BIRLA INSTITUTE OF TECHNOLOGY

CHOICE BASED CREDIT SYSTEM (CBCS) CURRICULUM

(NEW COURSE STRUCTURE - Effective from Academic Session 2021-22)

B.TECH IN PRODUCTION AND INDUSTRIAL ENGINEERING

PRODUCTION AND INDUSTRIAL ENGINEERING DEPARTMENT

Introduced and Approved in Meetings of Board of Studies, dated 23/03/2021, and 21/06/2021;
Revised and Approved in Meeting of Board of Studies, dated 15/02/2022.

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. programs and research projects.
- To develop effective teaching learning skills and state of 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 overall academic needs of society.

DEPARTMENT VISION:

- To become a Centre of Repute striving continuously towards providing Quality Education, Research and Innovation in the field of Production and Industrial Engineering

DEPARTMENT MISSION

- To provide quality education at both Undergraduate and Postgraduate levels
- To provide opportunities and facilities for research and innovation in Production and Industrial Engineering
- To produce industry-ready graduates to meet the demands of manufacturing industries, knowledge-based software firms, supply chain and logistic firms, and R&D organizations
- To integrate skills on state-of-the-art manufacturing technology with industrial engineering and operations management
- To impart latest knowledge in the domain area to students by continuous up-gradation of curricula and faculty

GRADUATE ATTRIBUTES

1. **Engineering Knowledge**: Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis**: Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. **Design/ Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
4. **Conduct investigations of complex problems** using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.
5. **Modern Tool Usage**: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6. **The Engineer and Society**: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
7. **Environment and Sustainability**: Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9. **Individual and Teamwork**: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
11. **Project Management and Finance**: Demonstrate knowledge and understanding of engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long Learning**: Recognize the need for and have the preparation and ability to engage in independent and life- long learning in the broadest context of technological change.

PROGRAM 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-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 inter-personal skill, team spirit and employability while believing on the ethical values
- ✓ **PEO 5:** To develop a strong foundation for building an engineering career with societal and humanitarian responsibility

(A) PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

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

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

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(B) PROGRAM SPECIFIC OUTCOMES (PSO)

13. **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.

14. **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.

15. **PSO 3:** Enable to apply the attained theoretical and practical knowledge to solve the industrial and societal problems in the broad areas of production and industrial engineering.

COURSE STRUCTURE

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING
Course Structure - Based on CBCS system & OBE model
Recommended scheme of study
(B. TECH in PRODUCTION AND INDUSTRIAL ENGINEERING)

Semester/ Session of Study (Recommended)	Category of Course	Course Code	Courses	Mode of delivery & credits L-Lecture; T-Tutorial; P-Practicals			Total Credits C-Credits
				L (Periods/ week)	T (Periods/ week)	P (Periods/ week)	C
	THEORY						
FIRST Monsoon	FS *Foundation Sciences*	MA103	Mathematics - I	3	1	0	4
		PH113	Physics	3	1	0	4
		BE101	Biological Science for Engineers	2	0	0	2
	GE *General Engineering*	EE101	Basic Electrical Engineering	3	1	0	4
		CS101	Programming for Problem Solving	3	1	0	4
	LABORATORIES						
	HSS *Humanities & Social Sci.*	MT 132	Communication Skills – I	0	0	3	1.5
	FS	PH114	Physics Lab	0	0	3	1.5
	GE	CS102	Programming for Problem Solving Lab	0	0	3	1.5
		PE101	Workshop Practice	0	0	3	1.5
	MC *Mandatory Course*	MC101/102/103/104	Choice of: NCC/NSS/PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL							25
SECOND Spring	THEORY						
	FS	MA107	Mathematics - II	3	1	0	4
		CH101	Chemistry	3	1	0	4
	MC	CE101	Environmental Science	2	0	0	2
	GE	ME101	Basics of Mechanical Engineering	3	1	0	4
		EC101	Basics of Electronics & Communication Engineering	3	1	0	4
	LABORATORIES						
	FS	CH102	Chemistry Lab	0	0	3	1.5
	GE	EC102	Electronics & Communication Lab	0	0	3	1.5
		ME102	Engineering Graphics	0	0	4	2
	MC	MC105/106/107/108	Choice of: NCC/NSS/PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL							24
GRAND TOTAL FOR FIRST YEAR							49

THIRD Monsoon	**THEORY**						
	FS	MA203	Numerical Methods	2	0	0	2
	HSS	MT131	UHV2: Understanding Harmony	3	0	0	3
	PC *Program Core*	PE203	Operations Research	3	0	0	3
		PE214	Metallurgical and Materials Engineering	3	0	0	3
		ME205	Strength of Materials	3	1	0	4
		ME289	Thermal and Fluid Engineering	3	0	0	3
	LABORATORIES						
	FS	MA204	Numerical Methods Lab	0	0	2	1
	PC	PE215	Metallurgical and Materials Engineering Lab	0	0	3	1.5
		ME204	Mechanical Engineering Lab - I	0	0	3	1.5
	MC	MC201/202/ 203/204	Choice of: NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL							**23**
FOURTH Spring	**THEORY**						
	PC	ME207	Kinematics and Dynamics of Machines	3	0	0	3
		PE216	Foundry, Forming and Welding Technologies	3	0	0	3
		PE218	Production and Operations Management	4	0	0	4
		PE219	Project Engineering	3	0	0	3
	PE *Program Elective*		Program Elective - I	3	0	0	3
	OE *Open Elective*		Open Elective - I / MOOC - I	3	0	0	3
	LABORATORIES						
	GE	EE102	Electrical Engineering Lab	0	0	3	1.5
	PC	PE217	Foundry, Forming and Welding Lab	0	0	3	1.5
		PE225	Modeling and Simulation Lab	0	0	2	1
	MC	MC205/206/ 207/208	Choice of: NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL							**24**
FIFTH Monsoon	**THEORY**						
	PC	PE326	Metrology & Statistical Quality Control	3	0	0	3
		PE328	Design of Machine Elements	3	0	0	3
		PE329	Machining Science and Machine Tools	3	0	0	3
	PE		Program Elective - II	3	0	0	3
			Program Elective - III	3	0	0	3
	OE		Open Elective - II / MOOC - II	3	0	0	3
	LABORATORIES						
	HSS	MT133	Communication Skills – II	0	0	3	1.5
	PC	PE327	Metrology and Measurement Lab	0	0	3	1.5
		PE330	Machine Tools Lab	0	0	3	1.5
		PE331	Machine Drawing and CAD Lab	0	0	3	1.5
TOTAL							**24**

Semester	Category	Code	Course	L	T	P	Credits
SIXTH Spring	**THEORY**						
	PC	PE334	Machine Tool Design	3	0	0	3
		PE338	Production Economics and Financial Management	3	0	0	3
		PE345	Work System Design	3	0	0	3
	PE		Program Elective - IV	3	0	0	3
			Program Elective - V	3	0	0	3
	OE		Open Elective - III / MOOC - III	3	0	0	3
	LABORATORIES						
	PC	PE335	Machine Tool Design Sessional	0	0	2	1
		PE346	Work Study and Ergonomics Lab	0	0	2	1
	PROFESSIONAL TRAINING						
	PROJ ***Project***	MC300	Summer Internship	NA	NA	NA	2
TOTAL							**22**
THEORY							
SEVENTH Monsoon	**PC**	PE401	Computer Integrated Manufacturing & Cyber-Physical Systems	3	0	0	3
		PE411	Supply Chain Management	3	0	0	3
	PE		Program Elective - VI	3	0	0	3
	OE		Open Elective - IV / MOOC - IV	3	0	0	3
	MC	MT204	Constitution of India	2	0	0	NC
	LABORATORIES						
	PC	PE410	Manufacturing Automation Lab	0	0	2	1
	PROJECT						
	PROJ	PE400M	Minor Project				3
TOTAL							**16**
EIGTH Spring	**PROJ**	PE400	**Research Project / Industrial Internship**	**Total**			**10**
GRAND TOTAL ***Minimum requirement for Degree award***							**168**

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING 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)**	PE210	Reliability and Maintenance Engineering	None	3	0	0	3
		PE220	Industrial Statistics	None	3	0	0	3
		PE221	Quantitative Techniques	None	3	0	0	3
		PE222	Discrete-event System Simulation	None	3	0	0	3
FIFTH Monsoon	**PE - II (Any one)**	PE306	Advanced Operations Research	Operations Research	3	0	0	3
		PE307	Competitive Manufacturing Strategies	None	3	0	0	3
		PE317	Advanced Welding Technology	Metallurgical and Materials Engineering; Foundry, Forming & Welding Technologies	3	0	0	3
		ME351	Finite Element Methods	Mathematics; Strength of Materials	3	0	0	3
	PE - III (Any one)	PE318	Rapid Prototyping and Tooling	None	3	0	0	3
		PE319	Material Deformation Processes	Strength of Materials; Foundry, Forming & Welding Technologies	3	0	0	3
		PE322	Circular Economy-Sustainable Materials Management	None	3	0	0	3
		ME377	Mechatronics	None	3	0	0	3
SIXTH Spring	**PE - IV (Any one)**	PE323	Product Design and Manufacturing	Foundry, Forming & Welding Technologies	3	0	0	3
		PE324	Surface Engineering and Laser Additive Manufacturing	None	3	0	0	3
		PE333	Tribology in Engineering	Foundry, Forming & Welding Technologies	3	0	0	3
		PE336	Tooling for Manufacturing	Foundry, Forming & Welding Technologies; Machining Science and Machine Tools	3	0	0	3
	PE - V (Any one)	PE337	Manufacturing Science	Foundry, Forming & Welding Technologies; Machining Science and Machine Tools	3	0	0	3
		PE348	Engineering Optimization	None	3	0	0	3
		PE349	Lean Manufacturing & Six-sigma	None	3	0	0	3
		PE350	Material Handling Systems	None	3	0	0	3
SEVENTH Monsoon	**PE - VI (Any one)**	PE406	Non-conventional Machining Processes	Machining Science and Machine Tools	3	0	0	3
		PE407	Advanced Manufacturing Processes	Foundry, Forming & Welding Technologies; Machining Science and Machine Tools	3	0	0	3
		PE412	Experimental Methods and Measurements	Metallurgical and Materials Engineering;	3	0	0	3
		PE413	AI and Data Analytics	None	3	0	0	3

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

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING OPEN ELECTIVES (OE)*							
Semester / Session of Study (Recommended)	**Course Code**	**Name of the OE Courses**	**Prerequisites Courses**	**L**	**T**	**P**	**C**
FOURTH/ Spring	PE209	Engineering Economy, Costing and Accounting	None	3	0	0	3
	PE227	Engineering Materials	None	3	0	0	3
FIFTH / Monsoon	PE309	Project Management	None	3	0	0	3
	PE315	Work Study & Ergonomics	None	3	0	0	3
SIXTH / Spring	PE332	Operation Research with Python	None	3	0	0	3
	PE347	Additive Manufacturing	None	3	0	0	3
SEVENTH / Monsoon	PE414	Automated Manufacturing Systems	None	3	0	0	3
	PE417	Production Management	None	3	0	0	3

*** OPEN ELECTIVES TO BE OFFERED ONLY TO THE STUDENTS OF OTHER DEPARTMENT.**

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING
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 DEPERTMENTAL SPECIALISATION (in-depth) in "Advanced Manufacturing and Production Management" should complete 20 credits and shall opt for courses listed below. The credits shall be over and above minimum requirement for degree award.

