deformable bodies.
CO2	Apply the fundamental concepts of stress-strain in real life problems.
CO3	Analyse stresses and strains in simple structural elements under various loading conditions.
CO4	Evaluate deflections and deformations of different structural elements using appropriate methods.

SYLLABUS

Module: 1 **[9]**
Stress at a point on a plane, Stress transformation equation, Principal stresses, Mohr's circle of stresses, Strain transformation equation, principal strain, strain rosette.

Module: 2 **[9]**
Types of Beams, Types of loading and support, Relationship between Shear force, Bending Moment and intensity of loading, SFD, BMD, Point of Contraflexure, second moment of area, parallel axes theorem, Bending stress and shear stress in beam.

Module: 3 **[9]**
Deflection of Beams, Double integration method, Macaulay's method, Moment area method, Torsion of circular shafts.

Module: 4 **[9]**
Buckling of columns. Strain energy method, Castigliano's theorem, application of energy method on different types of beams and thin circular ring.

Module: 5 **[9]**
Thin and thick cylinders: Radial and circumferential stresses, stresses produced due to shrink fit. Rotating Disc: Stresses in disc of uniform thickness and uniform strength.

Text Books:
1. Strength of Materials by E J Hearn.
2. Strength of Materials by S. S. Rattan.
3. Mechanics of Material by Riley, Sturges, Morris

Reference Books:
1. Mechanics of Materials by S. Timoshenko and James M. Gere.

2. Strength of Materials by Ryder.
3. Advanced Mechanics of Material by Seely& Smith

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>
Material nonlinearity, fatigue analysis, and real-world design standards and codes.

<u>POs met through Gaps in the Syllabus:</u>

<u>Topics beyond syllabus/Advanced topics/Design</u>
Analysis and design of composite beams and advanced stress analysis

<u>POs met through Topics beyond syllabus/Advanced topics/Design</u> PO 1-5, PO 11-12.

<u>DIRECT ASSESSMENT</u>

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Continuous Internal Assessment	% Distribution
Mid Semester Examination	25
Quiz, Assignment	10 + 10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment	√	√	√	√
Semester End Examination	√	√	√	√

<u>INDIRECT ASSESSMENT</u>
1.Student Feedback on Course Outcome

COURSE DELIVERY METHODS

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

MAPPING BETWEEN COURSE OUTCOMES AND POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	3	3	1	0	0	0	1	0	3	3	1	1
CO2	3	3	3	3	2	0	0	0	1	0	3	3	2	2
CO3	3	3	3	3	1	0	0	0	1	0	3	3	1	1
CO4	3	3	3	3	2	0	0	0	2	0	3	3	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course code: ME 24208
Course title: BASIC MECHANICAL ENGINEERING LAB
Pre-requisite(s): None
Co-requisite(s): None
Credits: 1 L: 0, T:0, P:2
Class schedule per week: 2
Class: B. Tech
Semester / Level: III / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1	Familiarize with the basic Mechanical Engineering principles.
2	Impart knowledge and skill to use common Mechanical Engineering Equipment and measuring instruments.
3	Educate students of safe handling of machines and Equipment.

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

CO1	Be conversant with the basic Mechanical Engineering principles.
CO2	Explain the basic principles of Mechanical Engineering using various Instruments, and Equipment's.
CO3	Apply the fundamentals of Mechanical Engineering principles to perform experiments.
CO4	Develop skills to work as an individual or in a team during Lab Experiments.

SYLLABUS

LIST OF EXPERIMENT:

1. **EXPERIMENT – 1**

Objective: Experimental determination of forces in members of statically determinant truss.

2. **EXPERIMENT – 2**

Objective: To find out the mechanical advantage, velocity ratio and mechanical efficiency of simple screw jack and plot a graph of applied load vs. actual effort, applied load vs. mechanical advantage and applied load vs. mechanical efficiency.

3. **EXPERIMENT – 3**

Objective: To evaluate the mechanical advantage, velocity ratio and the mechanical advantage of a worm and worm wheel and plot a graph of applied load vs. actual effort, applied load vs. mechanical advantage and applied load vs. mechanical efficiency.

4. **EXPERIMENT – 4**

Objective: To determine the shear force and bending moment in a simply supported and cantilever beam.

5. **EXPERIMENT – 5**

Objective: Determination of modulus of rigidity of a solid and hollow shaft using torsion test.

6. **EXPERIMENT – 6**

Objective: To determine the tensile strength of low and high carbon steel and plot stress-strain for the two specimens.

7. **EXPERIMENT – 7**

Objective: To determine the impact strength of mild steel and cast iron.

8. **EXPERIMENT – 8**

Objective: Measurement of Torque and Power in a rotating shaft.

9. **EXPERIMENT – 9**

Objective: Determination of Brinell and Rockwell hardness of mild steel and cast iron.

10. **EXPERIMENT – 10**

Objective: Plotting of I-V and P-V characteristics of a given solar photo-voltaic module with varying radiation intensity, temperature level and tilt angle.

11. **EXPERIMENT – 11**

Objective: To study the I-V and P-V characteristics of solar modules when (i) connected in series and (ii) connected in parallel.

12. **EXPERIMENT – 12**

Objective: Measurement of dry bulb temperature (DBT), wet bulb temperature (WBT), wet bulb depression and humidity of room air.

Text Books:

1. Engineering Mechanics: Statics and Dynamics by Shames and Rao (**T1**)
2. Strength of Materials by S.S.Rattan. (**T2)**

Reference Books:

1. Mechanics of Materials by S. Timoshenko and James M. Gere. (**R1**)

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	**% Distribution**
Day to day performance & Lab files	30
Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	3	2	2	2	2	1	3	3	2	2
CO2	3	3	3	3	3	2	2	2	2	1	3	3	2	2
CO3	3	3	3	3	3	2	2	2	2	1	3	2	3	2
CO4	3	3	3	3	3	3	3	3	3	2	3	2	3	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD3
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD1, CD3
CO5	CD1, CD3

COURSE INFORMATION SHEET

Course code: ME 24221
Course title: THERMAL AND FLUID ENGINEERING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 **L:**3 **T:**0 **P:**0
Class schedule per week: 3
Class: B. Tech
Semester / Level: III / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Comprehend the basics of classical thermodynamics.
2	Apply the laws of thermodynamics in heat transfer, fluid mechanics and energy conversion systems.
3	Comprehend and apply the basic concepts of heat transfer.
4	Present a comprehensive and rigorous treatment of classical fluid mechanics while retaining an engineering perspective.
5	Analyze various fluid flow devices and energy conversion systems.

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

CO1	Outline the basic concepts of thermodynamics.
CO2	Analyze non-flow and steady flow systems and evaluate the performance of cyclic devices.
CO3	Identify and paraphrase the modes, laws and operating conditions of heat transfer problems investigating the steady and unsteady state conduction.
CO4	Outline the concepts of continuum, system of control volume, fluid, and flow properties.
CO5	Apply the appropriate fundamental laws of fluid statics, dynamics to various fluid devices.

SYLLABUS

Module 1: Basics of Thermodynamics **[8]**
Thermodynamic system, control volume, properties, processes and cycles, thermodynamic equilibrium, concept of continuum, Quasi static process, Zeroth law of thermodynamics, Concept of ideal gases and their equations of state, pure substance and phase, work and heat transfer.

Module 2: First & Second Law of Thermodynamics **[12]**
First law of thermodynamics for cyclic and non-cyclic process, internal energy, enthalpy, steady flow energy equation, application of SFEE for devices such as boiler, turbine, heat exchangers, pumps, nozzles, etc. Concept of a heat engine, statements of the second law, their equivalence, heat pump, refrigerator, reversible heat engine, Carnot theorems and corollaries, Concept of reversibility, Absolute thermodynamic temperature scale. Air standard cycles – Otto, Diesel and Brayton cycles.

Module 3: Basics of Heat Transfer & Conduction **[8]**
Conduction, convection, and radiation - basic equation and applications, generalized conduction differential equation, simple steady and unsteady state solution, one dimensional heat conduction without heat generation and with heat generation composite walls, cylinders and spheres, electrical analogs of thermal systems.

Module 4: Fluid Statics & Kinematics **[8]**
Fluid statics: Fluid as continuum, Eulerian and Lagrangian description of fluid flow, Physical properties of fluids Hydrostatic force on submerged surfaces, Buoyancy, stability. **Fluid kinematics:** Velocity and acceleration of fluid particles**,** Stream function, velocity potential function, Vorticity, circulation.

Module 5: Fluid Dynamics **[8]**
Euler's equation, Bernoulli's equation and steady flow energy equation, applications of Bernoulli's equation, impulse momentum equation, flow through pipes, Viscous flow (Poiseuille and Couette flows), Rayleigh and Buckingham pi theorem.

Text Book

1. Nag, P.K, 1995, Engineering Thermodynamics, Tata McGraw-Hill Publishing Co. Ltd. **(T1)**
2. Fluid Mechanics, Fundamentals and Applications (in SI Unit) by Yunus A. Cangel and John M. Cimbala, McGraw Hill. **(T2)**
3. Heat Transfer, J. P. Holman, Souvik Bhattacharya, Mcgraw Higher Ed Publishers, 2011. **(T3)**

Reference Book

1. Sonntag, R. E, Borgnakke, C. and Van Wylen, G. J., 2003, 6th Edition, Fundamentals of Thermodynamics, John Wiley and Sons. **(R1)**
2. Fluid Mechanics by V. L. Streeter **(R2)**
3. Heat and Mass Transfer: Fundamentals and Applications, Yunus A. Cengel, Afshin J. Ghajar, McGraw Hill Education Publisher, 2017 **(R3)**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:
POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:
Forced and free convection, Heat exchanger analysis, Gas radiation

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	**% Contribution during CO Assessment**
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	**% Distribution**				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	2	0	0	0	0	1	0	2	3	2	3
CO2	3	3	3	2	0	0	0	0	1	0	2	3	2	3
CO3	3	3	3	2	0	0	0	0	1	0	2	3	2	3
CO4	3	3	3	2	0	0	0	0	1	0	2	3	2	3
CO5	3	3	3	2	0	0	0	0	1	0	2	3	2	3

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High)

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: ME 24207
Course title: KINEMATICS AND DYNAMICS OF MACHINES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 4 L:3 T:1 P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: IV / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand basic principles of kinematic chains, Degree of freedom.
2	Analyze velocity and acceleration of planar mechanisms, balancing in rotary and reciprocating machinery, forces and moments acting in planar mechanism
3	Evaluate and design contact ratio, tooth profile and related parameters of gears.
4	Design cam profiles for specified motion of follower, Flywheel and governor.
5	Understand conservation of angular momentum and gyroscopic couple.

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

CO1	Explain kinematic and dynamic principles of planar mechanism.
CO2	Apply the basic principles into planar mechanisms for relevant applications.
CO3	Anlayse the acceleration and forces during the motion of machines and mechanisms.
CO4	Evaluate the problems related to the motions of machines and mechanism.

SYLLABUS

Module 1: Planar mechanisms and kinematic analysis **[9]**
Mechanisms and machines, kinematic pairs, kinematic chains, kinematic inversions, mobility and range of movement, velocity and acceleration analysis, Coriolis' component of acceleration, instantaneous center of zero velocity, Aronhold-Kennedy theorem of three centers.

Module 2: Gear and Cam **[9]**
Basic terminology of a spur gear, types of gears, fundamental law of gearing, contact ratio, interference and undercutting, gear trains, basic terminology of cam, displacement diagram, velocity and acceleration of follower.

Module 3: Flywheel and Governor **[9]**
D'Alembert's principle and dynamic equilibrium, Dynamic force analysis (analytical method), Dynamically equivalent link, turning moment on crank shaft, Turning moment diagram, fluctuation of energy and speed, flywheel.
Principles of centrifugal governors: Porter, Proell and Hartnell governor.

Module 4: Balancing **[9]**
Balancing of reciprocating and rotating masses, two plane balancing, Balancing of inline, V twin, and radial engines.

Module 5: Gyroscope **[9]**
Gyroscopic couple, gyroscopic effect on aeroplanes, gyroscopic effect on naval ships, stability of an automobile, stability of a two-wheel vehicle, rigid disc at an angle fixed to a rotating shaft.

Text books:

1. S. S. Rattan, Theory of Machines, Tata McGraw Hill education, Third Edition. **[T1]**
2. Thomas Bevan, The theory of Machines, CBS Publishers and Distributers Privet Limited, Third edition. **[T2]**

Reference books:

1. John J. Uicker, Gordon R. Pennockand, Joseph E. Shigley Theory Of Machine and Mechanisms, Oxford University Press; 4th edition. **[R1]**
2. R. L. Norton, Kinematics and Dynamics of Machinery, McGraw Hill Education. **[R2]**
3. A. Ghosh and A. K. Mallik, Theory of Mechanisms and Machines, Affiliated East-West Press Privet Limited, Third edition **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	2	2	2	2	2	1	2	2	1	2
CO2	3	3	3	3	2	3	2	2	2	1	2	2	1	2
CO3	3	3	3	3	2	2	2	2	2	1	2	2	1	2
CO4	3	3	3	3	2	2	2	2	2	1	2	2	1	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2
CO4	CD1, CD2
CO5	CD1, CD2

COURSE INFORMATION SHEET

Course code: PE 24205
Course title: FOUNDRY, FORMING AND WELDING TECHNOLOGIES
Pre-requisite(s): None
Co- requisite (s): FOUNDRY, FORMING AND WELDING LAB
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: IV / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Examine the technical aspect related to sand casting and riser designing
2	Get acquainted with advantages, limitations of various casting process
3	Acquire fundamentals of various types of joining processes
4	Get familiar with NDT techniques and advantages, disadvantages and limitations of various welding processes
5	Develop an understanding of forming processes

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

CO1	Interpret foundry practices like the basic principles in casting and derive relationship in riser designing, cavity filling etc.
CO2	Select appropriate casting process for a given component
CO3	Identify the advantages and limitations of the various types of joining processes and select the appropriate one according to the application. Interpret the characteristic curves for welding transformer.
CO4	Apply NDT techniques to identify various casting and welding defects
CO5	Differentiate various metal forming processes such as hot and cold working, rolling, forging, extrusion, sheet metal works and drawing Processes.

SYLLABUS

Module 1: Sand Casting **[10]**
Introduction to casting process and its importance, Patterns, pattern materials, types of patterns, pattern allowances, molding and core sands, properties of molding and core sands, mould and core making. Sand testing: grain fineness, moisture content, clay content and permeability test, gating system design and risers & riser design, filling time problems, Sand casting defects

Module 2: Casting Processes **[5]**
Shell moulding; Investment casting; Evaporative Pattern casting; Die casting; Centrifugal casting; Continuous casting

Module 3: Welding **[8]**
Welding introduction and classification of welding processes, welding terminology, general principles, welding positions, welding join types, welding edge preparation.
Gas welding and gas cutting, principles of oxy-fuel welding and cutting
Arc Welding: Power sources and arc welding electrodes and its coating, working principles and applications of SMAW, welding characteristic curve, GMAW, GTAW, SAW; Modes of metal transfer in GMAW and their applications. Plasma arc welding, Stud arc welding, soldering and brazing

Module 4: Welding Processes and NDT inspection **[10]**

Working principles and applications of thermit welding, resistance welding; spot, seam, projection and butt welding, electroslag welding, Ultrasonic welding, electron beam welding (EBM), Laser beam Welding (LBW) Introduction to Non-Destructive Testing (NDT) testing: Dye penetration testing, eddy current testing, magnetic particles testing, x-ray inspection, and ultrasound testing

Module 5: Forming processes **[7]**

Introduction to recovery, recrystallization and grain growth; hot working and cold working

Rolling: Classification of rolling processes, rolling mills, products of rolling and main variables

Drawing: Drawing of rods, wires and tubes

Forging: Open and closed die forging, forging operations, hammer forging, press forging and drop forging

Extrusion: Classification of extrusion processes, hot and cold extrusion processes

Sheet metal forming operations: Blanking, piercing, deep drawing, bending**.**

Text books:

1. Serope Kalpakjian and Steven Schmidt , Manufacturing Processes for Engineering Materials, Pearson Education, 6th Edition **[T1]**
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Material. Processes, and systems, 2nd Edition, Wiley India, 2007 **[T2]**
3. P.N. Rao, Manufacturing Technology, Foundry, Forming and Welding, McGraw Hill **[T4]**
4. Hajra Choudhury, Elements of Workshop Technology–Vol.-II, Media Promoters and Publishers **[T5]**

Reference books:

1. E. P. DeGarmo, J. T. Black, and R. A. Kohser, Materials and processes in Manufacturing, PHI. **[R1]**
2. P. F. Ostwald, and Jairo Munoz, Manufacturing Processes and Systems, 9th ed., Wiley, India, 2002 **[R2]**
3. Principles of metal casting, Rosenthal. P. C, Tata Mc Graw Hill **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Melting furnaces, Physics of arc welding

POs met through Gaps in the Syllabus:

POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:

Advance Forming Processes

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1-3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	1	2	1	0	0	1	0	1	3	2	3
CO2	2	3	3	1	2	1	0	0	1	0	1	3	1	3
CO3	2	3	3	2	2	1	1	1	1	1	2	3	2	3
CO4	2	2	2	3	3	1	1	1	1	0	2	3	1	3
CO5	3	2	2	1	2	1	0	0	1	0	1	3	1	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24206
Course title: FOUNDRY, FORMING AND WELDING LAB
Pre-requisite(s): None
Co- requisite(s): FOUNDRY, FORMING AND WELDING TECHNOLOGIES
Credits: 1 L:0 T:0 P: 2
Class schedule per week: 2
Class: B.Tech
Semester / Level: IV / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Design the complete sand-casting process that produces defect-free components.
2	Select appropriate casting process for a given component.
3	Study the advantages and limitations of various joining processes to select the appropriate method for specific applications and interpret characteristic curves for welding transformers.
4	Apply NDT techniques to identify various casting and welding defects
5	Classify and compare various metal forming processes including hot and cold working, rolling, forging, extrusion, sheet metal work, and drawing processes.

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

CO1	Analyze the properties of the molding sand and create pattern for sand casting.
CO2	Perform different welding technique to weld the workpiece in different position and types.
CO3	Apply Non-Destructive Testing (NDT) methods to evaluate weld quality.
CO4	Perform operations in CNC Plasma Cutting and EDM Wire Cutting machines, demonstrating skill in precision cutting techniques and CNC programming skills.
CO5	Implement sheet metal forming techniques to achieve different products.

SYLLABUS

LIST OF EXPERIMENT:

1. **FOUNDRY and CARPENTARY SHOP**
EXPERIMENT – I: Pattern Study and Pattern Making
Objective: Study the various types of patterns used in sand casting. Prepare a single piece/split wooden pattern according to the given dimensions for aluminium casting.

2. **FOUNDRY SHOP**
EXPERIMENT – II: Moisture and Clay Content Test
Objective: Determine the amount of moisture in the given molding sand sample. And assess the amount of clay in the given molding sand sample.

3. **FOUNDRY SHOP**
EXPERIMENT – III: Grain Fineness Number
Objective: To determine the Grain fineness number for given molding sand sample.

4. **FOUNDRY SHOP**
EXPERIMENT – IV: Single piece pattern molding
Objective: Study the various steps that are required to prepare the single piece pattern molding.

5. **FOUNDRY SHOP**
EXPERIMENT – V: Two pieces pattern casting

Objective: Study the various steps that are required to prepare the two pieces pattern casting product according to given dimensions.

6. **WELDING SHOP**
EXPERIMENT – I: Shielded Metal Arc Welding
Objective: To study the effect of AC and DC arc in manual/shielded metal arc welding.

7. **WELDING SHOP**
EXPERIMENT – II: Gas Metal Arc Welding
Objective: Determine the metal deposition rate in Gas Metal Arc Welding (GMAW) and identify the quality of the weld joint using Dye Penetration Testing.

8. **WELDING SHOP**
EXPERIMENT – III: Submerged Arc Welding
Objective: Study Submerged Arc Welding (SAW) equipment and conduct SAW welding. Evaluate the weld joint quality using an ultrasound flow detector.

9. **WELDING SHOP**
EXPERIMENT – IV: Spot Welding
Objective: To study resistance welding equipment and perform spot welding on thin sheet.

10. **WELDING SHOP**
EXPERIMENT – IV: Spot Welding
Objective: To study resistance welding equipment and perform spot welding on thin sheet.

11. **WELDING SHOP**
EXPERIMENT –V: Friction stir welding (FSW)
Objective: To study FSW equipment and conduct the welding for similar and dissimilar material/ alloys.

12. **MACHINING SHOP**
EXPERIMENT – I: CNC PLASMA CUTTING
Objective: To study resistance welding equipment and perform spot welding on thin sheet.
13. **MACHINING SHOP**
EXPERIMENT – II: EDM WIRE CUTTING
Objective: To study resistance welding equipment and perform spot welding on thin sheet.

14. **FORMING PROCESSES**
EXPERIMENT – I: SHEET METAL FORMING
Objective: To prepare a sheet metal product (square container)

TEXT BOOK

1. S K Hajra Choudhury, A K. Hajra, “Elements of Workshop Technology: Vol- I and Vol -II”, Media Promotors Pvt Ltd. **(T1)**
2. B S Raghuwanshi, "A course in Workshop Technology", Dhanpat Rai Publications. **(T2)**

REFERENCE BOOK

1. P.N. Rao, “Manufacturing Technology Vol-1and Vol-II”, Tata McGraw Hill. **(R1)**
2. Kalpakjian, "Manufacturing Engineering and Technology", Pearson. **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Nil

POs met through Gaps in the Syllabus:
Nil

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Day to day performance & Lab files	√	√	√	√	√
Quiz 1	√	√	√	√	√
Quiz 2	√	√	√	√	√
Viva-voce	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	1	2	1	0	1	1	0	1	3	1	3
CO2	3	2	2	2	2	2	1	2	1	1	1	3	1	3
CO3	2	2	1	3	2	1	1	1	2	0	1	3	1	3
CO4	3	2	2	2	3	1	0	1	2	1	2	3	1	3
CO5	3	2	3	1	2	2	1	2	1	1	2	3	1	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD3
CO2	CD3
CO3	CD3
CO4	CD3
CO5	CD3

COURSE INFORMATION SHEET

Course code: PE 24207
Course title: METROLOGY & MEASUREMENT
Pre-requisite(s): None
Co- requisite(s): METROLOGY & MEASUREMENT LAB
Credits: 3 L: 3 T:0 P:0
Class schedule per week: 3
Class: B.Tech
Semester / Level: IV / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1	To understand different measurement systems, standards of measurement and measurement errors
2	To learn about the features of measuring instruments, gauges, comparators and advancements in the field of metrology
3	To develop the knowledge about 'Limits', 'Fits' and 'Gauges' used for inspection; and designing aspects for the limit gauges.
4	To study and apply various techniques of measurement of Screw threads, Gears, Geometric forms and Surface textures.
5	To understand the principles and operation of measurement tools for force, vibration, strain and other related factors.

Course Outcomes

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

CO1	Explain measurement systems, standards of measurement and identify measurement errors
CO2	Interpret the characteristics of measuring instruments, gauges, comparators and advanced techniques in the field of metrology
CO3	Solve numerical problems on limit gauges design
CO4	Select, calibrate and use the equipment for measuring screw threads, gears, surface textures/profiles
CO5	Implement and analyze measurement methods for variables like force, strain, vibration

SYLLABUS

Module – 2: Introduction **[6]**

Historical development, Basics of Metrology, Need for Inspection, Accuracy and Precision, Standards of measurements, system of measurement, line, end & wavelength standards, type and source of measurement errors, Linear metrology: conventional and modern techniques, Miscellaneous measurements: Taper measurement, angle measurement, radius measurement, sine bar & Angle gauges

Module – 2: Limit Fits and Gauge **[10]**

Interchangeable manufacture, selective assembly, concept of limits, fits and tolerances, Types of fit, Basic-Hole System, Basic-Shaft System, Problems, Tolerance grades, Metric fits, Indian standard system, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials, Considerations of gauge design, Taylor's principle of gauging, Wear allowance on gauges

Module – 3: Comparator and Optical gauges
[6] Principle and uses of mechanical, optical, Electrical, electronic and pneumatic Comparators Principle of interferometer, concept of optical flat, projector, microscope, autocollimator and interferometer, Laser-based techniques. Types of machine tool tests, alignment tests for lathe, milling and drilling machine tools

Module – 4: Form Measurement
[10] Terminology of screw threads, Measurement of minor, major, thread angle and effective diameter of screw threads by 2-wire and 3- wire methods, best size wire. Screw thread gauges, Tool maker's microscope.
Gear tooth terminology, gear tooth thickness & pitch measurement, involutes profile testing of gear.
Straightness, flatness and squareness and circularity tests, numerical evaluation, measurement of surface finish, related instruments.
Automated inspection system, Introduction & applications of Co-ordinate Measuring Machine (CMM)

Module – 5: Dynamic measurement **[8]**
Sensors and Transducers: Types of Sensors, types of transducers and their characteristics Force and Torque measurement: Direct methods and indirect method, force measuring instruments-load cells, Dynamometer, Power Measurements
Measurement of strain: types of strain gauges, gauge factors, theory of strain gauges and method of measurement, Wheatstone bridge circuit
Vibration and Noise Measurement: Piezoelectric Accelerometer and decibel meters

Text Books:

1. R.K. Jain, Engineering Metrology Khanna Publications, New Delhi **(T1)**
2. I. C. Gupta, A Text book of Engineering Metrology, Dhanpat Rai, New Delhi **(T2)**
3. Er. R K Rajput, Mechanical Measurements and Instrumentations, Kataria Publication (KATSON) **(T3)**
4. M. Mahajan, Engineering Metrology, Dhanpat Rai & Co. New Delhi **(T4)**

Reference Books:

1. K. J. Hume, Engineering Metrology **(R1)**
2. N V Raghavendra and Krishnamurthy, Engineering Metrology and Measurement, Oxford University Press **(R2)**
3. Bentley, Engineering Metrology and Measurements, Pearson Education **(R3)**
4. Anand Bewoor, Vinay Kulkarni, Metrology and Measurement, McGraw-Hill **(R4)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Limited scope to get acquainted with latest gadgets/instruments used in industries. No direct relation with environmental, societal issues, ethics etc.

POs met through Gaps in the Syllabus:
POs 5-8, 11-12

Topics beyond syllabus/Advanced topics/Design:
Latest equipment in the field of metrology

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 5, 6-8, 11-12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	55
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	1	0	2	0	0	0	0	0	0	0	2	1	2
CO2	3	0	0	1	0	0	0	0	0	0	0	2	1	2
CO3	3	2	3	2	0	0	0	0	0	0	0	2	1	2
CO4	3	2	2	1	0	0	0	0	0	0	0	2	1	2
CO5	3	2	2	1	0	0	0	0	0	0	0	2	1	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (Cos) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 3, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 3, CD 6
CO4	CD1, CD2, CD 3, CD 6
CO5	CD1, CD2, CD 3, CD 6

COURSE INFORMATION SHEET

Course code: PE 24208
Course title: METROLOGY & MEASUREMENT LAB
Pre-requisite(s): None
Co- requisite(s): METROLOGY & MEASUREMENT
Credits: 1 L:0 T:0 P: 2
Class schedule per week: 2
Class: B.Tech
Semester / Level: IV / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	To understand the operation of precision measurement tools and equipment used in modern manufacturing
2	To Select suitable instrument, gauge, method of inspection for determining geometrical and dimensional measurements
3	To calibrate measuring instruments and handle limit gauges
4	Understand the advances in Metrology in comparison with conventional methods and equipment for measurement
5	Acquire Hands on experience with various measuring instruments to utilize in industries

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

CO1	Demonstrate and use different length measuring instruments like vernier calipers and micrometers; and angle measuring instrument like sine bar
CO2	Operate different gauges and comparators.
CO3	Determine various parameters related to screw threads and gears.
CO4	Evaluate the surface quality and contour of a given specimen.
CO5	Perform dynamic measurements and non-destructive testing.

SYLLABUS

LIST OF EXPERIMENT:

EXPERIMENT – 1: Linear Measurement-I

Objective: To study the measurement of dimensions of a given work piece using Vernier caliper. Outside and inside micrometer and calculate the least count in each equipment.

EXPERIMENT – 2: Linear Measurement-II

Objective: To study the measurement of height and depth of a given work piece using height gauge and depth micrometer and calculate the least count in each equipment.

EXPERIMENT – 3: Gauges

Objective: Study of Gauges (slip gauges/feeler gauge/Go-NO Go gauges etc.).

EXPERIMENT – 4: Angular Measurement

Objective: Measurement of angle using Sine bar, angle gauges

EXPERIMENT – 5: Optical Metrology I

Objective: To study the profiles of single point cutting tool ("V" tool) / thread by profile projector

EXPERIMENT – 6: Optical Metrology II

Objective: To study the working of optical flat and monochromatic light source.

EXPERIMENT – 7: Gear Metrology

Objective: Measurement of gear tooth profile using gear tooth vernier /Gear tooth micrometer

EXPERIMENT – 8: Screw Thread Metrology

Objective: Measurement of Screw thread parameters using Two-wire or Three-wire method

EXPERIMENT – 9: Comparator: Geometric Form Measurement

Objective: To study the working of electronic comparator; measurement of thickness, flatness and roundness using dial gauge and electronic comparator

EXPERIMENT – 10: Surface Profile

Objective: To study the Taylor Hobson contour measurement instrument and determine the contour of a given test-piece.

EXPERIMENT – 11: Surface Roughness

Objective: Measurement of surface roughness (Ra, Rz values etc.)

EXPERIMENT – 12: Dynamic Measurement

Objective: Measurement of cutting tool forces using tool dynamometer

EXPERIMENT – 13: Ultrasonic flaw detector

Objective: Testing of welded/cast samples.

EXPERIMENT – 14: IoT-based Measuring Devices

Objective: Measurement of geometric features and IoT-based digital recording of measured data.

Text Book:

1. R.K. Jain, Engineering Metrology Khanna Publications, New Delhi **(T1)**
2. I. C. Gupta, A Text book of Engineering Metrology, Dhanpat Rai, New Delhi **(T2)**

Reference Book:

1. M. Mahajan, Engineering Metrology, Dhanpat Rai & Co. New Delhi **(R1)**
2. N V Raghavendra and Krishnamurthy, Engineering Metrology and Measurement, Oxford University Press **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Availability of limited number of advanced equipment.

POs met through Gaps in the Syllabus:
PO 5

Topics beyond syllabus/Advanced topics/Design:
Latest equipment in the field of metrology and measurement

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 5, 6-8, 11-12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:
Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Day to day performance & Lab files	√	√	√	√	
Quiz 1	√	√			
Quiz 2			√	√	
Viva-voce	√	√	√	√	
Examination: Experiment Performance	√	√	√	√	

Indirect Assessment –
1. Student Feedback on Course Outcome

Mapping of Course Outcomes (Cos) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	0	3	0	0	0	0	3	0	2	2	0	2
CO2	3	2	0	3	0	0	0	0	3	0	2	2	0	2
CO3	3	2	0	3	0	0	0	0	3	0	2	2	0	2
CO4	3	2	0	3	0	0	0	0	3	0	2	2	0	2
CO5	3	2	0	3	0	0	0	0	3	0	2	2	0	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (Cos) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD3, CD6
CO2	CD3, CD6
CO3	CD3, CD6
CO4	CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24209
Course title: PRODUCTION AND OPERATIONS MANAGEMENT
Pre-requisite(s): None
Co- requisite(s): None
Credits: 4 L:4 T: P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: IV / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students:

1	To introduce to various inherent concepts of production systems, planning and control systems of Manufacturing Industry.
2	To introduce of forecasting models, Product mix and aggregate planning.
3	To make routine process, scheduling process and identify different strategies employed in manufacturing industries to production planning.
4	To give basic concept of inventory control and its technique, EOQ, ABC analysis.
5	To know Facility design process and its all component.

Course Outcomes:
After the completion of this course, students will:

CO1	Able to understand the functions of production system its planning and control.
CO2	Able to make demand forecasts in the manufacturing sectors using selected quantitative and qualitative techniques.
CO3	Able to explain the importance and function of pre planning and post planning of production system.
CO4	Able to solve inventory problems and to be able to apply selected techniques for its control and management under dependent and independent circumstances.
CO5	Understand plant layout, building layout and location theory.

SYLLABUS

Module 1: Introduction to production and operation management **[8]**
Difference between manufacturing and service operations, Objectives and functions of production and operation management, historical evolution of production and operations management. type of Production systems and their characteristics, selection of a production system, concept of productivity.

Module 2: Preplanning **[10]**
Demand forecasting, common techniques of demand forecasting, Capacity management, aggregate planning and master scheduling.

Module 3: Production Planning **[10]**
Routing, Loading and scheduling with their different techniques, dispatching, Progress Report, Expediting and corrective measures.

Module 4: Inventory Control **[10]**
Field and scope of inventory control, inventory types and classification, Inventory control models, static model, dynamic model both deterministic and stochastic, Economic lot size, reorder point and their application, ABC analysis, VED analysis, modern practices in purchasing and store Management.

Module 5: Facility design **[12]**
Facility design problems and their analysis.
Facility location- Need of location, Factors affecting the location and site selection, multi-plant location, location theories and models.

Facility layout- Objectives, principles and classification of layouts; Factors affecting plant layout; models of product layout, process layout and service layout.

Text books:

1. Production & Operations management, Jay Heizer and Barry Render, Prentice Hall **[T1]**
2. William J. Stevenson, Operations Management, McGraw-Hill, 13th edition **[T2]**
3. S. N. Chary, Production and operations management, Tata McGraw-Hill Education, 5th Edition **[T3].**
4. P K Gupta, D.S Hira, Operations Research, S chand 7th edition **[T4]**

Reference books:

1. R. Panneerselvam, Production and operations management, PHI Learning Pvt. Ltd **[R1]**
2. Richard B. Chase, Nicholas J. Aquilano, Production & Operations Management: Manufacturing and Services, Publisher: Richard D Irwin; 7th edition **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Logistics and supply chain management, Inventory model design

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1 -4, 9, 11, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	2	2	1	0	1	2	3	3	3	2	3
CO2	3	3	1	2	2	1	0	1	2	3	2	3	2	3
CO3	3	3	3	2	2	1	0	1	2	2	3	3	2	3
CO4	3	3	1	2	2	1	0	1	2	2	2	3	2	3
CO5	3	3	1	3	2	1	0	1	2	2	2	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24210
Course title: MODELING AND SIMULATION LAB
Pre-requisite(s): None
Co- requisite(s): None
Credits: 1 L:0 T:0 P: 2
Class schedule per week: 2
Class: B.Tech
Semester / Level: IV / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Impart skill to use simulation software
2	Develop the ability to build models before simulation.
3	Think of various practical applications of simulation in manufacturing
4	Manually solve small simulation problems using random numbers and probability distributions.

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

CO1	Comprehend the basics of discrete event simulation as applied to various manufacturing and service problems
CO2	Build soft models in computer program/software for a given situation using randomly generated distributions
CO3	Develop a simulation table using pseudo-random numbers or a simulation model using software program
CO4	Analyze the output from a simulation model

SYLLABUS

LIST OF EXPERIMENT:

1. **EXPERIMENT – 1: Introduction to simulation**
   Objective: To explain the basics of modelling and simulation like discrete events, activities, queue and random numbers in simulation

2. **EXPERIMENT – 2: Simulation software**
   Objective: To study the various simulation software and their features particularly useful in manufacturing and logistics

3. **EXPERIMENT – 3: Introduction to simulation exercise (Manual)**
   Objective: To use pseudo-random numbers in solving simulation problems

4. **EXPERIMENT – 4: Simulation of bank operation**
   Objective: Simulation of a bank is to be performed using manual approach using probability distributions for arrival and service time

5. **EXPERIMENT – 5: Simulation of robotic work cell**
   Objective: Simulation of a robotic work cell is to be performed using manual approach using probability distributions for machine operation, loading unloading by robot

6. **EXPERIMENT – 6: Simulation of drill press operation**
   Objective: Simulation of a drill press is to be performed using manual approach using probability distributions for operation.

7. **EXPERIMENT – 7: Simulation of a grocery shop**
   Objective: Simulation of a grocery shop is to be performed using manual approach using probability distributions for arrival and service for customers

8. **EXPERIMENT – 8: Simulation exercise using GPSS software**
   Objective: Simulation of a food store is to be performed using GPSS software and analyze the output

9. **EXPERIMENT – 9: Simulation of factory maintenance**
   Objective: Simulation of a factory maintenance service is to be performed using GPSS software and analyze the output

10. **EXPERIMENT – 10: Simulation of ambulance dispatch**
    Objective: Simulation of an ambulance dispatch service is to be performed using GPSS software and analyze the output

11. **EXPERIMENT – 11: Simulation using WITNESS software**
    Objective: To learn the software WITNESS and its features for simulation

12. **EXPERIMENT – 12: Simulation of factory shop floor**
    Objective: To apply the software WITNESS for simulation of a factory shop floor

13. **EXPERIMENT – 13: Monte Carlo simulation**
    Objective: To apply MINITAB software for a Monte Carlo simulation problem

Reference Book

1. Jerry Banks, Discrete event system simulation, Pearson new International Edition **[R1]**
2. Averil M. Law and David Kelton, Simulation modelling and analysis, McGraw Hill **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Warehouse and logistic simulation

POs met through Gaps in the Syllabus:
POs 3,5

Topics beyond syllabus/Advanced topics/Design:
Simulation of sheet metal forming, casting and welding

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 2,4,5

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	√

Course Evaluation:
Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution				
Day to day performance & Lab files	30				
Quiz 1	10				
Viva-voce	20				
End Semester Examination	**% Distribution**				
Examination: Experiment Performance	30				
Quiz 2	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Day to day performance & Lab files	√	√	√	√	
Quiz 1	√	√	√		
Quiz 2			√	√	
Viva-voce	√	√	√	√	
Examination: Experiment Performance	√	√	√	√	

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	1	0	0	3	0	0	2	0	0	0	2	2	2
CO2	3	2	1	1	3	0	0	2	1	2	3	1	3	3
CO3	3	2	2	0	3	0	0	2	0	2	3	2	3	3
CO4	3	0	3	1	3	0	0	2	2	2	2	3	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD3, CD7
CO2	CD1, CD3, CD7
CO3	CD1, CD3, CD7
CO4	CD1, CD3, CD7

COURSE INFORMATION SHEET

Course code: PE 24211
Course title: RELIABILITY AND MAINTENANCE ENGINEERING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: IV / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Comprehend the fundamentals of reliability engineering
2.	Get acquainted with the concepts of reliability, maintainability and availability
3.	Familiarize with the different types of maintenance and root cause analysis
4.	Conceptualize the various levels of condition monitoring and risk assessment
5.	Explore failure mode effect analysis and Total productive maintenance

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

CO1	Analyse the reliability of different types of equipment/machines and products.
CO2	Apply the tools and techniques of reliability and maintainability
CO3	Estimate the root cause analysis and maintenance costs of different machines
CO4	Plan for risk assessment for condition monitoring
CO5	Analyse failure mode effect analysis of different machines and products.

SYLLABUS

Module 1: Reliability **[8]**

Introduction to reliability, measurement of reliability and Bath-tub curve. Probability distribution: Cumulative distribution function, Probability density function. Reliability function: Normal distribution, log normal distribution and exponential distribution function.

Module 2: **Maintainability** **[8]**

Definition, Importance, Purpose and results of maintainability efforts, maintainability in product life cycle, availability, repairability, maintainability testing, costing, budgeting, Control index of maintenance system.

Module 3: **Maintenance Strategy** **[8]**

Principle, relative advantage, limitation and application of various maintenance strategies like, preventive maintenance, predictive maintenance, Reliability based maintenance, computer integrated maintenance system. Improvement maintenance and POKA YOKE methods. Root cause analysis.

Module 4: **Condition Monitoring** **[8]**

Condition-based maintenance: methodology and levels, condition monitoring techniques: performance monitoring, visual, optical, tactile monitoring, temperature monitoring etc. Hazard Identification and Risk Assessment. Accident/ Incidence Investigation.

Module 5: Terotechnology **[8]**
Replacement policy, Product LCA, failure mode effect and critical analysis, fault tree analysis, cause and effect diagram. Total Productive Maintenance (TPM): objectives, principles and pillars of TPM.

Text books:
1. L.S. Srinath, Reliability Engineering, East-West Press, India **(T1)**
2. B.S. Dhillon, Engineering Maintainability, Eastern Economy Edition PHI **(T2)**
3. A.K. Gupta, Reliability Engineering and Technology, Macmillan India Limited **(T3)**

4. M. Mahajan, Statistical Quality Control, Dhanpat Rai & Co., India **(T4)**

Reference books:

1. V. Venkataraman, Maintenance Engineering and Management, PHI **(R1)**
2. S.K. Srivastav, Industrial Maintenance Management, S. Chand & Company, India **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements)

Maintenance of typical rotating and process equipment's like turbine, heat exchanger and pressure vessels

POs met through Gaps in the Syllabus

POs 1, 3, 4

Topics beyond syllabus/Advanced topics/Design

Maintainability of complex machines

POs met through Topics beyond syllabus/Advanced topics/Design:

PO4

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	**% Contribution during CO Assessment**
Progressive Evaluation	50
End Semester Examination	50
Progressive Evaluation	**% Distribution**
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	1	2	0	0	0	2	1	0	1	1	3
CO2	3	3	3	0	2	1	1	0	2	2	0	2	2	3
CO3	2	3	3	3	3	2	1	1	2	2	2	3	1	3
CO4	2	2	2	1	2	0	1	0	1	2	1	2	1	3
CO5	3	3	3	2	3	2	1	1	2	3	2	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE2 4213
Course title: INDUSTRIAL STATISTICS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: IV / Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the basic methods of statistics for data representation and its analysis by determining measures of central tendency; measures of dispersion; measures of skewness and kurtosis.
2	Understand the properties and application of different probability distribution functions in statistics.
3	Learn useful techniques of statistics to draw inferences about the population based on sample(s).
4	Understand the statistical techniques used for modelling and analysis of experiments using ANOVA, design of experiments and regression analysis.
5	Learn about the different methods used for statistical process control.

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

CO1	Understand the properties of a distribution based on central tendency, dispersion, skewness and kurtosis measures.
CO2	Understand the use of probability distribution functions in accordance with the problem.
CO3	Understand the basic concepts of sampling methods and the terminologies of Testing of Hypothesis.
CO4	Design and investigate the experiments using ANOVA, design of experiments and regression analysis.
CO5	Understand the application of different statistical process control tools in life problems.

SYLLABUS

Module 1: Descriptive Statistics **[8]**
Definition and Scope of Statistics; Classification of Data and Frequency Distribution; Graphical Representation of Data; Measures of Central Tendency; Measures of Dispersion; Measures of Skewness and Kurtosis.

Module 2: Probability Theory **[6]**
Discrete Probability Distributions - Binomial Distribution, Poisson Distribution, Discrete Uniform and Hypergeometric Distributions, Geometric and Negative Binomial Distributions.
Continuous Probability Distributions - Normal Distribution, Area Property of Normal Distribution, Continuous Uniform and Exponential Distributions, Gamma and Beta Distributions.

Module 3: **Statistical Inference** **[8]**
Concepts of sampling methods - Sampling Theory and Sampling Distribution, Simple Random Sampling, Elementary Concepts of other Sampling Techniques.
Test of significance - Testing of Hypothesis, Z – test and its applications, t – test and its applications, Chi – Square test and its applications, F – test and its applications.

Module 4: Statistical Techniques **[12]**

Analysis of Variance - Introduction to Analysis of Variance, No-way Analysis of Variance, One-way Analysis of Variance, Two-way Analysis of Variance.

Design of Experiments - Online and Offline Quality Control, Quality Loss Function, DOE Process Steps; Orthogonal Array Selection and Utilization, S/N Analysis.

Regression Modelling - Simple Linear Regression, Statistical Inference in Simple Linear Regression, Multiple Linear Regression, Selection of Variables and Testing Model Assumptions.

Module 5: Statistical Process Control **[6]**

Basic concepts of statistical process control, Seven Magnificent SPC Tool – Flow charts, Histogram or stem-and-leaf plot, Check sheet, Run chart, Pareto chart, Cause-and-effect diagram, Scatter diagram. Advanced methods of SPC – Tests of randomness, Cumulative sum control chart, Multivariate SPC.

Text Book

1. Introduction to Statistical Quality Control, Douglas C. Montgomery, Wiley **(T1)**
2. Design and analysis of Experiments, Douglas C. Montgomery, Wiley **(T2)**
3. Fundamentals of quality control and improvement, A Mitra, Wiley **(T4)**

Reference Book

1. Modern Industrial Statistics, Ron S. Kenett, Wiley **(R1)**
2. Industrial Statistics, Pere Grima Cintas, Wiley **(R2)**
3. Design of Experiments Using The Taguchi Approach, Ranjit K. Roy, Wiley **(R3)**

Gaps in the syllabus (to meet Industry/Profession requirements):

Control charts and acceptance sampling plans

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05

End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher’s Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	0	1	0	0	0	1	1	3	3	2	3
CO2	3	2	1	0	2	0	0	0	1	2	2	3	1	3
CO3	3	3	3	0	2	0	0	0	1	1	3	3	2	3
CO4	3	2	1	0	0	0	1	0	1	2	2	3	1	3
CO5	3	2	1	0	0	0	0	0	1	2	2	3	1	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24215
Course title: QUANTITATIVE TECHNIQUES FOR DATA ANALYSIS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L: 3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: IV/ Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	To understand the basics of statistical data and descriptive statistics
2	To learn the process of statistical sample survey
3	To gain knowledge of correlation and regression analysis
4	To learn and apply statistical inference
5	To gain knowledge about design of experiments and ANOVA

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

CO1	Analyze descriptive data using basic statistics and graphs
CO2	Plan and design proper statistical survey mechanism
CO3	Conduct correlation and various types of regression analysis
CO4	Apply statistical inference through hypothesis testing
CO5	Design experiments and apply ANOVA to check the impact of various factors

SYLLABUS

Module 1: Basics of Quantitative Analysis **[8]**

Classification and scope of Quantitative techniques, Nature and Classification of data, Primary and Secondary data, univariate, bivariate, and multivariate data, time-series and cross-sectional data, Measures of central tendency and dispersion, Pareto chart, Box plot, Histogram, Normal distribution

Module 2: Statistical Survey **[7]**

Planning and design of surveys, Business Data Sources: Primary and Secondary Data, Methods of collecting Primary data, Drafting a questionnaire, Collection of secondary data, Census method and Sampling, Sampling theory, Sampling methods, Sampling and non-sampling errors, Data estimators

Module 3: **Correlation and Regression Analysis** **[10]**

Correlation Analysis: Concepts, Scatter diagram, simple, linear and non-linear correlation, Correlation and Causation, Pearson’s co-efficient of correlation; calculation and properties.
Regression Analysis: Types of regression analysis, Principle of least squares and regression lines, Regression equations and estimation; Properties of regression coefficients. Non-linear regression, Business forecasting as an application to regression, time series analysis, numerical examples and introduction to statistical software (MS-Excel© or Minitab©) for regression analysis

Module 4: Statistical Inference **[7]**

Introduction to hypothesis testing, Framing null and research hypothesis, Testing hypothesis about a population mean (standard deviation-known and unknown), *z*-test, *t*-test, paired *t*-test, chi-square test, numerical examples and introduction to statistical software (MS-Excel© or Minitab©) for hypothesis testing

Module 5: Design of Experiments **[8]**

Full and Fractional Factorial Experiments, Steps of design of experiments (DoE), Orthogonal Arrays (OA), Degree of freedom and selection of OAs, Significance Testing, Analysis of Variance (ANOVA): One-way ANOVA, Two-way ANOVA, *F*-test, Numerical examples

Text Book

1. Ken Black, Business Statistics for Contemporary Decision Making, 5th Edition,Wiley Publications (India Edition) **(T1)**
2. Levin and Rubin, Statistics for Management, Prentice Hall of India, New Delhi. **(T2)**
3. S. P. Gupta, Statistical Methods, 34th Edition, Sultan Chand & Sons **(T3)**
4. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill, New Delhi. **(T4)**

Reference Book

1. Bruce Bowerman, Richard T. O' Connell and Emily Murphree, Business Statistics inPractice, 5th Edition, Tata McGraw Hill **(R1)**
2. Anderson, Sweeney and Williams, Statistics for Business and Economics, 11thEdition, Cengage Learning **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and ProgramSpecific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	2	3	2	2	3	1	0	1	0	1	3	3	3	3
CO2	2	3	2	2	3	1	2	2	0	1	3	3	3	3
CO3	2	3	2	2	3	1	0	1	0	1	3	3	3	3
CO4	2	3	2	2	3	1	0	1	0	1	3	3	3	3
CO5	2	3	2	3	3	1	1	1	0	1	3	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24217
Course title: DISCRETE-EVENT SYSTEM SIMULTION
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: IV/ Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	To learn the terminology, concepts and applications of discrete-event system simulation
2	To understand the various types of simulation models and practical use
3	To solve various discrete-event simulation problems of queuing and inventory systems
4	To know about software for modeling and simulation in various application areas
5	Understand the statistical aspect of simulation, verification and validation approaches for simulation models

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

CO1	Develop model frameworks for discrete-event system simulation
CO2	Apply pseudo-random number based manual simulation to discrete-event systems
CO3	Construct models for manufacturing, logistics and queuing problems for software application
CO4	Generate pseudo-random number distributions for queuing systems
CO5	Analyze the simulation output for statistical verification and validation

SYLLABUS

Module 1 **[8]**

Introduction to modeling and simulation concepts, System analysis and components, Simulation terminology, Model of a system and types of models, Discrete *verses* continuous systems, Static and Dynamic System simulation, Pros and cons of simulation

Module 2 **[9]**

Event verses activity, General principles of event-driven simulation, Steps in simulation study, Areas of application, Use of Pseudo-Random numbers in simulation of queuing systems, manufacturing systems, inventory systems and other examples

Module 3 **[8]**

Simulation of manufacturing and material handling systems, Modeling downtime and failures, Case studies, Introduction to simulation software and languages for manufacturing and material handling: ProModel, Witness and Arena.

Module 4 **[9]**

Mathematical and statistical models in simulation, Terminology and concepts, Useful statistical models: Discrete and continuous distribution, Poisson, Uniform, Exponential and Normal distribution, Empirical distribution, Random number generation

Module 5 **[8]**

Verification and validation of simulation models, Input-output validation using historical data, stochastic nature of output, Analysis of simulation results, Steady-State behavior, Output analysis and Replication method for steady-state simulation

Books:

Text books:

1. Discrete-Event System Simulation by Jerry Banks, Carson and Nelson, Prentice Hall of India Pvt. Ltd. (**T1**)

Reference books:

1. Simulation Modelling and Analysis by Law and Kelton, McGraw Hill, New York. (**R1**)
2. Introduction to simulation and SLAM II by Pritsker, John Wiley, New York. (**R2**)

Gaps in the syllabus (to meet Industry/Profession requirements)

NIL

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50
Progressive Evaluation	**% Distribution**
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	2	2	2	2	2	2	1	1	1	1	1	3	2	3
CO2	3	3	3	3	3	3	3	3	1	1	1	3	2	3
CO3	1	1	3	1	1	1	1	1	1	1	1	3	2	3
CO4	2	2	2	2	3	3	3	3	1	1	1	3	2	3
CO5	3	2	2	2	2	2	2	1	1	1	1	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24219
Course title: ENGINEERING ECONOMY, COSTING AND ACCOUNTING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L: 3 T:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: IV / Second
Branch: All (Open Elective)
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Assess the best feasible investment proposal among the alternatives based on the common index
2	Perform a replacement or retention study between a defender and the best challenger
3	Explores the relationship, which exists between costs, revenue, output levels and resulting profit
4	Acquire basic concepts of cost accounting relevant for managerial decision making.
5	Understand and explain the conceptual framework of Accounting

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

CO1	Evaluate investment opportunities and compare between alternatives using single and combined engineering economy factors
CO2	Perform a replacement study considering inflation and indirect cost allocation
CO3	Perform breakeven analysis and profitability analysis under different conditions.
CO4	Estimate the cost of component and total cost of operation
CO5	Recognize, measure and record the most common business transactions

SYLLABUS

Module 1: Time Value of Money [10]

Introduction to engineering economy, Time value of money, Simple and compound interest, Minimum attractive rate of return, Cash flows - single, uniform series, and gradient series, Multiple compounding periods in a year, Continuous compounding, Bases of comparison- present worth amount, annual equivalent amount, future worth amount, rate of return, Defining mutually exclusive alternatives, Decision criteria for selection of investment proposals, Comparison of alternatives with unequal service life, Sensitivity analysis

Module 2: Replacement Analysis and Depreciation [8]

Reasons for replacement, Economic service life, Evaluation of replacement involving excessive maintenance cost, decline in efficiency, inadequacy and obsolescence; Methods of depreciation and their comparison, Decision making based on expected value decision tree in the evaluation of alternatives

Module 3: Cost Analysis [6]

Cost - implicit and explicit costs, Cost structure - fixed and variable, direct and indirect, product and period, marginal and average, sunk and opportunity, recurring and non-recurring, short-run and long-run, incremental, cash and book, life-cycle cost, Elements of cost – material, labor, overhead expenses, Selling Price, Allocation of cost, Components of cost – prime cost, office cost, total cost, Methods of allocation of overhead expenses, Standard cost

Module 4: Break-even Analysis **[6]**

Concept of contribution, p/v ratio and break-even point, Concept of margin of safety, Cost- volume-profit relationship, Break-even analysis and the financial decision-making, Break-even chart, Effect of different variable on break-even point, Cost comparison of two or three alternatives.

Module 5: Accounting for Business Transactions **[10]**

Accounting concepts and principles, Classification of accounts, Double entry system, Journal and ledger entries, Preparation of final accounts - trading, profit & loss accounts, balance sheet.

Text books:

1. G.J Thusen, W.J. Fabrycky, Engineering Economy, Prentice-Hall, New York. **(T1)**
2. W.G Sullivan, E.M. Wicks, Engineering Economy, Pearson, New York. **(T1)**
3. S.N. Maheshwari, S.K. Maheshwari, S.K. Maheshwari, An Introduction to Accountancy, Vikas Publishing, New Delhi. **(T1)**

Reference books:

1. Blank & Tarquin, Engineering Economy, McGraw-Hill. **(R1)**
2. Newnan, Eschenbach & Lavelle, Engineering Economic Analysis, Oxford University Press. **(R1)**

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>
Business Ratios, Decision Making under Risk

<u>POs met through Gaps in the Syllabus:</u>
PO 1-5

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Using Spreadsheets and Microsoft Excel® in Engineering Economic Analysis, Goal Seek—A Tool for Breakeven and Sensitivity Analysis, Solver—An Optimizing Tool for Capital Budgeting, Breakeven, and Sensitivity Analysis.

<u>POs met through Topics beyond syllabus/Advanced topics/Design:</u>
PO 1-5, 11-12

<u>Course Delivery Methods:</u>

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

<u>Course Evaluation:</u>

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										
	1	2	3	4	5	6	7	8	9	10	11
CO1	3	3	3	3	1	0	0	0	0	3	2
CO2	3	3	3	3	1	0	0	0	0	3	2
CO3	3	3	3	3	1	0	0	0	0	3	2
CO4	3	3	2	3	1	0	0	0	0	3	2
CO5	1	2	1	2	1	0	0	0	1	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6
CO5	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course code: PE 24221
Course title: ENGINEERING MATERIALS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L: 3 T:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: IV / Second
Branch: All (Open Elective)
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Acquire knowledge on the importance of materials in engineering applications and examine the properties and structures of materials
2	Understand the basic thermodynamic approaches in metals and alloys and learn about the transformations associated with phase diagram, analyze the kinetics of phase transformations, and learn the heat treatment methods and processes with an emphasis on steels
3	Learn about the properties, microstructure, heat treatment and applications of different classes ceramics
4	Understand the types, properties, applications and processing techniques of composites and polymers
5	Analyze the various material testing methods related to the structural and functional properties

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

CO1	Analyze and select various engineering materials for various purposes
CO2	Explain the thermodynamics of solids, elucidate iron carbon diagram and understand the application of various heat treatment operations
CO3	Identify and examine different types of ceramic materials and utilize them for specified applications
CO4	Select and evaluate the specific applications and processing routes of different composites and polymers
CO5	Apply and examine various methods of material testing procedures

SYLLABUS

Module 1: Introduction Engineering Materials **[8]**

Introduction to materials – Introduction, Various types of materials, Structure-Property-Processing Relationship, Materials selection, Price and Availability of Materials; **Atomic structure and bonding -** Atomic structure, Bonding Forces and Energies, Primary and secondary bonding; **Atomic arrangement and crystal structure -** Short-Range Order and Long-Range Order, Unit Cells, Allotropic or Polymorphic Transformations, Points, Directions, and Planes in the Unit Cell, Close-Packed Crystal Structures, Interstitial Sites, Ionic Crystals, Covalent Structures; **Imperfections -** Point defects, Line defects, Surface defects, Volume defects

Module 2: Metals and Alloys **[10]**

Phase Diagrams – Basic Concepts, Gibbs Phase Rule, Lever Rule, Unary and Binary Phase Diagrams, Invariant and Non-invariant phase changes, Invariant transformation in the liquid and solid states, Microstructural evolution in binary systems, Typical examples and applications of phase diagrams; **Iron-carbon phase diagram** – Isothermal transformation, Continuous cooling transformation; **Heat treatment of steels** – Annealing, Normalizing, Hardening, Tempering, **Fabrication of Metals and Alloys** – Casting, Forming, Machining, Welding, Thermal Processing of Metals and Alloys; **Applications of Different Ferrous and**

Nonferrous Alloys – Properties and Applications of Various Types of Steels, Cast Iron (Ferrous Alloys), Properties and Applications of Aluminum Alloys, Titanium Alloys, Magnesium Alloys, Copper Alloys, Nickel Alloys (Nonferrous Alloys).

Module 3: Ceramics **[7]**

Structure and Properties of Ceramics – Crystal Structures, Silicates, Imperfections in Ceramics, Phase Diagrams, Mechanical Properties of Ceramics; **Types and Applications of Ceramics in Electronics and Aerospace** – Glasses, Glass Ceramics, Clay Products, Refractories, Abrasives, Advanced Ceramics; **Processing of Ceramics** – Fabrication of Glasses and Glass Ceramics, Clay Products, Powder Metallurgy, Advanced Techniques.

Module 4: Polymers and Composites **[7]**

Polymers – Classification of polymers, Chain formation mechanism, Structure and properties of thermoplastics and thermosetting polymers; Polymer crystallinity, Defects in polymers; **Composite Materials** – Types and Characteristics of Composites – Particle Reinforced Composites, Fiber Reinforced Composites, Structural Composites, Examples and Applications of Composites in Electronics, Aerospace and Chemical Engineering

Module 5: Testing and Properties **[8]**

Mechanical Properties – Elastic Properties, Plastic Properties, Tensile Properties, Hardness, Fatigue, Creep, Impact; **Electrical Properties** – Electrical Conductivity, Semi-conductivity, Dielectric Behavior, Piezoelectricity; **Thermal Properties** – Thermal Conductivity, Diffusivity, Heat Capacity, Thermal Expansion; **Optical Properties** – Basic Concepts, Properties of Metals and Non-metals, Applications; **Magnetic Properties** – Basic Concepts, Ferro-, Dia- and Para-magnetism, Influence of temperature, Hysteresis, Magnetic materials, Applications

Text Books

1. V. Raghavan, Material Science and Engineering, Prentice Hall India **(T1)**
2. William D. Callister Jr., Materials Science and Engineering, Wiley Publication **(T2)**
3. J. F. Shackelford – Introduction to Materials Science and Engineering – **(T3)**

Reference Books

1. Y. Lakhtin, Physical Metallurgy **(R1)**
2. R. E. Reedhill – Physical Metallurgy Principles **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Study of Advanced Materials, Nano Materials, Non-Destructive Testing methods

POs met through Gaps in the Syllabus:
POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:
Green tribology, Biomimetrics

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	**% Distribution**				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
CO1	3	2	2	3	0	0	0	3	1	0	3
CO2	3	3	3	3	1	2	0	0	2	0	3
CO3	3	3	2	3	1	1	0	2	0	0	3
CO4	3	3	2	3	2	3	1	2	0	2	2
CO5	3	3	2	3	3	1	0	2	2	0	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24301
Course title: MACHINING SCIENCE AND MACHINE TOOLS
Pre-requisite(s): None
Co- requisite(s): MACHINE TOOLS LAB
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Examine the technical aspect related to metal cutting and tool geometry.
2	Acquire knowledge of different types of tool materials, cutting fluid and lathe machines.
3	Get familiar with shaper and drilling machines.
4	Get acquainted with milling and grinding process.
5	Develop an understanding of advanced manufacturing processes.

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

CO1	Interpret different angles of single point cutting tool and mechanics involved in metal cutting
CO2	Identify, compare and analyse different tool material, cutting fluids, also understand the working of lathe machine and its attachments.
CO3	Explain working principle and classify shaper and drilling machine and estimate the machining time
CO4	Identify different types of milling cutters and select one for specific applications and select appropriate finishing processes and select grinding wheel for specific applications.
CO5	Suitably apply the various advance machining processes like EDM, ECM, CHM, USM and LBM for specific applications.

SYLLABUS

Module 1: Theory of Metal Cutting **[10]**
Orthogonal and oblique cutting, Tool forces in orthogonal cutting, Power required in metal cutting, Merchant's Circle diagram and Merchant's theory of metal cutting.
Geometry and nomenclature of single point tool; ASA system

Module 2: Tool Material and Machine Tools **[8]**
Different types of cutting tool materials; their uses, applications and relative advantages and limitations. Types of chips, tool failure, tool life, Machinability, and cutting fluids
Constructional features, specification, operations of lathe machine, working principles of capstan and Turret lathes

Module 3: Shaper and Drilling Machine **[7]**
Constructional features, specification, operations and drives of Shaper, Planer, & Slotter.
Constructional features, specification and operations of drilling machine; other drilling related operations; reaming, boring, tapping. Geometry and nomenclature of twist

Module 4: Milling and Grinding Machine **[8]**
Constructional features, specification and operations of milling machine, Geometry and nomenclature of plain milling cutter.
Grinding wheels and its variables, grinding wheel specification. Dressing, Truing and loading of wheels, Surface, Cylindrical and Center-less grinding.

Finishing operations: Broaching, lapping, honing, buffing and super finishing

Module 5: Advance Manufacturing Processes **[7]**
Introduction to Non-conventional machining Processes: Need, advantages and limitation; classification, Fundamental principles and application possibilities of Ultrasonic Machining (USM), Chemical Machining (CHM), Electro-Discharge Machining (EDM), Electro-Chemical Machining (ECM) and Laser Beam Machining (LBM)

Text books:

1. Serope Kalpakjian and Steven Schmidt , Manufacturing Processes for Engineering Materials, Pearson Education, 6th Edition **[T1]**
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Material. Processes, and systems, 2nd Edition, Wiley India, 2007 **[T2]**
3. P.N. Rao, Manufacturing Technology – Metal Cutting and Machine Tools, McGraw Hill. **[T3]**
4. Hajra Choudhury, Elements of Workshop Technology–Vol.-I, Media Promoters and Publishers **[T5]**

Reference books:

1. E. P. DeGarmo, J. T. Black, and R. A. Kohser, Materials and processes in Manufacturing, PHI. **[R1]**
2. P. F. Ostwald, and Jairo Munoz, Manufacturing Processes and Systems, 9th ed., Wiley, India, 2002 **[R2]**
3. Amitabha Battacharya , Metal Cutting Theory and Practice **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Inserts

POs met through Gaps in the Syllabus:
POs 1,2, 12

Topics beyond syllabus/Advanced topics/Design:
Mechanics of material removal in advanced manufacturing processes

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	2	2	2	0	0	0	0	0	2	3	1	2
CO2	3	3	2	2	2	0	0	0	0	0	2	3	1	2
CO3	3	3	2	2	2	0	0	0	0	0	2	3	1	2
CO4	3	3	2	2	2	0	0	0	0	0	2	3	1	2
CO5	3	3	2	2	2	0	0	0	0	0	2	3	1	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24302
Course title: MACHINE TOOLS LAB
Pre-requisite(s): None
Co- requisite(s): MACHINING SCIENCE AND MACHINE TOOLS
Credits: 1 L:0 T:0 P: 2
Class schedule per week: 2
Class: B.Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Get familiar with different types of lathe machine and their operations used in machining process.
2	Get hands on experience of milling machine.
3	Get acquaintance with slotter and shaper machine.
4	Develop skills on tool grinding machine.
5	Know different techniques used in EDM.

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

CO1	Apply lathe machines for various turning applications.
CO2	Identify different types of lathe attachments and milling cutters.
CO3	Distinguish between slotter and shaper machine with their respective applications.
CO4	Recognize different types angle used in ASA tool signature
CO5	Discriminate between the die sinking EDM and wire cut EDM.

SYLLABUS

LIST OF EXPERIMENT:

1. MACHINE SHOP
EXPERIMENT-1: Center Lathe
Objective: To perform external thread-cutting operations on a given job.

2. MACHINE SHOP
EXPERIMENT-2: Capstan Lathe
Objective: To obtain the final job as per the given dimensions using different types of lathe operation on the Capstan lathe.

3. Micro Manufacturing Process Lab
EXPERIMENT-3: Laser Welding
Objective: To study the Laser welding process and its application.

4. MACHINE SHOP
EXPERIMENT-4: Slab Milling
Objective: To perform slab milling operation on the job using a slab milling cutter on a horizontal knee-type milling machine.

5. MACHINE SHOP
EXPERIMENT-5: CNC Surface Grinding
Objective: To study and learn how to operate and perform on a CNC Surface Grinding Machine (Horizontal type). Make a job as per drawing.

6. MACHINE SHOP
EXPERIMENT-6: Shaper Machine
Objective: To obtain a hexagonal prismatic shape on the rectangular job using a shaper machine.

7. MACHINE SHOP
EXPERIMENT-7: Slotter Machine
Objective: To cut a slot on a job as per the given dimensions.

8. MACHINE SHOP
EXPERIMENT-8: CNC Lathe
Objective: To study and learn how to operate and perform different operations on a CNC lathe machine (Step turning, taper turning, radius cutting, etc.).

9. Welding shop
Experiment-9: Robotic MIG Welding
Objective: To study the robotic MIG welding process and their different weld programming.

10. Foundry Shop
Experiment-10: Centrifugal Casting
Objective: To study the centrifugal casting process and perform centrifugal casting**.**

11. Micro Manufacturing Process Lab
Experiment-11: Wire Cut EDM
Objective: To study and learn how to operate and perform on Wire Cut EDM Machine for different types of profile (Die & Punch) cutting.

TEXT BOOK

1. S K Hajra Choudhury, A K. Hajra, "Elements of Workshop Technology: Vol- I and Vol -II", Media Promotors Pvt Ltd. **(T1)**
2. B S Raghuwanshi, "A course in Workshop Technology", Dhanpat Rai Publications. **(T2)**

REFERENCE BOOK

1. P.N. Rao, "Manufacturing Technology Vol-1and Vol-II", Tata McGraw Hill. **(R1)**
2. Kalpakjian, "Manufacturing Engineering and Technology", Pearson. **(R2)**

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>

<u>POs met through Gaps in the Syllabus:</u>

<u>Topics beyond syllabus/Advanced topics/Design:</u>

<u>POs met through Topics beyond syllabus/Advanced topics/Design:</u>

<u>Course Delivery Methods:</u>

CD1	Lecture by use of boards/LCD projectors/OHP projectors	
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	
CD7	Simulation	

<u>Course Evaluation:</u>
Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Day to day performance & Lab files	√	√	√	√	√
Quiz 1	√	√	√	√	√
Quiz 2	√	√	√	√	√
Viva-voce	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	1	1	0	3	0	0	3	3	2	1	3	1	2
CO2	3	2	1	0	3	0	0	3	3	2	1	3	1	2
CO3	3	1	1	1	3	0	0	3	3	2	1	3	1	2
CO4	3	1	1	1	3	0	0	3	3	2	1	3	1	2
CO5	3	1	1	0	3	0	0	3	3	2	1	3	1	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD3
CO2	CD3
CO3	CD3
CO4	CD3
CO5	CD3

COURSE INFORMATION SHEET

Course code: PE 24303
Course title: DESIGN OF MACHINE ELEMENTS
Pre-requisite(s): STRENGTH OF MATERIALS
Co-requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the basics of designing various machine elements
2	Get acquainted with design considerations of stress and factor of safety
3	Analyse different aspects of the design approach for machine elements
4	Derive relationship and use empirical relations for design stress calculations for various elements

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

CO1	Apply the basic design principles for design of machine elements
CO2	Design cotter, knuckle, and welded joints
CO3	Design bolted and riveted joints
CO4	Design shafts, couplings, and belt drives
CO5	Design power screws, helical springs, and spur gears

SYLLABUS

Module 1: Principles of mechanical design **[7]**
Objective and scope of mechanical design; Designation and selection of materials; Design considerations; Modes of failure; Design/allowable stress; Factor of safety (FoS); Stresses in machine elements; Theories of failure – maximum normal stress theory, maximum shear stress theory, Distortion energy theory. Choice of Failure criteria

Module 2: Cotter, knuckle, and welded joints **[7]**
Design of (a) Cotter joint; (b) Knuckle joint and (c) Fillet Welded joint of brackets under different types of static loading.

Module 3: Bolted and riveted joints **[8]**
Design of bolted joints: Metric thread, standard sizes, use of lock nuts and washers; Applications in structures including brackets, circular base; Design of riveted joints: Unwin's formula; Brief discussion on single, double and triple row lap joints, butt joints with single or double strap/cover plate; Applications of riveted joint in different structures under static loading; Joint efficiencies.

Module 4: Shafts, couplings, and belt drives **[8]**
Design of: (a) Solid and hollow shafts, strength design of shafts, design based on torsional rigidity; ASME Code for shaft design, (b) Shaft coupling- construction, type, applications; Design of rigid couplings; (c) Belt drives - geometrical relations, derivation of torque and power transmission by flat and V-belt drives; Selection of flat belt from manufacturers catalogue.

Module 5: Power screws, helical springs, and spur gears **[10]**
Design of transmission screw; Design of helical compression spring - stress and deflection equations, stiffness, curvature effect: Wahl's factor, springs in parallel and series; Gears – types of gears; Spur Gears: terminology, forces analysis, beam strength of spur gear tooth. Lewis equation and form factor, design for strength, dynamic load and wear load.