Semester/ Session of Study (Recommended)	Category of Course	Course Code	Course Name	Mode of delivery & credits *L-Lecture; T-Tutorial; P-Practicals*			Total Credits *C-Credits*
				L (*Periods/week*)	**T (*Periods/week*)**	**P (*Periods/week*)**	**C**
FIFTH / Monsoon	**THEORY**						
	PC	PE339	Material Characterizations and Non-destructive Testing	4	0	0	4
		PE340	Sustainable Manufacturing Technologies	4	0	0	4
TOTAL							**8**
SIXTH / Spring	**THEORY**						
	PE (any one)	PE310	Industrial Robotics	4	0	0	4
		PE341	Processing of Polymers, Composite and Advanced Materials	4	0	0	4
		PE342	Manufacturing Management and Cost Optimization	4	0	0	4
TOTAL							**4**
SEVENTH / Monsoon	**THEORY**						
	PE (any one)	PE409	Finite Elements in Manufacturing Engineering Applications	4	0	0	4
		PE415	Micro and Nano Manufacturing	4	0	0	4
	PROJECT						
	PC	PE450	Applications-based Project				4
TOTAL							**8**
GRAND TOTAL							**20**

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DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING
MINOR in "Production and Industrial Engineering"
(OFFERED ONLY TO OTHER THAN PRODUCTION AND INDUSTRIAL ENGINEERING STUDENTS)

Students who have registered for Minor in Production and Industrial Engineering should complete 20 credits and shall opt for courses listed below. The credits shall be over and above minimum requirement for degree award.

Semester/ Session of Study (Recommended)	**Category of course**	**Course Code**	**Course Name**	**Prerequisite courses**	**Mode of delivery & credits** *L-Lecture; T-Tutorial; P-Practicals*			**Total Credits** *C-Credits*
					L (*Periods /week*)	**T (*Periods /week)***	**P (*Period s/week)***	**C**
FIFTH / Monsoon	**THEORY**							
	PC	PE223	Operation Research and Quantitative Techniques	None	4	0	0	4
	PE (any one)	PE224	Manufacturing Science and Technologies	None	4	0	0	4
				Only for other than Mechanical Engg. Department students				
		PE343	Modern Manufacturing Processes	Manufacturing Processes	4	0	0	4
				Only for Mechanical Engg. Department students				
TOTAL								**8**
SIXTH / Spring	**THEORY**							
	PC	PE344	Mechanical Measurement & Quality Control	None	4	0	0	4
TOTAL								**4**
SEVENTH / Monsoon	**THEORY**							
	PE (any one)	PE218	Production and Operations Management	None	4	0	0	4
		PE416	Logistics and Supply Chain Management	None	4	0	0	4
	PROJECT							
	PC	PE450	Applications-based Project					4
TOTAL								**8**
GRAND TOTAL								**20**

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	FS	PH114	Physics Lab	0	0	3	1.5
	GE	CS102	Programming for Problem Solving Lab	0	0	3	1.5
		PE101	Workshop Practice	0	0	3	1.5
	MC *Mandatory Course*	MC101/102/103/ 104	Choice of: NCC/NSS/PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL							**25**
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	FS	MA107	Mathematics - II	3	1	0	4
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	MC	CE101	Environmental Science	2	0	0	2
	GE	ME101	Basics of Mechanical Engineering	3	1	0	4
		EC101	Basics of Electronics & Communication Engineering	3	1	0	4
	LABORATORIES						
	FS	CH102	Chemistry Lab	0	0	3	1.5
	GE	EC102	Electronics & Communication Lab	0	0	3	1.5
		ME102	Engineering Graphics	0	0	4	2
	MC	MC105/106/107/ 108	Choice of: NCC/NSS/PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL							**24**
GRAND TOTAL FOR FIRST YEAR							**49**

THIRD Monsoon	**THEORY**						
	FS	MA203	Numerical Methods	2	0	0	2
	HSS	MT131	UHV2: Understanding Harmony	3	0	0	3
	PC ***Program Core***	PE203	Operations Research	3	0	0	3
		PE214	Metallurgical and Materials Engineering	3	0	0	3
		ME205	Strength of Materials	3	1	0	4
		ME289	Thermal and Fluid Engineering	3	0	0	3
	LABORATORIES						
	FS	MA204	Numerical Methods Lab	0	0	2	1
	PC	PE215	Metallurgical and Materials Engineering Lab	0	0	3	1.5
		ME204	Mechanical Engineering Lab - I	0	0	3	1.5
	MC	MC201/202/ 203/204	Choice of: NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL							**23**
FOURTH Spring	**THEORY**						
	PC	ME207	Kinematics and Dynamics of Machines	3	0	0	3
		PE216	Foundry, Forming and Welding Technologies	3	0	0	3
		PE218	Production and Operations Management	4	0	0	4
		PE219	Project Engineering	3	0	0	3
	PE ***Program Elective***		Program Elective - I	3	0	0	3
	OE ***Open Elective***		Open Elective - I / MOOC - I	3	0	0	3
	LABORATORIES						
	GE	EE102	Electrical Engineering Lab	0	0	3	1.5
	PC	PE217	Foundry, Forming and Welding Lab	0	0	3	1.5
		PE225	Modeling and Simulation Lab	0	0	2	1
	MC	MC205/206/ 207/208	Choice of: NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
TOTAL							**24**
FIFTH Monsoon	**THEORY**						
	PC	PE326	Metrology & Statistical Quality Control	3	0	0	3
		PE328	Design of Machine Elements	3	0	0	3
		PE329	Machining Science and Machine Tools	3	0	0	3
	PE		Program Elective - II	3	0	0	3
			Program Elective - III	3	0	0	3
	OE		Open Elective - II / MOOC - II	3	0	0	3
	LABORATORIES						
	HSS	MT133	Communication Skills – II	0	0	3	1.5
	PC	PE327	Metrology and Measurement Lab	0	0	3	1.5
		PE330	Machine Tools Lab	0	0	3	1.5
		PE331	Machine Drawing and CAD Lab	0	0	3	1.5
TOTAL							**24**

SIXTH Spring	**THEORY**						
	PC	PE334	Machine Tool Design	3	0	0	3
		PE338	Production Economics and Financial Management	3	0	0	3
		PE345	Work System Design	3	0	0	3
	PE		Program Elective - IV	3	0	0	3
			Program Elective - V	3	0	0	3
	OE		Open Elective - III / MOOC - III	3	0	0	3
	LABORATORIES						
	PC	PE335	Machine Tool Design Sessional	0	0	2	1
		PE346	Work Study and Ergonomics Lab	0	0	2	1
	PROFESSIONAL TRAINING						
	PROJ ***Project***	MC300	Summer Internship	NA	NA	NA	2
TOTAL							**22**
THEORY							
SEVENTH Monsoon	**PC**	PE401	Computer Integrated Manufacturing & Cyber-Physical Systems	3	0	0	3
		PE411	Supply Chain Management	3	0	0	3
	PE		Program Elective - VI	3	0	0	3
	OE		Open Elective - IV / MOOC - IV	3	0	0	3
	MC	MT204	Constitution of India	2	0	0	NC
	LABORATORIES						
	PC	PE410	Manufacturing Automation Lab	0	0	2	1
	PROJECT						
	PROJ	PE400M	Minor Project				3
TOTAL							**16**
EIGTH Spring	**PROJ**	PE400	**Research Project / Industrial Internship**	**Total**			**10**
GRAND TOTAL ***Minimum requirement for Degree award***							**168**

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING 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)**	PE210	Reliability and Maintenance Engineering	None	3	0	0	3
		PE220	Industrial Statistics	None	3	0	0	3
		PE221	Quantitative Techniques	None	3	0	0	3
		PE222	Discrete-event System Simulation	None	3	0	0	3
FIFTH Monsoon	**PE - II (Any one)**	PE306	Advanced Operations Research	Operations Research	3	0	0	3
		PE307	Competitive Manufacturing Strategies	None	3	0	0	3
		PE317	Advanced Welding Technology	Metallurgical and Materials Engineering; Foundry, Forming & Welding Technologies	3	0	0	3
		ME351	Finite Element Methods	Mathematics; Strength of Materials	3	0	0	3
	PE - III (Any one)	PE318	Rapid Prototyping and Tooling	None	3	0	0	3
		PE319	Material Deformation Processes	Strength of Materials; Foundry, Forming & Welding Technologies	3	0	0	3
		PE322	Circular Economy-Sustainable Materials Management	None	3	0	0	3
		ME377	Mechatronics	None	3	0	0	3
SIXTH Spring	**PE - IV (Any one)**	PE323	Product Design and Manufacturing	Foundry, Forming & Welding Technologies	3	0	0	3
		PE324	Surface Engineering and Laser Additive Manufacturing	None	3	0	0	3
		PE333	Tribology in Engineering	Foundry, Forming & Welding Technologies	3	0	0	3
		PE336	Tooling for Manufacturing	Foundry, Forming & Welding Technologies; Machining Science and Machine Tools	3	0	0	3
	PE - V (Any one)	PE337	Manufacturing Science	Foundry, Forming & Welding Technologies; Machining Science and Machine Tools	3	0	0	3
		PE348	Engineering Optimization	None	3	0	0	3
		PE349	Lean Manufacturing & Six-sigma	None	3	0	0	3
		PE350	Material Handling Systems	None	3	0	0	3
SEVENTH Monsoon	**PE - VI (Any one)**	PE406	Non-conventional Machining Processes	Machining Science and Machine Tools	3	0	0	3
		PE407	Advanced Manufacturing Processes	Foundry, Forming & Welding Technologies; Machining Science and Machine Tools	3	0	0	3
		PE412	Experimental Methods and Measurements	Metallurgical and Materials Engineering;	3	0	0	3
		PE413	AI and Data Analytics	None	3	0	0	3

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

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING OPEN ELECTIVES (OE)*							
Semester / Session of Study (Recommended)	**Course Code**	**Name of the OE Courses**	**Prerequisites Courses**	**L**	**T**	**P**	**C**
FOURTH/ Spring	PE209	Engineering Economy, Costing and Accounting	None	3	0	0	3
	PE227	Engineering Materials	None	3	0	0	3
FIFTH / Monsoon	PE309	Project Management	None	3	0	0	3
	PE315	Work Study & Ergonomics	None	3	0	0	3
SIXTH / Spring	PE332	Operation Research with Python	None	3	0	0	3
	PE347	Additive Manufacturing	None	3	0	0	3
SEVENTH / Monsoon	PE414	Automated Manufacturing Systems	None	3	0	0	3
	PE417	Production Management	None	3	0	0	3

*** OPEN ELECTIVES TO BE OFFERED ONLY TO THE STUDENTS OF OTHER DEPARTMENT.**

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING
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 DEPERTMENTAL SPECIALISATION (in-depth) in "Advanced Manufacturing and Production Management" should complete 20 credits and shall opt for courses listed below. The credits shall be over and above minimum requirement for degree award.