Text books:

1. Design of Machine Elements by V. B. Bhandari, TMH **[T1]**
2. Mechanical Engineering Design by Shigley and Mischke,TMH **[T2]**
3. Design of Machine Elements by M. F. Spotts, Prentice Hall **[T3]**

Reference books:

1. Machine Design by T.H. Wentzell, Cenage Learning. **[R1]**
2. Theory and Problems of Machine Design by Hall, Holowenko and Laughlin, TMH. **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Design of welded, riveted and bolted joints under dynamic loading

POs met through Gaps in the Syllabus:

POs 1-4, 12

Topics beyond syllabus/Advanced topics/Design:

Design of turnbuckles and pre-loaded bolt joints; design of flexible couplings; design of chain drives, design of clutches and brakes, screw jack, bevel and helical gears

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1-4, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	**% Contribution during CO Assessment**
Progressive Evaluation	50
End Semester Examination	50
Progressive Evaluation	**% Distribution**
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	13	14	15
CO1	3	3	3	1	0	0	0	0	1	0	2	2	2	3
CO2	3	3	3	1	0	0	0	0	1	0	2	2	2	3
CO3	3	3	3	1	0	0	0	0	1	0	2	2	2	3
CO4	3	3	3	1	0	0	0	0	1	0	2	2	2	3
CO5	3	3	3	1	0	0	0	0	1	0	2	2	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24304
Course title: MACHINE DRAWING AND CAD LAB
Pre-requisite(s): None
Co- requisite(s): None
Credits: 1.5 L:0 T:0 P: 3
Class schedule per week: 3
Class: B.Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	To learn the fundamental concepts of machine drawing & computer-aided drafting (CAD)
2	To comprehend CAD Software like CATIA and their practical usage in Manufacturing applications.
3	To recognize concepts of designing various components of Manufacturing jobs.
4	Prepare the assembly of various machine or engine components and miscellaneous machine components, with a focus on industrial applications.
5	Understand the concepts of development of prototype models by interpreting 3D part model

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

CO1	Apply the concepts of designing using 3D modeling software.
CO2	Create various real-world industrial components by using mechanical design Software like CATIA.
CO3	Analyze and design of an industrial component by interpreting part drawings.
CO4	Apply the concepts of CAD and assemble various mechanical components in the given software.
CO5	Develop Prototype models by interpreting 3D part models/ part drawings & assemblies.

<u>SYLLABUS</u>

LIST OF EXPERIMENT:

1. **EXPERIMENT – 1: Introduction to Machine Drawing & Computer-Aided Design Objective**: To demonstrate various features like Sketcher, Drafting & 3D Modeling

2. **EXPERIMENT – 2: Exercise on Padding, Pocketing & Revolving**
   Objective: To practice models related to padding, pocketing, and revolving features

3. **EXPERIMENT – 3: Exercise on Nut, Bolt & Threads**
   Objective: To practice various types of nuts, bolts & threads.
4. **EXPERIMENT – 4: Exercise on Chamfers, Fillets, Mirror & Offset**
   Objective: To practice models with features of chamfers, fillets, mirrors & offset

5. **EXPERIMENT – 5: Exercise on Hole & Pattern**
   Objective: To practice models having holes and models with various pattern features

6. **EXPERIMENT – 6: Exercise on Ribs, Shell, Sweep & Blend**
   Objective: To practice models with ribs, shell features, sweep & blend commands

7. **EXPERIMENT – 7: Exercise on Datum plane & Axis**
   Objective: To practice datum planes and various types of datum axes

8. **EXPERIMENT – 8: Exercise on Machine Drawing Assembly**
   Objective: To practice Assembly of Footstep Bearing/ Plummer-Block or similar etc.

9. **EXPERIMENT – 9: Exercise on Slider-crank Assembly**
   Objective: To practice assembly drawings of slider-crank, and bench-vice assembly.

10. **EXPERIMENT – 10: Exercise on Piston Assembly**
    Objective: To practice assembly drawings of Piston assembly.

11. **EXPERIMENT – 11: Exercise on 3D Realization of Solid Models -I**
    Objective: Develop Prototype models by interpreting 3D part models/ part drawings & assemblies.

12. **EXPERIMENT – 12: Exercise on 3D Realization of Solid Models -II**
    Objective: Develop Prototype models by interpreting 3D part models/ part drawings & assemblies.

Textbook:

1. Rao, P.N. CAD/CAM: Principles and Applications, McGraw Hill Publication, 2nd Edition, 2004. (**T1**)
2. 2. Machine Drawing –K.L. Narayana, P.Kannaiah & K. Venkata Reddy / New Age/ Publishers. (**T2**)
3. 3. Mikell P. Grover, E. Zimmer, Computer Aided Design and Manufacturing (CAD/CAM), Pearson Publication, 2nd Edition, 2006. (**T3**)

Reference Book

1. David Bedworth, "Computer Integrated Design and Manufacturing" Tata McGraw Hill, New Delhi, 1998. (**R1**)
2. 2. Radha Krishan P., Subramaniyam S., CAD CAM and CIM, New Age International, 2002 (**R2**)

Gaps in the syllabus (to meet Industry/Profession requirements):

Design of real-time Industrial projects.

POs met through Gaps in the Syllabus:

POs 1-5

Topics beyond syllabus/Advanced topics/Design:

Design Software for various analyses of components/parts

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 5, 10

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as the use of NPTEL materials and the internet.	√
CD7	Simulation	√

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Day to day performance & Lab files	√	√	√	√	√
Quiz 1	√	√	√	√	√
Quiz 2	√	√	√	√	√
Viva-voce	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (Cos) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	3	3	1	2	3	2	3	2	1	2
CO2	3	3	3	3	3	3	1	2	3	2	3	3	2	2
CO3	3	3	3	3	3	3	1	2	3	2	3	2	2	3
CO4	3	3	3	3	3	3	1	2	3	2	3	2	2	3
CO5	3	3	3	3	3	3	1	2	3	2	3	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (Cos) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD3, CD6
CO2	CD3, CD6
CO3	CD3, CD6
CO4	CD3, CD6
CO5	CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24305
Course Title: STATISTICAL QUALITY CONTROL
Pre-requisite(s): None
Co-requisite(s): None
Credits: 03 L:3 T: P:
Class schedule per week: 03
Class: B. Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:

This course enables the students to:

1	Understand the philosophy of quality improvement and the use of statistics in quality control.
2	Understand the concept of process capability analysis. and use various control charts for attributes and variables.
3	Understand the concept of acceptance sampling, OC curves and preparation of acceptance sampling plans for attributes.
4	Understand the general idea of Robust Parameter Design Approaches
5	Understand the concept of quality circle, quality audit, ISO 9000 and Six Sigma.

Course Outcomes:

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

CO1.	Understand the philosophy of quality improvement and the basic concepts of statistical quality control.
CO2.	Design, use, and interpret control charts and perform analysis of process capability.
CO3.	Prepare and analyze sampling plans for attributes.
CO4.	Comprehend the general idea of Robust Parameter Design Approaches
CO5	Understand the ISO-9000 quality system, quality audit and Six Sigma.

SYLLABUS

Module 1 **[6]**
Introduction to Quality Control, Statistics in quality control, Cost of Quality, Graphical and Analytical Methods for Central Tendency and Dispersion

Module 2 **[10]**
General Theory of Control Charts, Theory and Application of Control Charts for Averages, Range, Standard Deviation, Fraction Defective and Number of Defects, Process Capability Study, Interpretation of Control Chart

Module 3 **[10]**
100% Sampling Vs. Statistical Sampling, Elementary Concepts of Acceptance Sampling by Attributes, Concepts and Characteristics of O.C. Curves, Single, Double and Multiple Sampling Plans, Construction and Use of O.C. Curves for Sampling Plans, MIL-STD Plans, Sequential Sampling Plan

Module 4 **[8]**
Quality loss function, Concepts of Taguchi technique and robust design, signal-to-noise ratio, Introduction to Design of experiments (DOE), Orthogonal array and Analysis of variance (ANOVA)

Module 5 **[6]**
Concept of Quality Circle and TQM, ISO–9000 Quality Systems, Quality Audit, Concept of Six Sigma and DMAIC

Text Books:

1. Introduction to Statistical Quality Control, Douglas C. Montgomery, Wiley **[T1]**
2. Fundamentals of quality control and improvement, A Mitra, Wiley **[T2]**
3. Statistical Quality Control & Reliability, D.H. Besterfield, Prentice Hall, **[T4]**
4. Total Quality Management, D.H. Besterfield, Prentice HallStatistical, **[T5]**
5. Quality control, M. Mahajan, Dhanpat Rai & Sons, **[T6]**

Reference books:

3. Manufacturing Excellence in Global Markets, W. Euershelm **[R1]**
4. Manufacturing Systems Design & Analysis, B. Wa. **[R2]**
5. Computer Automation in Manufacturing, T.O.Boucher **[R3]**
6. Intelligent Manufacturing Planning, P. Gu. **[R4]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Sampling plan for variables

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (Cos) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	3
CO1	3	3	3	0	1	0	0	0	1	1	3	3	2	2
CO2	3	2	1	0	2	0	0	0	1	2	2	3	1	1
CO3	3	3	3	0	2	1	0	0	1	1	3	3	2	3
CO4	3	2	1	0	0	1	1	0	1	2	2	3	1	3
CO5	3	2	1	0	0	0	0	0	1	2	2	3	1	1

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (Cos) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24307
Course title: ADVANCED OPERATIONS RESEARCH
Pre-requisite(s): OPERATIONS RESEARCH
Co- requisite(s): None
Credits: 3 L:3 T:0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1	Apply the techniques of operations research in industrial engineering problems.
2	Understand the revised simplex method and sensitivity analysis for linear programming and perform iterations of it by hand
3	Carry out simulations of various industrial engineering problems
4	Solve problems of Decision Theory and Queueing Theory
5	Solve problems of DP, NLPP

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

CO1	Appropriately formulate Queuing models for service and manufacturing systems and apply Queuing models and algorithms to solve these Queuing problems.
CO2	Carry out sensitivity analysis for various types of LPP and apply decision theory in various managerial decision-making situations.
CO3	Appropriately formulate Integer Programming models for service and manufacturing systems and apply operations research techniques and algorithms to solve these IP problems.
CO4	Apply Monte Carlo simulation to various engineering problems.
CO5	Model and solve problems using dynamic programming and NLPP

SYLLABUS

Module 1: Queuing Theory and Revised simplex method **[8]**
Queuing theory: Basis of Queuing theory, elements of queuing theory, Kendall's Notation, Operating characteristics of a queuing system, Classification of Queuing models, essential features of queuing systems, operating characteristics of (M/M/I) (∞/FCFS/M/M/1: ∞ /SIRO, M/M/1: N/FCFS, M/M/S: N/FCFS).
Revised simplex method

Module 2: Sensitivity Analysis and Decision Theory **[8]**
Sensitivity analysis of LPP (Change in the Objective Coefficient: Non-Basic and Basic Variables, change in right hand side of the constraints and change in the cost/Profit coefficients),
Decision theory: Introduction, Decision under certainty, Decision under risk, Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion, savage MiniMax, Regret criterion, Hurwicz criterion, Decision tree.

Module 3: Integer Programming **[8]**
Integer programming: Introduction to integer programming, Branch and bound technique and its application to binary integer programming and mixed integer programming.

Module 4: Simulation and Dynamic Programming **[8]**
Simulation: Monte Carlo simulation and its application in queueing problem, production planning and budgeting problems etc.
Dynamic Programming: Formulation of Dynamic programming problem, solutions by tabular methods

Module 5: Non-Linear Programming **[8]**

Non-Linear programming methods: Problem formulation, Lagrange Multipliers, Kuhn – Tucker Conditions, Sufficiency of Kuhn – Tucker Condition, NLPP with one inequality constraint.

Text books:

1. Operations Research, D.S. Hira, P.K. Gupta, S. Chand & Company Ltd, 2014 **(T1)**
2. Quantitative Techniques Vol I and Vol II, L. C. Jhamb, Everest Publishing House **(T2)**
3. Operations Research, - Kanti Swarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons **(T3)**

Reference books:

1. Operations Research an Introduction, Hamady A. Taha, 4TH Edition, Pearson Education. **(R1)**
2. Introduction to Operations Research, 9e, Frederick S. Hillier, Gerald J. Lieberman, Bodhibrata Nag and Preetam Basu, McGraw Hill. **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	2	3	3	0	0	0	0	3	2	3	3	3
CO2	3	3	2	3	3	0	0	0	0	3	2	3	3	3
CO3	3	3	2	3	3	0	0	0	0	3	2	3	3	3
CO4	3	3	2	3	3	0	0	0	0	3	2	3	3	3
CO5	3	3	2	3	3	0	0	0	0	3	2	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24309
Course title: COMPETITIVE MANUFACTURING STRATEGIES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the concept manufacturing as strategy, WTO and competitive advantages
2	Learn about the product verity, manufacturability, vendor development and vendor rating.
3	Understand the concept of JIT, MRP & ERP must be explained to the students
4	Know the effectiveness CIM, E-manufacturing and simulation as tool of competitive manufacturing
5.	Learn about the various types of Manufacturing systems i.e. Dedicated manufacturing system, Flexible manufacturing system (FMS), cellular manufacturing system (CMS), and Re-configurable manufacturing system (RMS)

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

CO1	Explain the concept of manufacturing strategy.
CO2	Recognize the role of product verity management, product modularity, vendor development, vendor rating and design for manufacturing in improving competitiveness
CO3	Comprehend JIT and MRP based systems
CO4	Explore latest advancements in manufacturing like CIM and e-manufacturing and the role of ERP and simulation as strategy in manufacturing.
CO5	Select proper manufacturing system for a given product and market scenario.

SYLLABUS

Module 1: Competitive Strategies **[8]**
The competitive environment in the market, The WTO agreement and its effect on Indian Industries, Manufacturing as a competitive strategy, Competitive Advantages and Disadvantages

Module 2: Product Modularity **[7]**
Product Variety, Modular Design, Design for manufacturability, Vendor Development, Vendor rating.

Module 3: Manufacturing philosophy **[7]**
Just in time (JIT) manufacturing, Kanban system, Agile Manufacturing, Lean manufacturing and tools

Module 4: E-Manufacturing **[10]**
Simulation as tools for competitive manufacturing, MRP, ERP, Concept of CIM and E-Manufacturing, Industry 4.0

Module 5: Recent Manufacturing Scenarios **[8]**
Selection of manufacturing systems for different manufacturing scenarios - Dedicated manufacturing system, Flexible manufacturing system (FMS), cellular manufacturing system (CMS), and Re-configurable manufacturing system (RMS); Elementary of DMS, FMS, CMS, and RMS.

Text books:
1. Manufacturing Excellence in Global Markets W. Euershelm **[T1]**
2. Manufacturing Systems Design & Analysis B. Wa. **[T2]**
3. Computer Automation in Manufacturing T.O.Boucher **[T3]**

4. Intelligent Manufacturing Planning P. Gu. **[T4]**

Reference books:

1. Serope Kalpakjian and Steven Schmidt, Manufacturing Processes for Engineering Materials, Pearson Education, 6th Edition **[R1]**
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Material. Processes, and systems, 2nd Edition, Wiley India, 2007 **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Forecasting techniques, Marketing strategies,

POs met through Gaps in the Syllabus:
POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:
Advance Management and marketing techniques

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	3	2	2	1	1	1	0	1	3	3	2	2
CO2	3	2	1	1	1	1	0	0	1	1	2	3	1	3
CO3	3	2	2	1	0	1	0	1	1	1	3	3	2	3
CO4	3	2	1	1	1	1	0	1	1	1	2	3	1	3
CO5	3	2	1	1	0	0	0	1	1	1	2	3	1	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24311
Course title: CIRCULAR ECONOMY-SUSTAINABLE MATERIAL MANAGEMENT
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: V/ Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the concept of circular economy and sustainability.
2	Learn about innovation challenges in industry.
3	Understand the policy challenges in implementation of circular economy.
4	Understand the various business models.
5	Understand the effect of implementation of circular economy in sustainable material management.

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

CO1	Implement these new concepts in current manufacturing scenario.
CO2	Get ready for recent industrial requirements.
CO3	Adapt to new policies and act accordingly.
CO4	Compare the interchangeable concepts for different scenarios.
CO5	Utilize the sustainability concept for management for future generations.

SYLLABUS

Module 1: Introduction to Circular Economy [8]
The scope of the circular economy, linear industrial economy, circularity, sustainability, understanding the principles and analyzing the circular industrial economy, innovation and challenges using case studies.

Module 2: The Era of 'R': The Decision Makers [8]
Characteristics of Reuse, Repair, Remarket, Remanufacture, Re-refine and Reprogramme goods along with case studies. Trust, skills and people, economic value and savings in the era of 'R', Research, innovation, and policy challenges.

Module 3: The Era of 'D': Economic Actors Recovering Resource Assets [9]
Identification of parameters i.e. De-polymerize, De-alloy, De-laminate, De-vulcanize, De-coat materials and De-construct high-rise buildings and major infrastructure. Foundation and characteristics of the era of 'D'. R&D, technology, knowledge and people, Innovation, and opportunities for policymakers. The performance economy, business models, uncertainty and economy of scale, resilience.

Module 4: Sustainable Manufacturing [9]
Fundamentals, Tools and Techniques, Environment impact assessment methods (i.e. screening, scope, impact assessment, Mitigation measures, action). Sustainability assessment methods and assessment. Life Cycle Assessment (GaBi/Sima Pro software).

Module 5: Sustainable Business Management **[6]**
Fundamentals of sustainable business, Understanding wastes, Process, Preservation, People, Place, Product, Production using different case studies.

Text Book

1. The Circular Economy - A User's Guide. Walter R. Stahe. RoutledgeTaylor & Francis Group, **(T1)**
2. THE SUSTAINABLE BUSINESS, Jonathan T. Scott, Greenleaf publishing (**T2**)

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	2	0	0	0	0	0	0	2	3	2	3
CO2	3	3	3	2	0	0	0	0	0	1	2	3	2	3
CO3	3	3	3	2	0	0	0	0	0	1	2	3	2	3
CO4	3	3	3	2	0	0	0	0	0	1	2	3	2	3
CO5	3	3	3	2	0	0	0	0	0	1	2	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 24317
Course title: FINITE ELEMENT METHODS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students:

1	To present a comprehensive treatment on finite element methods.
2	To lay the groundwork for subsequent studies in the fields of stress and strain, including the design aspects.
3	To develop an intuitive understanding of various mathematical techniques to solve the problems.
4	To be able to understand and tackle various problems under different loading conditions.

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

1.	Explain the principles of various techniques used in FEM.
2.	Apply the concepts to one-dimensional and two-dimensional problems.
3.	Analyze the thermal and structural problems.
4.	Evaluate planar problems associated with real-world applications.

SYLLABUS

Module 1: **[8]**

Energy methods: Variational principles and weighted residual techniques (least square method, collocation, sub-domain collocation, Galerkin method) for one-dimensional equation, Rayleigh-Ritz Formulation.

Module 2 **[8]**

Two-dimensional elements: Two-dimensional grids, Linear triangular element, Bilinear rectangular element.

Module 3 **[8]**

Coordinate systems: Local coordinate systems, Natural coordinate systems, Rectangular elements, Area coordinates, solving finite element problems using code/software.

Module 4 **[8]**

Field equations and boundary conditions: Governing differential equations, Integral equations for the element matrices, Element matrices: Triangular and rectangular elements. Different boundary conditions for fluid flow and heat transfer problems.

Module 5 **[8]**

Applications: Heat transfer, Axial force members, Truss elements, Beam elements, Torsion of non-circular sections.

Books:
Text books:

1. L.J. Segerlind, Applied Finite Element Analysis, 2nd Ed., John Wiley and Sons, 1984. (**T1**)
2. S.S. Rao, The Finite Element Method in Engineering, 5th Ed., Butterworth-Heinemann, 2012. (**T2**)
3. Chandrupatla, A.D. Belegundu, Introduction to Finite Elements in Engineering, 3rd Ed., PHI Learning Pvt. Ltd, 2002. (**T3**)

4. R.D. Cook, D.A. Malkus, M.E. Plesha, R.J. Witt, Concepts and Applications of finite element analysis, John Wiley & Sons, 4th edition, 2002. (**T4**)

Reference books:

1. D.L. Logan, A First Course in Finite Element Method, Fourth Ed., Cengage Learning, 2007. (**R1**)

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

<u>Course Delivery Methods:</u>

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

<u>Course Evaluation:</u>

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	145
CO1	3	3	2	1	1	1	0	1	0	0	3	3	2	2
CO2	3	3	2	2	1	1	0	1	0	0	3	2	3	2
CO3	3	3	2	2	1	1	0	1	0	0	2	2	3	3
CO4	3	3	3	3	1	1	1	1	2	1	3	2	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24313
Course title: ADVANCED WELDING TECHNOLOGY
Pre-requisite(s): INTRODUCTION TO MATERIALS ENGINEERING; FOUNDRY, FORMING & WELDING TECHNOLOGIES / MANUFACTURING PROCESSES
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the fundamental principles, process parameters and application possibilities of solid-state welding and radiant beam welding processes
2	Learn about the fundamental principles, process parameters and application possibilities of hybrid welding and allied processes
3	Understand different techniques applied for different welding positions and welding conditions
4	Understand the use of welding symbols and design procedure for weld joints under different loading conditions
5	Learn about weldability of specific materials and welding applications

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

CO1	Classify solid-state welding and radiant beam welding processes and identify their advantages, limitations and application possibilities
CO2	Compare the fundamental principles, equipment, parameters and applications of different hybrid welding, thermal cutting and metal surfacing processes
CO3	Select appropriate techniques for different welding positions and welding conditions
CO4	Design weld joints for different loading conditions and to minimize weld distortion
CO5	Select appropriate welding techniques for different sets of materials for different welding applications

SYLLABUS

Module 1: Solid state welding and radiant beam welding [8]
Fundamental principles, process parameters, machines and equipment, advantages, limitations and application possibilities of cold welding, diffusion welding, forge welding, friction and inertia welding, explosive welding, ultrasonic welding;

Fundamental principles, process parameters, machines and equipment, advantages, limitations and application possibilities of electron beam welding and laser beam welding; principle of conduction mode and keyhole welding;

Module 2: Advanced welding and allied processes [8]
Laser arc hybrid welding - fundamental principles, hybrid laser GMAW process, hybrid laser GTAW process, hybrid laser PAW process, paraxial and coaxial arrangements, welding parameters, joint gap, joint configuration and edge preparation, weld quality and industrial applications;
Thermal cutting processes – oxygen cutting, arc cutting, high energy beam cutting; metal surfacing – cladding, hard facing, build-up, buttering; metal spaying processes; soldering, brazing and braze welding;

Module 3: Welding positions and welding conditions [7]
Processes and conditions for welding in down hand or flat, horizontal, vertical and overhead positions;
Welding in wind; welding at low ambient temperatures; welding in vacuum; welding in space; underwater welding processes;

Module 4: Residual stress, weld design, and pre/post heat treatments **[9]**

Principle of residual stress, types of residual stress, methods of identifying residual and the stress reliving methods. Numerical problems in residual stresses; principle of distortions, types of distortion, methods of the eliminating distortion;

Types of welded joints, design of butt joints, lap joints, eccentrically loaded joints, welding symbols, estimation of preheat temperature and post heat temperature

Module 5: Weldability of specific materials and welding applications **[8]**

Weldability of carbon steels, stainless steels, high alloy steels, cast iron, aluminium, copper and titanium;

Application of welding in automobile industries, aerospace industries, ship building industries; concept of robotized welding and welding automation

Text books:

1. R. L. Little, Welding and Welding Technology, Tata McGraw Hill **[T1]**
2. R.S. Parmar, Welding Process and Technology, Khanna Publishers [**T2]**
3. O.P. Khanna, Welding Technology, Dhanpat Rai Publication **[T3]**

Reference books:

1. H.B. Cary and S.C. Helzer, Modern Welding Technology, Pearson/Prentice Hall. **[R1]**
2. J. Lawrence, Advances in Laser Materials Processing 2e, Woodhead Publishing/ Elsevier. **[R2]**
3. Welding Handbook, 9th ed., Vol. 2, Welding Processes. American Welding Society. **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Welding of polymers and composites, Simulation of welding process

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1-4, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	1	0	2	1	0	0	1	0	2	3	2	3
CO2	3	3	2	2	3	2	0	0	1	0	2	3	2	3
CO3	2	2	3	1	2	2	0	2	1	1	1	3	3	3
CO4	3	2	3	2	2	2	0	1	1	2	1	3	3	3
CO5	3	2	3	1	3	2	1	1	1	1	2	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24315
Course title: RAPID PROTOTYPING AND TOOLING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1	Understand technology used in rapid prototyping and tooling.
2	Recognized importance of rapid prototyping in advance manufacturing process.
3	Acquire knowledge, techniques and skills to select relevant rapid prototyping and tooling process.
4	Comprehend the potential of rapid prototyping and tooling in different industrial sectors.
5	Illustrated 3D printing technology for Rapid prototyping and tooling

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

CO1	Explain rapid prototyping and tooling for manufacturing complex geometries.
CO2	Identify and solve problems related to rapid prototyping and tooling.
CO3	Select suitable process and materials for rapid prototyping and tooling
CO4	Distinguish technique of CAD and reverse engineering for geometric transformation in rapid prototyping and tooling.
CO5	Determine part orientation, apply suitable slicing algorithm and generate tool path for minimum build time.

SYLLABUS

Module 1: Introduction **[8]**

Evolution, basic principle, concept, procedure and need of rapid prototyping and tooling, Classification of rapid prototyping and tooling processes (Additive/Subtractive/Deformative), Classifications of materials used for Rapid prototyping and tooling, Industrial applications of rapid prototyping and tooling, Most commonly used processes for rapid prototyping.

Module 2: Processes used for rapid prototyping and tooling **[8]**

Stereolithography Apparatus (SLA), Fused Deposition Modeling (FDM), Selective Deposition Lamination (SDL), Laminated Object Manufacturing (LOM), Ultrasonic Consolidation, Laser Engineered Net Shaping (LENS), Electron Beam Free Form Fabrication (EBFFF), Selective Laser Sintering (SLS), Electron Beam Melting (EBM).
Convectional Tooling vs Rapid Tooling, Classification of Rapid Tooling, Direct and Indirect rapid tooling methods.

Module 3: CAD for rapid prototyping and tooling **[8]**
Preparation of 3D-CAD model in STL format, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and generation of codes for tool path.

Module 4: Constructions of manipulator systems for rapid prototyping and tooling **[8]**
Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors, Energy delivery systems, Material delivery systems.

Module 5: Post processing in rapid prototyping and tooling **[8]**
Support material removal, Surface texture improvement, Accuracy improvement, Aesthetic improvement, Property enhancements using non-thermal and thermal techniques.

Text books:
1. Chua C.K., Leong K.F., and Lim C.S., “Rapid prototyping: Principles and applications”, Third Edition, World Scientific Publishers, 2010. **[T1]**
2. Gebhardt A., “Rapid prototyping”, Hanser Gardener Publications, 2003. **[T2]**
3. Ian Gibson, “Software Solutions for Rapid Prototyping”, Professional Engineering Publishing Limited, UK, 2002. **[T3]**

Reference books:
1. Liou L.W. and Liou F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development”, CRC Press, 2007. **[R1]**
2. Kamrani A.K. and Nasr E.A., “Rapid Prototyping: Theory and practice”, Springer, 2006. **[R2]**
3. Hilton P.D. and Jacobs P.F., “Rapid Tooling: Technologies and Industrial Applications”, CRC press, 2000. **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Rapid Freeze Prototyping

POs met through Gaps in the Syllabus:
POs 1,2,5

Topics beyond syllabus/Advanced topics/Design:
Rapid Tooling Injection Molded Prototypes

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1,8,12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher’s Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	1	2	0	0	0	0	1	0	3	2	2
CO2	2	3	2	2	2	0	0	0	1	0	0	2	3	2
CO3	2	2	3	2	2	1	1	0	0	0	0	3	2	3
CO4	2	2	2	2	3	0	0	0	1	0	0	2	2	3
CO5	2	2	3	3	3	0	0	0	0	0	1	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24317
Course title: MATERIAL DEFORMATION PROCESSES
Pre-requisite(s): STRENGTH OF MATERIALS, FOUNDRY, FORMING AND WELDING TECHNOLOGIES
Co- requisite(s): None
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students:

1	To study various metal working, un-conventional forming operations (conventional as well as modern) and thermo-mechanical treatment
2	To conceptualize theory of elasticity, plasticity and yielding as related to material deformation processes
3	To apply the concepts of friction and lubrication in various material deformation processes
4	To analyse plane-strain and axi-symmetric deformation processes
5	To conceptualize and apply various methods for analysis of deformation processes

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

CO1	Understand the principles of various material deformation processes
CO2	Learn the importance of various mechanical and metallurgical factors which control forming processes
CO3	Analyze the forming processes mathematically, in terms of their operating parameters and outputs
CO4	Familiarize about recent trends and techniques adopted in the field of material deformation processes.
CO5	Select proper lubrication based on type of material deformation process they are required for

SYLLABUS

Module 1: Basics of Plastic Deformation **[7]**
Basic concepts of hot, cold and worm working, forming operations, forces and stresses in forming processes, Thermo-mechanical treatment
Emerging Deformation Processes: Principles and applications of Isothermal forging, water hammer forging, liquid metal forging (squeeze casting), continuous extrusion (conform extrusion), hydro–static extrusion, hydro–dynamic wire drawing, spray forming, explosive forming

Module 2: Material Deformation Theories **[10]**
State of stress at a point, equilibrium equations, stress tensor, spherical tensor and deviator stress tensor, principal stress, deformation tensor, compatibility equation
Engineering and true stress –strain, flow curve, idealized stress-strain model, plastic deformation equations, Levy–Mises equations, Prandlt–Reuss equations, strain hardening, strain rate and Bauschinger effects
Velocity field and strain rate, Von – Mises and Tresca yield criterion, biaxial and triaxial yield surfaces, experimental verification of yield criterion, lode–stress parameter

Module 3: Friction and Lubrication **[5]**
Interfacial friction laws–Coulombs friction law, constant shear factor law, composite friction law and hydrodynamic friction law, friction mechanism during plastic deformation, lubrication mechanisms– boundary, hydrodynamic and solid lubrication, metal working lubricants–types and characteristics

Module 4: Plain Strain Deformation Processes **[9]**
Basic concepts of slip-line method, slab method (equilibrium technique) and energy method (upper bound technique)
Analysis of following deformation processes:
Forging of strip: pressure distribution and forging load

Rolling of strip: pressure distribution, roll–separating force and driving torque

Module 5: Axi-Symmetric Deformation Processes **[9]**
Analysis of following deformation processes:
Forging of disc: pressure distribution and forging load
Extrusion of cylindrical rod: extrusion load and frictional power loss
Drawing of cylindrical wire: drawing load and maximum allowable reduction
Pipe drawing operation

Text books:
1. George E. Dieter, Mechanical Metallurgy, McGraw Hill, 3rd Edition **[T1]**
2. Ghosh and Mallik, Manufacturing Science, Pearson India, 2nd Edition **[T2]**
3. B.L Juneja, Fundamentals of Metal Forming Processes, New Age International, 2nd Edition [**T3]**

Reference books:
1. G.W. Rowe, Edward Arnold, Principle of Industrial Metal Working, CBS Publishers, 1st edition **[R1]**
2. B. Avitzur, Metal Working Processes and Analysis, McGraw Hill, 1st edition **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Finite Element Method, Slip Line method

POs met through Gaps in the Syllabus:
POs 1-5

Topics beyond syllabus/Advanced topics/Design:
Upper Bound Solution

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-5

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	3	2	0	0	2	0	1	2	2	3	2
CO2	3	3	2	3	3	2	0	0	0	0	2	2	3	2
CO3	3	3	3	3	3	0	0	2	2	0	2	2	2	2
CO4	1	2	0	2	3	2	3	1	2	0	1	3	2	2
CO5	2	0	0	2	0	2	1	0	0	1	2	1	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: ME 24323
Course title: MECHATRONICS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: V/ Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students:

1	To present a comprehensive treatment on Mechatronics and Real time interfacing.
2	To lay the groundwork for subsequent studies in the fields of sensors, actuators and digital technologies
3	To develop an intuitive understanding of various microcontrollers and automated systems for system design
4	To be able to understand and tackle various problems of conventional approach to design and solve case studies with robotics and automation

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

1.	Explain the mechatronic system and its hydraulic and electronic components.
2.	Apply control theories to design mechatronic system.
3.	Analyze theoretical and practical aspects of computer interfacing and real time data acquisition and control.
4.	Evaluate real time problem related to mechatronic system.

SYLLABUS

Module 1: Introduction **[8]**

Introduction: Definition of Mechatronics, Mechatronics in manufacturing products and design, Review of fundamentals of electronics, Gates and K map Minimization, JK Flip Flop

Module 2: Signal Conditioning **[8]**

Signal Conditioning: Mechatronics elements, Data Conversion Devices, Sensors and transducers, Microsensors, Signal processing Devices, Relays, Comparators, Filters, Timers, Transfer Systems, PLC's programming

Module 3: Processors Controllers and Drives **[8]**

Processors Controllers and Drives: Microprocessors, Microcontrollers, Drives, Linear motion bearings, cams and ball screws, PID controllers, Closed Loop and Open loop

Module 4: Actuators **[8]**

Actuators: Servo motors, Stepper motors, Hydraulic actuators, Flow, Pressure and Direction control valves, Pneumatic Actuators, Distribution and conditioning of Compressed air, system components and graphic representations

Module 5: CNC Technology and Robotics **[8]**

Real time Systems, Industrial Robotics, Case Studies, CNC and Industrial Robotics

Books:

Text books:
1. Introduction to Mechatronics and Measurement System by David G. Alciatore, Michael B. Histamd, McGraw Hill (**T1**)
2. Mechatronics by Bolton, Pearson Education (**T2**)

Reference books:
1. Mechatronics System Design by Devdas and Shetty, Pearson Education (**R1**)
2. CNC TECHNOLOGIES BY HMT LTD MGH (**R2**)

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	2	3	0	0	0	2	0	2	3	2	2
CO2	3	3	3	2	3	0	0	0	2	0	3	2	3	3
CO3	3	3	3	3	3	0	0	0	2	0	3	2	3	3
CO4	3	3	3	3	3	0	0	0	3	0	3	1	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24319
Course title: PROJECT MANAGEMENT
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: All (Open Elective)
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Decide the scope and classification of projects
2	Develop the stages of Project Life Cycle and identify project constraints
3	Comprehend organizational structure of project management
4	Be aware of environmental issues and social cost benefit analysis of projects
5	Apply various project scheduling tools (PERT and CPM)

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

CO1	Comprehend the various project morphology, organizational structure and elements of project
CO2	Recognize the importance environmental issues in projects
CO3	Handle real-life projects as in various organizations
CO4	Solve complex scheduling problems in project management using PERT/CPM
CO5	Prepare project report and budget planning

SYLLABUS

Module 1: Definitions and basic terms **[7]**
Definition and types of project, Turnkey projects, Scope of project and creep, Project life cycle, Project constraints

Module 2: Organization and appraisal of projects **[8]**
Organizational structures for projects, Responsibilities of project manager, Project risk analysis, Project appraisal (Technical, economic, financial, management)

Module 3: Environmental and social aspects of project **[8]**
Environmental considerations in project evaluation, Primary issues and secondary issues in Feasibility study, Social cost benefit analysis

Module 4: Network analysis **[7]**
Network modeling of a project, Activity on Arc (AOA) verses Activity on Node (AON), Forward and backward pass computation, Critical paths, floats and slack

Module 5: PERT/CPM models **[10]**
Project Scheduling Techniques, PERT, CPM Models, Time-Cost Trade-off in a project, Project Monitoring Techniques,

Text books:
1. Project Management by Prasanna and Chandra, Tata McGraw Hill. [**T1**]
2. Elements of Project Management by Pete Spinner, Prentice Hall, USA. [**T2**]

Reference Books:
1. Production and Operation Management by Alan Muhlemann, John Oakland and Keith Lockyer, MacMillan India Ltd. [**R1**]

2. A course in PERT and CPM by R. C. Gupta, Dhanpat Rai Publications(P) Ltd, Delhi. [**R2**]
3. Industrial Engineering and Management by O. P. Khanna, Dhanpat Rai & Sons. [**R3**]

Gaps in the syllabus (to meet Industry/Profession requirements):
Software applications for project management

POs met through Gaps in the Syllabus:
PO 5

Topics beyond syllabus/Advanced topics/Design:
Project selection using decision making tools

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 3, 11

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	√
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	**% Distribution**				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2	3	1	0	0	0	0	0	0	0
CO2	1	1	1	3	1	2	0	0	0	0	0
CO3	1	2	2	2	0	3	0	0	0	0	0
CO4	2	2	2	2	0	0	0	0	0	0	0
CO5	1	2	2	1	0	2	0	0	0	0	0

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD4, CD6
CO2	CD1, CD2, CD4, CD6
CO3	CD1, CD2, CD4, CD6
CO4	CD1, CD2, CD4, CD6
CO5	CD1, CD2, CD4, CD6

COURSE INFORMATION SHEET

Course code: PE 24321
Course title: WORK STUDY & ERGONOMICS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: V / Third
Branch: All (Open Elective)
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the basic concept as well as scope of work study and Ergonomics.
2	Analyses existing work method at macro and micro level to eliminate the unwanted activities for improvement of existing method and development of the best work method.
3	Estimate standard time for existing as well as proposed work method.
4	Evaluate job as well as rate the merit of the worker and estimate the wages and wage incentives for fair days' work.
5	Understand the basic principle of ergonomics, metabolism and measure of physiological functions.

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

CO1	Apply the concept of work study and ergonomics for enhancement of industrial productivity.
CO2	Analyse the work method and develop an improved work method.
CO3	Find out the standard time of carrying out task under specified working conditions.
CO4	Evaluate the job and rate the merit of the worker.
CO5	Analyse the human factor engineering.

SYLLABUS

Module 1: Productivity and Work Study **[10]**
Definition, objective and scope of work study and ergonomics and its historical background, Interrelationship between work study and ergonomics, Concept of Productivity, Reasons for low productivity, Role of work study and ergonomics in productivity improvement.

Module 2: Method study **[6]**
Definition, objectives and procedure of method study, Various recording techniques for method analysis, principles of motion economy and their application in work design, Therbligs, Objectives procedure and application of micromotion analysis.

Module 3: Work measurement **[8]**
Conceptual framework, objectives and basic procedure of work measurement; procedure of stop watch time study, concept and methods of rating and allowances, evaluation of standard time. Work sampling: Basic procedure of work sampling study and establishment of standard-time by work sampling method. Predetermined motion time system, Methods Time Measurement (MTM).

Module 4: Job evaluation, merit rating and wage incentive plans **[8]**
Definition, objectives and techniques of job evaluation and merit rating. Various wage incentive techniques such as straight-line method, Taylor's differential wage incentives plans, Mevrick plan, Gantt plan, Emersion's efficiency plan, Halsey plan, Rowan plan.

Module 5: Ergonomics **[8]**

Man – machine interaction, design of controls and displays, work physiology and its application in work design, work station design.

Text Books:

1. Ralph M. Barnes, Motion and Time Study: Design and Measurement of Work, Wiley, 7th Edition **[T1]**
2. Sanders, M. S., & McCormick, E. J., Human factors in engineering and design. McGraw-Hill book company. **[T2]**
3. David J. Oborne, Ergonomics at Work, Wiley, 2nd edition **[T3]**
4. O.P. Khanna, A Text-Book of Work Study, Dhanpat Rai Publications **[T4]**

Reference Books:

1. George Kanawaty, Introduction to work study. 4th revised edition, ILO **[R1]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Advance human factor Engineering

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1-5, 7, 9, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**										
	1	2	3	4	5	6	7	8	9	10	11
CO1	3	3	3	3	2	3	1	3	3	2	2
CO2	3	3	3	3	2	3	1	3	3	2	2
CO3	3	3	3	3	2	3	1	3	3	2	2
CO4	3	3	3	3	2	3	1	3	3	2	2
CO5	3	3	3	3	3	3	1	3	3	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24329
Course title: MACHINE TOOL DESIGN
Pre-requisite(s): INTRODUCTION TO MATERIALS ENGINEERING; STRENGTH OF MATERIALS; DESIGN OF MACHINE ELEMENTS
Co- requisite(s): MACHINE TOOL DESIGN SESSIONAL
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about kinematic structure and general requirements of machine tool design
2	Learn about regulation of spindle speeds and design of gear box
3	Understand the basic design procedures for machine tool structures like beds, tables and columns
4	Understand the basic design procedures for machine tool guideways, spindle and elements of machine tool controls
5	Understand the effect of vibrations on machine tools and the methods of elimination of vibration

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

CO1	Select drives for machine tools
CO2	Design of gear box for speed and feed regulation
CO3	Design machine tool structures like beds, tables and columns.
CO4	Design machine tool guideways, spindle and to select elements for machine tool controls
CO5	Design for elimination of vibration to increase machine tool life

SYLLABUS

Module 1: Kinematics of Machine Tools **[7]**

Definition and Classifications of machine tools; basic motions and general requirements of machine tool design; mechanisms for transmission of motions; fundamental of kinematic structures of machine tools; types of drives and their elements; selection and design requirements of machine tool drives; classification of speed and feed boxes.

Module 2: Regulation of spindle speeds and design of gear box **[9]**

Aim of speed and feed rate regulation; stepped regulations and productivity loss; layout of spindle speeds; preferred numbers; design of gear box for speed and feed regulation: structure diagram, ray diagram, determination of shaft size, number of gear teeth, gear width, module; rules for layout of gear boxes having sliding clusters; stepless regulation.

Module 3: **Design of Machine Tool Structures** **[10]**

Classifications of machine tool structures; basic principles of design for strength and rigidity; unit strength and unit rigidity, optimum design criteria; materials for machine tool structures; profiles of machine tool structures; methods of increasing strength and rigidity; basic design procedure for machine tool structure; design for strength and rigidity for bending and torsion; design of lathe bed, design of machine tool column.

Module 4: Machine Tool Guideways and spindles **[8]**

Function, requirements and types of guideways; constructional features and tribological aspects of guideways; slideways; slideway profiles and their applications; materials for slideways; design of slideways for wear resistance and stiffness; protecting devices for slideways; antifriction guideways; antifriction guideways profiles and their applications; combination guideways; Function, requirements and basic design procedure of spindles; materials for spindles.

Module 5: Machine Tool Controls; and Machine Tool Vibrations [6]

Basic elements of machine tool controls; principle of lever, wheel and push button operations; mechanical controls, electrical controls; ergonomic considerations applied to the design of control members;

Vibration in machine tools; dynamic rigidity and stability; sources of vibration; effect of vibration on machine tool, cutting conditions, workpiece and tool life; machine tool chatter; analysis of single degree of freedom machine tool chatter: velocity principle and related models; elimination of vibration.

Text Book

1. A. Bhattacharya and S. G. Sen., Principles of Machine Tool, New central book agency Calcutta. **(T1)**
2. N.K. Mehta, Machine Tool Design and Numerical Control, Tata McGraw Hill. **(T2)**
3. D. K Pal, S. K. Basu, Design of Machine Tool, Oxford. **(T3)**

Reference Book

1. N. S. Acherkan, Machine Tool, Vol. I, II, III and IV, MIR publications. **(R1)**
2. F. Koenigsberger, Design Principles of Metal Cutting Machine Tools, The Macmillan Company, New York **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of spindle supports, knee and tables

POs met through Gaps in the Syllabus:
POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:
Numerical control of machine tools

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	2	0	0	0	0	0	0	2	3	2	3
CO2	3	3	3	2	0	0	0	0	1	0	2	3	2	3
CO3	3	3	3	2	0	0	0	0	1	0	2	3	2	3
CO4	3	3	3	2	0	0	0	0	1	0	2	3	2	3
CO5	3	3	3	2	0	0	0	0	1	0	2	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24330
Course title: MACHINE TOOL DESIGN SESSIONAL
Pre-requisite(s): None
Co- requisite(s): MACHINE TOOL DESIGN
Credits: 1 L:0 T:0 P: 2
Class schedule per week: 2
Class: B.Tech.
Semester / Level: VI / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn classification and requirements of machine tools
2	Get acquainted with different mechanisms of mechanical transmission
3	Understand the techniques used for regulations of spindle speeds and design of gear box
4	Develop an understanding of basic design procedures for machine tool structures like beds, guideways
5	Learn ergonomic consideration applied to the design of different control members

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

CO1	Classify the machine tools and specify different machine tools
CO2	Select feasible mechanisms of mechanical transmission during machine tool design
CO3	Design gear boxes for required speed layout of machine tools
CO4	Design machine tool structures like beds, guideways
CO5	Design control elements used in machine tools

SYLLABUS

LIST OF EXPERIMENT:

1. **EXPERIMENT – 1: Classification of machine tools**

Objective: To classify the machine tools

i. Classify the machine tools according to their weight, degree of automation and degree of specialization.
ii. Classify the machine tools and to specify the machine tools available in workshop and/or machine tools lab

.

2. **EXPERIMENT – 2: Study of different mechanisms of mechanical transmission used in machine tools (Part - I)**

Objective: To study different mechanisms of mechanical transmission used in machine tools:

i. Elementary transmission that transfer rotation
ii. Elementary transmission that transform rotary motion into translatory motion

3. **EXPERIMENT – 3: Study of different mechanisms of mechanical transmission used in machine tools (Part – II)**

Objective: To study different mechanisms of mechanical transmission used in machine tools:

i. Devices for intermittent motion
ii. Reversing and differential mechanisms

4. **EXPERIMENT – 4: Study of kinematic structures of different machine tools**

Objective: To study the kinematic structures of different machine tools:

i. Elementary kinematic structure in broaching machine, milling machine, cylindrical grinding machine with hydraulic table feed movement
ii. Complex kinematic structure in screw cutting lathe, lathe for cutting taper threads

iii. Compound kinematic structure in arrangement for thread milling, cylindrical grinding (tapered or conical profile)

5. EXPERIMENT – 5: Speed layout of machine tools and analysis of productivity loss

Objective: To find the speed layout ad to calculate the productivity loss:

i. Find the speed layout (steps) arranged in Geometric, Harmonic and Logarithmic progression for the following conditions. $N_1 = 30$ rpm; $N_Z = 375$ rpm and speed steps Z = 12.
ii. Find the average and maximum productivity losses for above speed layouts

6. EXPERIMENT – 6: Analysis of speed structure and design of gear box (Part - I)

Objective: To design a 4-speed gear box for transmitting 10 HP with speeds ranging from 400 rpm, with $\varphi = 1.4$.

i. Study the basic rules for constructing admissible structural forms
ii. Select a suitable structural form
iii. Select the optimum ray diagram.
iv. Calculate the shaft sizes

7. EXPERIMENT – 7: Analysis of speed structure and design of gear box (Part - II)

Objective: To design a 4-speed gear box for transmitting 10 HP with speeds ranging from 400 rpm, with $\varphi = 1.4$.

i. Calculate the gear sizes, module and width of the gears.
ii. Study the rules for layout of gear boxes having sliding clusters
iii. Draw the gearing diagram.

8. EXPERIMENT – 8: Study of different gearing arrangements for feed regulations in machine tools

Objective: To study the different gearing arrangements for feed regulations in machine tools:

i. Feed boxes with change gears
ii. Feed boxes with sliding gears
iii. Feed boxes with gear cone and sliding key
iv. Feed boxes with tumbler gear (Norton's gear)
v. Feed boxes with Meander's mechanism

9. EXPERIMENT – 9: Design of lathe bed (Part – I)

Objective: To design a lathe bed using 'design for strength' criteria

i. Design for strength by considering the shear stress due to torsion,
ii. Design for strength by considering the bending stress due to bending in vertical and horizontal directions

10. EXPERIMENT – 10: Design of lathe bed (Part – II)

Objective: To design a lathe bed using 'design for stiffness' criteria

i. Determine the moment of inertia of the bed about Y-Y and Z-Z axes for determining σ_{zmax} and σ_{ymax} and the deflections in the Z and Y directions
ii. Determine the torsional moment of inertia for determining τ_{max} and the maximum angle of twist.

11. EXPERIMENT – 11: Design of sideways

Objective: To design of slideways for 'wear resistance'

i. Determination of forces acting on the mating surfaces in a combination of two flat slideways
ii. Determination of average pressure
iii. Determination of maximum pressure

.

12. EXPERIMENT – 12: Design of control elements

Objective: Study the various ergonomic consideration applied to the design of different control members.

i. Push buttons
ii. Toggles
iii. Knobs
iv. Crank
v. Hand wheel, etc

Text Book

1. A. Bhattacharya and S. G. Sen., Principles of Machine Tool, New central book agency Calcutta. **(T1)**
2. N.K. Mehta, Machine Tool Design and Numerical Control, Tata McGraw Hill. **(T2)**
3. D. K Pal, S. K. Basu, Design of Machine Tool, Oxford. **(T3)**

Reference Book

1. N. S. Acherkan, Machine Tool, Vol. I, II, III and IV, MIR publications. **(R1)**
2. F. Koenigsberger, Design Principles of Metal Cutting Machine Tools, The Macmillan Company, New York **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of spindles

POs met through Gaps in the Syllabus:
POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:
Use of software for design analysis

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Day to day performance & Lab files	√	√	√	√	√
Quiz 1	√	√	√	√	√
Quiz 2	√	√	√	√	√
Viva-voce	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	2	2	1	1	0	0	0	0	1	0	1	2	2	2
CO2	3	2	2	1	0	0	0	0	0	0	2	3	2	3
CO3	3	3	3	2	0	0	0	0	1	0	3	3	2	3
CO4	3	3	3	2	0	0	0	0	1	0	3	3	2	3
CO5	3	3	3	2	0	0	0	0	1	0	3	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD3, CD6
CO2	CD1, CD3, CD6
CO3	CD1, CD3, CD6
CO4	CD1, CD3, CD6
CO5	CD1, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24331
Course title: WORK SYSTEM DESIGN
Pre-requisite(s): None
Co- requisite(s): WORK SYSTEM DESIGN LAB
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the basic concept as well as scope of Work study, Method Study and Micromotion Study at macro and micro level of existing work method to eliminate the unwanted activities for improvement of existing method and development of the best work method.
2	Analyses basic procedure of work measurement and establishment of standard-time by different work measurement method to estimate standard time for existing as well as proposed work method.
3	Evaluate job as well as rate the merit of the worker and estimate the wages and wage incentives for fair days' work.
4	Understand the basic principle of ergonomics, metabolism and measure of physiological functions.
5	Understand the basic principle of human body with respect of postures and body mechanics.

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

CO1	Apply the concept of work system for enhancement of industrial productivity.
CO2	Find out the standard time of carrying out task under specified working conditions.
CO3	Evaluate the job and rate the merit of the worker.
CO4	Analyse the human factor engineering.
CO5	Analyse the Physiology and develop an improved work system method.

SYLLABUS

Module 1: Introduction, work study, method study **[12]**
Definition, objective and scope of work study and ergonomics and its historical background. Concept of Productivity, Reasons for low productivity, Role of work study and ergonomics in productivity improvement. Definition, objectives and procedure of method study, Various recording techniques for method analysis, principles of motion economy and their application in work design, Therbligs, Objectives procedure and application of micromotion analysis.

Module 2: Work measurement **[8]**
Conceptual framework, objectives and basic procedure of work measurement; procedure of stop watch time study, concept and methods of rating and allowances, evaluation of standard time. Work sampling: Basic procedure of work sampling study and establishment of standard-time by work sampling method. Predetermined motion time system, Methods Time Measurement (MTM).

Module 3: Job evaluation, merit rating and wage incentive plans **[6]**
Definition, objectives and techniques of job evaluation and merit rating. Various wage incentive techniques such as straight-line method, Taylor's differential wage incentives plans, Mevrick plan, Gantt plan, Emersion's efficiency plan, Halsey plan, Rowan plan.

Module 4: Ergonomics **[6]**
Introduction to industrial ergonomics, constituents' areas of ergonomics, man-machine system, History of ergonomics, Modern ergonomics, metabolism and organization of work, ergonomic aspects in design of controls and displays and

their layout, light and vibration consideration in ergonomically designed system, working conditions and environment, ergonomics and safety.

Module 5: Anthropometry and physiology **[8]**

Anthropometric Principles and Postural Analysis in Workspace Design: Anthropometry and its uses, principles of applied anthropometry, applications of anthropometry in design, postures and body mechanics, musculoskeletal problems in sitting and standing. Design of Manual Handling Tasks: Anatomy and biomechanics of manual handling, design of manual handling tasks; lifting and carrying, Physiology, Workload, and Work Capacity: Physical work capacity, factors affecting work capacity, measurement of physiological cost of work, fitness for work.

Text Books:

1. Ralph M. Barnes, Motion and Time Study: Design and Measurement of Work, Wiley, 7th Edition **[T1]**
2. Sanders, M. S., & McCormick, E. J., Human factors in engineering and design. McGraw-Hill book company. **[T2]**
3. David J. Oborne, Ergonomics at Work, Wiley, 2nd edition **[T3]**
4. O.P. Khanna, A Text-Book of Work Study, Dhanpat Rai Publications **[T4]**

Reference Books:

1. George Kanawaty, Introduction to work study. 4th revised edition, ILO **[R1]**

Gaps in the syllabus (to meet Industry/Profession requirements):

NIL

POs met through Gaps in the Syllabus:

NIL

Topics beyond syllabus/Advanced topics/Design:

Advance human factor Engineering

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1-5, 7, 9, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	√
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	1	2	3	1	2	2	3	3	3	2	3
CO2	3	3	3	1	2	3	1	2	2	3	3	3	2	3
CO3	3	3	3	1	2	3	1	2	2	3	3	3	2	3
CO4	3	3	3	1	2	3	1	2	2	3	3	3	2	3
CO5	3	3	3	1	2	3	1	2	2	3	3	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24332
Course title: WORK SYSTEM DESIGN LAB
Pre-requisite(s): None
Co- requisite(s): WORK SYSTEM DESIGN
Credits: 1 L:0 T:0 P: 2
Class schedule per week: 2
Class: B.Tech.
Semester / Level: VI / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the method of drawing different process chats and learn the best way of assembly.
2	Exposure to the students of various work sampling methods and methods of performance evaluation.
3	Evaluate the physical working capacity of humans at various working conditions.
4	Examine the effect of posture on humans at the time of work.
5	Analyze multi-activity charts and evaluate them as per assembly.

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

CO1	Construct different process charts and compute a time study.
CO2	Analyze idle time of operation and evaluate performance by different rating methods.
CO3	Plot different flow process charts as per the given narrative.
CO4	Analyze the effect of posture in any operation by cycle ergometer and wireless EMG systems.
CO5	Plot multi-activity charts for any given assembly.

SYLLABUS

LIST OF EXPERIMENT:

1. **EXPERIMENT – 1: Two hand process chart**
   Objective: To draw two hand process charts for bolt and washer assembly by old and improved method.

2. **EXPERIMENT – 2: Assembly of rope clip**
   Objective: Assembly of rope clip by old and improved methods.

3. **EXPERIMENT – 3: Pin board assembly**
   Objective: To find the best method for pin board assembly.

4. **EXPERIMENT – 4: Assembly of bracket**
   Objective: Assembly of bracket and bolt by old and improved methods.

5. **EXPERIMENT – 5: Work sampling method-I**
   Objective: To find the idle time by work sampling method.

6. **EXPERIMENT – 6: Performance evaluation**
   Objective: Performance evaluation by card rating.

7. **EXPERIMENT – 7: Time study-I**
   Objective: Time study for drilling and chamfering operations.

8. **EXPERIMENT – 8: Preparation of flow process chart**
   Objective: To prepare a flow process chart as per the given narrative.

9. **EXPERIMENT – 9: Assembly of nuts and bolts**
   Objective: Assembly of nuts and bolts in various subjects.

10. **EXPERIMENT – 10: Effect of Posture**
    Objective: Effect of posture on the response to cycle ergometer exercise and measured by Wireless EMG system.

11. **EXPERIMENT – 11: Effect of Posture-II**
    Objective: Effect of different postures on the response to cycle ergometer exercise and measured by Wireless EMG system.

12. **EXPERIMENT – 12: Physical working capacity**
    Objective: Evaluation of the physical working capacity of various machines.

13. **EXPERIMENT – 13: Time study-II**
    Objective: Time study for turning operation in the center lathe.

14. **EXPERIMENT – 14: Work sampling-II**
    Objective: work sampling study from the given machines.

Text Book

1. Ralph M. Barnes, Motion and Time Study: Design and Measurement of Work, Wiley, 7th Edition [**T1**]
2. Sanders, M. S., & McCormick, E. J., Human factors in engineering and design. McGRAW-HILL book company. [**T2**]
3. O.P. Khanna, A Text-Book of Work Study, Dhanpat Rai Publications [**T3**]

Reference Book

1. George Kanawaty, Introduction to work study. 4th revised edition, ILO **[R1]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Unavailability of advanced equipment.

POs met through Gaps in the Syllabus:
PO-5

Topics beyond syllabus/Advanced topics/Design:
Latest equipment in the field of workstudy and ergonomics.

POs met through Topics beyond syllabus/Advanced topics/Design:
PO-5, PO-6, PO-12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Day to day performance & Lab files	30
Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Day to day performance & Lab files	√	√	√	√	√
Quiz 1	√	√	√	√	√
Quiz 2	√	√	√	√	√
Viva-voce	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (Cos) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	2	2	1	2	2	1	2	2	3	3
CO2	3	3	3	3	2	2	1	2	2	1	2	2	3	3
CO3	3	3	3	3	2	2	1	2	2	1	2	2	3	3
CO4	3	3	3	3	2	2	1	2	2	1	2	2	3	3
CO5	3	3	3	3	2	2	1	2	2	1	2	2	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD3, CD6
CO2	CD3, CD6
CO3	CD3, CD6
CO4	CD3, CD6
CO5	CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24333
Course title: SUPPLY CHAIN MANAGEMENT
Pre-requisite(s): OPERATIONS RESEARCH
Co- requisite(s): None
Credits: 3 L: 3 T:0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI/ Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Provide an insight on the fundamentals of supply chain strategy
2	Know the various distribution and transportation networks and their applications
3	Acquire the concepts of logistics in improving the supply chain and other functional areas of an organization
4	Understand the role of sourcing, information technology, and coordination in a supply chain
5	Know the recent trends in supply chain management

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

CO1	Identify the goals of a supply chain and analyze the impact of supply chain decisions on the success of a firm
CO2	Develop a framework for making decisions on supply chain network design
CO3	Implement practical concepts in logistics to improve supply chain operations
CO4	Evaluate and select the best supplier and take decisions on outsourcing for a firm
CO5	Understand the recent trends in supply chain management

SYLLABUS

Module 1: Introduction to Supply Chain Management **[8]**
Understanding the supply chain, Supply Chain Performance- Achieving strategic fit and scope, key issues, Supply chain modelling, Supply Chain Drivers and Metrics, Centralized vs. decentralized systems.

Module 2: Designing the Supply Chain Network **[9]**
Distribution Networks– Design options for a distribution network, e-Business and the distribution network, Network design in an uncertain environment. Transportation Networks- Design options for a transportation network, Trade-offs in transportation design, Vehicle routing and scheduling, Supply Chain Optimization.

Module 3: **Logistics Management** **[8]**
Logistics Management: Logistical operation, integration, network design, logistical performance cycle, customer service global logistics, logistical resources, logistics planning, Third- and fourth-party logistics providers, Measuring logistics costs and performance, e-logistics, Reverse logistics.

Module 4: Managing Cross-Functional Drivers in a Supply Chain **[8]**
Sourcing Decisions- Make or buy decisions, Sourcing Processes. Information Technology in a Supply Chain, Supply chain 4.0, Coordination in a Supply Chain-Bullwhip effect.

Module 5: Recent Trends in Supply Chain Management **[7]**
Lean Supply Management, Agile Supply Management, Green and Sustainable Practices of Supply Chain, Supply Chain Digitization, Circular Supply Chains, Supply chain cases.

Text Book

1. Chopra, S., and Meindl, P. "Supply Chain Management, strategy, planning, and operation" 6/e – PHI, second edition, 2014. **[T1]**
2. Christopher, M., "Logistics and Supply Chain Management", Pearson Education Asia, New Delhi. **[T2]**

Reference Book

1. Taylor and Brunt, "Manufacturing Operations and Supply Chain Management (The Lean Approach)", Business Press Thomson Learning, NY. **[R1]**
2. Arjan J. Van Weele, "Purchasing and Supply Chain Management (Analysis Planning and Practice)", Engineering, Business Press, Thomson Learning NY. **[R2]**
3. Shah, J. "Supply Chain Management, text and cases", Pearson Education South Asia,2009. **[R3]**
4. Balkan Cetinkaya, Richard Cuthbertson, Graham Ewer, "Sustainable Supply Chain Management: Practical ideas for moving towards best practice", Springer, 2011. **[R4]**
5. Sople, V.V "Supply Chain Management, text and cases", Pearson Education South Asia, 2012. **[R5]**
6. Donald B., "Logistic Management - The Integrated Supply Chain process", McGraw Hill. **[R6]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Mathematical Modelling of Supply Chain
Application of meta-heuristics for supply chain optimization

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	2	2	2	2	2	2	3	3	3	1	1	3	3	3
CO2	1	2	2	2	2	2	3	3	3	3	3	3	3	3
CO3	3	1	1	1	1	2	2	2	2	2	2	3	3	3
CO4	1	3	3	3	3	3	2	2	3	3	3	3	3	3
CO5	1	1	3	3	3	3	3	3	1	1	1	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24335
Course title: SURFACE ENGINEERING AND LASER ADDITIVE MANUFACTURING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L: 3 T:0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI/ Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the science and importance of surfaces, surface dependent properties of engineering solids
2	Learn about appropriate testing procedures to evaluate surface dependent engineering properties
3	Acquire fundamentals and practices of various surface engineering techniques to improve surface dependent engineering properties of metallic, ceramic and polymeric solids
4	Get familiar with directed energy beam techniques (laser, ion, and electron beams) and in particular laser assisted surface engineering and material processing
5	Develop an understanding of laser assisted additive manufacturing techniques and its application

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

CO1	Classify and relate various surface degradation and surface-initiated failure mechanisms of engineering solids occurring under different service conditions.
CO2	Analyze the importance, relative advantages and limitations and overall scope of application of various surface engineering methods
CO3	Compare and contrast different surface modification and coating technologies from various perspectives of applicability, economy, efficiency, and scopes of further improvement
CO4	Analyze real life surface failure problems (case studies) and prescribe the correct surface engineering solution
CO5	Explore the applications potential of laser additive manufacturing of engineering components – flexibility, advantages, limitations, current status and future developments awaited

SYLLABUS

Module 1: Structure of Solids, Surface Dependent Engineering Properties and Mechanisms of Surface Degradation and Failures **[9]**
Introduction to the structure of solids: structure, morphology, energy, types, and classification, Surface-dependent engineering properties: physical, chemical, and mechanical – their definition, origin, and importance, Common surface-initiated engineering degradation/failures and their mechanism: wear, friction, fatigue, corrosion, oxidation

Module 2: Classification and Outline of Surface Engineering Practices and Strengthening Mechanisms of Engineering Solids **[5]**

Importance of surface engineering (SE), Classification and scope of surface engineering of alloys and components, Methods and principles of surface modification of materials; Strengthening mechanism of engineering materials – metallic and non-metallic

Module 3: Surface Modification Techniques based on Mechanical and Diffusional Treatments (without change in dimension) **[6]**

Conventional surface modification methods: shot peening, flame and induction hardening, carburizing, nitriding, diffusion-aided surface alloying

Module 4: Surface Modification Techniques based on Diffusional, Chemical and Electro-chemical Treatments (with change in dimension) **[10]**

Surface coating techniques by chemical/electrochemical routes: electro/electroless deposition, anodizing, galvanizing, etc.

Module 5: Advanced Surface Modification Techniques and Laser Additive Manufacturing **[10]**

Surface coating by physical routes: thermal/plasma spray, physical/chemical vapor deposition, sputtering, Advanced surface modification methods: ion and electron beam assisted surface engineering, Laser surface engineering involving both changes in microstructure and composition, Additive manufacturing vis-à-vis subtractive manufacturing, Advantages, and challenges, recent trends and innovations, laser-assisted additive manufacturing of polymers, metals and alloys, characterization and testing

Text and Reference Books:

1. Surface Engineering for Wear Resistances (Introduction and classification of Wear), By: K.G. Budinski, Prentice Hall, Englewood Cliffs, 1988 **[T1]**
2. Corrosion Engineering (classification of Corrosion), By: M.G. Fontana, M.C. Graw Hill, N. York, 1987 **[T2]**
3. Materials Science and Engineering by W. D. Callister
4. Introduction to Surface Engineering and Functionally Engineered Materials, by Peter Martin, WILEY, 2011
5. Surface Engineering of Metals: Principles, Equipment, Technologies, by: Tadeusz Burakowski, Tadeusz Wierzchon, CRC Press, 1988
6. Surface Engineering for Corrosion and Wear Resistance, by JR Davis, ASM International, 2001
7. Additive Manufacturing by Andreas Gebhardt and Jan-Steffen Hötter, Springer, 2016
8. Additive Manufacturing of Metals by John O. Milewski, Springer, 2017

<u>Gaps in the syllabus (to meet Industry/Profession requirements)</u>: No Practical exposer

<u>POs met through Gaps in the Syllabus</u>: NA

<u>Topics beyond syllabus/Advanced topics/Design</u>: NA

<u>POs met through Topics beyond syllabus/Advanced topics/Design</u>: NA

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	√
CD5	Industrial visits/in-plant training	√
CD6	Self-learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	2	2	3	2	1	1	1	1	2	2	3	3
CO2	3	3	3	2	3	2	1	1	1	1	2	2	3	3
CO3	3	3	3	2	3	2	1	2	2	1	2	3	3	3
CO4	3	3	3	3	3	2	1	2	2	1	2	3	3	3
CO5	3	3	3	2	3	2	1	1	1	1	2	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6
CO5	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course code: PE 24337
Course title: TRIBOLOGY IN ENGINEERING
Pre-requisite(s): FOUNDRY, FORMING & WELDING TECHNOLOGIES
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI /Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the fundamentals of tribology including its importance in industrial applications and learn about the basic theories of friction, adhesion and wear
2	Learn about the different types, applications and parameters affecting various lubricants and understand the basic regimes of lubrication and the associated theories
3	Examine the properties, behavior and utilization of the different types of materials in tribology
4	Investigate the different experimental methods utilized for the measurement of friction and wear, and learn the techniques to analyze the wear debris and friction surfaces
5	Acquire knowledge about the application of tribology to different real-life domains such as micro-tribology, bio-tribology, metal forming and MEMS/NEMS

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

CO1	Explain the basic theories and rules of friction, adhesion and wear
CO2	Select lubricants for different real life industrial applications and analyze the lubrication conditions for different conditions
CO3	Design and select the best suited material for specific applications
CO4	Interpret and analyze the experimental data generated during friction and wear testing under different conditions
CO5	Apply the theories of tribology to specific domains of engineering applications

SYLLABUS

Module 1: Introduction to Tribology, Friction and Wear [12]

Introduction – Importance of tribology, Interdisciplinary approach, Industrial Significance; **Contact of Surfaces** – Single Asperity Contact, Multiple Asperity Contact, Measurement of Contact Area; **Adhesion Theory**; **Friction** – Solid-solid Contact, Liquid Mediated Contact, Laws of Friction; **Wear** – Abrasion, Adhesion, Fatigue, Impact, Fretting, Wear Debris

Module 2: Lubricants and Lubrication [10]

Properties of Lubricants – Density, Viscosity, Wettability, Effect of Temperature and Pressure on Viscosity, Viscosity Index; **Types of lubricants** – liquid lubricants, solid lubricants, extreme pressure lubricants, advanced lubricants; **Selection of lubricants**; **Lubrication regimes** – Boundary lubrication, Mixed lubrication, Hydrodynamic lubrication; **Basic theories of hydrodynamic lubrication**

Module 3: Tribological Applications of Materials [5]

Importance of materials in tribology; **Conventional materials for tribology** – Steel, Cast iron, Copper alloys, Aluminum alloys, Titanium alloys; **Advanced materials for tribology** – Ceramics, Polymers, Cemented carbides, Nanostructured materials, Graphite and allotropes, Thermal barrier coatings

Module 4: Experimental Methods in Tribology **[6]**

Introduction to experimental methods in tribology; **Friction and Wear Testing Equipment** – Pin on Disc, Block-on-Ring, Disc-on-Disc, Four Ball Tribometer, Pin Abrasion Wear Tester; **Methods for Wear Product Analysis** – Weighing, Length Measurement, Profile Analysis, Indentation, Grooving, Chemical Analysis, Ferrography; **Methods for Friction Surface Morphology Analysis** – Surface Topography, Atomic Force Microscopy, Surface Structure Analysis, Surface Chemical Composition Analysis

Module 5: Applied Tribology **[7]**

Analysis of the Mechanics of Friction, Wear, and Lubrication in – **Micro Tribology**, **Metal Forming Tribology**, **Bio Tribology**, **Tribology for MEMS/NEMS**

Text Book

1. K. C. Ludema, Friction, Wear, Lubrication: A Textbook in Tribology, CRC Press. **(T1)**
2. G. W. Stachowiak, Andrew W. Batchelor, Engineering Tribology, Elsevier. **(T2)**
3. B. Bhushan, Introduction to Tribology, Wiley. **(T3)**

Reference Book

1. F. P. Bowden, D. Tabor, Friction: An Introduction to Tribology, Kreiger Co. **(R1)**
2. I. Hutchings, P. Shipway, Tribology: Friction and Wear of Engineering Materials, Butterworth-Heinemann, **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Tribological Components and Industrial Applications

POs met through Gaps in the Syllabus:
POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:
Green tribology, Biomimetrics

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher’s Assessment	05

End Semester Examination	% Distribution				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
CO1	3	3	3	2	3	3	0	1	2	0	2	3	2	3
CO2	3	3	3	2	2	3	1	2	1	1	2	3	2	3
CO3	3	3	3	2	3	3	1	3	1	1	2	3	2	3
CO4	3	3	3	2	3	3	1	2	1	2	2	3	2	3
CO5	3	3	3	2	1	3	0	3	1	1	2	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE24339
Course Title: TOOLING FOR MANUFACTURING
Pre-requisite(s): FOUNDRY, FORMING & WELDING TECHNOLOGIES; MACHINING SCIENCE AND MACHINE TOOLS
Co-requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI /Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	To analyze the properties of various tooling materials and evaluate their economic implications in manufacturing processes.
2	Critically evaluate the principles and types of location and clamping, and synthesize knowledge on the design and application of various jigs and fixtures
3	Critically analyze and apply advanced principles of sheet metal layout design and die design
4	Critically evaluate and synthesize concepts in the design of drawing dies
5	Formulate and evaluate procedures for designing single-point cutting tools, form tools, drill bits and milling cutters

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

CO1	Critically evaluate and justify the selection of tool materials and conduct a comprehensive economic analysis of tool usage.
CO2	Employ creative synthesis to conceptualize and design a range of jigs and fixtures tailored to meet industrial needs.
CO3	Implement the design process for blanking and piercing dies, and the sheet metal layout planning required in sheet metal fabrication.
CO4	Critically analyze and apply theoretical concepts of drawing blank development, identify and troubleshoot common defects, and implement effective remedies in the context of sheet metal forming processes.
CO5	Synthesize and apply design principles to develop tools for producing holes, surfaces of revolution, and flat surfaces.

SYLLABUS

Module 1: Introduction to Tooling materials and economics of tooling **[6]**
Introduction to tool design, tooling materials: Materials for cutting tools, Materials for dies and punches, Materials for Gauges; Economics of Tooling.

Module 2: Conceptual Design of Jigs & Fixtures **[10]**
Introduction to Jigs & Fixture; Principal of design and construction of Jigs and fixtures; Location, and clamping techniques; Basic Design Concepts for Turning Fixtures, Milling Fixtures, Drilling Jigs, Indexing Jigs; Modular fixture.

Module 3: **Sheet Metal Die Design** **[10]**
Introduction to Die Assembly; Classification of Dies; Blanking and Piercing Dies; Shearing Action in Die Operations; Punch and Die Clearance; Centre of Pressure; Cutting Force Calculation; Design of Die Elements; Strip Layout Design; Practical Applications and Case Studies

Module 4: **Drawing Die Design** **[6]**
Theory of Drawing; blank development, strain factor; Calculation of blank diameter; calculation of the number of stages of drawing; force calculation; defects, and remedies; ironing

Module 5: Cutting tool **[8]**
Design of single-point tools; Design of flat and circular form tools, Design of drills, and milling cutters.