Semester/ Session of Study (Recommended)	**Category of Course**	**Course Code**	**Course Name**	**Mode of delivery & credits** *L-Lecture; T-Tutorial; P-Practicals*			**Total Credits** *C-Credits*
				L (*Periods/week*)	**T (*Periods/week*)**	**P (*Periods/week*)**	**C**
FIFTH / Monsoon	**THEORY**						
	PC	PE339	Material Characterizations and Non-destructive Testing	4	0	0	4
		PE340	Sustainable Manufacturing Technologies	4	0	0	4
TOTAL							**8**
SIXTH / Spring	**THEORY**						
	PE (any one)	PE310	Industrial Robotics	4	0	0	4
		PE341	Processing of Polymers, Composite and Advanced Materials	4	0	0	4
		PE342	Manufacturing Management and Cost Optimization	4	0	0	4
TOTAL							**4**
SEVENTH / Monsoon	**THEORY**						
	PE (any one)	PE409	Finite Elements in Manufacturing Engineering Applications	4	0	0	4
		PE415	Micro and Nano Manufacturing	4	0	0	4
	PROJECT						
	PC	PE450	Applications-based Project				4
TOTAL							**8**
GRAND TOTAL							**20**

DEPARTMENT OF PRODUCTION AND INDUSTRIAL ENGINEERING
MINOR in "Production and Industrial Engineering"
(OFFERED ONLY TO OTHER THAN PRODUCTION AND INDUSTRIAL ENGINEERING STUDENTS)

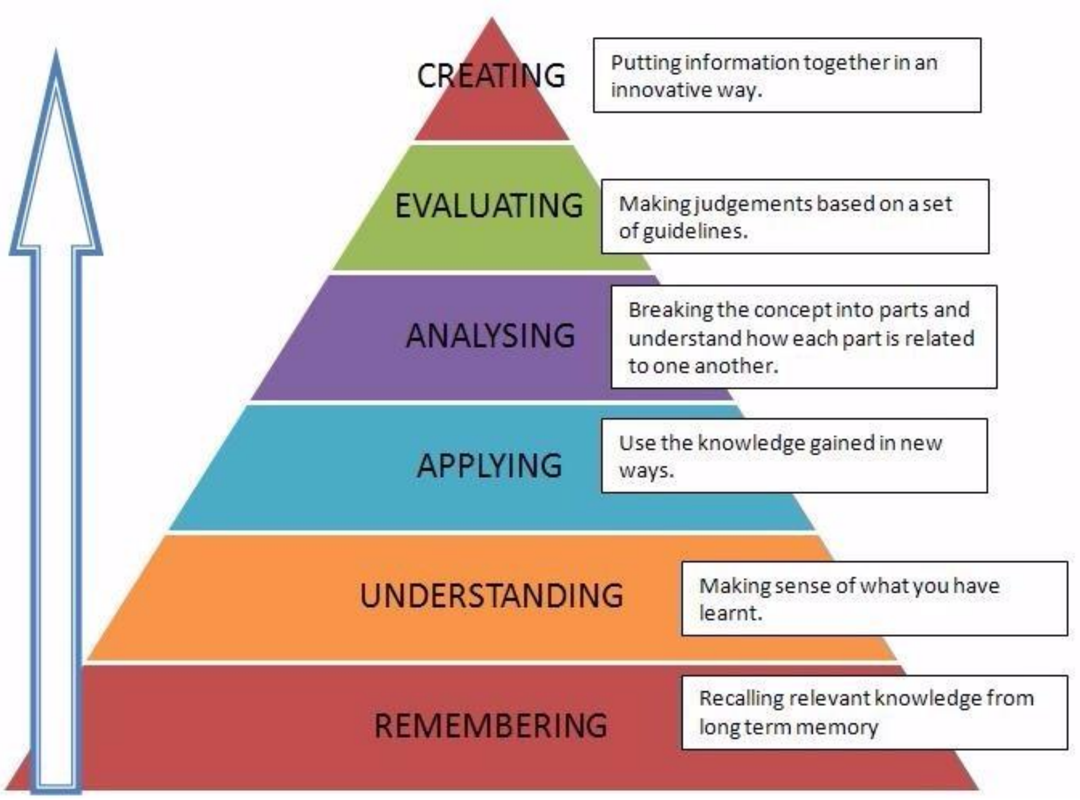
Students who have registered for Minor in Production and Industrial Engineering should complete 20 credits and shall opt for courses listed below. The credits shall be over and above minimum requirement for degree award.

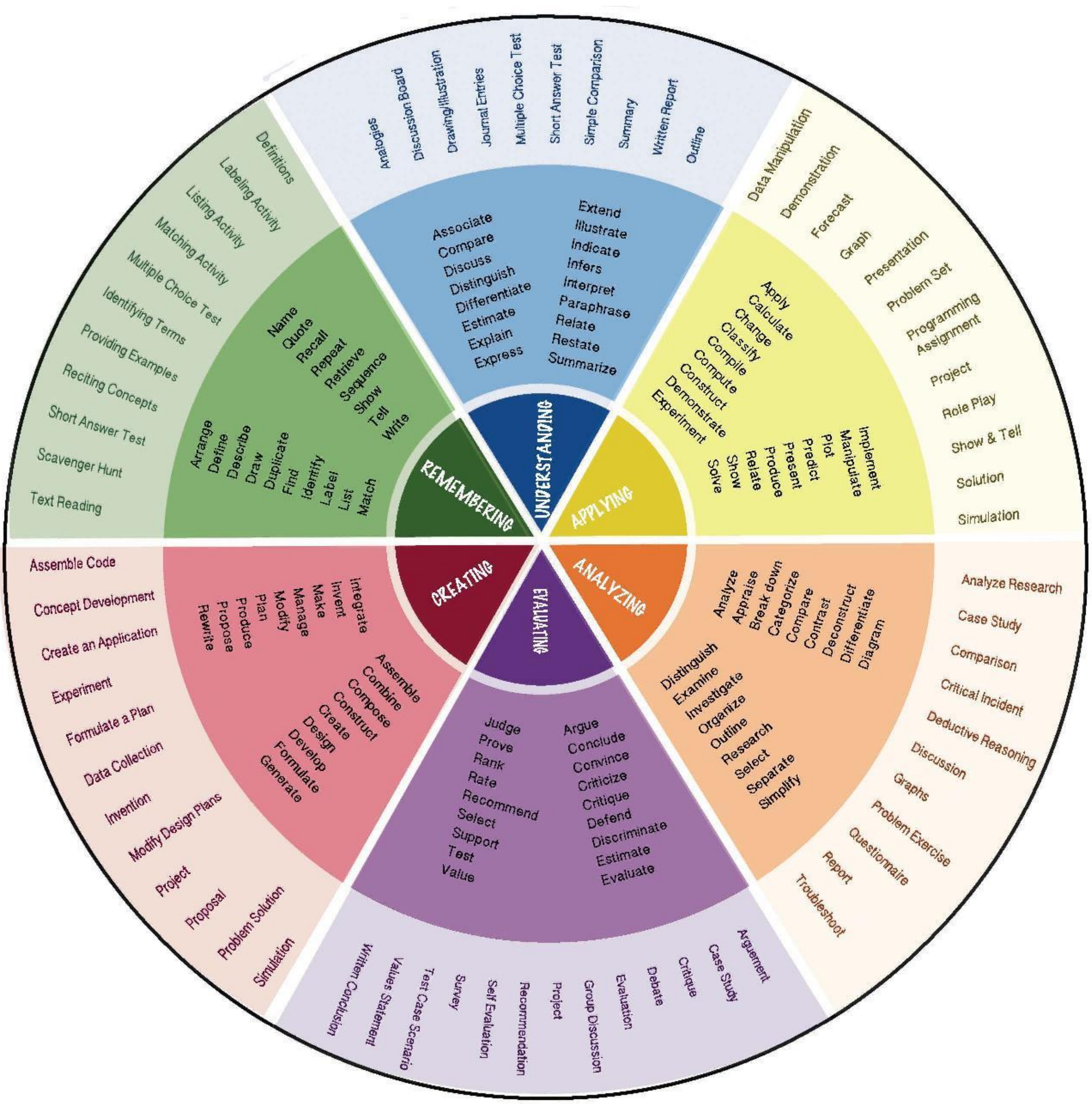
Semester/ Session of Study (Recommended)	Category of course	Course Code	Course Name	Prerequisite courses	Mode of delivery & credits *L-Lecture; T-Tutorial; P-Practicals*			Total Credits *C-Credits*
					L (*Periods/week*)	T (*Periods/week*)	P (*Periods/week*)	C
FIFTH / Monsoon	THEORY							
	PC	PE223	Operation Research and Quantitative Techniques	None	4	0	0	4
	PE (any one)	PE224	Manufacturing Science and Technologies	None	4	0	0	4
				Only for other than Mechanical Engg. Department students				
		PE343	Modern Manufacturing Processes	Manufacturing Processes	4	0	0	4
				Only for Mechanical Engg. Department students				
TOTAL								8
SIXTH / Spring	THEORY							
	PC	PE344	Mechanical Measurement & Quality Control	None	4	0	0	4
TOTAL								4
SEVENTH / Monsoon	THEORY							
	PE (any one)	PE218	Production and Operations Management	None	4	0	0	4
		PE416	Logistics and Supply Chain Management	None	4	0	0	4
	PROJECT							
	PC	PE450	Applications-based Project					4
TOTAL								8
GRAND TOTAL								20

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
UNDERSTANDING
APPLYING
ANALYZING
EVALUATING
CREATING
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
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
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
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
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
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

COURSE INFORMATION SHEET

Course code: PE 101
Course title: WORKSHOP PRACTICE
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: I or II / First
Branch: All
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Familiarize with the basic 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 of 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 machining, welding, fitting, carpentry, foundry and forging.
CO3	Manufacture different components using various workshop trades.
CO4	Take safety and precautionary measures of self and machines during operations.
CO5	Develop skills to work as an individual or in a team during trade practices.

SYLLABUS

LIST OF EXPERIMENT:

1. **CARPENTRY SHOP**
   EXPERIMENT-I: Carpentry Tools and Instruments
   Objective: To study the various tools, instruments and equipment used in carpentry practice.

2. **CARPENTRY SHOP**
   EXPERIMENT-II: Carpentry Practice
   Objective: To perform the carpentry work by making a wooden job using different tools.

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 pattern).

4. **FOUNDRY SHOP**
   EXPERIMENT-II: Aluminium Casting
   Objective: To get acquainted with melting and pouring of metal in a mould (given two-piece patterns of handle) and to make aluminium casting.

5. **FORGING SHOP**
   EXPERIMENT-I: Forging Tools
   Objective: To study different tools and equipment used in hand forging practice.

6. **FORGING SHOP**
   EXPERIMENT-II: Forging Practice
   Objective: To learn about hand forging practice by making a job (make a square bar from round blank and bend it at a sharp corner of 90 degree as per drawing).

7. **MACHINE SHOP**
   EXPERIMENT – I: Center Lathe
   Objective: To study lathe machine and to machine a given job on center lathe as per drawing.

8. **MACHINE SHOP**
   EXPERIMENT-II: Shaper Machine
   Objective: To study Shaper machine and to machine a given job on shaper as per drawing.

9. **FITTING SHOP**
   EXPERIMENT-I: Fitting Tools and Measuring Instruments
   Objective: To study the various tools used in fitting shop and perform fitting operations (like marking, chipping, hack-sawing, filing, drilling etc.)

10. **FITTING SHOP**
    EXPERIMENT-II: Fitting Assembly Practice
    Objective: To make a job clamping plate as per given drawing by fitting operations and to check for its assembly with a given component.

11. **WELDING SHOP**
    EXPERIMENT-I: Manual Metal Arc Welding
    Objective: To study arc welding processes including arc welding machines (AC & DC), electrodes and equipment. To joint two pieces of given metal by arc welding process.

12. WELDING SHOP

EXPERIMENT-II: Gas Welding

Objective: To study gas welding processes including types of flames produced, filler metals and fluxes etc. To joint two pieces of given metal by gas welding process.

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**
Day to day performance & Lab files	√	√	√	√	√
Quiz 1	√	√	√		
Quiz 2	√	√	√		
Viva-voce	√	√	√	√	
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	2	2				1					2	3	2	2
CO2	3	1	2									1	3	2	3
CO3	3	2	2	1								2	2	2	3
CO4	2					2						1	1	1	2
CO5	2	2	2	1		1			3	1		1	2	2	2

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, CD3, CD6
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD1, CD3
CO5	CD3

COURSE INFORMATION SHEET

Course code: MA 203
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	Derive appropriate numerical methods to solve algebraic and transcendental equations
2	Derive appropriate numerical methods to solve linear system of equations
3	Approximate a function using various interpolation techniques
4	Find the numerical solution of initial value problems and boundary value problems

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

CO1	Solve algebraic and transcendental equation using an appropriate numerical method arising in various engineering problems
CO2	Solve linear system of equations using an appropriate numerical method arising in computer programming, engineering problems etc.
CO3	Approximate a function using an appropriate numerical method in various research problems
CO4	Evaluate derivative at a value using an appropriate numerical method in various research problems
CO5	Solve differential equation numerically

SYLLABUS

Module 1: Errors and Nonlinear Equations **[5]**
Error Analysis: Definition and sources of errors, propagation of errors, floating-point arithmetic, Solution of Nonlinear equations: Bisection method, Regula-Falsi method, Secant method, Newton- Raphson method and its variants, General Iterative method

Module 2: System of Linear Equations **[5]**
Gauss-Elimination, Gauss-Jordan, LU-Decomposition, Gauss-Jacobi and Gauss- Siedel methods to solve linear system of equations and Power method to find least and largest eigenvalues.

Module 3: Interpolation **[5]**
Lagrange's interpolation, Newton's divided differences interpolation formulas, inverse interpolation, interpolating polynomial using finite differences

Module 4: Differentiation and Integration **[5]**
Differentiation using interpolation formulas, Integration using Newton-Cotes formulas: Trapezoidal rule, Simpson's rule

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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
End Semester Examination	√	√	√	√	√
Quiz (es)	√	√	√		
Assignment	√	√	√	√	

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	2	2	1	1	1	1	3	3	2	2	1	2	2
CO2	3	2	2	2	1	1	2	1	3	3	2	2	1	2	2
CO3	3	3	2	2	1	1	1	1	3	3	2	2	1	2	2
CO4	2	2	3	1	1	1	1	1	3	3	2	2	1	2	2
CO5	2	2	3	3	1	2	1	1	3	3	2	2	1	2	2

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, 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 204
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:

SYLLABUS

LIST OF EXPERIMENT:

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

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

3. ASSIGNMENT – 3
0 **Objective**: Find a simple root of $f(x) = 0$ using Newton Raphson method. Read any initial approximation x_0, maximum number of iterations n and error tolerance eps.

4. ASSIGNMENT – 4
Objective: Solution of a system of n x n linear equations using Gauss elimination method with partial pivoting. The program is for 10 x 10 system or higher order system.

5. ASSIGNMENT – 5
Objective: Matrix inversion and solution of n x n system of equations using Gauss-Jordan method. If the system of equations is larger than 15 x 15 change the dimensions of the float statement.

6. ASSIGNMENT – 6
Objective: Program to solve a system of equation using Gauss-Seidel iteration method. Order of the matrix is n, maximum number of iterations *niter*, error tolerance is eps and the initial approximation to the solution vector is x_0. If the system of equations is larger than 10 x 10 change the dimension in float.

7. ASSIGNMENT – 7
Objective: Program to find the largest Eigen value in magnitude and the corresponding Eigen vector of a square matrix A of order n using power method.

8. ASSIGNMENT – 8
Objective: Program for Lagrange interpolation

9. ASSIGNMENT – 9
Objective: Program for Newton divided difference interpolation

10. ASSIGNMENT – 10
Objective: Program for Newton's forward and backward interpolation

11. ASSIGNMENT – 11
Objective: Program for Gauss's central difference interpolation (both backward and forward).

12. ASSIGNMENT – 12
Objective: Program to evaluate the integral of $f(x)$ between the limits a to b using Trapezoidal rule of integration based on n subintervals or n + 1 nodal points. The values of a, b and n are to be read. The program is tested for $f(x) = 1/ (1 + x)$

13. ASSIGNMENT – 13
Objective: Program to evaluate the integral of $f(x)$ between the limits a to b using Simpson's rule of integration based on 2n subintervals or 2n + 1 nodal points and the integrand is written as a function subprogram. The values of a, b and n are to be read. The program is tested for $f(x) = 1/ (1 + x)$

14. ASSIGNMENT – 14
Objective: Program to solve an IVP, dy/dx = f(x), $y(x_0) = y_0$ using Euler method. The initial value x_0, y_0, the final value x_f and the step size h are to be read. The program is tested for $f(x,y) = -2xy^2$.

15. ASSIGNMENT – 15
Objective: Program to solve an IVP, dy/dx = f(x), $y(x_0) = y_0$ using classical Runge-Kutta fourth order method with step size h, h/2 and also computes the estimate of the truncation error. Input parameters are: initial point, initial value, number of intervals and the step length h. Solutions with h, h/2 and the estimate of the truncation error are available as output. The right hand side The program is tested for $f(x,y) = -2xy^2$.

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
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 Faculty
2. Student Feedback on Course Outcome

Mapping Between Course Outcomes (COs) and Course Delivery Method

Course Outcomes	Course Delivery Method
CO1	
CO2	
CO3	
CO4	

COURSE INFORMATION SHEET

Course code: MT 131
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: Production and Industrial Engineering
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

- Assessment by faculty mentor: 10 marks
- Self-assessment: 10 marks
- Assessment by peers: 10 marks
- Socially relevant project/Group Activities/Assignments: 20 marks Semester
- End Examination: 50 marks

COURSE INFORMATION SHEET

Course code: PE 203
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 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 and Queuing theory for performance evaluation of engineering and management system.
CO5	Solve engineering and managerial decision theories problems by 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 **[9]**

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 **[7]**

Introduction, Characteristics of Game Theory, Two Person, Zero sum games, Pure strategy. Dominance theory, Mixed strategies (2x2, mx2), Algebraic and sub games 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]**

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

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.