Text Book

1. Production Engineering Design (Tool Design) by Surender Kumar, Umesh Chandra and S.C. Srivastava, Satya Prakashan (T1)
2. P. H. Joshi, Jigs and Fixtures Design Manual, Mc Graw Hill, 2003
3. Tool Design by C. Donaldson, G.H.Lecain, V.C.Goold, and Joyjeet Ghose, Tata McGraw Hill (T2)
4. Manufacturing Technology, Volume-1 , Foundry, Forming and Welding, P. N. Rao, Tata McGraw Hill (T3)

Reference Book

1. K. A. Victor, Properties and Selection of Tool Material, ASM, 1975 **(R1)**
2. Fred H. Colvin, Jigs & Fixtures, McGraw-Hill Book Co., 1948 **(R2)**
3. Handbook, Fundamentals of Tool Design, ASTME **(R3)**
4. E. Osterguard, Basic Die Making, Mc-Graw Hill Book Co, 2013. **(R4)**
5. F. W. Wilson, Fundamentals of Tool Design, Literary Licensing, LLC, 2012. **(R5)**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	√
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	3	2	1	1	0	0	1	0	3	2	2
CO2	2	3	2	2	3	1	0	0	2	2	0	2	3	2
CO3	3	2	3	3	3	1	0	0	2	1	0	3	2	3
CO4	3	2	3	3	2	2	1	0	1	1	0	3	2	3
CO5	3	2	3	2	3	1	0	0	2	1	0	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24341
Course title: MANUFACTURING SCIENCE
Pre-requisite(s): FOUNDRY, FORMING & WELDING TECHNOLOGIES; MACHINING SCIENCE AND MACHINE TOOLS
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: Production and Industrial Engineering Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the gating system design, riser design and product design for casting
2	Understand the mechanisms of different bulk forming and sheet metal forming techniques
3	Understand the mechanics of orthogonal and oblique cutting including process mechanics of different machining processes
4	Understand the principles of fusion welding, solid state welding and solid-liquid state welding
5	Learn about the mechanism of material removal, process parameters and applications of different modern machining processes

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

CO1	Design the gating system, riser and products for sand casting
CO2	Explain the mechanisms of forming processes and able to design of dies and presses for sheet-metal processes
CO3	Analyse the cutting forces, estimate machining time, determine economics of machining
CO4	Describe and utilise the conceptual ideas of fusion, solid state and solid-liquid state welding, including techniques for weld inspection and defect minimization
CO5	Exploit the technical know how about different modern machining processes for manufacturing applications

SYLLABUS

Module 1: Casting Processes **[8]**

Pattern, mould and pattern allowances; melting and pouring - gating design, pouring time, choke area, sprue design and aspiration effect, other gating elements and gating ratios, slag trap systems; riser design and placement – Caine's method, modulus method, Naval Research Laboratory method, feeding distances and chills; product design for sand casting.

Module 2: Forming processes **[8]**

Bulk forming and sheet metal forming; material behaviour in metal forming; temperature in metal forming; strain rate sensitivity; friction and lubrication in metal forming; mechanisms of forming processes – rolling, forging, drawing, deep drawing, extrusion, punching and blanking; hydroforming and electroforming.

Module 3: **Machining processes** **[8]**

Mechanics of orthogonal and oblique cutting; mechanics of machining processes – shaping and planning, turning and boring, drilling and milling; selection of cutting conditions and calculation of machining time; economics of machining.

Module 4: Joining processes **[8]**

Principle of fusion welding – heat sources, modes of metal transfer in arc welding, heat flow characteristics, gas metal reaction, heat balance in resistance welding, cooling of fusion weld; principle of solid state welding – friction and forge welding; principle of solid-liquid state welding - soldering and brazing; weld design considerations, weld defects and inspection, weldability.

Module 5: Modern manufacturing processes **[8]**

Mechanism of material removal, process parameters and applications of abrasive jet machining, water jet machining, ultrasonic machining, electro-discharge machining, electro- chemical machining, laser beam machining, electron beam machining; concept and principle of operation of layered manufacturing.

Text books:

1. Ghosh and A.K. Mallik, Manufacturing Science, Affiliated East- West Press **[T1]**
2. P. N. Rao, Manufacturing Technology, Vol 1 & 2, Tata McGraw Hill **[T2]**
3. J.T. Black and R.A. Kohser, Degarmo's materials and processes in manufacturing, John Wiley & Sons,Inc **[T3]**

Reference books:

1. M P. Groover, Fundamentals of modern manufacturing John Wiley & Sons, Inc.**[R1]**
2. T. Childs, K. Maekawa, T. Obikawa, Y. Yamane, Metal Machining: Theory and Applications, Arnold.**[R2]**
3. P.K. Mishra, Nonconventional Machining, Narosa Publishing House Pvt. Ltd.**[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Process modelling of casting, forming, machining and joining. Advanced studies on non- conventional machining and additive manufacturing.

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-5, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	3	1	1	2	1	0	3	3	3	3
CO2	3	3	3	2	2	0	0	2	1	0	3	3	3	3
CO3	3	3	3	3	2	0	0	2	0	0	3	3	2	3
CO4	3	3	3	2	2	2	0	2	0	0	3	3	2	3
CO5	3	2	2	3	1	1	1	1	0	0	3	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24343
Course title: PRODUCT DESIGN AND MANUFACTURING
Pre-requisite(s): FOUNDRY, FORMING & WELDING TECHNOLOGIES
Co- requisite(s): None
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn the concept of Design, redesign and reverse design
2	Learn to capture customer needs and address it with product function.
3	Understand the Product architecture and platform architecture.
4	Understand the selection of product modelling and error analysis
5	Understand the method of Physical prototyping and optimisation.

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

CO1	Analyse the need of customer and convert it to product functionality
CO2	Design Product architecture and Platform architecture
CO3	Develop the physical model and mathematical model of the products
CO4	Design the product based on manufacturing assembly and environment
CO5	Analyse and create optimised product.

SYLLABUS

Module 1: Introduction to Product Design [8]

Engineering Design, Types of Design and redesign, Product development process, Concept of reverse engineering and redesign,

Understanding Customer needs: Voice of customer, Customer need models, Organizing and prioritizing customer needs,

Product function: product functional decomposition, Product functional modeling and analysis process, function structure, Bench marking and establishing engineering specifications.

Module 2: Product Architecture [8]

Product portfolio and portfolio architecture, Platform architecture, Product architecture, Product modularity architecture and design,

Product application brain storming: C-sketch/6-3-5 Method, logical concept generation, Theory of inventive problem-solving method (TIPS or TRIZ) to solve engineering conflicts.

Module 3: Concept Selection and Modeling of Product [8]

Technical estimation, concept selection process, methods of concept selection, concept selection with error analysis,

Concept Embodiment, System Modelling, FMEA method of linking fault to system modeling

Model selection, Mathematical modeling vs physical prototyping constructing product model.

Module 4: Design for Manufacturing, Design for Assembly and Design for Environment [8]

Design for Manufacturing guidelines, Design for assembly methods, Design for disassembly, Design for environment, Lifecycle costing, Circular economics

Module 5: Physical Prototypes, Physical Model, and experimentation [8]

Scale, Dimensional analysis and similitude, Physical prototype design and planning,

Design of experiments, Reduced tests and fractional factorial experiments. Taguchi Methods

Textbook

1. Kevin N. Otto, Kristin L Wood, "Product Design", Pearson Education **(T1)**
2. Daniel E Whitney, "Mechanical Assemblies" Oxford series on Advanced Manufacturing **(T2)**

Reference Book

1. Asimow Morris; Introduction to Design, Prentice Hall, Englewood Cliffs, N.J., 1962
2. Pulos, Arthur, The American Design Ethic, MIT, USA, **(R1)**
3. Roozenburg and Eekels, Product Design: Fundamentals and Methods, Publisher: John Wiley & Sons Inc; New Ed **(R2)**
4. Ulrich, Karl T., Eppinger, Steven D.; Product Design and Development, McGraw-Hill **(R3)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Small Projects and practical application for Human factor engineering in product design

POs met through Gaps in the Syllabus:
POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:
AR AND VR application for Product design for reverse engineering and Maintenance

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Case based learning	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	2	1	2	2	2	2	2	3	3	3
CO2	3	3	3	3	2	1	1	1	1	1	2	3	3	3
CO3	3	3	3	3	2	1	1	1	1	1	2	3	2	3
CO4	3	3	3	3	2	1	1	1	1	1	2	3	2	3
CO5	3	3	3	3	2	3	2	2	2	2	2	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24345
Course title: ENGINEERING OPTIMIZATION
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about various optimization techniques used in Engineering
2	Formulate an Engineering problem in form of an optimization problem
3	Understand specialized problems such as dynamic programming problem
4	Understand the simple and classical methods of solving an engineering optimization problem
5	Understand some heuristics and metaheuristic approaches for solving the optimization problems

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

CO1	Prepare optimization problem formulation from an engineering problem
CO2	Execute simplex method to solve a linear programming problem
CO3	Apply dynamic programming methods to solve a dynamic problem
CO4	Choose a proper optimization technique to solve a non-linear optimization problem
CO5	Understand heuristics and metaheuristics to solve an optimization problem

SYLLABUS

Module 1: Introduction to optimization and Liner Programming **[10]**

Introduction, Statement of an optimization problem, Classifications, Linear programming problems: formulation, graphical solution, simplex method, Big M and Two-phase method.

Module 2: Dynamic Programming Problems **[6]**

Introduction and network representation of dynamic programming problem, Forward and backward recursion method for solution, Mathematical formulation of dynamic programming recursions.

Module 3: Non-Linear Optimization-I – One dimensional optimization methods **[9]**

Unimodal function, Elimination Methods: Unrestricted search, Exhaustive search, Dichotomous search, Interval having method, Fibonacci method, Golden section method, Interpolation Methods: Newton method, Quasi newton method, Secant method.

Module 4: Non-Linear Optimization -II – Classical optimization techniques **[7]**

Single variable optimization, Multiple variable optimizations with no constraints, Multiple variable optimizations with equity constraints, multiple variable optimization with inequity constraints.

Module 5: Heuristics and Metaheuristics for solving Optimization problems **[8]**

Reasons for using heuristic and metaheuristic approaches, Types of search approaches, Steepest Ascent and Steepest Descent method, Local search heuristics: SWAP, INSERT, genetic crossover, Metaheuristics: Genetic Algorithm, Ant Colony Optimization, Simulated Annealing.

Textbook:

1. S.S. Rao, Engineering Optimization: Theory and Practise, Wiley-Interscience Publications. **(T1)**
2. K. Deb, Optimization for Engineering Design: Algorithms and Examples, PHI publications. **(T2)**

Reference Books:

1. Wayne L. Winston, Operations Research: Applications and Algorithms, Duxbury Press **(R1)**
2. Hamdy A. Taha, Operations Research: An Introduction, Prentice Hall PTR, Pearson **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):

Integer programming, goal programming, multi-objective optimization

POs met through Gaps in the Syllabus:

POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:

Multi Objective Optimization, Advanced Operations Research

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1, 3, 5, 7, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	√

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	1	1	0	1	0	0	0	2	3	3	3	3
CO2	3	2	2	0	0	1	1	2	0	3	3	3	3	3
CO3	3	2	3	0	0	1	1	2	0	3	3	3	3	3
CO4	3	3	3	0	0	1	1	2	0	3	3	3	3	3
CO5	3	3	2	2	3	0	1	2	0	2	3	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: PE 24347
Course title: LEAN MANUFACTURING & SIX-SIGMA
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the basic difference between conventional manufacturing system and Lean manufacturing
2	Get knowledge about basic Lean tools that are applied in the industry
3	Understand some advanced lean tools that are useful to analyse the production system
4	Learn various tools and techniques of total quality management
5	Understand principle and various steps involved in six-sigma

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

CO1	Understand how lean manufacturing system has evolved and how it is different from the conventional manufacturing system
CO2	Experiment with various lean manufacturing tools to analyses the problems of a system
CO3	Explain various lean manufacturing methodologies and their uses to improve the process in a manufacturing system
CO4	Apply various tools used in total quality management
CO5	Analyse how six sigma can be used to reduce the total number of defects in any process of an industry

SYLLABUS

Module 1: Introduction and basic concepts of Lean Manufacturing [8]

Push and Pull system: definitions, characteristics, and differences, Basic concept of lean manufacturing, Seven wastes, Historical development, just-in-time system: Kanban and CON-WIP

Module 2: Lean Manufacturing tools [6]

Ishikawa Fishbone Diagram, Pareto Chart, Spider Chart, Poka yoke, Single Minute Exchange of Die (SMED), 5S, Time and Motion Study, 5 Whys

Module 3: Lean Manufacturing Methodologies [8]

Kaizen: what is kaizen, plan-do-check-act (PDCA) cycle, case study; Value Stream Mapping (VSM): what is VSM, current state map, future state map, comparison, case study; Total Productive Maintenance (TPM): what is TPM, pillars of TPM, overall equipment availability, six big losses.

Module 4: Total Quality Management [8]

Introduction, Bench marking, FMEA, Quality Function Deployment (QFD), Taguchi quality loss function.

Module 5: Six Sigma and Lean Six Sigma [10]

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; Lean Six Sigma: what is lean six sigma, lean six sigma tools, case study.

Textbook:

1. John M. Nicholas, Competitive manufacturing management: continuous improvement, lean production, and customer focused quality, Tata Mcgraw Hill Education **(T1)**
2. D.H. Besterfield, Total Quality Management, Pearson **(T2)**

Reference Books:

1. Javier Santos, Richard Wysk, Jose Manuel Torres, Improving Production with Lean Thinking, John Wiley & Sons **(R1)**
2. A Mitra, Fundamentals of quality control and improvement, Wiley **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher’s Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher’s Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	2	1		1	0	1	0	0	1	3	1	3	1	2
CO2	2	3	3	1	2	1	1	3	2	3	3	3	3	3
CO3	2	3	3	2	2	1	1	3	2	3	3	3	3	3
CO4	2	2	3	1	2	1	1	3	2	3	3	3	2	3
CO5	2	3	3	3	2	1	1	3	2	3	3	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24349
Course title: **MATERIAL HANDLING SYSTEMS**
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about conveying equipment and material handling systems
2	Understand the various mechanisms such as hoisting mechanisms, travelling mechanisms, lifting mechanisms, slewing mechanisms of cranes, elevators, and lifts.
3	Understand the design and operation of various material handling systems, as well as their workspace.
4	Understand the fundamental design concepts of material handling equipment.
5	Learn about computer-aided material handling and automated guided vehicles.

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

CO1	Classify the material handling systems and their operational workspace and characteristics.
CO2	Examine the many types of lifting and load-handling equipment.
CO3	Determine the best material handling methods to meet a variety of needs.
CO4	Design of material handling system.
CO5	Explore the application possibilities of computer-aided systems for material handling.

SYLLABUS

Module 1: Overview of Material Handling and Material Handling Equipment **[8]**
Principles of Material Handling, Classification of Material Handling equipment, General Characteristics, and application of Material Handling Equipment, Lifting Equipment: Hoist, Components of Hoist – Load Handling attachments: hooks, grabs and clamps – Grabbing attachments for bulk material – Wire ropes and chains.

Module 2: Material Handling Mechanisms **[8]**
Lifting tackle pulleys for gain of force and speed: Tension in drop parts – Drums, Shears and sprockets – Arresting gear and brakes – Block brakes, Band brakes, thrust brakes – Safety hand cranks. Principle operation of electric overhead travelling crane, gantry and jib cranes, Hoisting Mechanisms, Travelling mechanisms, lifting mechanisms – Slewing Mechanisms – Elevators and lifts.

Module 3: Material Handling Machines: I **[8]**
Conveying Machines: Belt conveyors – Types, Principal components of a conveyor and their purpose – conveyor belts – tractive elements – take up devices, Special types of belt conveyors – Metal Belt conveyor – Apron conveyor, Elevators, Passenger conveyor – Flight conveyor, Principal types and application: Bucket flight conveyors – Cradle conveyor – conveyor elevators.

Module 4: Material Handling Machines: II **[8]**

Overhead conveyors – Overhead pusher conveyor, Overhead load towing truck conveyor – Load carrying car conveyors – Load towing and walking beam conveyors – Bucket elevators – Cradle conveyors – Screw conveyors – Oscillating conveyor – Roller conveyor; Hydraulic and pneumatic conveyor – Chutes Bins.

Module 5: Current trends in Material Handling **[8]**

Current trends in Material Handling: Computer Aided Systems for Material Handling, Automated guided vehicles (AGV) - Applications of AGV, Production line equipment - pick and place robots - transfer devices - feeder lines.

Text books:

1. Apple, J.M., "Material Handling System Design, John Wiley & Sons. **[T1]**
2. Allegri, T.H., "Materials Handling: Principles and Practice, CBS Publishers & Distributers, N. Delhi. **[T2]**
3. Immer J.R., "Material Handling", McGraw Hills. **[T3]**
4. Ray, S., "Introduction to Material Handling", New Age International Publishers, 2008. **[T4]**
5. Groover, M.P. "Automation, Production systems and computer integrated manufacturing" Part V, P HAllInc.New Delhi, 2007. **[T5]**

Reference books:

1. Spivakovsky, A and Dyachkov, V., "Conveyors and Related Equipment's", Peace Publishers, Moscow. **[R1]**
2. Alexandrov, M.P., "Material Handling Equipment, Part-I and II", Mir Publishers, Moscow. **[R2]**
3. Rudenko, N., "Materials Handling Equipment", Peace Publishers, Moscow. **[R3]**
4. Ray, T.K., "Mechanical Handling of Materials", Asian Books Private Ltd. **[R4]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Use of Internet of Things (IoT) in Material Handling

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1-5, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	√

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05

End Semester Examination	% Distribution				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	1	1	0	1	1	0	0	0	0	1	3	1	2
CO2	3	2	2	1	1	0	0	0	0	0	1	3	1	3
CO3	3	3	2	3	0	0	0	0	0	0	1	3	2	3
CO4	3	3	1	3	0	0	0	0	0	0	1	3	2	3
CO5	3	3	2	3	1	0	0	0	0	0	1	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6, CD7
CO2	CD1, CD2, CD6, CD7
CO3	CD1, CD2, CD6, CD7
CO4	CD1, CD2, CD6, CD7
CO5	CD1, CD2, CD6, CD7

COURSE INFORMATION SHEET

Course code: PE 24351
Course title: OPERATIONS RESEARCH WITH PYTHON
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0 C:3
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: All (Open Elective)
Name of Teacher:

Course Objectives
This course enables the students to:

1	Apply the techniques of operations research in industrial engineering problems using python.
2	Formulate a real-world industrial problem as a mathematical programming model
3	Understand the simplex method for linear programming and perform iterations of it by hand
4	Solve specialized linear programming problems like the transportation and assignment problems
5	Operations research helps in solving problems in different environments that needs decisions, such as sequencing, queuing and games theory.

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

CO1	Apply python for simple programs and learn basics of python.
CO2	Formulate and solve engineering and managerial situations as LPP and also using python
CO3	Formulate and solve engineering and managerial situations as transportation and assignment problems and also using python
CO4	Apply Sequencing and Queuing theory for performance evaluation of engineering and management system and also using python
CO5	Solve engineering and managerial decision theories problems by Game Theory and also using python

SYLLABUS

Module 1: Introduction to Python: [8]
Installing Python and Environment Setup, Python Statements and Comments, Keywords and Identifier, Python Data types, Python I/O and Import, Python operators, Precedence and Associativity, If else statement, For loop, While loop, Break and Continue, Pass, Looping techniques, introduction some python libraries for data science applications.

Module 2: Linear Programming: [8]
Requirement of LP, Basic Assumptions, Mathematical formulation of the of LP, Graphical solution; numerical problems. Simplex method for LP problems.
Installing PuLP library. Solving LPP, ILP, MLP with python PuLP

Module 3: Transportation & Assignment Model [9]
Basic feasible solution by different methods (Northwest corner method, least cost method, Vogel's approximation method), finding optimal solutions (MODI method), unbalanced transportation problems; numerical problems based on these methods. Balanced and unbalanced assignments, travelling salesman Problem; numerical problems based on these methods.
Solving the transportation/assignment model with python.

Module 4: Queuing Model [8]
Basis of Queuing theory, elements of queuing theory, Operating characteristics of a queuing system, Classification of Queuing models, Queuing system and their characteristics of M/M/1/FIFO/ Queuing system. Problem; numerical problems.

Simulating a Single Server Queuing System with Python

Module 5: Games Theory **[7]**
Introduction, Characteristics of Game Theory, Two Person, Zero sum games, Pure strategy. Dominance theory, Mixed strategies (2x2, mx2), Algebraic and sub games methods.
Game solution with python.

Text books:
1. Operations Research, (Revised Edition), D.S. Hira, P.K. Gupta, S. Chand & Company Ltd, 2014 **[T1]**
2. Quantitative Techniques Vol I and Vol II, L. C. Jhamb, Everest Publishing House **[T2]**
3. Operations Research, - Kanti Swarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons **[T3]**

Reference books:
1. Operations Research an Introduction –Hamady A. Taha, Prentice Hall. **[R1]**
2. Introduction to Operations Research, 9e, Frederick S. Hillier, Gerald J. Lieberman, Bodhibrata Nag and Preetam Basu, McGraw Hill **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Revised Simplex, Integer programming, other queuing models, Decision theory, Goal programming, Dynamic programming, Non-linear programming and Simulation. These topics are to be covered in an advanced course.

POs met through Gaps in the Syllabus:
POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:
Advanced Operation Research

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1, 3, 5, 7, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**										
	1	2	3	4	5	6	7	8	9	10	11
CO1	3	3	3	1	0	1	1	0	0	1	3
CO2	3	3	3	1	0	1	1	2	0	2	2
CO3	3	3	2	0	0	1	0	2	0	1	3
CO4	3	2	1	0	0	1	1	2	0	2	2
CO5	3	2	1	0	0	1	0	2	0	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24353
Course title: ADDITIVE MANUFACTURING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0 C:3
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: All (Open Elective)
Name of Teacher:

Course Objectives
This course enables the students to:

1	Understand the various Additive Manufacturing Processes and Technologies
2	Recognize importance of 3D Printing in advance manufacturing processes.
3	Acquire knowledge, techniques and skills to select relevant rapid prototyping and Tooling process.
4	Comprehend the potential of Additive manufacturing in different industrial applications
5	Design and Develop a Product for any Additive manufacturing process.

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

CO1	Apply rapid prototyping and tooling for manufacturing complex geometries.
CO2	Identify and solve problems related to 3D Printing/ Additive manufacturing processes
CO3	Select suitable materials and processes for Additive manufacturing of products
CO4	Distinguish technique of CAD and reverse engineering for geometric transformation in rapid prototyping and tooling.
CO5	Explore the Applications of Additive manufacturing in various Industrial fields.

SYLLABUS

Module 1: Introduction to Additive Manufacturing (AM) [8]
Evolution, basic principle of AM, need for Additive Manufacturing, generic AM processes, distinction between AM and CNC. Distinction between additive, subtractive and deformative processes. Classification of AM processes, Steps in AM process, Advantages of AM.

Module 2: Additive Manufacturing Processes - I [8]

Liquid-Based AM processes: Stereo-lithography Apparatus (SLA), Solid Ground Curing (SGC). *Solid-Based AM processes:* Laminated Object Manufacturing (LOM); Fused Deposition Modeling (FDM); Solid foil polymerization.

Module 3: Additive Manufacturing Processes - II [8]
Powder-Based AM processes: Selective Laser Sintering (SLS), Three-Dimensional Printing (3DP). Directed Energy Deposition (DED).

Module 4: CAD for Additive Manufacturing **[8]**
Preparation of 3D-CAD models in STL format, reverse engineering, reconstruction of 3D-CAD models using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and generation of codes for tool path. Pre-processing and post processing of AM Parts.

Module 5: Rapid Tooling and Rapid Manufacturing **[8]**
Classification of rapid tooling methods. Direct and indirect tooling methods. Conventional tooling vs. rapid tooling. Rapid manufacturing methods. Applications of AM parts on product development.

Text books:

1. Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015 **[T1]**
2. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications", 4th Edition, World Scientific, 2015 **[T2]**
3. Hilton P.D. and Jacobs P.F., "Rapid Tooling: Technologies and Industrial Applications", CRC Press, 2000. **[T3]**

Reference books:

1. Liou L.W., and Liou F.W., "Rapid Prototyping and Engineering Applications: A Tool box for prototype development", CRC Press, 2007 **[R1]**
2. Gebhardt A., "Rapid Prototyping", Hanser Gardener Publications, 2003 **[R2]**
3. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and Practice", Springer, 2006. **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Rapid Freeze Prototyping

POs met through Gaps in the Syllabus:
POs 1, 2, 5

Topics beyond syllabus/Advanced topics/Design:
Rapid Tooling Injection Molded Prototypes

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1,8,12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	√
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05

End Semester Examination	% Distribution				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program-Specific Outcomes (PSOs):</u>

COs	**POs**									
	1	2	3	4	5	6	7	8	9	10	11
CO1	1	2	0	3	2	0	1	1	0	0	1
CO2	1	3	1	2	0	0	0	2	0	0	1
CO3	1	0	2	1	0	1	0	1	0	0	0
CO4	0	2	2	1	2	0	0	1	2	0	0
CO5	1	3	0	1	1	0	0	2	1	0	1

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

<u>Mapping Between Course Outcomes (COs) and Course Delivery Method</u>

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24401
Course title: COMPUTER INTEGRATED MANUFACTURING & CYBER-PHYSICAL SYSTEMS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII / Fourth
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about manufacturing automation & CIM
2	Learn about CNC Machine Tools and CNC programming
3	Learn about manufacturing architecture and its simulation
4	Learn about the Flexible Manufacturing System & Reconfigurable Manufacturing systems
5	Learn about Industry 4.0 and role of big data and cloud manufacturing

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

CO1	Understand manufacturing automation & CIM
CO2	Design CNC programs for a particular part
CO3	Use appropriate sensor for manufacturing automation
CO4	Design Flexible Manufacturing System
CO5	Understand Industry 4.0, components of Cyber-Physical System

SYLLABUS

Module 1: Manufacturing Automation and Fundamentals of CIM [8]
Manufacturing automation, components and types of automation, CAD, CAM, Computer Control of Manufacturing Systems. Mechatronics in Manufacturing Systems.
Role of computer in manufacturing; Needs of CIM- Hardware, CIM Software, CIM workstations.
CIM architecture and key building block; Design for manufacturing and assembly, Computer aided process planning and control, concurrent engineering.

Module 2: CNC Machine Tools [8]
Basic Principles, classification and structure of CNC systems, Constructional features and feedback devices for CNC machine tools, part programming (Fanuc), Direct numeric control and distributed numeric control and adaptive control.

Module 3: Sensors, Control Technologies & Automated Material Handling System [8]
Sensors, actuators, control system in manufacturing: Mechanical & Electric mechanical system, Pneumatics and hydraulics and servo control in CNC machine tools, Illustrative examples and case studies. Discrete control and programmable logic controllers; AS/RS and AGV

Module 4: Flexible Automation **[8]**

Flexible automation: Flexible Manufacturing Systems: concept, need, structure & operation, objectives and benefits. Quantitative Analysis of Flexible Manufacturing Systems, Cellular Manufacturing, Reconfigurable manufacturing systems

Module 5: Industry 4.0 & Cyber-Physical Systems **[8]**

Globalization and Emerging Issues, The Fourth Revolution, Smart and Connected Business Perspective, Smart Factories, Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Cloud Computing for IOT, Cyber-physical manufacturing systems, Cyber Physical Systems and Next Generation Sensors, augmented reality and virtual reality, role of IOT on predictive maintenance, industrial automation, supply-chain & logistics,

Textbook

1. Tayfur Altiok, "Performance Analysis of Manufacturing Systems", Springer-Verlag
2. S. Kant Vajpayee, "Principles of Computer Integrated Manufacturing", PHI India
3. Mikell P. Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing"
4. Vijay Madisetti, Arshdeep Bahga, "Internet of Things- A Hands on Approach", University Press.
5. Adrian McEwen, "Designing the Internet of Things", Wiley.

Reference Books:

1. Ulrich Rembold, Christian Blume, Ruediger Dillmann, "Computer Integrated Manufacturing Technology and systems" Marcel Dekker INC
2. Internet of Things for Industry 4.0Design, Challenges and Solutions
3. Editors: Kanagachidambaresan, G.R., Anand, R., Balasubramanian, E., Mahima, V. (Eds.)
4. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
5. Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill.
6. Cuno P fister, "Getting Started with the Internet of Things", O Reilly Media

Self-Learning Materials

1. https://nptel.ac.in/courses/112/104/112104289/
2. https://technologystudent.com/rmprp07/intman1.html
3. https://opencourses.emu.edu.tr/course/view.php?id=75

Gaps in the syllabus (to meet Industry/Profession requirements):

Circular economy

POs met through Gaps in the Syllabus:

PO 5, PO 6, PO 7

Topics beyond syllabus/Advanced topics/Design:

Reconfigurable manufacturing systems, Rapid Manufacturing, Quality control in cyber physical system

POs met through Topics beyond syllabus/Advanced topics/Design:

PO 3, PO 5, PO 7

Course Delivery Methods:

CD1	Classroom teaching with using different Tools and aid	√
CD2	Assignments/Seminars	√
CD3	Mini projects	√
CD4	Industrial/guest lectures	√
CD5	Industrial visits/in-plant training	√
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Case study discussion	√

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher’s Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher’s Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	1	3	2	1	2	2	2	3	3	3	3
CO2	3	3	3	1	3	2	1	2	2	2	3	3	3	3
CO3	3	3	3	1	3	2	1	2	2	2	3	3	3	3
CO4	3	3	3	1	3	2	1	2	2	2	3	3	3	3
CO5	3	3	3	1	3	2	1	2	2	2	3	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1; CD5, CD6
CO2	CD1; CD2; CD4; CD5, CD6
CO3	CD1; CD2; CD3; CD4; CD5, CD6; CD7
CO4	CD1; CD2; CD3; CD4; CD5, CD6; CD7
CO5	CD1; CD2; CD3; CD5, CD6; CD7

COURSE INFORMATION SHEET

Course code: PE 24402
Course title: MANUFACTURING AUTOMATION LAB
Pre-requisite(s): None
Co- requisite(s): COMPUTER INTEGRATED MANUFACTURING & CYBER-PHYSICAL SYSTEMS
Credits: 1 L:0 T:0 P:2
Class schedule per week: 2 **Class:**
B.Tech.
Semester / Level: VII/Fourth
Branch: Production and Industrial Engineering Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the various types of CAM software like Fanuc, Siemens etc. and their practical usage in manufacturing applications
2	Learn concepts of machining parameters and cutting tools for CNC machines and develop components on software by interpreting 3D part models/ part drawings
3	in a rigging an industrial pneumatics and electro-pneumatics circuit and PLCs
4	Learn the concept of different Sensors.
5	Get a hands-on experience of using Arduino for different applications.

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

CO1	Apply the concepts of machining for the selection of appropriate machining centers, cutting tools, and machining parameters for CNC Machines.
CO2	Create and validate NC part program data using manual data input (MDI) for manufacturing of required components using CNC milling or turning applications through CAM software.
CO3	Create a typical pneumatic and electro-pneumatic circuit on the PLC Demonstration Kit. create a program on PLC for a simple demonstration.
CO4	Analyze the working principle of different sensors.
CO5	Create a simple industrial component by using different Arduino.

SYLLABUS

LIST OF EXPERIMENT:

1. **EXPERIMENT – 1: (Automated Step Turning: CNC Program Development and Simulation)**

Objective: To write a manual part program for step turning operation for a given drawing and simulate in FANUC/SIEMENS CNC lathe simulator.

2. **EXPERIMENT – 2: (Manual CNC Lathe Programming: Radius Cutting and Taper Turning Simulation)**

Objective: To write a manual part program for radius cutting and taper turning operation for a given drawing and simulate in FANUC/SIEMENS CNC lathe simulator.

3. **EXPERIMENT – 3: (Grooving and Threading CNC Lathe Programming and Simulation)**

Objective: To write a program for grooving and threading operation for a given drawing. and simulate in FANUC/SIEMENS CNC lathe simulator.

4. **EXPERIMENT – 4: (Conversion and Step Turning Program in CNC Lathe from CNC Mill Machine)**

Objective: To convert a modular CNC-mill machine into CNC-Lathe machine and write a program for step turning operation in CNC Lathe.

5. **EXPERIMENT – 5: (Precision Taper Turning: Manual CNC Lathe Programming for Given Drawing)**

Objective: To write a manual part program for taper turning operation for a given drawing in CNC Lathe

6. **EXPERIMENT – 6: (Advanced CNC Milling: Profile Milling with Interpolation Techniques for Given Drawing)**

Objective: To write a part program for profile milling operation using linear and circular interpolation cutting for a given drawing and simulate in FANUC/SIEMENS CNC milling

7. **EXPERIMENT – 7: (Integrated CNC Milling: Manual Programming for Pocketing, Profile Cutting, Sub-programming, and Tool Compensation)**

Objective: To write a manual part program for circular and rectangular pocketing, profile cutting with sub-program, and tool compensation for a given drawing, and simulate them in FANUC/SIEMENS CNC milling simulator.

8. **EXPERIMENT – 8: (PLC Control of Single-Acting Cylinder Operation)**

Objective: To understand and implement the operation of a single-acting cylinder using a PLC (Programmable Logic Controller) trainer kit.

9. **EXPERIMENT –** 9**: (Exploring Sensors and PLC Programming: A Comprehensive Study)**

Objective: To study the various types of sensors and PLC Programming

10. **EXPERIMENT – 10: (PLC Control of Double-Acting Cylinder Operation: Learning and Implementation)**

Objective: To learn and implement the operation of a double-acting cylinder using a PLC (Programmable Logic Controller) trainer kit.

11. **EXPERIMENT – 11: (Arduino Uno-based Automation Experiment)**

Objective: Automation with the help of Arduino Uno.

12. **EXPERIMENT – 12: (Object Detection Automation Using Diverse Sensor Technologies)**

Objective: Automation of Object Detection Utilizing a Variety of Sensors.

Text Books:

1. Mikell P. Groover "Automation, Production Systems and Computer-Integrated Manufacturing" Pearsons Education, New Delhi. **(T1)**
2. Rao, P.N. "CAD/CAM: Principles and Applications", McGraw Hill Publication, 2nd edition, 2004. **(T2)**
3. Mikell P. Groover, E. Zimmer, Computer-Aided Design and Manufacturing (CAD/CAm)", Pearson Publication, 2nd Edition, 2006 **(T3).**

Reference Books:

1. David Bedworth "Computer-Aided Design and Manufacturing", Tata McGraw Hill, New Delhi, 1998. **(R1)**
2. Radhakrishna P. , Subhramaniyam S., "CAD/CAM and CIM", New Age International, 2002 **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of real-time Industrial projects.

POs met through Gaps in the Syllabus:
PO 5

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 4,5, 11,12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	√

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	60
End Semester Test	40

Continuous Internal Assessment	**% Distribution**
Day-to-day performance & Lab files	30
Lab Quiz 1	10
Viva-voce	20
End Semester Examination	**% Distribution**
Examination: Experiment Performance	30
Lab Quiz 2	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment	√	√	√	√	√
Semester End Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	3	3	3	1	1	1	2	2	3	2	3	3
CO2	2	2	3	3	3	1	1	1	2	3	2	3	2	3
CO3	3	2	3	2	3	1	1	1	2	2	3	2	3	3
CO4	3	2	3	3	3	1	1	1	2	2	3	2	3	3
CO5	3	2	3	3	3	1	1	1	2	2	3	2	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD3
CO2	CD1, CD3, CD7
CO3	CD1, CD3, CD7
CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD2, CD3, CD6, CD7

COURSE INFORMATION SHEET

Course code: PE 24403
Course title: PRODUCTION ECONOMICS AND FINANCIAL MANAGEMENT
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L: 3 T:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI / Third
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Acquire the knowledge of economics and financial management needed for economic decision making.
2	Explores the relationship, which exists between costs, revenue, output levels and resulting profit.
3	Assess the best feasible investment proposal among the alternatives based on the common index.
4	Conduct a replacement or retention study, as well as a depreciation review.
5	Develop the skills to analyze financial statements.