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

POs 1-3, 12

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

Advanced Operation Research

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

POs 1, 3, 5, 7, 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
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	1		1		1			1	3	3	3	3
CO2	3	3	3	1		1	1	1	2		2	2	3	2	3
CO3	3	3	2			1	1		2		1	3	3	2	3
CO4	3	2	1			1	1	1	2		2	2	3	3	3
CO5	3	2	1			1			2		2	2	3	3	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: PE 214
Course title: METALLURGICAL AND MATERIALS ENGINEERING
Pre-requisite(s): None
Co- requisite(s): METALLURGICAL AND MATERIALS ENGINEERING LAB
Credits: 03 L:3 T: P:
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	

<u>Course Evaluation:</u>

Direct Assessment-

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

Progressive Evaluation	% Distribution
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	1	2	3
CO1	3	2	2	3			2		3	1		3	3	3	3
CO2	3	3	3	3	1	2	2			2		3	3	2	3
CO3	3	3	2	3	1	1	1		2			3	3	2	3
CO4	3	3	2	3	2	3	3	1	2		2	2	2	3	3
CO5	3	3	2	3	3	1			2	2		2	2	2	2

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

<u>Mapping Between Course Outcomes (COs) and Course Delivery Method</u>

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 215
Course title: METALLURGICAL AND MATERIALS ENGINEERING LAB
Pre-requisite(s): None
Co- requisite(s): METALLURGICAL AND 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 use tools, equipment, and measuring instruments related to metallographic study
3	Analyse 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	Use tools, equipment, and measuring instruments related to metallographic study
CO3	Analyze microstructure of metals/alloys (ferrous/non-ferrous)
CO4	Conduct heat treatment processes and analyze various factors related to those processes
CO5	Understand and explain non-conventional metallographic testing methods

SYLLABUS

LIST OF EXPERIMENT:

Experiment 1: Study of Metallurgical Microscope

Objective: To study the working of metallurgical microscope

Experiment 2: Sample Preparation (ferrous alloy) for metallography

Objective: To prepare the sample for microstructure study of mild steel specimen containing 0.1% carbon

Experiment 3: Microstructure study

Objective: To Observe the microstructure of mild steel specimen (0.1% Carbon) through metallurgical microscope

Experiment 4: Effect of quenching media on microstructure

Objective: To study the effect of quenching media on the hardness of steel specimens containing 0.2, 0.4, 0.6, 0.8 and 1.0% carbon

(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

Experiment 5: Effect of time of heat treatment on material property

Objective: To study the effect of period of time of heat treatment on the hardness of steel specimens containing 0.2, 0.4, 0.6, 0.8 and 1.0% carbon

(a) Calculation of optimum period of heat treatment for maximum hardness

(b) Observation of the microstructure through metallurgical microscope

Experiment 6: Effect of temperature of heat treatment on material property

Objective: To study the effect of temperature on the hardness of steel specimens containing 0.2, 0.4, 0.6, 0.8 and 1.0% carbon

(a) Calculation of optimum temperature for heating the steel specimens for maximum hardness

(b) Observation of the microstructure through microscope

Experiment 7: Effect of tempering temperature on Steel

Objective: To study the effect of tempering temperature on the properties of water quenched steel

Experiment 8: Effect of tempering time on Steel

Objective: To study the effect of tempering time on the properties of water quenched steel

Experiment 9: Jominy end-quench test

Objective: To conduct Jominy End Quenching test on a mild steel specimen.

Experiment 10: Non-ferrous alloy sample preparation

Objective: To prepare the sample for study of microstructure of Aluminum Alloy.

Experiment 11: Non-ferrous alloy microstructure study

Objective: To Observe the microstructure of Aluminum alloy through Metallurgical microscope.

Experiment 12: Recent methods for microstructure and materials property analysis

Objective: To Demonstrate the basic principle and working of modern testing methods such as XRD, SEM, TEM

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 are 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 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 Faculty
2. 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	1	2	2
CO1	3				3				1				1	1	1
CO2		2			3				2				1	1	1
CO3				2					2				2	2	2
CO4				3					2				2	2	2
CO5	2			3	3		2			2		2	2	2	2

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

<u>Mapping Between Course Outcomes (COs) and Course Delivery Method</u>

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

COURSE INFORMATION SHEET

Course code: ME 205
Course title: STRENGTH OF MATERIALS
Pre-requisite(s): BASICS OF MECHANICAL ENGINEERING, MATHEMATICS COURSE WITH ORDINARY DEFERENTIAL EQUATIONS
Co-requisite(s):
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 the nature of stresses developed in structural members such as beams, shafts, curved bars, cylinders and spheres for various types of simple loads.
2	Calculate the elastic deformation and deflection occurring in various simple geometries for different types of loading.

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

CO1	Understand the basic Strength of Materials theorems and to apply the concept in structural problems.
CO2	Analyze different structural bodies viz. beam, column, circular ring, cylinder and rotating disc.
CO3	Evaluate the influence of various geometric and loading parameters of structural bodies.
CO4	Compare the results obtained from bending theory of beam and strain energy method of structural problems.
CO5	Create new ideas in the field of Solid Mechanics and Design.

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 Beam, 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 Beam, Double integration method, Macaulay's method, Moment area method, Buckling of column. Strain energy method, Castigliano's theorem, application of energy method on different types of beam and thin circular ring.

Module: 4 **[9]**

Torsion of circular shafts, Shear Centre: Theory of shear flow, shear flow diagrams and shear centre for thin-walled symmetrical sections, Bending of curved beams: Beams of small and large initial curvature, evaluation of circumferential stresses.

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. (**T1**)
2. Strength of Materials by S.S.Rattan. (**T2)**

Reference Books:

1. Mechanics of Materials by S. Timoshenko and James M. Gere. (**R1**)
2. Strength of Materials by Ryder. (**R2**)
3. Advanced Mechanics of Material by Seely & Smith (**R3**)

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

Combined stresses

POs met through Gaps in the Syllabus:

POs 1-5

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**
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	2	1	1		1	1		1			2	2	2	2
CO2	3	3	2	2		1	1		2			2	2	1	2
CO3	3	3	2	3		1	1		2			2	2	1	2
CO4	3	3	3	3		1	1		2	1		2	2	1	2
CO5	3	2	3	3	2	1	1	1	2		1	2	2	1	2

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, 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: ME 289
Course title: THERMAL AND FLUID ENGINEERING
Pre-requisite(s): BASIC OF PHYSICS, CHEMISTRY, MATHEMATICS-I
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2						1		2	3	2	3
CO2	3	3	3	2						1		2	3	2	3
CO3	3	3	3	2						1		2	3	2	3
CO4	3	3	3	2						1		2	3	2	3
CO5	3	3	3	2						1		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 204
Course title: MECHANICAL ENGINEERING LAB - I
Pre-requisite(s): BASICS OF MECHANICAL ENGINEERING
Co-requisite(s): STRENGTH OF MATERIALS
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	Make student familiar with modern and conventional tools for material testing.
2	Present real-world engineering examples of solid mechanics.

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

CO1	Examine the hardness of materials (Hard steel and mild steel).
CO2	Evaluate the tensile and impact strength of materials.
CO3	Validate truss analysis for redundant truss and statically indeterminate trusses results experimentally.
CO4	Analysis of rods.
CO5	Compare the properties of two different lifting machines (Self-locking system)

<u>SYLLABUS</u>

LIST OF EXPERIMENT:

1. **EXPERIMENT – 1**
Objective: To determine Brinell hardness number of mild steel

2. **EXPERIMENT – 2**
Objective: To determine Rockwell hardness number (HRC Scale) of hard steel.

3. **EXPERIMENT – 3**
Objective: To determine the tensile strength of mild steel

4. **EXPERIMENT – 4**
Objective: To determine the impact strength of hard steel using conventional method.

5. **EXPERIMENT – 5**
Objective: To determine impact strength of mild steel using computer aided system.

6. **EXPERIMENT – 6**
Objective: To determine forces in members of statically determinant truss

7. **EXPERIMENT – 7**
Objective: To determine forces in members of statically indeterminant truss

8. **EXPERIMENT – 8**
Objective: To determine the property of proving ring

9. **EXPERIMENT – 9**
Objective: To determine shear force in a simply supported beam

10. **EXPERIMENT – 10**
Objective: To determine bending moment in simply supported beam

11. **EXPERIMENT – 11**
Objective: To determine the modulus of rigidity of a shaft using Torsion test.

12. **EXPERIMENT – 12**
Objective: To determine the properties of Screw Jack

13. **EXPERIMENT – 13**
Objective: To determine the properties of Worm and Worm Wheel

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 Faculty
2. 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	15
CO1	1	1	1	3	3			3	3	3			2	1	2
CO2	1	3	2	3	3			3	3	3			2	1	2
CO3	3	3	3	3	3			3	3	3			2	1	1
CO4	3	3	3	3	3			3	3	3			2	1	1
CO5	3	3	3	3	1			3	3	3			2	1	1

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, CD3
CO2	CD1, CD3
CO3	CD1, CD3
CO4	CD1, CD3
CO5	CD1, CD3

COURSE INFORMATION SHEET

Course code: ME 207
Course title: KINEMATICS AND DYNAMICS OF MACHINES
Pre-requisite(s): BASICS OF MECHANICAL ENGINEERING
Co- requisite(s): None
Credits: 3 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:

1	To understand basic principles of kinematic chains, Degree of freedom.
2	To analyse velocity and acceleration of planar mechanisms, balancing in rotary and reciprocating machinery, forces and moments acting in planar mechanism
3	To evaluate and design contact ratio, tooth profile and related parameters of gears.
4	To design cam profiles for specified motion of follower, Flywheel and governor.
5	To Understand vibration characteristics of single degree of freedom system and working principles of gyroscope.

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

CO1	Demonstrate various principles related to kinematics of planar mechanisms
CO2	Design planar mechanisms for relevant applications
CO3	Evaluate dimensions and kinematic parameters related to gear systems
CO4	Design cam profiles
CO5	Evaluate natural frequency of simple vibrating system, gyroscopic couple and precessional velocity of a gyroscopic system.

SYLLABUS

Module 1: Planar mechanisms and kinematic analysis [8]

Mechanisms and machines, Kinematic pairs, Kinematic chains, Kinematic inversions, Mobility and range of movement, Velocity and acceleration analysis (graphical and analytical), Coriolis' component of acceleration, Instantaneous centre of zero velocity, Aronhold-Kennedy theorem of three centres.

Module 2: Force analysis and principles flywheel and Governor: [8]

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 3: Balancing **[8]**
Balancing of rotating masses, Two plane balancing, Balancing of inline, V tween, and radial engines, principles of balancing machines

Module 4: Gear and Cam **[8]**
Basic terminology of a spur gear, Types of gears, Fundamental law of gearing, contact ratio, Interference and undercutting, Gear trains, Basic terminology cam, Displacement diagram, Velocity and acceleration of follower, Graphical determination of cam profiles

Module 5: Gyroscope and Vibrations **[8]**
Euler's equation of motion, Euler's modified equation of motion, Steady state, Stability of spinning top, ship, two wheeled and four wheeled vehicle, Basic elements of vibration, Lumping of parameters, Types of vibration, (a) Free undamped, (b) Damped and (c) forced vibration of a single degree of freedom system, Logarithmic decrement, Transmissibility, Vibration isolation, Torsional and transverse vibrations.

Text books:

1. A. Ghosh and A. K. Mallik, Theory of Mechanisms and Machines, Affiliated East-West Press Privet Limited, Third edition. **[T1]**
2. Thomas Bevan, The theory of Machines, CBS Publishers and Distributers Privet Limited, Third edition. **[T2]**
3. R. L. Norton, Kinematics and Dynamics of Machinery, McGraw Hill Education **[T3]**

Reference books:

1. John J. Uicker, Gordon R. Pennock and Joseph E. Shigley, Theory of Machine and Mechanisms, Oxford University Press; 4th edition. **[R1]**
2. J. L. Meriam and L. G. Kraige, Engineering Mechanics: Dynamics, John Wiley and Sons Inc. Seventh edition. **[R2]**
3. S. S. Rattan, Theory of Machines, Tata McGraw Hill education, Third Edition. **[R3]**

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>
Detailed force analysis of gear and cam

<u>POs met through Gaps in the Syllabus:</u>
POs 1-5

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Balancing of locomotives

<u>POs met through Topics beyond syllabus/Advanced topics/Design:</u>
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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	3	3	1	1	1	2	1	1	1	1	1	1
CO2	3	3	3	3	3	1	1	1	1			1	1	1	1
CO3	3	3	3	3	3	1	1	1	1			1	1	1	1
CO4	3	3	3	3	3	1	1	1	1	1	1	1	2	1	1
CO5	3	3	3	3	3	1	1	1	2		1	1	1	1	1

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
CO2	CD1, CD2
CO3	CD1, CD2
CO4	CD1, CD2
CO5	CD1, CD2

COURSE INFORMATION SHEET

Course code: PE 216
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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	1	1	1				1	1	3	3	2	3
CO2	3	2	1			1				1	2	2	3	1	3
CO3	3	3	3			1				1	1	3	3	2	3
CO4	3	2	1			1	1	1		1	2	2	3	1	3
CO5	3	2	1							1	2	2	3	1	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: PE 217
Course title: FOUNDRY, FORMING AND WELDING LAB
Pre-requisite(s): None
Co- requisite(s): FOUNDRY, FORMING AND WELDING TECHNOLOGIES
Credits: 1.5 L:0 T:0 P: 3
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 different patterns used in sand casting.
2	Get familiar with sand testing and drawing inference from it.
3	Get hands on experience of arc welding and selecting best technique in engineering practices.
4	Develop skills on ultrasonic welding and spot welding.
5	Know different techniques used in polymer processing.

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

CO1	Distinguish and develop the patterns used in sand casting.
CO2	Judge the composition of molding sand for sand casting.
CO3	Compare arc welding processes and identify their respective applications.
CO4	Classify welding process and identify their respective applications.
CO5	Discriminate between the processes used in polymer processing.

SYLLABUS

LIST OF EXPERIMENT:

1. **FOUNDRY SHOP**
   EXPERIMENT – I: Pattern Study
   Objective: To study different types of pattern used in sand casting.

2. **CARPENTARY SHOP**
   EXPERIMENT-I: Pattern Making
   Objective: To prepare a single piece wooden pattern according to given dimension for Al casting.

3. **FOUNDRY SHOP**
   EXPERIMENT-II: Permeability Test
   Objective: To determine the permeability number for given molding sand sample.

4. **FOUNDRY SHOP**
EXPERIMENT-III: Moisture Test
Objective: To determine the amount of moisture for given molding sand sample.

5. **FOUNDRY SHOP**
EXPERIMENT-IV: Clay Content Test
Objective: To determine the amount of clay for given molding sand sample.

6. **FOUNDRY SHOP**
EXPERIMENT-V: Grain Fineness Number
Objective: To determine the Grain fineness number for given molding sand sample.

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

8. **WELDING SHOP**
EXPERIMENT-II: Gas Metal Arc Welding
Objective: To determine metal deposition rate in GMAW.

9. **WELDING SHOP**
EXPERIMENT-III: Submerged Arc Welding
Objective: To study Submerged arc welding equipment and perform SAW welding.

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

11. **POLYMER**
EXPERIMENT-I: Ultrasonic Welding
Objective: To study ultrasonic welding setup and perform plastic welding using the same.

12. **POLYMER**
EXPERIMENT-II: Blow Molding
Objective: To study blow molding equipment and perform molding operation.

13. **POLYMER**
EXPERIMENT-III: Injection Molding
Objective: To study injection molding machine and perform molding operation.

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 Faculty
2. 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	15
CO1	3	1	3						3	2	1	1	3	1	3
CO2	3	1	1	3					3	2	1	1	3	1	3
CO3	3	1	1	1					3	2	1	1	3	1	3
CO4	3	2	1	1					3	2	1	1	3	1	3
CO5	3	1	1						3	2	1	1	3	1	2

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

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 218
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2	2		1		1	2	3	3	3	2	3
CO2	3	3	1	2	2		1		1	2	3	2	3	2	3
CO3	3	3	3	2	2		1		1	2	2	3	3	2	3
CO4	3	3	1	2	2		1		1	2	2	2	3	2	3
CO5	3	3	1	3	2		1		1	2	2	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: PE 219
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: IV / Second
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	

<u>Course Evaluation:</u>

Direct Assessment-

Assessment Tool	**% Contribution during CO Assessment**				
Progressive Evaluation	50				
End Semester Examination	50				
Progressive Evaluation	**% Distribution**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	1	1	1								3	2	1	2	2
CO2	1					2	3	1			1		3	1	3
CO3		3	2	3	1				1		1	1	1	3	3
CO4		2	1	1	1						1		2	3	3
CO5		2					1		2	3	2	1	1	2	3

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

<u>Mapping Between Course Outcomes (COs) and Course Delivery Method</u>

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 210
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**
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√	√	√	
Quiz 2	√	√	√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	2	2	1	2				2	1		1	1	1	3
CO2	3	3	3		2	1	1		2	2			2	2	3
CO3	2	3	3	3	3	2	2	1	2	2	2	2	3	1	3
CO4	2	2	2	1	2		1		1	2	1	1	2	1	3
CO5	3	3	3	2	3	2	2	1	2	3	2	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 220
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)**

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

Control charts and acceptance sampling plans

<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
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3		1					1	1	3	3	2	3
CO2	3	2	1		2					1	2	2	3	1	3
CO3	3	3	3		2		1			1	1	3	3	2	3
CO4	3	2	1				1	1		1	2	2	3	1	3
CO5	3	2	1							1	2	2	3	1	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 221
Course title: QUANTITATIVE TECHNIQUES
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

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

CO1	Conduct descriptive data analysis including various measures of central tendency and dispersion
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 based on orthogonal arrays

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, Quartile deviation, Inter-quartile range, Percentiles

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, Managing Total Survey Error

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 in Practice, 5th Edition, Tata McGraw Hill **(R1)**
2. Anderson, Sweeney and Williams, Statistics for Business and Economics, 11th Edition, 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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	2	2	2	1	1	1	1		1	1	3	3	3
CO2	3	3	2	2	2	1	1	1	1	2	1	1	3	3	3
CO3	3	3	2	2	2	1	1	1	1		1	1	3	3	3
CO4	3	3	2	2	2	1	1	1	1		1	1	3	3	3
CO5	3	3	2	3	2	1	1	1	1		1	1	3	3	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 222
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

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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	

<u>Course Evaluation:</u>

Direct Assessment-

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

Progressive Evaluation	% Distribution
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	2	1	2	3							2	3	2	3
CO2	3	2	2	2	3							2	3	2	3
CO3	2	2	1	2	1							2	3	2	3
CO4	2	3	3	2	1							2	3	2	3
CO5	3	3	2	3	2							2	3	2	3

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

<u>Mapping Between Course Outcomes (COs) and Course Delivery Method</u>

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 209
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

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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)**

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

Business Ratios, Decision Making under Risk

POs met through Gaps in the Syllabus:

PO 1-5

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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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

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

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, 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 227
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	12
CO1	3	2	2	3			2		3	1		3
CO2	3	3	3	3	1	2	2			2		3
CO3	3	3	2	3	1	1	1		2			3
CO4	3	3	2	3	2	3	3	1	2		2	2
CO5	3	3	2	3	3	1			2	2		2

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

<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 225
Course title: MODELLING 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]**

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

Warehouse and logistic simulation

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

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 Faculty
2. 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	15
CO1	1	2			3		1				1	1	2	2	2
CO2		2	2	3	2	1		1				1	1	3	3
CO3		2		3	3		1	1	3		1		2	3	3
CO4			2	2	2	1			2	2		1	3	2	2

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

<u>Mapping Between Course Outcomes (COs) and Course Delivery Method</u>

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: EE 102
Course title: ELECTRICAL ENGINEERING LABORATORY
Pre-requisite(s): PHYSICS, FUNDAMENTALS OF MATHEMATICS AND ELECTRICAL ENGINEERING
Co- requisite(s): None
Credits: 1.5 L:0 T:0 P: 3
Class schedule per week: 3
Class: B.Tech.
Semester / Level: IV / First
Branch: All
Name of Teacher:

Course Objectives:
This course enables the students:

1	To describe 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:
At the end of the course, a student should 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	Analyse response of a circuit and calculate unknown circuit parameters
CO5	Recommend and justify power factor improvement method in order to save electrical energy

SYLLABUS

LIST OF EXPERIMENT:

1. **EXPERIMENT – 1: Measurement of low & high resistance of DC shunt motor**
Objective: (i) To measure low resistance of armature winding of DC shunt motor
(ii) To measure high resistance of shunt field winding of DC shunt motor.

2. **EXPERIMENT – 2: AC series circuit**

Objective: (i) To obtain current & voltage distribution in AC RLC series circuit and to draw phasor diagram

(ii) To obtain power & power factor of single-phase load using 3- Voltmeter method and to draw phasor diagram

3. **EXPERIMENT – 3: AC parallel circuit**

Objective: (i) To obtain current & voltage distribution in AC RLC parallel circuit and to draw phasor diagram

(ii) To obtain power & power factor of single-phase load using 3- Ammeter method and to draw phasor diagram

4. **EXPERIMENT – 4: Resonance in AC RLC series circuit**

Objective: (i) To obtain the condition of resonance in AC RLC series circuit

(ii) To draw phasor diagram

5. **EXPERIMENT – 5: 3 phase Star connection**

Objective: (i) To establish the relation between line & phase quantity in 3 phase star connection

(ii) To draw the phasor diagram

6. **EXPERIMENT – 6: 3 phase Delta connection**

Objective: (i) To establish the relation between line & phase quantity in 3 phase delta connection

(ii) To draw phasor diagram

7. **EXPERIMENT – 7: 3 phase power measurement**

Objective: (i) To measure the power input to a 3-phase induction motor using 2 wattmeter method

(ii) To draw phasor diagram

8. **EXPERIMENT – 8: Self & mutual inductance**

Objective: To determine self & mutual inductance of coils

9. **EXPERIMENT – 9: Verification of Superposition, Thevenin's and Reciprocity theorem**

Objective: (i) To verify Superposition theorem for a given circuit

(ii) To verify Thevenin's theorem for a given circuit

10. **EXPERIMENT – 10: Verification of Norton's, Tellegen's and Maximum Power transfer theorem**