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

CO1	Evaluate the economic theories, cost concepts and pricing policies.
CO2	Derive and use the engineering economy factors to account for the time value of money.
CO3	Apply financial management concepts to project evaluation and capital funding decisions.
CO4	Make replacement and retention decisions, as well as quantify capital asset depreciation.
CO5	Recognize, quantify, and record the common business transactions, and analyze financial statements using ratio analysis.

SYLLABUS

Module 1: Economics, Cost and Pricing Concepts [8]
Economics and economy; Concept of firm, industry, and market; Economic theories, Demand and supply, Theory of production, Interaction between economic theory and production; Cost analysis - Cost concepts, Elements of costs, Cost estimation and indirect cost allocation, Economies of scale and economies of scope; Cost-volume-profit relationship - Concept of contribution, p/v ratio, breakeven point, and margin of safety, Break-even analysis and the financial decision-making; Price fixation, pricing policies and pricing methods.

Module 2: Principles of Money-Time Relationships [7]
Time value of money, Interest rate and rate of return, Inflation, Economic Equivalence, Simple and compound interest, Minimum attractive rate of return (MARR), Cash flow diagrams, Equivalence - Single payment in the future (P/F, F/P), Present payment compared to uniform series payments (P/A, A/P), Future payment compared to uniform series payments (F/A, A/F), Arithmetic gradient, Geometric gradient. Multiple compounding periods in a year, Continuous compounding.

Module 3: Project Evaluation, and Capital Financing [8]
Project evaluation **-** Formulating alternatives, Present, future and annual worth method of comparing alternatives, Rate of return, Incremental rate of return, Defining mutually exclusive alternatives, Comparison of alternatives with unequal service life; Capital Financing **-** MARR relative to the cost of capital; Debt-equity mix and weighted average cost of capital; Cost of debt capital, equity capital and the MARR; Effect of debt-equity mix on investment risk.

Module 4: Replacement Analysis, and Depreciation Methods **[7]**

Replacement and retention decisions - Reasons for replacement, Economic service life, Evaluation of replacement involving excessive maintenance cost, decline in efficiency, inadequacy and obsolescence; Depreciation of capital assets - Causes of depreciation, Deprecation methods: Straight line, Declining and double declining balance, Units of production, and Sum of years digits methods.

Module 5: Accounting System, Statement, and Financial Analysis **[10]**

Accounting concepts and principles, Classification of accounts; Double entry system - Journal and ledger entries; Financial statements – trading account, profit & loss account, balance sheet; Financial ratios.

Text books:

1. L.T. Blank, A.J. Tarquin, Engineering Economy, McGraw-Hill. **(T1)**
2. G.J. Thusen, W.J. Fabrycky, Engineering Economy, Prentice-Hall, New York. **(T2)**
3. N. Wilkinson, Managerial Economics: A Problem-Solving Approach, Cambridge University Press **(T3)**
4. S.N. Maheshwari, S.K. Maheshwari, S.K. Maheshwari, An Introduction to Accountancy, Vikas Publishing, New Delhi. **(T4)**

Reference books:

1. P. Chandra, Financial Management: Theory and Practice, McGraw Hill India **(R1)**
2. W.G. Sullivan, E.M. Wicks, Engineering Economy, Pearson, New York. **(R2)**
3. D.G. Newnan, T.G. Eschenbach, J.P. Lavelle, Engineering Economic Analysis, Oxford University Press. **(R3)**

Gaps in the syllabus (to meet Industry/Profession requirements):

Decision Making under Risk, After-Tax Economic Analysis, Sensitivity Analysis

POs met through Gaps in the Syllabus:

PO 1-5, 11-12

Topics beyond syllabus/Advanced topics/Design:

Using Spreadsheets and Microsoft Excel® in Engineering Economic Analysis, Goal Seek—A Tool for Breakeven and Sensitivity Analysis, Solver—An Optimizing Tool for Capital Budgeting, Breakeven, and Sensitivity Analysis.

POs met through Topics beyond syllabus/Advanced topics/Design:

PO 1-5, 11-12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	1	1	1	2	1	0	0	0	0	2	1	1	3	3
CO2	1	1	1	1	1	0	0	0	0	2	1	1	2	3
CO3	1	2	1	2	1	0	0	0	0	3	2	1	3	3
CO4	1	2	1	2	1	0	0	0	0	3	1	1	3	3
CO5	1	2	1	2	1	0	0	0	1	2	1	1	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6
CO5	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course code: PE 24405
Course title: PROJECT ENGINEERING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L: 3 T:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII / Fourth
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Comprehend the scope and types of projects
2	Identify the Project Life Cycle and project constraints
3	Construct organizational structure of project management
4	Realize environmental issues and social cost benefit analysis of projects
5	Apply project scheduling tools (PERT and CPM)

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

CO1	Recognise the project morphology, organizational structure and elements of project
CO2	Incorporate the importance environmental issues in projects
CO3	Handle real-life projects as in various organizations
CO4	Solve complex scheduling problems in project management using PERT/CPM
CO5	Prepare project report and budget planning

SYLLABUS

Module 1: Basic terms and definitions **[6]**
Definition and types of project, Project engineering verses project management, Projects verses programs, Forward and backward integrated projects, Turnkey projects, Scope of project and project creep, Project life cycle, Project constraints, Iron-triangle of project management

Module 2: Organization structure **[8]**
Organizational structures for projects, Functional, Product and project organization, Matrix and modified matrix structure, Responsibilities of project manager, Project risk analysis, Techniques of risk analysis - Break-even, expected monetary value (EMV) and make-or-buy decision

Module 3: Social and environmental aspects of project **[6]**
Environmental considerations in project evaluation, Primary issues and secondary issues in Feasibility study, Social cost benefit analysis , Project appraisal (Technical, economic, financial, management)

Module 4: Network models **[10]**
Network modeling of a project, Activity on Arc (AOA) verses Activity on Node (AON), Rules for network drawing, Numbering (Fulkerson's rule), skip numbering, Forward and backward pass computation, Critical paths, floats and slack, Numerical examples

Module 5: Scheduling and monitoring of projects **[10]**
Project Scheduling Techniques, Bar charts, Program-progress chart, PERT, CPM Models**,** Crashing of project time, Line of balance, Time-Cost Trade-off in a project, Numerical problems, Project Monitoring Techniques, Resource Leveling

Text books:
1. Project Management by Prasanna and Chandra, Tata McGraw Hill.(**T1**)
2. Elements of Project Management by Pete Spinner, Prentice Hall, USA.(**T2**)

Reference books:
1. Production and Operation Management by Alan Muhlemann, John Oakland and Keith Lockyer, MacMillan India Ltd. (**R1**)
2. A course in PERT and CPM by R. C. Gupta, Dhanpat Rai Publications(P) Ltd, Delhi. (**R2**)
3. Industrial Engineering and Management by O. P. Khanna, Dhanpat Rai & Sons. (**R3**)

Gaps in the syllabus (to meet Industry/Profession requirements):
Computer and software applications in project scheduling

POs met through Gaps in the Syllabus:
POs 3, 5

Topics beyond syllabus/Advanced topics/Design:
Application of MS Project© in network modeling, Simulation models in project management

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 4, 5, 11

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	1	1	1	0	1	1	3	2	1	2	2
CO2	1	2	2	1	1	3	2	1	1	2	2	3	1	3
CO3	1	2	3	2	2	2	1	3	2	3	2	1	3	3
CO4	2	2	2	3	3	1	0	1	1	3	2	2	3	3
CO5	1	1	2	1	2	1	1	2	3	3	2	1	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD 6
CO2	CD1, CD2, CD 6
CO3	CD1, CD2, CD 6
CO4	CD1, CD2, CD 6
CO5	CD1, CD2, CD 6

COURSE INFORMATION SHEET

Course code: MT 24204
Course title: CONSTITUTION OF INDIA
Pre-requisite(s): None
Co- requisite(s): None
Credits: 0 L:2 T: P:
Class schedule per week: 2
Class: B. Tech
Semester / Level: VII / Second
Branch: All
Name of Teacher:

Course Objectives:
This course enables the students:

1	To describe the importance and role of the Constitution of India
2	To explain the provisions related to Social Problems and Issues in Constitution
3	To explain the significance of the Constitution for maintaining social unity and integrity
4	To describe the process for formulating and designing public policies in accordance with constitutional provisions

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

CO1	Outline the need and importance of the Indian Constitution
CO2	Explain the fundamental rights and duties of citizens of India
CO3	Relate appropriate Constitutional Provisions with relevant social issues
CO4	Describe the role of different departments of government
CO5	Describe the Government policies and programs designed for society at large

SYLLABUS

Module 1 **[9]**
Introduction to the Constitution of India, Salient Features of the Constitution: Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy.

Module 2 **[9]**
Union and State Executives: President and Prime Minister, Council of Ministers, Cabinet, and Central Secretariat, Lok Sabha, and Rajya Sabha. Governor: Role and Position, Chief Ministers, and Council of Ministers.

Module 3 **[9]**
The Indian Judicial System - The Supreme Court and The High Courts' composition, Jurisdiction, and functions, The Role of the Judiciary.

Module 4 **[9]**
Local Government- District's Administration: Role and Importance, The Panchayatas - Gram Sabha, Constitution and Composition of Panchayatas, Constitution and Composition of Municipalities

Module 5 **[4]**
Miscellaneous- Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

Books recommended:

1. The Constitution of India by "Ministry of Law India" Kindle Edition

2. Constitutional History of India by Prof.M.V.PYLEE-S.Chand Publishing
3. Indian Administration by Avasti and Avasti-Lakshmi Narain Agarwal Educational Publishers.2017 edition.
4. Introduction to the Constitution of India by D D Basu by Lexis Nexis : 20th edition.
5. Constitution of India V.N.Shukla's EBC Explorer Edition 13th ,2017

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping between COs, POs, and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11
CO1	2	2	1	2	1	2	2	2	2	1	2
CO2	2	2	1	2	2	2	2	2	1	2	2
CO3	2	2	1	2	1	2	2	2	2	1	1
CO4	2	2	1	2	2	2	2	2	2	1	1
CO5	2	2	1	2	1	2	2	2	2	3	3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1
CO2	CD1
CO3	CD1
CO4	CD2
CO5	CD2

COURSE INFORMATION SHEET

Course code: MC 24400
Course title: SUMMER INTERNSHIP
Pre-requisite(s):
Co- requisite(s):
Credits: 4 L: T: P:
Class schedule per week: NA
Class: B. Tech
Semester / Level: VII / Fourth
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students:

1	To provide opportunities for learning, understanding and sharpening the technical / management skills required in the job in real time
2	To enhance knowledge of production engineering acquired by students in the classroom through field experience
3	To expose students to current technological developments relevant to the training subject
4	To expose students to the duties and ethics of the engineer
5	To promote professional, academic and/or personal development

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

CO1	Understand an industry's structure, culture and work and gain awareness of potential careers
CO2	Relate and strengthen what was taught at the classes through practical experience in the related field
CO3	Effectively perform in assigned responsibilities
CO4	Identify and understand different industrial practices and professional ethics
CO5	Effectively and professionally communicate with people and work in groups

The student should undergo industrial training / internship for a minimum period of one month during the summer vacation of 3rd year. Research project or internship in an academic institution within the country (IISc / IITs / NITs / Engineering Institute or University of repute) or university abroad is also permitted instead of industrial training.

<u>Course Evaluation:</u>

Evaluation through Seminar Presentation/Viva-Voce
The assessment will be based on the following criteria:

i. Quality of content presented.
ii. Proper planning of presentation.
iii. Effectiveness of Presentation
iv. Depth of knowledge and skills.

Evaluation of Student's Report
The training report will be evaluated according to the following criteria:

i. Originality
ii. Adequacy and purposeful write-up
iii. Organization, format, drawing, sketches, style, language etc.
iv. Variety and relevance of learning experience
v. Practical applications, relationships with basic theory and concepts taught in the course.

Assessment Tool	% Contribution during CO Assessment
Presentation and/or Viva-voce	50
Student's reports	50

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	2	2	2	2	3	2	0	2	2	2	2
CO2	1	1	1	1	3	2	2	3	0	0	1	3	3	2
CO3	2	1	1	2	2	2	2	3	0	2	2	3	3	2
CO4	2	1	1	1	1	1	3	3	3	0	2	3	3	3
CO5	1	1	1	1	0	1	3	1	1	0	2	2	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

COURSE INFORMATION SHEET

Course code: PE 24407
Course title: NON-CONVENTIONAL MACHINING PROCESSES
Pre-requisite(s): MACHINING SCIENCE AND MACHINE TOOLS / MANUFACTURING PROCESSES
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII / Fourth
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the different non-conventional machining processes and their operational characteristics
2	Learn about the basic construction of the different non-conventional machines, and about the tools, equipment and consumable required
3	Understand the effects of different process parameters on part quality, and how the parameters are to be controlled
4	Study different empirical, analytical and theoretical approach for analysis of material removal for different processes.
5	Learn about the developments of different hybrid non-conventional machining techniques

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

CO1	Explain the fundamental principles, techniques, equipment, applications, advantages and limitations of different non-conventional machining processes.
CO2	Find solutions for meeting demand of machining hard-to-machine materials, producing complex shape and size with greater product accuracy and surface finish
CO3	Analyse the influence of process parameters on part quality
CO4	Explain the developments and operation potential of different hybrid non-conventional machining techniques
CO5	Select appropriate non-conventional machining technique based on work materials used and the part features to be produced

SYLLABUS

Module 1: Introduction and mechanical processes (AJM, WJM, AWJM, USM) [8]
Need and classifications of non-conventional Machining Processes
Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Abrasive Jet Machining (AJM), Water Jet Machining (WJM) and Abrasive Water Jet Machining (AWJM); calculation of material removal rate (MRR) for ductile and brittle materials in AJM;
Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Ultrasonic Machining (USM); Calculation of MRR in USM by empirical approach, Cook’s model, Shaw theory.

Module 2: Chemical and electrochemical processes (ChM, ECM) [8]
Fundamental principles, application possibilities, process parameters, operational characteristics and tooling of Chemical Machining (ChM); Chemical Milling, Photochemical Milling, Electropolishing;
Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Electrochemical Machining (ECM); electrolytes; electrochemistry of ECM; kinematics and dynamics of ECM, Effect of heat and hydrogen bubble generation; design of tool shape, electrolyte flow and insulation, surface finish and accuracy.

Module 3: Thermal processes (EDM, WEDM) [8]

Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Electro Discharge Machining (EDM); mechanics of EDM; theories of material removal in EDM; types of EDM; dielectric fluid; electrode material; pulse generation; flushing techniques, effects on material surface, surface finish and accuracy; dry EDM;

Operation principles, applications, process parameters of Wire Electro Discharge Machining (WEDM)

Module 4: Thermal Processes (LBM, EBM, PAM, IBM) [8]

Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Laser Beam Machining (LBM); types of lasers and lasing process; mechanics of LBM; surface finish and accuracy;

Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Electron Beam Machining (EBM), and Plasma Arc Machining (PAM), Ion Beam Machining (IBM).

Module 5: Hybrid Machining Processes [8]

Fundamental principles, applications and operational characteristics of Electrochemical Grinding, Electrodischarge Grinding, Electrochemical Discharge Machining and Electrochemical Discharge Grinding, Abrasive Electrodischarge Machining, EDM with Ultrasonic Assistance, Ultrasonic-Assisted ECM, Laser-Assisted ECM, Laser-Assisted Oxygen cutting.

Text books:

1. P. C. Pandey and H. S. Shan, Modern Machining Processes, Tata McGraw-Hill **[T1]**
2. P. K. Mishra, Non-conventional Machining, Narosa Publishing House **[T2]**
3. Hassan El-Hofy, Advanced Machining Processes, McGraw-Hill **[T3]**

Reference books:

1. Ghosh and A.K. Mallik, Manufacturing Science, Affiliated East- West Press **[R1]**
2. Bhattacharyya, New Technology, The Institution of Engineers (India) **[R2]**
3. M P. Groover, Fundamentals of Modern Manufacturing, John Wiley & Sons, Inc. **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Hands-on exposure on non-conventional machining processes

POs met through Gaps in the Syllabus:

POs 1-5, 12

Topics beyond syllabus/Advanced topics/Design:

Machining and super-finishing in sub-micron level

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1-5, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	1	0	0	0	0	0	0	3	3	2	3
CO2	3	3	3	3	1	0	0	0	0	0	3	3	2	3
CO3	3	3	3	2	1	0	0	0	0	0	3	3	2	3
CO4	3	3	3	2	0	0	0	0	0	0	3	3	2	3
CO5	3	3	3	3	1	0	0	0	0	0	3	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24409
Course title: ADVANCED MANUFACTURING PROCESSES
Pre-requisite(s): FOUNDRY, FORMING & WELDING TECHNOLOGIES; MACHINING SCIENCE AND MACHINE TOOLS
Co- requisite(s): None
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII / Fourth
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students:

1	To understand the concepts of advanced casting processes like Squeeze casting; Rheo-casting; Thixo-casting;
2	To identify suitable hybrid welding processes for joining dissimilar materials.
3	To understand the latest forming Techniques like Super plastic forming, Thixoforming, etc.
4	To understand the principles of powder metallurgy processes and their applications.
5	To understand the Processing methods of Plastics.

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

CO1	Design the Gating and Riser systems of modern casting processes;
CO2	Understand the environmental issues of advanced welding processes;
CO3	Handle real-life projects in various organizations
CO4	Solve complex problems with the knowledge of latest powder metallurgy processes
CO5	Explore the processing methods of Plastics and advanced materials.

SYLLABUS

Module 1: Advanced Casting Processes **[8]**

Newer casting processes - plaster mold and ceramic mold casting – vacuum casting – Evaporative pattern casting, ceramic shell and investment casting, slush casting, squeeze casting; Rheo-casting, and Thixo-casting - Rapid solidification of Amorphous alloys.

Module 2: Advanced Welding Processes **[8]**

Cold welding, diffusion welding, forge welding, Friction stir welding, explosive welding, Vacuum welding, vacuum welding, Underwater Welding Processes, Laser beam welding; Concept of robotized welding and welding automation.

Module 3: Advanced Forming **[8]**

High Energy Rate Forming (HERF) techniques, Super plastic forming techniques, Orbital forging, Ring Rolling, Incremental forming, Isothermal forging, Hot and cold iso-static pressing, High speed extrusion, Rubber pad forming, Explosive forming, Hydroforming; Vacuum forming; Thixoforming;

Module 4: Powder Metallurgy **[8]**

Methods of Powder production – Blending of metal powders- Compaction of metal powders- Sintering – hot pressing –Isostatic pressing – hot and cold (HIPing and CIPing), laser Sintering; Metal Injection moulding, pressure less compaction, ceramic moulds – spray deposition - Finishing of sintered parts.

Module 5: Manufacturing Process for Plastics **[8]**

Extrusion, Injection, Blow and rotational moulding of plastics-Thermoforming-Compression moulding – Transfer moulding – Foam moulding - Processing of reinforced plastics and composite – Moulding – compression, vacuum bag – contact – resin transfer – transfer / injection moulding.

Text books:

1. Serope Kalpakjian, Steven R. Schemid, "Manufacturing processes for Engineering Materials", Fourth edition, Pearson Education, 2003 **[T1]**
2. Serope Kalpakjian, "Manufacturing Engineering and Technology", Third Edition-Addison-Wesley Publication Co., 1995. **[T2]**

Reference books:

1. Brahem.T.Smith, "Advanced machining", I.F.S., U.K.1989. **[R1]**
2. Amstead B.H., Ostwald Phylips and Bageman.R.L., "Manufacturing Processes" John Wileys Sons, 1987. **[R2]**
3. Muccic, E.A., "Plastic Processing Technology", Materials park, OHIO, ASM Int., 1994. **[R3]**
4. Jaeger R.C., "Introduction to microelectronic Fabrication", Addision-Wesley, 1988. **[R4]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Advances in Machining and Non-traditional machining

POs met through Gaps in the Syllabus:

POs 4,5

Topics beyond syllabus/Advanced topics/Design:

Rapid prototyping

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 4-6

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05

End Semester Examination	% Distribution				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	1	1	1	0	0	0	1	3	3	1	2
CO2	3	2	1	0	0	1	0	0	0	1	2	3	1	3
CO3	3	3	3	0	0	1	0	0	0	1	2	3	2	3
CO4	3	2	1	0	0	1	1	1	0	1	3	3	2	3
CO5	3	3	1	0	0	0	0	0	0	1	2	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24411
Course title: EXPERIMENTAL METHODS AND MEASUREMENTS
Pre-requisite(s): INTRODUCTION TO MATERIALS ENGINEERING
Co- requisite(s): None
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII / Fourth
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:

This course enables the students to:

1	Associate with experimental techniques conventionally available in production engineering
2	Investigate the characteristics of variety of products/samples made of different materials
3	Understand various recently developed experimental techniques in material characterization, measurement of dimensions, geometric form.
4	Evaluate the factors in material characterization, form measurement, surface topology, dynamic entities like force, vibration, strain etc.
5	Analyze experimental data with various tools and techniques

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

CO1	Identify and illustrate experimental techniques adopted in various domains of production engineering
CO2	Apply various tools and techniques in metallography
CO3	Determine various entities related to dimensions of mechanical components, geometric form, surface texture
CO4	Estimate variety of dynamic entities like force, vibration, strain etc.
CO5	Analyze experimental data and minimize experimental errors

SYLLABUS

Module 1: Conventional Material Characterization Techniques [12]
Introduction and Classification of Material Characterization Techniques; X-Ray Diffraction – Properties of X-rays, Diffraction of X-rays by crystalline materials, Bragg's law, Diffractometer diffraction experiments, Indexing of powder diffraction patterns; Optical Microscopy – Basic terminology, Construction of an optical microscope, Optical contrasting techniques; Scanning Electron Microscopy – Construction of SEM and its various parts, Interaction of electrons with solid surfaces, Terminology in SEM, Imaging techniques in SEM, Energy Dispersive Spectroscopy; Transmission Electron Microscopy – Basic Construction of a TEM and its parts, Imaging techniques in TEM, Sample preparation techniques in TEM; Thermal Analysis Techniques – Principles, Construction, Applications, Advantages and Disadvantages of DTA, DSC and TGA

Module 2: Advanced Material Characterization Techniques [8]
Basic principle and applications of scanning probe microscopy, scanning tunnelling microscopy, atomic force microscopy, lateral force microscopy, scanning transmission electron microscopy, phase detection microscopy, photoelectron spectroscopy, auger spectroscopy, and electron energy loss spectroscopy, Raman Spectroscopy, dynamic light scattering

Module 3: Alignment Tests and Form Measurements [6]
Principle and uses of mechanical and optical Comparators
Types of machine tool tests: Alignment tests for lathe, milling and drilling machine tools Principle of interferometer, concept of optical flat, Interferometer

Terminology of screw threads, Measurement of minor, major, thread angle and effective diameter of screw threads. Screw thread gauges, tool maker's microscope and recent techniques
Gear tooth terminology, gear tooth thickness & pitch measurement, involutes profile testing of gear
Straightness, flatness, squareness and circularity tests, numerical evaluation, measurement of surface finish, related instruments
Introduction & applications of Co-ordinate Measuring Machine (CMM)

Module 4: Dynamic Measurement **[8]**
Sensors and Transducers: Types of Sensors, types of transducers and their characteristics
Force and Torque measurement: Direct methods and indirect methods, force measuring instruments-load cells, Dynamometer, Power Measurements
Measurement of strain: types of strain gauges, gauge factors, theory of strain gauges and method of measurement, Wheatstone bridge circuit
Vibration and Noise Measurement: Piezoelectric Accelerometer and decibel meters

Module 5: Analysis of Experimental Data **[6]**
Introduction, Causes and Types of Experimental Errors, Error Analysis, Uncertainty Analysis and Evaluation, Statistical analysis of experimental data, Probability of error distribution, Gaussian and normal distribution of error, Regression analysis

Textbooks

1. Goodhew, Humphreys and Beanland, Electron Microscopy and Microanalysis, Taylor and Francis **(T1)**
2. Cullity, Elements of X-Ray Diffraction, Prentice Hall **(T2)**
3. Brown, Introduction to Thermal Analysis Techniques and Applications, Kluwer Academic Publishers **(T3)**
4. J. P. Holman, Experimental Methods for Engineers, McGraw Hill **(T4)**
5. R.K. Jain, Engineering Metrology Khanna Publications, New Delhi **(T5)**
6. I. C. Gupta, A Text book of Engineering Metrology, Dhanpat Rai, New Delhi **(T6)**
7. Er. R K Rajput, Mechanical Measurements and Instrumentations, Kataria Publication (KATSON) **(T7)**
8. M. Mahajan, Engineering Metrology, Dhanpat Rai & Co. New Delhi **(T8)**

Reference Books
1. William, Carter, Transmission Electron Microscopy, Springer **(R1)**
2. K. J. Hume, Engineering Metrology **(R2)**
3. N V Raghavendra and Krishnamurthy, Engineering Metrology and Measurement, Oxford University Press **(R3)**
4. Bentley, Engineering Metrology and Measurements, Pearson Education **(R4)**
5. Anand Bewoor, Vinay Kulkarni, Metrology and Measurement, McGraw-Hill **(R5)**

Gaps in the syllabus (to meet Industry/Profession requirements):
This type of course requires hand-on practices. Sessional classes are not included.

POs met through Gaps in the Syllabus:
1-5,9

Topics beyond syllabus/Advanced topics/Design:
Indepth XRD analysis, phase analysis, Rietveld analysis

POs met through Topics beyond syllabus/Advanced topics/Design:
1-5

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	3	1	1	2	1	0	3	3	3	3
CO2	3	3	3	2	2	0	0	2	1	0	3	3	3	3
CO3	3	3	3	3	2	0	0	2	0	0	3	3	2	3
CO4	3	3	3	2	2	2	0	2	0	0	3	3	2	3
CO5	3	2	2	3	1	1	1	1	0	0	3	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24413
Course title: AI AND DATA ANALYTICS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII / Fourth
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about basic tools of AI and the application areas
2	Understand the concept of ML and various tools under it
3	Gain knowledge on fuzzy logic and practical applications
4	Know about data science and its applications in business and decision making
5	Learn and apply data analytics tools like R and Python

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

CO1	Apply ML tools to various engineering and management problems
CO2	Develop fuzzy systems for inference using Matlab simulation app
CO3	Develop ANN based deep learning models for practical problems
CO4	Implement data pre-processing like cleaning, sorting, reduction, etc.
CO5	Apply various data analytics tools using software or programming

SYLLABUS

Module 1: Fundamental of AI **[7]**
AI Concepts, terminology and application areas, Components and tools of AI, Comparison of features and characteristics of AI systems with biological systems, Examples of real-life practical application of AI, Societal impact and Ethical issues

Module 2: Machine Learning (ML) **[8]**
ML techniques overview, Decision trees, classification and clustering as ML tools, Artificial Neural Network (ANN), Supervised, unsupervised and reinforced learning, Perceptron and back propagation, Deep learning, Applications and real-life examples

Module 3: **Fuzzy Logic and Applications** **[8]**
Introduction to fuzzy set theory, Fuzzy set properties and operations, Linguistic variables, Fuzzy rules, Fuzzy quantifiers, Fuzzy logic, Mamdani and Sugeno Fuzzy Inference Systems (FIS), Matlab© simulations, Examples of real-life applications of fuzzy systems

Module 4: Introduction to Data Science **[7]**
Introduction, Types of data, Big data, Data Pre-processing, Knowing data, Data cleaning, Data reduction, Data transformation, Data discretization -Visualization and Graphing, Application of Python© programming, Numerical examples

Module 5: Data Analytics **[10]**

Data Analytics Process, Qualitative verses Quantitative Analysis, Data Analysis and Data Mining, Business Analytics, Types of Data Analytics: Diagnostic Analysis, Predictive Analysis, Prescriptive Analysis, Statistical Analysis (Descriptive and Inferential), Text Analysis, Examples and Application of R and Python© programming,

Text Book

1. S. Rajasekaran and Vijayalakshmi Pai, Neural Networks, Fuzzy Systems and Evolutionary Algorithms: Synthesis and Applications, PHI, India **(T1)**
2. Ajit Kumar Roy and Pradip Kumar Choudhury, Applied Big Data Analytics, ISBN-13 : 978-1512347180 **(T2)**
3. Russell, Norvig, Artificial Intelligence: A Modern Approach, Third edition, Prentice Hall, 2010 **(T3)**

Reference Book

1. Bharti Motwani, Data Analytics Using Python, Wiley, India **(R1)**
2. Garret Grolemund and Hadley Wickham, R for Data Science, ISBN-13: 978-1491910399 **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	**POs**											**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	2	1	1	1	1	2	2	2	3	3
CO2	3	3	3	3	2	2	2	1	1	2	2	2	3	3
CO3	3	3	3	3	3	1	1	1	1	2	2	2	3	3
CO4	3	3	3	3	2	3	1	1	1	2	2	2	3	3
CO5	3	3	3	3	2	2	1	1	1	1	1	2	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24415
Course title: AUTOMATED MANUFACTURING SYSTEMS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII / Fourth
Branch: ALL (Open Elective)
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the fundamental of automation and components of a manufacturing system
2	Learn about automated production and assembly lines
3	Learn the design criteria of robots and cellular manufacturing in CIM.
4	Learn the design criteria of flexible manufacturing systems
5	Learn about the fundamental concepts of smart manufacturing systems

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

CO1	Able to select a manufacturing system for a given product
CO2	Design automated assembly lines
CO3	Design a cell for the cellular manufacturing
CO4	Identify the components required for a flexible manufacturing system
CO5	Apply the smart technologies digital twin, AR, VR and mixed reality to automate the manufacturing system

SYLLABUS

Module 1: Introduction to Automation in Manufacturing Systems [05]
Types of Manufacturing operations and production facilities; Basic Elements of Automation; Level of Automation; Components of Manufacturing Systems; Classification Scheme for Manufacturing Systems

Module 2: Manual and Automated Production and Assembly Lines [08]
Fundamental of Manual Assembly Lines; Analysis of Single Model Assembly Line; Line Balancing Algorithms; Mixed Model Assembly Lines.
Fundamentals of Automated Production and Assembly Lines; Applications of Automated Production and Assembly Lines; Analysis of Transfer Lines and Assembly Systems

Module 3: **Computer Integrated Manufacturing & Robotics [10]**
Role of computer in manufacturing; Needs of CIM Hardware, CIM Software, CIM workstations.
CIM architecture and key building block; Design for manufacturing and assembly, Computer aided process planning and control, concurrent engineering.
Industrial robotics; robot anatomy, robot joints and configuration, DOF, robot actuation, end effectors.

Module 4: Flexible Manufacturing System [10]
Introduction to material handling, Material transport equipment; AGV, Analysis of material transport systems; Automated storage systems,
FMS components; FMS Planning and Implementation Issues; Quantitative Analysis of Flexible Manufacturing Systems

Module 5: Smart Manufacturing **[08]**
Introduction to Smart manufacturing; Smart manufacturing systems.
Concept of digital twin, levels of the digital twin: the master, the shadow, and the twin.
Applications of smart manufacturing with real-time industry examples.

Textbook

1. Mikell P. Groover, "Automated Production systems and computer Integrated Manufacturing", PHI, Eastern Economy Edition.
2. B.S. Nagendra Parashar, "Cellular Manufacturing Systems- An Integrated Approach", PHI, Eastern Economy Editions.
3. P N Rao, N K Tiwari, T K Kundra, "Computer Aided Manufacturing", Tata McGraw Hill

Self-Learning Materials

1. https://onlinecourses.nptel.ac.in/noc21_me120/preview

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of material handling system, Supply chain

POs met through Gaps in the Syllabus:
POs 2, 5

Topics beyond syllabus/Advanced topics/Design:
Smart factory; Re-configurable manufacturing

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 3, 4, 5

Course Delivery Methods:

CD1	Classroom teaching with using different Tools and aid	√
CD2	Assignments/Seminars	√
CD3	Mini projects	√
CD4	Industrial/guest lectures	√
CD5	Industrial visits/in-plant training	√
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Case study discussion	√

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	1	1	2	0	0	0	0	0	0
CO2	3	3	3	3	2	2	0	0	0	0	0
CO3	3	3	3	3	2	2	0	0	0	0	0
CO4	3	3	3	2	2	2	0	0	0	0	0
CO5	3	3	1	1	3	3	2	0	0	0	0

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1; CD5, CD6
CO2	CD1; CD2; CD4; CD5, CD6
CO3	CD1; CD2; CD3; CD4; CD5, CD6; CD7
CO4	CD1; CD2; CD3; CD4; CD5, CD6; CD7
CO5	CD1; CD2; CD3; CD5, CD6; CD7

COURSE INFORMATION SHEET

Course code: PE 24417
Course title: PRODUCTION MANAGEMENT
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T:0 P:
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII / Fourth
Branch: ALL (Open Elective)
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Introduce to basic concepts of production management,
2	Understand basic inventory management techniques followed in the industry
3	Understand how production planning and scheduling is made to control the manufacturing in the industry
4	Provide basic idea of supply chain management
5	Understand the basic concept of comparatively new production philosophy: lean production

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

CO1	Understand the basic concept and scope of production management and Choose proper location of production plant along with the layout
CO2	Apply forecasting methods to predict the product requirements and subsequently can Prepare basic aggregate planning of manufacturing
CO3	Estimate material requirements and Prepare schedule of each operation
CO4	Determine inventory types and inventory procurement using some inventory model
CO5	Explain the idea of lean philosophy used in production management

SYLLABUS

Module 1: Introduction to Production Management **[8]**

Introduction and scope of production management, Types of production, Plant Location: various factors affecting plant location; Facility Layout: definition, types of facility layout, types of flow patterns, Systematic Layout Planning: operations process chart, from-to chart, activity relationship chart, relationship diagram

Module 2: Forecasting **[8]**

Definition, Quantitative models: simple average, moving average, linear regression, simple seasonality model; Qualitative model: Delphi method; Aggregate Production Planning: level strategy and chase strategy

Module 3: Material Requirement Planning and Scheduling **[8]**

Material Requirement planning (MRP): what is MRP, master production schedule (MPS), bill of material (BOM); Scheduling and Sequencing: makespan, flowtime, due date, single machine sequencing, two machine flow shop scheduling: Johnson's rule, three machine modification of Johnson's rule, various dispatching rules in job shop scheduling, loading.

Module 4: Inventory Control **[8]**

Definition, Type, Classification of inventory, ABC and VED method, Inventory cost, Economic Order Quantity (EOQ) and Economic Production Quantity (EPQ) models, Price break in EOQ, Robustness of EOQ

Module 5: Lean Philosophy in Production Management **[8]**

Push and Pull system, Basic concept of lean manufacturing, Historical development, Kanban system, Basic lean tools: Kaizen, Value stream mapping, 5S.

Textbook:

1. Jay Heizer and Barry Render, Production & Operations management, Prentice Hall **(T1)**
2. James. L. Riggs, Production Systems: Planning, Analysis, and Control, Wiley **(T2)**

Reference Books:

1. R. Panneerselvam, Production and operations management, PHI Learning Pvt. Ltd **(R1)**
2. S. N. Chary, Production and operations management, Tata McGraw-Hill Education **(R2)**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	**% Distribution**				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (Cos) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										
	1	2	3	4	5	6	7	8	9	10	11
CO1	2	2	0	2	0	0	0	0	0	3	1
CO2	2	2	1	2	2	0	0	0	2	3	2
CO3	2	2	1	2	0	0	0	0	2	3	2
CO4	2	2	1	2	0	0	0	0	1	3	2
CO5	1	0	0	1	3	1	0	2	1	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (Cos) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24450
Course title: PROJECT-IV
Pre-requisite(s):
Co- requisite(s):
Credits: 6 L: T: P:
Class schedule per week:
Class: B. Tech
Semester / Level: VIII / Fourth
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Use the relevant knowledge and skills acquired during the domain course to solve the problem.
2	Extract relevant literature survey information and formulate project specifications, and implement project plan
3	Use appropriate techniques and tools to conduct experiments, analyse data and draw appropriate results-based conclusions and identify applications
4	Draw appropriate conclusions based on the results and identify applications
5	Prepare a technical report in the form of a thesis and effectively communicate using multimedia tools through oral presentation

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

CO1	Identify and understand current trends and real-world issues in production engineering
CO2	Formulate project specifications, identify a set of feasible solutions and prepare and implement project plan
CO3	Use critical thinking skills to review, analyse and interpret data and results
CO4	Demonstrate work knowledge of ethics and professional responsibility at various stages such as project formulation, design, implementation and presentation
CO5	Publish the results of the project work in journal or conference proceedings, present the work effectively and communicate with confidence in the defence of the work

Course Evaluation:

Project work can be carried out preferably independently or by a group of students not exceeding three (3). More than three students in a group shall be discouraged. Department Committee shall be appointed by the Head of the Department. The Guide of the candidate shall not participate in the evaluation process by the department committee.

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Assessment by Department Committee	25
Assessment by Project Guide (s):	25
End Semester Examination	**% Distribution**
End Sem Exam (External Examiner)	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Assessment by Department committee	√	√	√	√	√
Assessment by Project Guide (s):	√	√	√	√	√
End Sem Exam (External Examiner)	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	3	3	0	1	0	0	2	3	3	3
CO2	3	3	3	3	3	3	0	1	0	0	2	3	3	3
CO3	3	3	3	3	3	3	0	1	0	0	2	3	3	3
CO4	3	3	3	3	3	3	3	2	0	3	2	3	3	3
CO5	2	2	2	2	2	2	0	1	3	0	2	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

COURSE INFORMATION SHEET

Course code: PE 24490
Course title: INDUSTRY INTERNSHIP
Pre-requisite(s):
Co- requisite(s):
Credits: 6 L: T: P:
Class schedule per week:
Class: B. Tech
Semester / Level: VIII / Fourth
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Apply the technical knowledge and skills acquired during the program to solve various problems in the real-life industry
2	Get acquainted with industry and corporate culture
3	Use appropriate tools and techniques to conduct experiments, analyse data and draw results-based conclusions
4	Provide suggestions based on technical findings for improvement in operations/processes of the industry they work with
5	Prepare an internship report containing problem statement, solution methodology, result and analysis and communicate effectively through oral presentation

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

CO1	Identify technical problems and develop a set of feasible solutions in industries
CO2	Apply their technical knowledge and skill to real-world problems in the domain of production and industrial engineering
CO3	Use critical thinking skills to review, analyse and interpret data and results
CO4	Demonstrate professional responsibility, work ethics and team spirit at the workplace
CO5	Document the internship work in the form of a complete report and communicate the work effectively in their defence presentation

Course Evaluation:

Internship being offered by various industries can be carried out by the student independently at the site of the industry or remotely as decided by the employer. Department UG Internship Committee shall be appointed by the Head of the Department comprises of minimum five faculty members comprising of Chairperson (A senior faculty member) and members. The role of the committee is to continuously monitor and evaluate the performance of students through mid-semester progress presentation (online) and end-semester evaluation (offline). The Guide of the student shall not participate in the evaluation process.

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Assessment by Department Committee	25
Assessment by Coordinator(s):	25
End Semester Examination	**% Distribution**
End Sem Exam	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Assessment by Department committee	√	√	√	√	√
Assessment by Project Coordinator(s):	√	√	√	√	√
End Sem Exam	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):</u>

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	3	3	0	1	0	0	2	3	3	3
CO2	3	3	3	3	3	3	0	1	0	0	2	3	3	3
CO3	3	3	3	3	3	3	0	1	0	0	2	3	3	3
CO4	3	3	3	3	3	3	3	2	0	3	2	3	3	3
CO5	2	2	2	2	2	2	0	1	3	0	2	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

In-depth Specialization in

“Advanced Manufacturing and Production Management”

Syllabus (UG Program)
B.Tech in Production and Industrial Engineering

(OFFERED ONLY TO PRODUCTION AND INDUSTRIAL ENGINEERING STUDENTS)

Students who have registered for DEPERTMENTAL SPECIALISATION (in-depth) in "Advanced Manufacturing and Production Management" should complete 16 credits and shall opt for courses listed in Course Structure for the In-depth Specialization Program. The credits shall be over and above minimum requirement for degree award.

COURSE INFORMATION SHEET

Course code: PE 24323
Course title: MATERIAL CHARACTERISATION AND NON-DESTRUCTIVE TESTING
Pre-requisite(s): PHYSICS, METALLURGICAL AND MATERIALS ENGINEERING, STRENGTH OF MATERIALS
Co- requisite(s): None
Credits: 4 L: 4 T: P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: V / Third (for In-depth Specialization in Adv. Mfg. Prod. Mgmt.)
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students:

1	To understand various Material Characterization techniques
2	To get acquainted with various physical and mechanical characterization methods
3	To learn about the various Non-Destructive testing methods
4	To learn about the various Surface and Sub Surface Testing methods
5	To study about the various applications of NDT Tests in Industries

MATERIAL CHARACTERISATION AND NON-DESTRUCTIVE TESTING

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

CO1	Use various techniques of Material Characterization for industrial and scientific purposes
CO2	Identify methods of various physical and mechanical characterization
CO3	Comprehend the principal behind various Non-Destructive Testing methods
CO4	Explore various surface and subsurface Non-Destructive Methods
CO5	Distinguish between different NDT techniques in terms of technology used and their application

SYLLABUS

Module1: Material Characterization – I **[10]**
Importance of material characterisation; classification of material characterization techniques; Physical Characterization including Density, Thermal (conductivity, specific heat, etc.), Electrical (conductivity, dielectric coefficient, etc.), Chemical (composition, corrosion, etc.) and Mechanical (Hardness, Strength, Toughness, Fatigue, Torsion, Wear) Properties.

Module 2: Material Characterization – II **[10]**
Fundamentals of optics, Sample preparation and Optical Microscope, Introduction to Scanning electron microscopy (SEM), Spectroscopy, Application of SEM, Basics of XRD, Introduction to transmission electron microscopy (TEM), Diffraction and image formation, Applications of TEM

Module 3: Introduction to Non Destructive Testing; and Surface Testing Methods **[10]**
NDT versus Destructive testing, Overview of the Non-Destructive Testing Methods for the detection of manufacturing defects. Relative merits and limitations, Various physical characteristics of materials, Visual inspection – Unaided and aided. Liquid Penetrant Testing, Advantages and limitations of various methods, Testing Procedure. Magnetic Particle Testing

Module 4: Thermography and Eddy Current Methods **[10]**
Thermography Contact and non-contact inspection method, Advantages and limitation, Instrumentations and methods, Applications. Eddy Current Testing-Generation of eddy currents, Eddy current sensing elements, Types of arrangement, Applications, advantages, Limitations, Evaluation.

Module 5: Ultrasonic Testing and Acoustic Emission **[10]**
Ultrasonic Testing, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique, Acoustic Emission parameters, Applications

Text Books:

1. Baldev Raj, T.Jayakumar, M.Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing House, 2009. **[T1]**
2. Smallman R. E., 'Modern Physical Metallurgy', 4th Edition, Butterworths, 1985 **[T2]**
3. Philips V. A., 'Modern Metallographic Techniques and their Applications', Wiley
4. Interscience, 1971 [**T3]**
5. Ravi Prakash, "Non-Destructive Testing Techniques", 1st revised edition, New Age International Publishers, 2010 [**T4]**

References:

1. ASM Metals Handbook,"Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17. **[R1]**
2. Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005 **[R2]**
3. Charles, J. Hellier, "Handbook of Nondestructive evaluation", McGraw Hill, New York 2001. **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Radiography Testing

POs met through Gaps in the Syllabus:
POs 1-5

Topics beyond syllabus/Advanced topics/Design:
Principles of various Non-destructive Testing Methods

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1-5

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05

End Semester Examination	% Distribution				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
CO1	2	3	2	1	3	2	0	1	0	0	2	3	3	3
CO2	2	2	3	3	1	0	0	2	2	0	2	2	3	3
CO3	3	2	2	3	3	2	0	2	1	0	2	2	2	2
CO4	3	2	2	3	3	2	0	2	0	0	2	3	2	3
CO5	3	3	2	3	3	0	0	1	0	0	2	1	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation – 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24325
Course title: SUSTAINABLE MANUFACTURING TECHNOLOGIES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 4 L: 4 T: 0 P: 0
Class schedule per week: 4
Class: B. Tech
Semester / Level: V / Third (for In-depth Specialization in Adv. Mfg. Prod. Mgmt.)
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students:

A.	To understand the Importance of Sustainable Manufacturing
B.	To study various tools/techniques of sustainable manufacturing
C.	To assess environmental impacts of manufacturing processes
D.	To develop eco-friendly Products/processes
E.	To perform Product Life Cycle Assessment

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

CO1	Recognise the Need of Sustainable Manufacturing;
CO2	Explore the State-of-art Tools & Techniques of Stainable Manufacturing
CO3	Solve case studies related to sustainability assessment of projects
CO4	Characterise Eco-friendly processes/products
CO5	Perform Product Life cycle assessment

SYLLABUS

Module 1: Introduction to Sustainable Manufacturing **[10]**
Introduction to Sustainable Manufacturing; Drivers of Sustainable Manufacturing; Concept of Triple bottom line; Environmental, Economic and Social Dimensions of Sustainability; Relation between Lean and Sustainable manufacturing; Green manufacturing

Module 2: Tools and Techniques **[10]**
Environmental Conscious, Quality Function Deployment, Design for Environment; Design for Disassembly, Design for recycling, Eco friendly Product design methods. Environmental Impact Assessment Methods and Standards;

Module 3: Sustainability Assessment **[10]**
Sustainability Assessment -Concept Models and Various Approaches, Product Sustainability and Risk/Benefit assessment; Corporate Social Responsibility.

Module 4: Sustainable Characteristics **[10]**
Sustainable characteristics of manufacturing processes - Energy efficiency analysis of manufacturing processes - Sustainability analysis and Scope of sustainable manufacturing centers.

Module 5: Sustainable Technologies **[10]**

Sustainable Product design; Principles of Life cycle assessment; Product Life Cycle Assessment, Introduction to Software packages related to Sustainable Manufacturing.

Text books:

1. Mrityunjay Singh, T.Ohji and Rajiv Asthana, "Green and Sustainable Manufacturing of Advanced Materials" Elsevier (1st Ed.) 2015. **[T1]**
2. G. Seliger, Marwan, M.K. Khraisheh, I.S. Jawahir, D. Rodick, "Advances in Sustainable Manufacturing", IRP, Springer publishers, 2011 **[T2]**

Reference books:

1. G. Atkinson, S. Dietz, E. Neumayer, "Handbook of Sustainable Manufacturing", Edward Elgar Publishing Limited, 2007. **[R1]**
2. P. Lawn, Sustainable Development Indicators in Ecological Economics, Edward Elgar Publishing Limited. **[R2]**
3. D. Rodick, Industrial Development for the 21st Century: Sustainable Development Perspectives, New York, 2007. **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Sustainability for global challenges, climate and environmental protection

POs met through Gaps in the Syllabus:

POs 3,12

Topics beyond syllabus/Advanced topics/Design:

Sustainable Business Management

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 2, 3, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	1	1	1	0	0	0	1	3	3	2	2
CO2	3	2	1	0	0	1	0	0	0	1	2	3	1	3
CO3	3	3	3	0	0	1	0	0	0	1	3	3	2	3
CO4	3	2	1	0	0	1	1	1	0	1	2	3	2	2
CO5	3	2	1	0	0	0	0	0	0	1	2	3	1	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24355
Course title: INDUSTRIAL ROBOTICS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 4 L:3 T:1 P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: VI / Third (for In-depth Specialization in Adv. Mfg. Prod. Mgmt.)
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Know the various robot structures and their workspace
2	Understand the use of end-effectors and sensors
3	Perform kinematics analysis of robot systems
4	Get the knowledge of dynamic and trajectory planning of robot
5	Provide robot programming in area of manufacturing automation

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

CO1	Classify the robots based on mechanical structures, operational workspace and characteristics
CO2	Select the robot end-effectors and sensors
CO3	Solve forward and inverse kinematics of simple robot manipulators
CO4	Analyse the dynamic and Trajectory Planning of robot
CO5	Programme of simple robot manipulators for manufacturing applications

SYLLABUS

Module 1: Fundamental of Robot Technology **[8]**
Introduction, Types of robot joints, Robot classification, specification, Robot anatomy, Arm Geometry, Degree of freedom, Drive and configuration of industrial robots, Robot selection.

Module 2: Robot End-effectors and Sensors **[10]**
Types of end-effectors, Mechanical grippers, Gripper force analysis, Special-purpose grippers, Grippers selection and design. Robot sensors, Sensor classification, Microswitches, Solid-state switches, Proximity sensors, Photoelectric sensors, Uses and selection of sensors.

Module 3: Robot Motion Analysis **[12]**
Robot motion analysis: Coordinate system in robot kinematics, Homogeneous transformation matrix, direct and inverse kinematics, D – H representation, Jacobian matrix of manipulator.

Module 4: Dynamic Analysis and Trajectory Planning **[12]**
Lagrangian formulation of manipulator dynamics, Newton-Euler formulation, Joint space planning, Cartesian-space planning.

Module 5: Robot Programming and Industrial Application of Robots **[8]**
Methods of robot programming, Lead and teach method, Explicit languages. Selection and use of robots in metal casting, welding, material handling, machining, inspection, assembly and painting.

Text books:
1. James G. Keramas, “Robot Technology Fundamentals” Cengage Learning India. **[T1]**
2. Srinivas, J., R.V. Dukkipati, K. Ramji, “Robotics Control and Programming”, Narosa **[T2]**

Reference books:

1. Yoram Koren, "Robotics for Engineers", McGraw-Hill Companies. **[R1]**
2. King Sun Fu, Rafael C. González, C. S. George Lee, "Robotics, Control, Sensing, Vision and Intelligence", McGraw-Hill. **[R2]**
3. Groover M.P., "Industrial Robotics Technology Programming Application", Tata McGrawHill. **[R3]**
4. Deb S.R., "Robotics Technology and Flexible Automaton", Tata McGraw-Hill. **[R4]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Use of Internet of Things (IoT) in Robotics

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1-5, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	√

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	1	1	1	3	1	2	0	0	1	1	2
CO2	3	2	2	1	1	1	3	1	3	0	0	3	1	3
CO3	3	3	2	3	1	3	2	3	0	0	0	3	2	3
CO4	3	3	1	3	1	3	2	3	0	0	0	3	2	3
CO5	3	3	2	3	1	1	3	3	3	0	0	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6, CD7
CO2	CD1, CD2, CD6, CD7
CO3	CD1, CD2, CD6, CD7
CO4	CD1, CD2, CD6, CD7
CO5	CD1, CD2, CD6, CD7

COURSE INFORMATION SHEET

Course code: PE 24357
Course title: PROCESSING OF POLYMERS, COMPOSITE AND ADVANCED MATERIALS
Pre-requisite(s): INTRODUCTION TO MATERIALS ENGINEERING; FOUNDRY, FORMING & WELDING TECHNOLOGIES
Co- requisite(s): None
Credits: 4 L: 4 T:0
Class schedule per week: 4
Class: B. Tech
Semester / Level: VI / Third (for In-depth Specialization in Adv. Mfg. Prod. Mgmt.)
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand different types of polymer materials
2	Learn about the plastic processing methods for different applications
3	Know about ceramic materials based on its properties for different applications
4	Familiarise with the polymer composite processing methods for different applications
5	Know about the different types of advanced materials and their applications

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

CO1	Select appropriate polymeric materials based on its properties for different applications
CO2	Decide suitable plastic processing methods for different applications
CO3	Select appropriate ceramic materials based on its properties for different applications.
CO4	Choose suitable polymer composite processing methods for different applications
CO5	Identify the different types of advanced materials and their applications

SYLLABUS

Module 1: Introduction to polymer materials **[10]**
Structure of polymers, polymerization, polymer blends, additives in polymers, thermoplastics & thermosets: behavior and properties, thermoplastics & thermosets: general characteristics and applications

Module 2: Processing of plastics **[12]**
Extrusion, Injection Molding, Blow Molding, Thermoforming, Compression Molding, Transfer Molding, Casting, Cold Forming and Solid-Phase Forming
Module 3: **Introduction to composites** **[10]**
Definition of composites, Classification of composites, components in a composite material, General characteristics of reinforcement, properties of composite materials, Metal matrix composites, ceramic matrix composites, polymer matrix composites, processing composite materials

Module 4: Processing of polymer composites **[10]**
Processing of polymer composites, hand-layup, spray-layup, compression molding, Injection molding, reaction injection molding, autoclaving, resin transfer molding, filament winding, pultrusion.

Module 5: Advanced Materials **[8]**

Shape memory alloys, functionally graded materials, bulk metallic glasses, nano materials (introduction, properties at nano scales, advantages & disadvantages, applications in comparison with bulk materials (nano–structure, wires, tubes, composites).

Text books:

1. Serope Kalpakjian and Steven Schmidt, Manufacturing Processes for Engineering Materials, Pearson Education, 6th Edition (SI), 2018 **(T1)**
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Material. Processes, and systems, 2nd Edition, Wiley India, 2007 **(T2)**
3. D.H.Morton-Jones , Polymer processing, Chapmman &Hall, New York,1989 **(T3)**
4. Tadmor, Z and Gogos, C.G., Principles of Polymer Processing, John Wiley and Sons, 1982. **(T4)**

Reference books:

1. T. G. Gutowski, (Ed.) Advanced Composites Manufacturing, John Wiley & Sons, New York 1997. **(R1)**
2. K.K. Chawla, Ceramic Matrix Composites, Kluwer Academic Publishers, 2003. **(R2)**
3. N. Chawla, K.K. Chawla, Metal Matrix Composites, Springer-Verlag, 2006. **(R3)**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program-Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	2	2	1	0	0	0	0	0	1	3	2	3
CO2	3	2	2	2	1	0	0	0	0	0	1	3	2	3
CO3	3	2	2	2	1	0	0	0	0	0	1	3	2	3
CO4	3	2	2	2	1	0	0	0	0	0	1	3	2	3
CO5	3	2	2	2	1	0	0	0	0	0	1	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2 & CD6
CO2	CD1, CD2 & CD6
CO3	CD1, CD2 & CD6
CO4	CD1, CD2 & CD6
CO5	CD1, CD2 & CD6

COURSE INFORMATION SHEET

Course code: PE 24359
Course title: MANUFACTURING MANAGEMENT AND COST OPTIMISATION
Pre-requisite(s): PRODUCTION AND OPERATION MANAGEMENT
Co- requisite(s): None
Credits: 4 L:4 T: P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: VI / Third (for In-depth Specialization in Adv. Mfg. Prod. Mgmt.)
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Acquire productivity concepts
2	Know the role of production management system
3	Understand the concept of product design
4	Outline the basics of Value Engineering
5	Comprehend break-even and costs in decision making

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

CO1	Define productivity concepts, productivity measurement approaches of the organizations
CO2	Discuss the role of production management system
CO3	Explain the concept of product design
CO4	Apply value analysis and engineering in an organisation
CO5	Evaluate break-even and costs in decision making

SYLLABUS

Module 1: Productivity **[10]**
Concept, productivity improvement factors, productivity appraisal, productivity analysis in the enterprise- The Kurosawa structural approach, Lawlor's approach, Gold's approach, Quick Productivity Appraisal approach (QPA), Inter-Firm Comparison (IFC).

Module 2: Production Management Systems **[10]**
Capacity Requirement Planning (CRP), Aggregate Production Planning (APP), Master Production Schedule (MPS), MRP, MRP II, Lot sizing in MRP- Lot for lot, Economic order quantity, Periodic order quantity, Part period balancing.

Module 3: Product Design and Development **[10]**
Principles of good product design, tolerance design; quality and cost considerations; product life cycle; standardization, simplification, diversification, concurrent engineering; comparison of production alternatives.

Module 4: Value Engineering and Analysis **[10]**
Fundamental concepts, types of value, methodology, approaches and applications of value analysis and engineering, Function Analysis System Technique (FAST) diagram, case study.

Module 5: Cost Optimization **[10]**
Elements of cost, cost classification- material cost, labor costs, overheads cost, cost of a product, break-even analysis, costs in decision making, make or buy decisions.

Text books:

1. Prokopenko, J. "Productivity Management, A Practical Handbook", International Labour Organisation, 1992. **[T1]**
2. Browne, Hairnet &Shimane, "Production management – A CIM perspective", Addison Wesley publication Co., 1989. **[T2]**
3. Parker, D.E., "Value engineering theory", Sundaram publishers, 2000. **[T3]**
4. Montgomery, J.C and Levine, L. O., "The transition to agile manufacturing – Staying flexible for competitive advantage", ASQC Quality Press, Wisconsin, 1996. **[T4]**

Reference books:

1. Gopalakrishnan "Simplified Lean Manufacture – Elements, Rules, Tools and Implementation", PHI Learning Private Limited, New Delhi, India, 2010. **[R1]**
2. Devadasan, S.R., Sivakumar, V., Mohan Murugesh, R., Shalij, P, R. "Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities", Prentice Hall India, 2012. **[R2]**
3. Tutty Herald G, "Compendium on Value Engineering", Indo-American Society, 1983. **[R3]**
4. Panneerselvam, R. "Production and Operation management", PHI, 2005. **[R4]**
5. Orlicky, J; "Material Requirement Planning: the new way of life in production and inventory management", McGraw Hill, 1975. **[R5]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Nil

POs met through Gaps in the Syllabus:

Nil

Topics beyond syllabus/Advanced topics/Design:

Systems engineering

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1-5, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	√

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program-Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	2	1	0	2	0	2	1	2	1	2	2	3
CO2	3	3	3	2	1	2	0	1	1	1	1	3	3	3
CO3	3	3	3	3	0	1	0	0	1	2	1	3	3	3
CO4	3	3	3	3	2	2	0	0	0	2	1	3	3	3
CO5	2	2	1	0	0	0	0	0	0	0	0	2	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6, CD7
CO2	CD1, CD2, CD6, CD7
CO3	CD1, CD2, CD6, CD7
CO4	CD1, CD2, CD6, CD7
CO5	CD1, CD2, CD6, CD7

COURSE INFORMATION SHEET

Course code: PE 24419
Course title: FINITE ELEMENTS IN MANUFACTURING ENGINEERING APPLICATIONS
Pre-requisite(s): MATHEMATICS (Calculus, Differential Equations, Linear Algebra), STRENGTH OF MATERIALS, BASICS OF MANUFACTURING PROCESSES
Co- requisite(s): None
Credits: 4 L:3 T:1 P:0
Class schedule per week: 4
Class: B. Tech
Semester / Level: VII / Fourth (for In-depth Specialization in Adv. Mfg. Prod. Mgmt.)
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand the concept of finite element method (FEM)
2	Formulate and solve one-dimensional structural problems using FEM
3	Develop two-dimensional FE formulations for scalar and vector variable problems
4	Develop two-dimensional FE formulations for isoparametric elements
5	Apply the knowledge of FEM for simulation of manufacturing processes

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

CO1	Summarize the basics of finite element formulation
CO2	Apply finite element formulations to solve one-dimensional problems
CO3	Apply finite element formulations to solve two-dimensional scalar and vector problems
CO4	Apply finite element method to solve problems on isoparametric elements
CO5	Implement finite element method in manufacturing engineering

SYLLABUS

Module 1: Introduction **[10]**
Historical background, Relevance of FEM to engineering problems, Application to the continuum – Discretization, Matrix approach, Matrix algebra – Gaussian elimination, Governing equations for continuum, Classical Techniques in FEM, Weighted residual method, Ritz method, Galerkin method

Module 2: One-dimensional problems **[10]**
Finite element modeling – Coordinates and shape functions, Potential energy approach – Element matrices and vectors, Assembly for global equations, Boundary conditions, Higher order elements - Shapes functions, Applications to axial loadings of rods – Extension to plane trusses,
Bending of beams – Finite element formulation of stiffness matrix and load vectors, Assembly to Global equations, boundary conditions, Solutions and Post processing

Module 3: Two-dimensional problems – scalar and vector variable problems **[10]**
Two dimensional problems – scalar variable problems: Finite element modeling – CST element, Element equations, Load vectors and boundary conditions, Assembly, Application to heat transfer
Two dimensional problems – vector variable problems, Elasticity equations – Plane Stress, Plane Strain and Axisymmetric problems, Formulation, element matrices, Assembly, boundary conditions, and solutions

Module 4: Isoparametric elements for two dimensional problems **[8]**
Natural coordinates, Isoparametric elements, Four node quadrilateral element, Shape functions, Element stiffness matrix and force vector, Numerical integration, Stiffness integration, Displacement and Stress calculations

Module 5: Computer implementation and application in manufacturing **[12]**
Computer implementation - Pre-processor, Processor, Post-processor. Discussion about finite element packages.

Application of FEM in metal casting, cutting, metal forming and welding, moulds and dies.

Text books:

1. K-J. Bathe, Finite Element Procedures, Prentice Hall. **[T1]**
2. J.N. Reddy, An Introduction to the Finite Element Method, McGraw-Hill. **[T2]**
3. R.D. Cook, D.S. Malkus and M.E. Plesha, Concepts and Applications of Finite Element Analysis, Prentice Hall-India, New Delhi. **[T3]**
4. T.R. Chandrupatla and A.D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall of India. **[T4]**

Reference books:

1. C.S. Krishnamoorthy, Finite Element Analysis, TMH. **[R1]**
2. O.C. Zienkiewicz, R.L. Taylor, J.Z. Zhu, The Finite Element Method: Its Basis and Fundamentals, Elsevier. **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Three-dimensional FE formulation

POs met through Gaps in the Syllabus:

PO 1-5

Topics beyond syllabus/Advanced topics/Design:

Use of commercial finite element software for manufacturing engineering process modelling and analyses

POs met through Topics beyond syllabus/Advanced topics/Design:

PO 1-5, 11-12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	√

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	2	1	0	0	0	0	0	2	2	2	2
CO2	3	3	3	3	1	0	0	0	0	0	2	2	3	3
CO3	3	3	3	3	1	0	0	0	0	0	2	2	3	3
CO4	3	3	3	3	1	0	0	0	0	0	2	2	3	3
CO5	3	3	3	3	1	0	0	0	0	0	3	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6, CD7
CO2	CD1, CD2, CD6, CD7
CO3	CD1, CD2, CD6, CD7
CO4	CD1, CD2, CD6, CD7
CO5	CD1, CD2, CD6, CD7

COURSE INFORMATION SHEET

Course code: PE 24421
Course title: MICRO AND NANO MANUFACTURING
Pre-requisite(s): INTRODUCTION TO MATERIALS ENGINEERING; FOUNDRY, FORMING & WELDING TECHNOLOGIES, MACHINING SCIENCE AND MACHINE TOOLS
Co- requisite(s): None
Credits: 4 L:4 T:0 P:0
Class schedule per week: 4
Class: B. Tech
Semester / Level: VII / Fourth (for In-depth Specialization in Adv. Mfg. Prod. Mgmt.)
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students to:

1	Understand the mechanical micro machining process.
2	Illustrate the Thermal micro machining process.
3	Learn the Nano Polishing and Nano technology Concepts.
4	Comprehend the concepts of micro forming and welding.
5	Be acquainted with Micro and Nano manufacturing process.

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

CO1	Classify the basic micro machining processes
CO2	Compare the various thermal energy based micro machining processes
CO3	Describe the Nano technology concepts and application.
CO4	Discuss the process of Micro-fabrication, forming and micro welding.
CO5	Distinguish the recent trends and applications of micro machining

SYLLABUS

Module 1: Introduction **[10]**
Introduction of micro machining process; Fundamental principles, application possibilities, process parameters, and operational characteristics of Mechanical Micro machining: micro turning, micro milling, and micro drilling; Ultrasonic, Abrasive Jet, Water Jet and Abrasive Water Jet micro machining; Chemical and Electro Chemical Micro Machining.

Module 2: Thermal micro machining **[10]**
Fundamental principles, application possibilities, process parameters, and operational characteristics of Beam Energy based micro machining: Electron beam, Laser beam, Focused ion Beam; Electric Discharge, and Plasma Beam Micro Machining. Hybrid Micro machining processes include Electro Chemical Spark Micro Machining (ECSMM), Electrochemical Micro Deburring (EMD).

Module 3: Nano finishing **[10]**
Fundamental principles, application possibilities, process parameters, and operational characteristics of Nano Polishing using Abrasive Flow finishing, Magnetic Abrasive Finishing, Magneto Rheological abrasive flow finishing, Magnetic Float polishing, Elastic Emission Machining, chemo-mechanical Polishing.

Module 4: Micro forming and welding **[8]**

Fundamental principles, application possibilities, process parameters, and operational characteristics of Micro Forming; Micro and Nano structured surface development by Nano plastic forming and roller imprinting. LASER micro welding, Electron beam micro welding.

Module 5: Metrology and applications of micro and nano machining **[12]**

Metrology for micro machined components: Scanning Electron Microscopy, optical microscopy, atomic force microscope, molecular measuring machine, micro-CMM; Ductile regime machining, Acoustic emission-based tool wear compensation, Machining of Micro gear, micro nozzle, micro pins and their Applications.

Text books:

1. Jain V.K., Introduction to Micro machining, Narosa Publishing House. **[T1]**
2. Jain V. K., Micro Manufacturing Processes, CRC Press, Taylor & Francis Group. **[T2]**
3. Norio Taniguchi, Nano Technology, Oxford University Press, New York. **[T3]**

Reference books:

1. Bharat Bhushan, Handbook of nanotechnology, springer, Germany. **[R1]**
2. Jain V.K., Advanced Machining Processes, Allied Publishers, Delhi. **[R2]**
3. Mcgeoug.J.A., Micromachining of Engineering Materials, CRC press. **[R3]**

Gaps in the syllabus (to meet Industry/Profession requirements):

Diamond turning.

POs met through Gaps in the Syllabus:

POs 1,5,6

Topics beyond syllabus/Advanced topics/Design:

Nanoimprint Lithography for Nanomanufacturing

POs met through Topics beyond syllabus/Advanced topics/Design:

POs 1,2,5,9

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	2	1	2	1	0	0	0	0	0	1	3	2	2
CO2	3	2	1	2	1	0	0	0	0	0	1	3	2	2
CO3	3	2	1	2	1	0	0	0	0	0	1	3	2	2
CO4	3	2	1	2	1	0	0	0	0	0	1	3	2	2
CO5	3	2	1	2	1	0	0	0	0	0	1	3	2	2

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

MINOR in "Production and Industrial Engineering"

Syllabus (UG Program)

<u>(OFFERED ONLY TO THE STUDENTS OF OTHER DEPARTMENTS)</u>

Students who have registered for B. Tech Minor in "Production and Industrial Engineering" should complete 16 credits and shall opt for courses listed in Course Structure for the Minor Program. The credits shall be over and above minimum requirement for degree award.

COURSE INFORMATION SHEET

Course code: PE 24223
Course title: OPERATION RESEARCH AND QUANTITATIVE TECHNIQUES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 4 L:4 T:0 P: 0
Class schedule per week: 4
Class: B. Tech
Semester / Level: V / Second (for MINOR in "Production and Industrial Engineering")
Branch: All
Name of Teacher:

Course Objectives
This course enables the students to:

1	Apply the techniques of operations research in industrial engineering problems.
2	Formulate a real-world industrial problem as a mathematical programming model
3	Understand the simplex method for linear programming and perform iterations of it by hand
4	Solve specialized linear programming problems like the transportation and assignment problems
5	Operations research helps in solving problems in different environments that needs decisions, such as sequencing, queuing and games theory .

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

CO1	Understand how to translate a real-world problem, given in words, into a mathematical formulation.
CO2	Formulate and solve engineering and managerial situations as LPP.
CO3	Formulate and solve engineering and managerial situations as transportation and assignment problems
CO4	Apply Sequencing, Game theory and Queuing theory for performance evaluation of engineering and management system.
CO5	Conduct descriptive data analysis including various measures of central tendency and dispersion. Also Plan and design proper statistical survey mechanism

SYLLABUS

Module 1 Introduction & Linear Programming: [12]
Importance of Operation Research, Methodology, Characteristics, Scope, Application and Limitation of Operations Research
Requirement of LP, Basic Assumptions, Mathematical formulation of LP, Graphical solution; numerical problems based on these methods. Analytical Methods Simplex method, Big-M method

Module 2 Transportation and Assignment Model [8]
Basic feasible solution by different methods (North-west corner method, least cost method, Vogel's approximation method), finding optimal solutions (MODI method), unbalanced transportation problems; numerical problems based on these methods (preferably industrial engineering-based problems)
Balanced and unbalanced assignments, travelling salesman Problem; numerical problems based on these methods (preferably industrial engineering-based problems)

Module 3 Sequencing and Queuing Model [10]
Processing of ***n*** jobs through two machines, processing ***n*** jobs through three machines; Processing of 2 jobs through ***m*** machines –graphical method, numerical problems based on these methods
Basis of Queuing theory, elements of queuing theory, Kendall's Notation, Operating characteristics of a queuing system, Classification of Queuing models, Queuing system and their characteristics of M/M/1/FIFO/ Queuing system

Module 4: Games Theory **[8]**
Introduction, Characteristics of Game Theory, Two Person, Zero sum games, Pure strategy. Dominance theory, Mixed strategies (2x2, mx2), Algebraic and sub games methods.

Module 5: Basics of Quantitative Analysis **[12]**
Classification and Scope of Quantitative Techniques, Nature and Classification of data, Primary and Secondary data, univariate, bivariate, and multivariate data, time-series and cross-sectional data, Measures of central tendency and dispersion, Quartile deviation, Inter-quartile range, Percentiles.
Planning and design of surveys, Business Data Sources: Primary and Secondary Data, Methods of collecting Primary data, Drafting a questionnaire, Collection of secondary data, Census method and Sampling, sampling theory, Sampling Methods, Managing Total Survey Error

Text books:
1. Operations Research, (Revised Edition), D.S. Hira, P.K. Gupta, S. Chand & Company Ltd, 2014 [**T1]**
2. Quantitative Techniques Vol I and Vol II, L. C. Jhamb, Everest Publishing House **[T2]**
3. Operations Research, - Kanti Swarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons **[T3]**
4. Ken Black, Business Statistics for Contemporary Decision Making, 5th Edition, Wiley Publications (India Edition) **(T4)**
5. Levin and Rubin, Statistics for Management, Prentice Hall of India, New Delhi. **(T5)**
6. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill, New Delhi. **(T6)**

Reference books:
1. Operations Research an Introduction –Hamady A. Taha, Prentice Hall. **[R1]**
2. Introduction to Operations Research, 9e, Frederick S. Hillier, Gerald J. Lieberman, Bodhibrata Nag and Preetam Basu, McGraw Hill **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):
Revised Simplex, Integer programming, other queuing models, Decision theory, Goal programming, Dynamic programming, Non-linear programming and Simulation. These topics are to be covered in a advanced course.