Objective: (i) To verify Norton's theorem for a given circuit

(ii) To verify Maximum Power transfer 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:

POs 1-3,7

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++ softwares
2. Active/reactive power calculation for 3 – Φ circuits

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

POs 5,6, 9-11

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**
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 Faculty
2. 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	15
CO1	3	3	3	3	3	1	3	3	3	3	3	3	1	1	1
CO2	3	3	3	2	2	2	2	3	3	3	3	3	1	1	1
CO3	3	3	3	2	2	2	2	2	3	3	2	3	1	1	1
CO4	3	3	3	3	3	1	2	2	3	3	2	2	1	1	1
CO5	3	3	3	3	3	2	3	3	3	3	3	3	1	1	1

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, CD3, CD6
CO3	CD1, CD3, CD6, CD7
CO4	CD1, CD2, CD3, CD6
CO5	CD3, CD6

COURSE INFORMATION SHEET

Course code: PE326
Course title: METROLOGY & STATISTICAL QUALITY CONTROL
Pre-requisite(s): None
Co- requisite(s): METROLOGY AND MEASUREMENT LAB
Credits: 03 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 different measurement systems, standards of measurement, and about limits, fits, tolerance.
2	Understand the philosophy of quality improvement and use of statistics in quality control.
3	Understand and use process capability analysis and various control charts
4	Understand the concept of acceptance sampling, OC curves and preparation of acceptance sampling plans for attributes.
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.	To understand the basics of Metrology
CO2.	Understand the philosophy of quality improvement, basic concept of statistical quality control.
CO3.	Demonstrate the ability to design, use, and interpret control charts and perform analysis of process capability.
CO4.	Prepare and analyze sampling plans for attributes
CO5	Understanding the concept of TQM, ISO-9000 quality system, quality audit and six sigma.

SYLLABUS

Module 1: Introduction to metrology; Limits, fits, and tolerances [8]
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.
Interchangeability, 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.

Module 2: Introduction to quality control; Statistics in quality control [6]
Introduction to Quality Control, Statistics in quality control, Cost of Quality, Graphical and Analytical Methods for Central Tendency and Dispersion

Module 3: 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 4: Acceptance sampling plans **[10]**

100% Sampling Vs. Statistical Sampling, 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

Module 5: Quality management systems **[6]**

Quality Circle, Concept of 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. 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)**

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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√	√		
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	1	2	3
CO1	3	3	3		1					1	1	3	2	3	2
CO2	3	2	1		2					1	2	2	1	1	1
CO3	3	3	3		2		1			1	1	3	1	3	3
CO4	3	2	1				1	1		1	2	2	1	3	3
CO5	3	2	1							1	2	2	2	2	1

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: PE 327
Course title: METROLOGY AND MEASUREMENT LAB
Pre-requisite(s): None
Co- requisite(s): METROLOGY & STATISTICAL QUALITY CONTROL
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	Provide an understanding and appreciation of the science of measurement.
2	Expose to various measuring devices and understand the different degree of accuracy obtained from different types of instruments.
3	Impart knowledge and skill to use measuring tools and gauges
4	Handle appropriate measurement equipment or method for variables like strain, force, vibration

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

CO1	Be familiar with the different instruments that are available for linear, angular, and various geometric form measurements.
CO2	Select and use the appropriate measuring instrument according to a specific requirement (in terms of accuracy).
CO3	Learn how to measure various parameters related to different products or components in assembly and surface texture.
CO4	Measure cutting tool forces, vibration in machine tool, modulus of elasticity

SYLLABUS

LIST OF EXPERIMENT:

Experiment 1: Linear measurement I
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
To study the measurement of height and depth of a given work piece using height gauge and calculate the least count.

Experiment 3: Gauges
Study of Gauges (slip gauges/feeler gauge/Go-NO Go gauges etc.).

Experiment 4: Angular measurement
Measurement of angle using Sine bar, angle gauges

Experiment 5: Optical metrology I
To study the profiles of single point cutting tool (“V” tool) / thread by profile projector

Experiment 6: Optical metrology II
To study the working of optical flat and monochromatic light source.

Experiment 7: Screw Thread metrology
Measurement of Screw thread parameters using two wire or Three-wire method

Experiment 8: Comparator
To study the working of electronic comparator, measurement of thickness of given workpiece

Experiment 9: Surface Profile
To study the Taylor Hobson contour measurement instrument and determine the contour of a given test-piece.

Experiment 10: Dynamic measurement I
Measurement of cutting tool forces using tool Dynamometer

Experiment 11: Dynamic measurement II
Determination of modulus of elasticity of a mild steel specimen using strain gauges

Experiment 12: Dynamic measurement III
To study the piezoelectric accelerometer and determine the vibration response of machine tool during operation

Books recommended:
TEXT BOOK

1. 1. R.K. Jain, Engineering Metrology Khanna Publications, New Delhi **(T1)**
2. 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)**

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>
Limited number of advanced equipment/techniques.

POs met through Gaps in the Syllabus:
PO 5

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

POs met through Topics beyond syllabus/Advanced topics/Design:
PO 5, PO 6-8, PO 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 Faculty
2. 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	15
CO1	3	2		3					3	3		2	2	3	2
CO2	3	2		3					3	3		2	2	3	2
CO3	3	2		3					3	3		2	2	3	2
CO4	3	2		3					3	3		2	2	3	2

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

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 328
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 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:

CO1	Apply the basic design principles for design of machine elements
CO2	Able to design cotter, knuckle and weld joints
CO3	Able to design bolted and riveted joints
CO4	Able to design shaft and coupling, belt and chain drives
CO5	Able to design power screws, screw jack, helical springs and spur gear

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 weld 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 [6]
Design of bolted joints: Metric thread, standard sizes, use of lock nuts and washers; Applications in structures including brackets; 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 simple structures under static loading; Joint efficiencies.

Module 4: Shaft and coupling, belt and chain drive **[10]**

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, (d) Chain drives – roller chains, polygonal effect, power rating, sprocket wheel.

Module 5: Power screws, helical springs and spur gear **[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]**

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

Design of welded, riveted and bolted joints under dynamic loading; design of flexible couplings; applications of riveted joints in pressure vessels

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

POs 1-4, 12

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

Design of clutches and brakes, screw jack, bevel and helical gears

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

POs 1-4, 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	

Course Evaluation:

Direct Assessment-

Assessment Tool	% Contribution during CO Assessment				
Progressive Evaluation	50				
End Semester Examination	50				
Progressive Evaluation	**% Distribution**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	1						1		2	2	2	3
CO2	3	3	3	1						1		2	2	2	3
CO3	3	3	3	1						1		2	2	2	3
CO4	3	3	3	1						1		2	2	2	3
CO5	3	3	3	1						1		2	2	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 329
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]**

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

<u>POs met through Gaps in the Syllabus:</u>
POs 1,2, 12

<u>Topics beyond syllabus/Advanced topics/Design:</u>
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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	3	1			1				1	1	3	3	1	2
CO2	3	3	1			2				1	2	2	3	1	2
CO3	3	3	1			1				1	1	3	3	1	2
CO4	3	3	2	1		1				1	2	3	3	1	2
CO5	3	3	1			1	1			1	2	2	3	1	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: PE 330
Course title: MACHINE TOOLS LAB
Pre-requisite(s): None
Co- requisite(s): MACHINING SCIENCE AND MACHINE TOOLS
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	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 – I: Center Lathe
Objective: To perform different types of center lathe operation on job as per given dimensions.

2. **MACHINE SHOP**
EXPERIMENT-II: Equipment Study
Objective: To study different types of lathe attachments and milling cutters.

3. **MACHINE SHOP**
EXPERIMENT-III: Capstan Lathe
Objective: To obtain final job as per given dimensions using different types of lathe operation on Capstan lathe.

4. MACHINE SHOP
EXPERIMENT-IV: Turret Lathe
Objective: To perform taper turning on given job using turret lathe

5. MACHINE SHOP
EXPERIMENT-V: Retrofitted Lathe
Objective: To study retrofitting attachment used on lathe

6. MACHINE SHOP
EXPERIMENT-VI: Center Lathe
Objective: To perform external thread cutting operation on given job.

7. MACHINE SHOP
EXPERIMENT-VII: Slab Milling
Objective: To perform slab milling operation on job using slab milling cutter on horizontal knee type milling machine.

8. MACHINE SHOP
EXPERIMENT-VIII: Gear Cutting
Objective: To cut a tooth on gear blank using simple indexing mechanism.

9. MACHINE SHOP
EXPERIMENT-IX: Shaper Machine
Objective: To obtain hexagonal prismatic shape on rectangular job using shaper machine.

10. MACHINE SHOP
EXPERIMENT-X: Slotter Machine
Objective: To cut a slot on a job as per given dimensions.

11. MACHINE SHOP
EXPERIMENT-XI: Tool Grinding
Objective: To grind a single point cutting tool as per ASA tool signature.

12. ADVANCE MACHINE SHOP
EXPERIMENT-I: Die Sinking Electro Discharge Machine
Objective: To study Electro Discharge Machine (EDM) and its process parameter, calculate material removal rate for a particular parameter setting

13. ADVANCE MACHINE SHOP
EXPERIMENT-II: Wire cut EDM
Objective: To study wire cut EDM and cut a job as per given dimensions using NC programming.

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**
Day to day performance & Lab files	√	√	√	√	√
Quiz 1	√	√	√	√	√
Quiz 2	√	√	√	√	√
Viva-voce	√	√	√	√	√
Examination: Experiment Performance	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	1	1						3	2	1	1	3	1	2
CO2	3	2	1						3	2	1	1	3	1	2
CO3	3	1	1	1					3	2	1	1	3	1	2
CO4	3	1	1	1					3	2	1	1	3	1	2
CO5	3	1	1						3	2	1	1	3	1	2

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

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 331
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 Design & Drafting (CAD)
2	To understand the various types of CAD Software's like CATIA V5, Unigraphics NX, etc. and their practical usage in Manufacturing applications
3	Understand concepts of Designing various components of Manufacturing jobs
4	Develop Industrial components by interpreting 3D part models/ part drawings
5	Understand the concepts of CAD Software, Design. The student also is enabled to prepare the assembly of various machine or engine components and miscellaneous machine components, with focus on Industrial Applications

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

CO1	Apply the concepts of concepts of designing using 3D modeling software
CO2	Create Designs of various real-world Industrial components by using mechanical design Software's like CATIA, Unigraphics NX, etc.
CO3	Produce an industrial component by interpreting 3D part model/ part drawings using Computer Aided Design, Drafting & Analysis.
CO4	Apply the concepts of CAD Drawings and Assemble various components of Manufacturing with focus on Industrial Applications
CO5	Develop Prototype models by interpreting 3D part model/ part drawings& Assemblies

SYLLABUS

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 revolve 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, mirror & offset

5. **EXPERIMENT – 5: Exercise on Hole & Pattern**
Objective: To practice models having hole and models with various pattern features

6. **EXPERIMENT – 6: Exercise on Ribs & Shell**
Objective: To practice models with ribs & shell features

7. **EXPERIMENT – 7: Exercise on Sweep & Blend**
Objective: To practice models with Sweep & blend commands

8. **EXPERIMENT – 8: Exercise on Datum plane & Axis**
Objective: To practice datum planes and various types of datum axes

9. **EXPERIMENT – 9: Exercise on Machine Drawing Assembly**
Objective: To practice Assembly of Foot-step Bearing/ Plumber-Block

10. **EXPERIMENT – 10: Exercise on Slider-crank Assembly**
Objective: To practice assembly drawings of slider-crank, Bench-vice assembly.