POs met through Gaps in the Syllabus:
POs 1-3, 12

Topics beyond syllabus/Advanced topics/Design:
Advanced Operation Research

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1, 3, 5, 7, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher’s Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher’s Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	1	0	1	1		0	1	3	3	3	3
CO2	3	3	3	1	0	1	1	2	0	2	2	3	2	3
CO3	3	3	2	0	0	1	0	2	0	1	3	3	2	3
CO4	3	2	1	0	0	1	1	2	0	2	2	3	3	3
CO5	3	2	1	0	0	1	0	2	0	2	2	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24225
Course title: MANUFACTURING SCIENCE AND TECHNOLOGIES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 4 L:4 T: P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: V / Second (for MINOR in "Production and Industrial Engineering")
Branch: All [except Mechanical Engineering]
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the gating system design, riser design and product design for casting
2	Understand the mechanisms of different bulk forming and sheet metal forming techniques
3	Understand the mechanics of orthogonal and oblique cutting including process mechanics of different machining processes
4	Understand the principles of fusion welding, solid state welding and solid-liquid state welding
5	Learn about the mechanism of material removal, process parameters and applications of different modern machining processes

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

CO1	Design a suitable sand casting process for given component. Also select appropriate casting for a given component
CO2	Derive the mathematical relationship between the cutting forces and understand the mechanics of metal cutting.
CO3	Select appropriate machine tool for a particular machining process
CO4	Select appropriate welding process for a given joint
CO5	Select appropriate forming process for a given product

SYLLABUS

Module 1: Casting Processes **[10]**

Introduction to foundry process and its importance; Sand casting: patterns, pattern allowances, moulding sand, gating system design and riser design. Other casting processes: centrifugal casting, hot chamber and cold chamber die casting, investment casting; Casting defects and their remedies

Module 2: Theory of Metal Cutting **[10]**

Geometry of single point cutting tool; Introduction to orthogonal cutting; Tool forces in orthogonal cutting; Types of chips; Tool failure and tool life, Machinability, Cutting tool materials

Module 3: **Machine Tools** **[10]**

Construction, operations and specifications of lathe and shaper; Construction, operations and specifications of milling & drilling machine; Introduction to grinding and types of grinding processes.

Module 4: Welding Processes **[10]**

Principle, working and application of oxy-acetylene gas welding; Electric arc welding: Power source, electrode coating, MMAW/SMAW, SAW, GTAW and GMAW, Resistance welding; Soldering and Brazing

Module 5: Metal Deformation Processes **[10]**

Metal forming processes: Introduction to recovery, recrystallization, and grain growth; Hot working and cold working.
Rolling: Classification of rolling processes, types of rolling mills, products of rolling.
Forging: Open and closed die forging.
Extrusion: Classification of extrusion processes, hot and cold extrusion processes
Sheet metal forming operations: Blanking and piercing, deep drawing, bending.

Text books:

1. Serope Kalpakjian and Steven Schmidt, Manufacturing Processes for Engineering Materials, Pearson Education, 6th Edition
2. Mikell P. Groover, Fundamentals of Modern Manufacturing: Material. Processes, and systems, 2nd Edition, Wiley India, 2007
3. P.N. Rao, Manufacturing Technology – Metal Cutting and Machine Tools, McGraw Hill.
4. P.N. Rao, Manufacturing Technology, Foundry, Forming and Welding, McGraw Hill
5. Hajra Choudhury, Elements of Workshop Technology–Vol.-II, Media Promoters and Publishers

Reference books:

1. T. Childs, K. Maekawa, T. Obikawa, Y. Yamane, Metal Machining: Theory and Applications, Arnold.**[R1]**
2. P.K. Mishra, Nonconventional Machining, Narosa Publishing House Pvt. Ltd.**[R2]**

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>

<u>POs met through Gaps in the Syllabus:</u>

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Process modelling of casting, forming, machining and joining. Advanced studies on non-conventional machining and additive manufacturing.

<u>POs met through Topics beyond syllabus/Advanced topics/Design:</u>
POs 1-5, 12

<u>Course Delivery Methods:</u>

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

<u>Course Evaluation:</u>

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Quiz	10				
Mid Sem Exam	25				
Assignment	10				
Teacher’s Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher’s Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program-Specific Outcomes (PSOs):

COs	POs										PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	3	1	0	0	0	1	0	3	3	3	3
CO2	3	3	3	2	1	0	0	0	1	0	3	3	3	3
CO3	3	3	3	3	1	0	0	0	0	0	3	3	2	3
CO4	3	3	3	2	1	0	0	0	0	0	3	3	2	3
CO5	3	3	3	3	1	0	0	0	0	0	3	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24327
Course title: MODERN MANUFACTURING PROCESSES
Pre-requisite(s): MANUFACTURING PROCESSES
Co- requisite(s):
Credits: 4 L:4 T: P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: V / Third (for MINOR in "Production and Industrial Engineering")
Branch: Mechanical Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the basic construction of the different non-conventional machines, and about the tools, equipment and consumable required
2	Understand the effects of different process parameters on part quality, and how the parameters are to be controlled
3	Learn about the fundamental principles, process parameters and application possibilities of different advanced welding processes
4	Understand importance of additive manufacturing in advance manufacturing process
5	Acquire knowledge, techniques and skills to select relevant additive manufacturing process.

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

CO1	Explain the fundamental principles, techniques, equipment, applications, advantages and limitations of different non-conventional machining processes.
CO2	Find solutions for meeting demand of machining hard-to-machine materials, producing complex shape and size with greater product accuracy and surface finish
CO3	Compare the fundamental principles, equipment, parameters and applications of different advanced welding processes
CO4	Analyse and select suitable process and materials used in Additive Manufacturing
CO5	Identify, analyse and solve problems related to Additive Manufacturing

SYLLABUS

Module 1: Non-conventional machining processes - I **[10]**
Non-conventional Machining Processes: Need and Classification; Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Abrasive Jet Machining (AJM), Water Jet Machining (WJM), Abrasive Water Jet Machining (AWJM), Ultrasonic Machining (USM), and Electrochemical Machining (ECM)

Module 2: Non-conventional machining processes - II **[10]**
Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Electro Discharge Machining (EDM) and Wire Electro Discharge Machining (WEDM), Laser Beam Machining (LBM), Electron Beam Machining (EBM), and Plasma Arc Machining (PAM)

Module 3: Advanced welding processes **[12]**
Fundamental principles, process parameters, machines and equipment, and application possibilities of cold welding, diffusion welding, forge welding, friction and inertia welding, explosive welding, and ultrasonic welding; Fundamental principles, process parameters, machines and equipment, and application possibilities of electron beam welding and laser beam welding; Laser arc hybrid welding

Module 4: Additive manufacturing processes – I **[8]**

Overview, fundamental principle, need and advantages of additive manufacturing; Procedure of product development in additive manufacturing; Classification of additive manufacturing processes; Materials used in additive manufacturing; Challenges in Additive Manufacturing

Module 5: Additive manufacturing processes – II **[10]**

Additive manufacturing processes: Z-Corp. 3D printing, Stereo-lithography apparatus (SLA), Fused deposition modeling (FDM), Laminated object manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).

Text books:

1. P. C. Pandey and H. S. Shan, Modern Machining Processes, Tata McGraw-Hill **[T1]**
2. P. K. Mishra, Non-conventional Machining, Narosa Publishing House **[T2]**
3. H.B. Cary and S.C. Helzer, Modern Welding Technology, Pearson/Prentice Hall. **[T3]**
4. Gibson, I, Rosen, D W., and Stucker,B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer **[T4]**

Reference books:

1. Ghosh and A.K. Mallik, Manufacturing Science, Affiliated East- West Press **[R1]**
2. M P. Groover, Fundamentals of Modern Manufacturing, John Wiley & Sons, Inc. **[R2]**
3. R.S. Parmar, Welding Process and Technology, Khanna Publishers **[R3]**
4. C. K. Chua, K. F. Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers **[R4]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	2	0	0	0	0	0	0	3	3	2	3
CO2	3	3	3	2	0	0	0	0	0	0	3	3	2	3
CO3	3	3	3	2	0	0	0	0	0	0	3	3	2	3
CO4	3	3	3	2	0	0	0	0	0	0	3	3	2	3
CO5	3	3	3	2	0	0	0	0	0	0	3	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 24361
Course title: MECHANICAL MEASUREMENT & QUALITY CONTROL
Pre-requisite(s): None
Co- requisite(s): None
Credits: 4 L:4 T: P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: VI/ Third (for MINOR in "Production and Industrial Engineering")
Branch: All
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Understand and analyse different measurement systems, Standards of Measurement, Measurement Errors
2	Know about Limits, Fits, tolerance and gauges used in measurement and designing aspects for those
3	Understand the philosophy of quality improvement and use of statistics in quality control.
4	Understand and use various control charts for attributes and variables.
5	Learn the concept of process capability analysis.
6	Understand the concept of acceptance sampling, OC curves and preparation of acceptance sampling plans for attributes.

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

CO1.	Distinguish between accuracy and precision, identify different measurement errors, able to select linear or angular measuring instrument for measurement of various components
CO2.	Design limit gauges used for various components and purposes
CO3.	Understand the philosophy of quality improvement, basic concept of statistical quality control, TQM and six sigma.
CO4.	Demonstrate the ability to design, use, and interpret control charts and perform analysis of process capability.
CO5	Prepare and analyse sampling plans for attributes

SYLLABUS

Module – I: Introduction to metrology **[10]**
Historical development, Basics of Metrology, Need for Inspection, Accuracy and Precision, Standards of measurements, system of measurement, line, end & wavelength standards, type and source of measurement errors.
Linear metrology: Steel rule, callipers, Vernier calliper, Vernier height gauge, Vernier depth gauge, micrometres, universal calliper. Miscellaneous measurements: Taper measurement, angle measurement, radius measurement, sine bar & Angle gauges.

Module – 2: Limits, fits and gauges **[10]**
Interchangeable manufacture, selective assembly, concept of limits, fits and tolerances, Types of fit, Basic-Hole System, Basic-Shaft System, Problems, Tolerance grades, Metric fits, Indian standard system, Types of gauges-plain plug gauge, ring gauge, snap gauge, limit gauge and gauge materials, Considerations of gauge design, Taylor's principle of gauging, Wear allowance on gauges

Module 3: Introduction to quality control **[10]**
Introduction to Quality Control, Cost of Quality, Quality Circle, Concept of TQM and Six Sigma.
Statistical Quality Control, Graphical and Analytical Methods for Central Tendency and Dispersion.

Module 4: Control charts for variables and attributes **[10]**
General Theory of Control Charts, Theory and Application of Control Charts for Averages, Range, Standard Deviation, Fraction Defective and Number of Defects, Process Capability Study, Interpretation of Control Chart

Module 5: Acceptance sampling plans **[10]**
Elementary Concepts of Acceptance Sampling by Attributes, Concept and Characteristics of O.C. Curves, Single, Double and Multiple Sampling Plans, Construction and Use of O.C. Curves for Sampling Plans, MIL – STD Plans, Sequential Sampling Plan.

Text Books:
1. Introduction to Statistical Quality Control, Douglas C. Montgomery, Wiley [T1]
2. Fundamentals of quality control and improvement, A Mitra, Wiley [T2]
3. Total Quality Management, D.H. Besterfield, Prentice HallStatistical, [T3]
4. Quality control, M. Mahajan, Dhanpat Rai & Sons, [T4]
5. R.K. Jain, Engineering Metrology Khanna Publications, New Delhi (T5)
6. I. C. Gupta, A Text book of Engineering Metrology, Dhanpat Rai, New Delhi **(T6)**

Reference books:
1. Manufacturing Excellence in Global Markets, W. Euershelm [R1]
2. Manufacturing Systems Design & Analysis, B. Wa. [R2]
3. Computer Automation in Manufacturing, T.O.Boucher [R3]
4. Intelligent Manufacturing Planning, P. Gu. [R4]
5. K. J. Hume, Engineering Metrology **(R5)**

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>
Sampling plan for variables

<u>POs met through Gaps in the Syllabus:</u>

<u>Topics beyond syllabus/Advanced topics/Design:</u>

<u>POs met through Topics beyond syllabus/Advanced topics/Design:</u>

<u>Course Delivery Methods:</u>

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

<u>Course Evaluation:</u>

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher’s Assessment	05

End Semester Examination	% Distribution			
End Semester Examination	50			
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs										PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	0	1	0	0	0	0	1	3	1	3	2
CO2	3	2	1	0	2	0	0	0	0	1	2	1	3	3
CO3	3	3	3	0	2	0	1	0	0	1	3	2	2	2
CO4	3	2	1	0	0	0	1	1	0	1	2	1	3	3
CO5	3	2	1	0	0	0	0	0	0	1	2	1	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24209
Course title: PRODUCTION AND OPERATIONS MANAGEMENT
Pre-requisite(s): None
Co- requisite(s): None
Credits: 4 L:4 T: P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: VII / Third (for MINOR in "Production and Industrial Engineering")
Branch: All
Name of Teacher:

Course Objectives:
This course enables the students:

1	To introduce to various inherent concepts of production systems, planning and control systems of Manufacturing Industry.
2	To introduce of forecasting models, Product mix and aggregate planning.
3	To make routine process, scheduling process and identify different strategies employed in manufacturing industries to production planning.
4	To give basic concept of inventory control and its technique, EOQ, ABC analysis.
5	To know Facility design process and its all component.

Course Outcomes:
After the completion of this course, students will:

CO1	Able to understand the functions of production system its planning and control.
CO2	Able to make demand forecasts in the manufacturing sectors using selected quantitative and qualitative techniques.
CO3	Able to explain the importance and function of pre-planning and post-planning of the production system.
CO4	Able to solve inventory problems and to be able to apply selected techniques for its control and management under dependent and independent circumstances.
CO5	Understand plant layout, building layout and location theory.

SYLLABUS

Module 1: Introduction to production and operation management **[8]**
Difference between manufacturing and service operations, Objectives and functions of production and operation management, historical evolution of production and operations management. type of Production systems and their characteristics, selection of a production system, concept of productivity.

Module 2: Preplanning **[10]**
Demand forecasting, common techniques of demand forecasting, Capacity management, aggregate planning and master scheduling.

Module 3: Production Planning **[10]**
Routing, loading and scheduling with their different techniques, dispatching, Progress Report, Expediting and corrective measures.

Module 4: Inventory Control **[10]**
Field and scope of inventory control, inventory types and classification, Inventory control models, static model, dynamic model both deterministic and stochastic, Economic lot size, reorder point and their application, ABC analysis, VED analysis, modern practices in purchasing and store Management.

Module 5: Facility design **[12]**
Facility design problems and their analysis.

Facility location- Need of location, Factors affecting the location and site selection, multi-plant location, location theories and models.
Facility layout- Objectives, principles and classification of layouts; Factors affecting plant layout; models of product layout, process layout and service layout.

Text books:

1. Production & Operations management, Jay Heizer and Barry Render, Prentice Hall **[T1]**
2. William J. Stevenson, Operations Management, McGraw-Hill, 13th edition **[T2]**
3. S. N. Chary, Production and operations management, Tata McGraw-Hill Education, 5th Edition **[T3].**
4. P K Gupta, D.S Hira, Operations Research, S chand 7th edition **[T4]**

Reference books:

1. R. Panneerselvam, Production and operations management, PHI Learning Pvt. Ltd **[R1]**
2. Richard B. Chase, Nicholas J. Aquilano, Production & Operations Management: Manufacturing and Services, Publisher: Richard D Irwin; 7th edition **[R2]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Logistics and supply chain management, Inventory model design

POs met through Topics beyond syllabus/Advanced topics/Design:
POs 1 -4, 9, 11, 12

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	√
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10
Mid Sem Exam	25
Assignment	10
Teacher's Assessment	05
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program Specific Outcomes (PSOs):

COs	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	3	3	3	2	2	1	0	1	2	3	3	3	2	3
CO2	3	3	1	2	2	1	0	1	2	3	2	3	2	3
CO3	3	3	3	2	2	1	0	1	2	2	3	3	2	3
CO4	3	3	1	2	2	1	0	1	2	2	2	3	2	3
CO5	3	3	1	3	2	1	0	1	2	2	2	3	2	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3, CD6
CO2	CD1, CD2, CD3, CD6
CO3	CD1, CD2, CD3, CD6
CO4	CD1, CD2, CD3, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 24423
Course title: LOGISTICS AND SUPPLY CHAIN MANAGEMENT
Pre-requisite(s): None
Co- requisite(s): None
Credits: 4 L: 4 T: P:
Class schedule per week: 4
Class: B. Tech
Semester / Level: VII/Fourth (for MINOR in "Production and Industrial Engineering")
Branch: All
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Provide an insight on the fundamentals of supply chain strategy
2	Know the various distribution and transportation networks and their applications
3	Acquire the concepts of logistics in improving the supply chain and other functional areas of an organization
4	Understand the role of sourcing, information technology, and coordination in a supply chain
5	Know the recent trends in supply chain management

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

CO1	Define the goal of a supply chain and analyse the impact of supply chain decisions on the success of a firm
CO2	Develop a framework for making supply chain network design decisions
CO3	Apply logistics concepts to improve supply chain operations.
CO4	Evaluate and select the best supplier for a firm or organisation
CO5	Discuss the recent trends in supply chain management

SYLLABUS

Module 1: Introduction to Supply Chain Management **[10]**
Understanding the supply chain, Supply Chain Performance- Achieving strategic fit and scope, key issues, Supply chain modelling, Supply Chain Drivers and Metrics, Centralized vs. decentralized systems, Digital Supply Chain Transformation

Module 2: Designing the Supply Chain Network **[10]**
Distribution Networks– Design options for a distribution network, e-Business and the distribution network, Network design in an uncertain environment. Transportation Networks- Design options for a transportation network, Trade-offs in transportation design, Vehicle routing and scheduling, Supply Chain Optimization, Manufacturing Systems and Supply Chain Design, Supply chain risk pooling: centralization, postponement, Omni channel

Module 3: **Logistics Management** **[10]**
Logistics Management: Logistical operation, integration, network design, logistical performance cycle, customer service global logistics, logistical resources, logistics planning, Third- and fourth-party logistics providers, Measuring logistics costs and performance, e-logistics, Reverse logistics.

Module 4: Managing Cross-Functional Drivers in a Supply Chain [10]

Sourcing Decisions- Make or buy decisions, Sourcing Processes. Information Technology in a Supply Chain, Supply chain 4.0, Coordination in a Supply Chain-Bullwhip effect, Data Analysis for Supply Chain Management, Supply chain strategy: achieving strategic fit, dual sourcing; network design

Module 5: Recent Trends in Supply Chain Management [10]

Lean Supply Management, Agile Supply Management, Green and Sustainable Practices of Supply Chain, Supply Chain Digitization, Circular Supply Chains, Global supply chain: buy-sell, turnkey, transfer price, Supply chain cases.

Text Book

1. Chopra, S., and Meindl, P. "Supply Chain Management, strategy, planning, and operation" 6/e – PHI, second edition, 2014. **[T1]**
2. Christopher, M., "Logistics and Supply Chain Management", Pearson Education Asia, New Delhi. **[T2]**

Reference Book

1. Taylor and Brunt, "Manufacturing Operations and Supply Chain Management (The Lean Approach)", Business Press Thomson Learning, NY. **[R1]**
2. Arjan J. Van Weele, "Purchasing and Supply Chain Management (Analysis Planning and Practice)", Engineering, Business Press, Thomson Learning NY. **[R2]**
3. Shah, J. "Supply Chain Management, text and cases", Pearson Education South Asia,2009. **[R3]**
4. Balkan Cetinkaya, Richard Cuthbertson, Graham Ewer, "Sustainable Supply Chain Management: Practical ideas for moving towards best practice", Springer, 2011. **[R4]**
5. Sople, V.V "Supply Chain Management, text and cases", Pearson Education South Asia, 2012. **[R5]**
6. Donald B., "Logistic Management - The Integrated Supply Chain process", McGraw Hill. **[R6]**

Gaps in the syllabus (to meet Industry/Profession requirements):

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Mathematical Modelling of Supply Chain

Application of meta-heuristics for supply chain optimization

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods:

CD1	Lecture by use of boards/LCD projectors/OHP projectors	√
CD2	Assignments/Seminars	√
CD3	Laboratory experiments/teaching aids	
CD4	Industrial/guest lectures	
CD5	Industrial visits/in-plant training	
CD6	Self- learning such as use of NPTEL materials and internets	√
CD7	Simulation	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution
Quiz	10

Mid Sem Exam	25				
Assignment	10				
Teacher's Assessment	05				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz	√	√			
Assignment	√	√	√	√	√
Teacher's Assessment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Course Outcome

<u>Mapping of Course Outcomes (COs) onto Program Outcomes (POs) and Program-Specific Outcomes (PSOs):</u>

COs	**POs**										**PSOs**		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CO1	2	2	2	2	3	3	2	2	2	2	2	3	3	3
CO2	2	2	2	2	3	3	2	2	2	3	3	3	3	3
CO3	2	3	3	3	3	3	2	2	2	3	3	3	3	3
CO4	2	3	3	3	3	3	2	2	2	3	3	3	3	3
CO5	3	3	3	3	3	2	2	2	2	2	2	3	3	3

Grading: No correlation – 0, Low correlation - 1, Moderate correlation – 2, High Correlation - 3

<u>Mapping Between Course Outcomes (COs) and Course Delivery Method</u>

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

Vocational Courses

The department, in collaboration with the allied departments, offers two skill-based vocational courses at the end of the first year (Level 1) and two more at the end of the second year (Level 2). Each course is worth 3 credits and is mandatory for students who plan to exit after the first or second year. However, these courses are optional and non-credit for other students.

COURSE INFORMATION SHEET

Course code: PE 24190
Course title: WELDING TECHNOLOGY
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:1 T: P: 4
Class schedule per week: 5
Class: Certificate in Engineering
Level: First
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the fundamental principles, process parameters, and application possibilities of arc and gas welding processes.
2	Learn about the fundamental principles, process parameters, and application possibilities of GMAW and GTAW processes.
3	Understand welding principles, equipment setup, parameters, and SAW practice.
4	Understand welding principles, equipment setup, parameters, and practice spot welding.
5	Learn about Friction stir welding principles, equipment setup, and parameters.

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

CO1	Understand welding terminology, principles, positions, joint preparation for gas/arc welding techniques, and identify their advantages, limitations, and applications.
CO2	Compare GMAW/GTAW principles, setup, techniques, advantages, limitations, and applications.
CO3	Explain the SAW principles, setup, parameters, and identify advantages, limitations, and applications.
CO4	Understand the spot-welding principles, setup, parameters, skills, advantages, limitations, applications.
CO5	Perform the FSW welding and identify its advantages, limitations, and application possibilities.

SYLLABUS

MODULE
Module – I **Introduction to Welding:** Classification of welding processes, terminology, general principles, welding positions, joint types, and edge preparation. Overview and hands-on practice with gas welding techniques and equipment. Overview and hands-on practice with arc welding techniques and equipment.
Module – II **Gas Metal Arc Welding (GMAW) and Gas Tungsten Arc Welding (GTAW):** Principles and Process Characteristics: Understanding welding principles, process characteristics, and equipment setup and operation. Exploring welding parameters and their effects on weld quality. Practical sessions on Gas Metal Arc Welding (GMAW) and Gas Tungsten Arc Welding (GTAW).
Module – III **Submerged arc welding (SAW):** Principles and process characteristics, Equipment setup and operation, Welding parameters and their effects. Hands-on practice on SAW.
Module – IV **Spot welding :** Principles and process characteristics, Equipment setup and operation, Welding parameters and their effects. Hands-on practice on Spot welding.
Module – V **Friction stir welding:** Principles and process characteristics, Equipment setup and operation, Welding parameters and their effects. Setup and operation of FSW equipment and hands-on practice on welding of non-ferrous materials.

BOOKS:

1. A text book of Welding Technology by O. P. Khanna. Dhanpat Rai Publication.
2. Foundation of Welding Technology by K. S. Ghosh. PHI Publication.
3. Welding Technology and Design by V.M. Radahrishnan and M. Kamaraj. New Age International Pub.

COURSE INFORMATION SHEET

Course code: ME 24104
Course title: WORKING WITH AUTOCAD
Pre-requisite(s): ENGINEERING GRAPHICS
Co- requisite(s): None
Credits: 3 L:1 T: P: 4
Class schedule per week: 5
Class: Certificate in Engineering
Level: First
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Familiarization with basic commands of AutoCAD
2	Utilization of various tools of AutoCAD to draw various engineering drawings.

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

CO1	Be conversant with the basic AutoCAD commands.
CO2	Explain the basic utilities available in AutoCAD.
CO3	Apply the basic AutoCAD commands to draw various figures related to Engineering and Technology.
CO4	Develop skills to work as an individual or in a team during Lab Exercises.

SYLLABUS

<table>
<tr><th>MODULE</th><th>(NO. OF LECTURE HOURS)</th></tr>
<tr><td>Module – I
Draw the following figures with the help of AutoCAD commands studied Units, limits, grid, line, spline, donut, polygon, circle, rectangle, chamfer, fillet, offset, move, scale, text, Dimensioning.</td><td></td></tr>
<tr><td>Module – II
Draw the following figures with the help of AutoCAD commands studied.

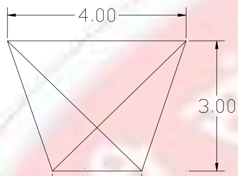


Fig 2.1

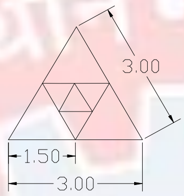


Fig 2.2

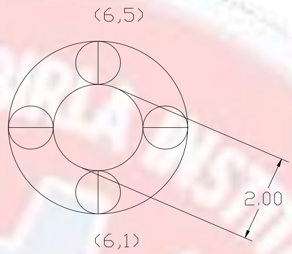


Fig 2.3

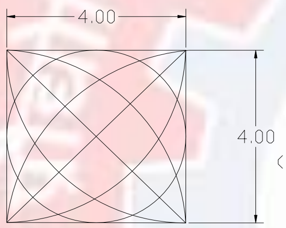


Fig 2.4

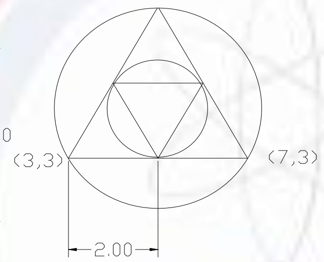


Fig 2.5

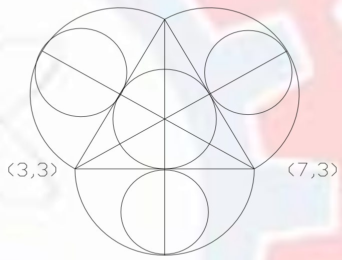


Fig 2.5
</td><td></td></tr>
<tr><td>Module – III
Draw the following figures with the help of AutoCAD commands studied.

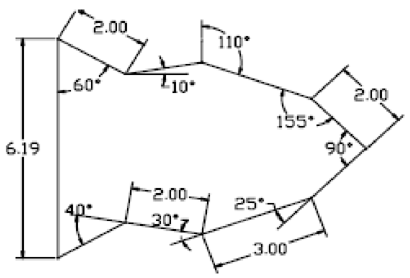


FIG:- 3.1

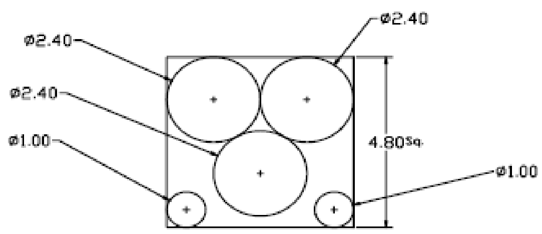


Fig:- 3.2

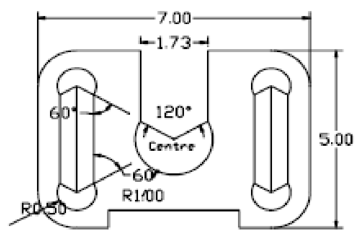


FIG : 3.3

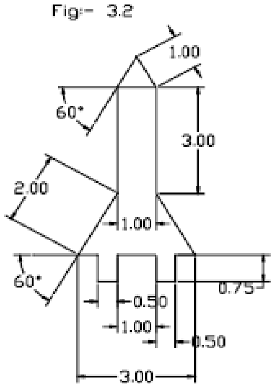


FIG:- 3.4
</td><td></td></tr>
</table>

Module – IV
Draw the following figures with the help of AutoCAD commands studied.

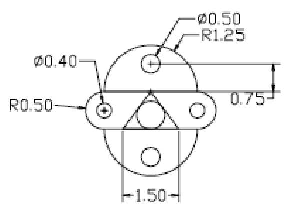


Fig :- 4.1

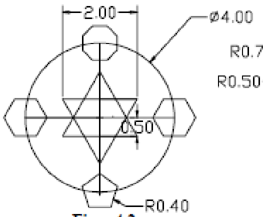


Fig :- 4.2

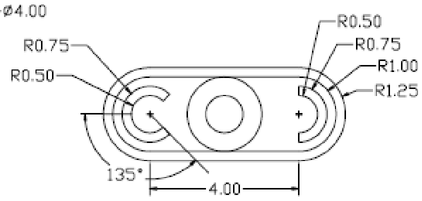


Fig :- 4.3

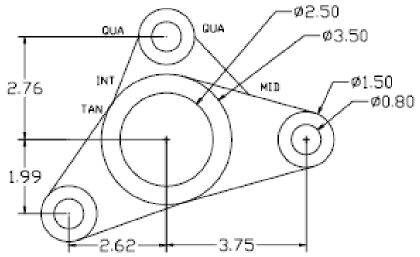


Fig :- 4.4

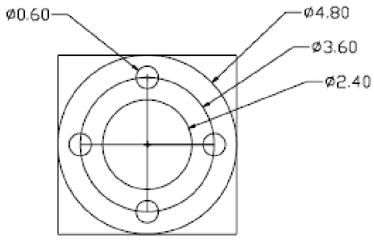
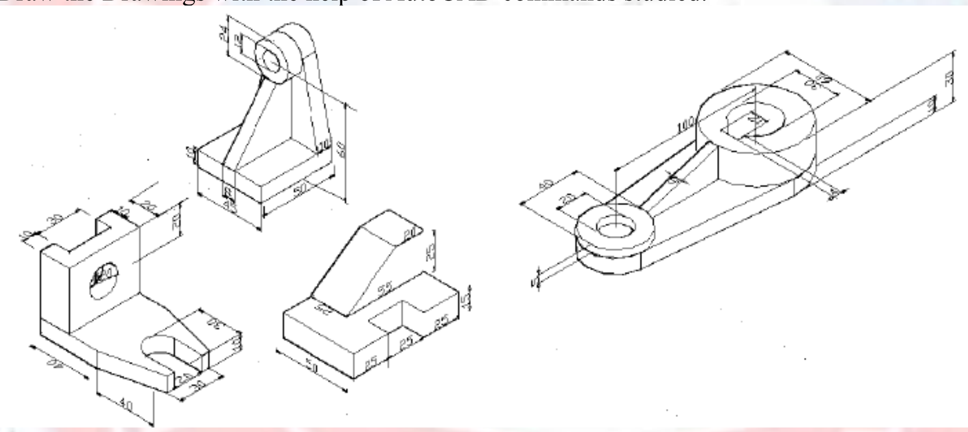


Fig :- 4.5

Module – V
Draw the Drawings with the help of AutoCAD commands studied.



BOOKS:

1. Learn AutoCAD; Sunil K. Pandey, S.K. Kataria & Sons; ISBN: 978-8185749785
2. AutoCAD 2020 Beginners Guide; Amit Bhatt; CADFOLKS; ISBN: 978-8193063071
3. Learning AutoCAD A-Z Coverage of Every Feature and Command; Atish B. Mane, PBT
4. A Hand Book on AutoCAD Tools Practice, Azhar Wahab, PBT

COURSE INFORMATION SHEET

Course code: PE 24290
Course title: CNC MACHINING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L: 1 T: P: 4
Class schedule per week: 5
Class: Diploma in Engineering
Level: Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Gain foundational knowledge of CNC machines, numerical control, programming languages, and CNC features.
2	Develop proficiency in CNC programming, including toolpath generation and optimizing machining cycles.
3	Learn programming and execution of turning, facing, interpolation, and thread-cutting on CNC lathes.
4	Acquire skills in programming profile milling, interpolation, and pocket milling on CNC milling machines.
5	Understand setup, safety, and perform basic to advanced grinding operations on CNC grinding machines.

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

CO1	Understand CNC machines, numerical control, programming languages, and their advantages and limitations.
CO2	Proficiency in CNC programming, including toolpath generation and optimizing machining cycles.
CO3	Competence in programming and executing turning, facing, interpolation, and thread-cutting on CNC lathes.
CO4	Develop program profile milling, interpolation, and pocket milling on CNC milling machines.
CO5	Perform grinding operations on CNC grinding machines, including toolpath optimization and troubleshooting.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I **Foundational Knowledge:** Introduction to CNC Machines, Basic Concept of numerical control, Understanding CNC Programming Languages, Advantages and Limitations of CNC, Features of CNC.	
Module – II **CNC Programming Basics:** Coordinate Systems, G-code and M-code, Toolpath Generation, Basic machining cycles, Advanced machining cycles, Mirroring commands, Subroutines (Subprogram) and, how to reduce the machining cycle time.	
Module – III **CNC lathe:** Program for turning, facing operation, circular interpolation, thread-cutting operation, and Machining.	
Module – IV **CNC milling;** Program for profile milling operation, circular interpolation, rectangular pocket milling and Machining.	
Module – V **CNC grinding:** Understand CNC grinding machine setup, safety, and perform basic surface and cylindrical grinding tasks. Learn advanced grinding operations, toolpath optimization, troubleshooting, and complete a comprehensive hands-on grinding job.	

BOOKS:

1. CNC Machines by M. Adithan and B.S. Pable.New Age International Pub.
2. CNC Machining Technology: Volume I: Design, Development and CIM Strategies-1, by Graham T. Smith.Springer Verlag.
3. CNC Machining Technology: Volume II Cutting, Fluids and Workholding Technologies-2, by Graham T. Smith.Springer Verlag.

COURSE INFORMATION SHEET

Course code: ME 24212
Course title: INSTALLATION, TESTING AND MAINTENANCE OF SOLAR APPLIANCES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L: 1 T: P: 4
Class schedule per week: 5
Class: Diploma in Engineering
Level: Second
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Familiarization with Solar panels
2	Design and Installation of Solar devises.
3	Testing of various Solar Appliances.

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

CO1	Be conversant with the Solar Panels.
CO2	Explain the basic utilities of Solar Panels.
CO3	Apply the basic knowledge of Solar Panels for its optimal usage.
CO4	Develop skills to work as an individual or in a team during the Installation and Testing.

SYLLABUS

MODULE	(NO. OF LECTURE HOURS)
Module – I Solar Panel Installation: Site Assessment: Evaluate property suitability and energy needs. Design and Sizing: Customize the system for maximum efficiency. Permitting and Approvals: Obtain necessary permits and comply with regulations. Equipment Procurement: Source reliable, high-quality components.	
Module – II Installation: Mount panels and make electrical connections. System Testing: Ensure optimal performance and functionality. System Activation: Start generating clean, renewable energy.	
Module – III Solar Panel Maintenance: Regular Cleaning: Remove dirt and debris to maximize efficiency. Inspection and Monitoring: Identify issues and track performance.	
Module – IV Electrical System Maintenance: Check connections and wiring. Professional Service: Engage experts for comprehensive care. Performance Optimization: Explore upgrades and monitoring solutions.	
Module – V Testing a Solar Panel: Follow the Safety Precautions. Measurement of Voltage, Current, and Resistance.	

BOOKS:

1. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, U.K., 1996.
2. Rai. G.D., “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, 2011.
3. Twidell, J.W. & Weir, A., “Renewable Energy Sources”, EFN Spon Ltd., UK, 2006.
4. Sukhatme. S.P., “Solar Energy”, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1997.
5. Tiwari. G.N., Solar Energy – “Fundamentals Design, Modelling& Applications”, Narosa Publishing House, New Delhi, 2002.
6. Freris. L.L., “Wind Energy Conversion Systems”, Prentice Hall, UK, 1990. 4. Chetan Singh Solanki, Solar Photovoltaics, “Fundamentals, Technologies and Applications”, PHI Learning Private Limited, New Delhi, 2009.