11. **EXPERIMENT – 11: Exercise on Piston Assembly**
Objective: To practice assembly drawings of Piston assembly.

12. **EXPERIMENT – 12: Exercise on Manufacturing Simulation**
Objective: To demonstrate the Basics of Manufacturing Simulation with an Example on Z-CAST- Casting Simulation

Text Books

1. Rao, P.N. CAD/CAM: Principles and Applications, McGraw Hill Publication, 2nd Edition, 2004. **(T1)**
2. Machine Drawing –K.L. Narayana, P.Kannaiah & K. Venkata Reddy / New Age/ Publishers. **(T2)**
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. Radhakrishan P., Subramaniyam S., CAD CAM and CIM, New Age International, 2002 **(R2)**

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>
Design of real-time Industrial projects.

<u>POs met through Gaps in the Syllabus:</u>
POs 1-5

Topics beyond syllabus/Advanced topics/Design:
Design Software for various analyses of component/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 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 Faculty
2. 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	15
CO1	3	2	1	1						1		1	2	1	2
CO2	2	2	3	1								1	3	2	2
CO3	3	3	3	1								2	2	2	3
CO4	3	3	2	2	2					1		3	2	2	3
CO5	3	3	3	2	2					1		3	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, CD3, CD6
CO2	CD1, CD3, CD6
CO3	CD1, CD3, CD6
CO4	CD1, CD3, CD6
CO5	CD1, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 306
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)**

<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	

Course Evaluation:

Direct Assessment-

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

Progressive Evaluation	**% Distribution**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	2	3	3						3	2	3	3	3
CO2	3	3	2	3	3						3	2	3	3	3
CO3	3	3	2	3	3						3	2	3	3	3
CO4	3	3	2	3	3						3	2	3	3	3
CO5	3	3	2	3	3						3	2	3	3	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 307
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.

<u>SYLLABUS</u>

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, 6^{th} 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
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	2	3	2	2	1	1	1		1	1	3	3	2	2
CO2	3	2	1	1	1	1			1	1	2	2	3	1	3
CO3	3	3	2	1		1		1	1	1	1	3	3	2	3
CO4	3	2	1	1	1	1		1	1	1	2	2	3	1	3
CO5	3	2	1	1				1	1	1	2	2	3	1	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: PE 317
Course title: ADVANCED WELDING TECHNOLOGY
Pre-requisite(s): METALLURGICAL AND 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]**

<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>

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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	2	2	1								2	3	2	3
CO2	3	2	2	1	1							2	3	2	3
CO3	3	3	3	2	1							2	3	3	3
CO4	3	3	3	2	1					1		2	3	3	3
CO5	3	3	3	2	1							3	3	3	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 351
Course title: FINITE ELEMENT METHODS
Pre-requisite(s): MATHEMATICS; 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:

1	To present a comprehensive treatment on finite element methods.
2	To lay the groundwork for subsequent studies in the fields of stress, 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.	To understand the fundamentals of Finite Element Methods.
2.	To develop an intuitive understanding of finite element techniques by emphasizing the engineering arguments.
3.	To apply the finite element methods for solving differential equations arising in solid and fluid mechanics.
4.	To evaluate the stresses, strains in real-world examples related to mechanical engineering
5.	To analyze the strength of the mechanical members.

SYLLABUS

Module 1: **[7]**

Overview of engineering systems: Continuous and discrete systems. Introduction to finite element method.

Module 2 **[11]**

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 3 **[9]**

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 4 **[9]**

Finite elements for two-dimensions: Equivalence between energy formulation and Galerkin approach, discretization concepts, choice of elements, derivation of element shape functions (Lagrangian and Hermite) in physical coordinates, Iso-parameteric mapping, numerical integration.

Module 5 **[9]**

Generate shape function and natural coordinates; solving finite element problems using code/software.

Books:

Text books:

1. S.S. Rao, The Finite Element Method in Engineering, 5th Ed., Butterworth-Heinemann, 2012. (**T1**)
2. T.R. Chandrupatla, A.D. Belegundu, Introduction to Finite Elements in Engineering, 3rd Ed., PHI Learning Pvt. Ltd, 2002. (**T2**)
3. T3. 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. (**T3**)

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)

Implementation of finite element methods in computer codes

POs met through Gaps in the Syllabus

PO1 TO PO6 & PO9

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	

Course Evaluation:

Direct Assessment-

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

Progressive Evaluation	% Distribution				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	-	-	1	2	-	1	1	-	-	2	3	2	3
CO2	3	3	2	-	3	2	1	1	2	2	-	2	3	2	3
CO3	3	3	3	2	3	3	1	1	2	2	2	2	3	2	3
CO4	3	3	2	3	3	3	1	1	2	-	-	2	3	2	3
CO5	3	3	3	3	3	3	1	2	3	2	2	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 318
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
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	1	2		3	2		1	1	1			1	2	1	2
CO2	1	3	1	2					2			1	2	2	2
CO3	1		2	1		1			1				3	1	3
CO4		2	2	1	2		1		1	2			3	1	3
CO5	1	3		1	1		1		2	1		1	2	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 319
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]**

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

Finite Element Method, Slip Line method

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

POs 1-5

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

Upper Bound Solution

<u>POs met through Topics beyond syllabus/Advanced topics/Design:</u>
POs 1-5

<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
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	2	2	3	2		1		2		1	2	2	3	2
CO2	3	3	2	3	3	2	1					2	2	3	2
CO3	3	3	3	3	3				2	2		2	2	2	2
CO4	1	2		2	3	2	2	3	1	2		1	3	2	2
CO5	2			2		2	3	1			1	2	1	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: PE 322
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2								2	3	2	3
CO2	3	3	3	2						1		2	3	2	3
CO3	3	3	3	2						1		2	3	2	3
CO4	3	3	3	2						1		2	3	2	3
CO5	3	3	3	2						1		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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: ME 377
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 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.	Understand the importance of mechatronics and its application in real world.
2.	Know for the latest design considerations and concepts in new products
3.	Analyze different systems and take challenges to design newer technology
4.	Understand the different components like drives and sensors
5.	Outline the concepts changes done and what are the needs and advantages of implementing Mechatronics.

SYLLABUS

Module 1: Introduction **[8]**

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]**

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]**

Microprocessors, Microcontrollers, Drives, Linear motion bearings, cams, and ball screws, PID controllers, Closed Loop and Open loop

Module 4: Actuators **[8]**

Servo motors, Stepper motors, Hydraulic actuators, Flow, Pressure and Direction control valves, Pneumatic Actuators, Distribution and conditioning of Compressed air, sytem components and graphic representations

Module 5: CNC Technology and Robotics **[10]**

CNC Machines and Part programming, Real time Systems, Industrial Robotics, Case Studies

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

<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
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5

End Semester Examination	% Distribution				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	-	-	1	2	-	1	1	-	-	2	3	2	2
CO2	3	3	2	-	3	2	1	1	2	2	-	2	3	2	2
CO3	3	3	3	2	3	3	1	1	2	2	2	2	3	2	2
CO4	3	3	2	3	3	3	1	1	2	-	-	2	3	2	2
CO5	3	3	3	3	3	3	1	2	3	2	2	2	3	2	2

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: PE 309
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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	12
CO1	2		2								3	1
CO2	1	1			1		3			1	2	
CO3	1		2			2			2		3	2
CO4		2	2	2							2	
CO5	1				2			2		1	2	1

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, 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 315
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	12
CO1	3	3	3	2	2	1	1		1	2	2	3
CO2	3	3	2	2	2	1	1		1	2	2	2
CO3	3	3	3	2	3	1	1		1	2	2	3
CO4	3	3	2	2	2	1	1		1	2	2	2
CO5	3	3	2	3	3	1	1		1	2	2	2

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: PE 334
Course title: MACHINE TOOL DESIGN
Pre-requisite(s): METALLURGICAL AND 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 Spindle **[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

4. A. Bhattacharya and S. G. Sen., Principles of Machine Tool, New central book agency Calcutta. **(T1)**
5. N.K. Mehta, Machine Tool Design and Numerical Control, Tata McGraw Hill. **(T2)**
6. 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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2								2	3	2	3
CO2	3	3	3	2						1		2	3	2	3
CO3	3	3	3	2						1		2	3	2	3
CO4	3	3	3	2						1		2	3	2	3
CO5	3	3	3	2						1		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: PE 335
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)**

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

Design of spindles

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

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 Faculty
2. 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	15
CO1	2	2	1	1						1		1	2	2	2
CO2	3	2	2	1								2	3	2	3
CO3	3	3	3	2						1		3	3	2	3
CO4	3	3	3	2						1		3	3	2	3
CO5	3	3	3	2						1		3	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, CD3, CD6
CO2	CD1, CD3, CD6
CO3	CD1, CD3, CD6
CO4	CD1, CD3, CD6
CO5	CD1, CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 338
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)**

<u>Gaps in the syllabus (to meet Industry/Profession requirements):</u>
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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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

COs	**POs**												**PSOs**		
	1	2	4	4	5	6	7	8	9	10	11	12	13	14	15
CO1	1	1	1	2	1						2	1	1	3	3
CO2	1	1	1	1	1						2	1	1	2	3
CO3	1	2	1	2	1						3	2	1	3	3
CO4	1	2	1	2	1						3	1	1	3	3
CO5	1	2	1	2	1					1	2	1	1	3	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, 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 345
Course title: WORK SYSTEM DESIGN
Pre-requisite(s): None
Co- requisite(s): WORK STUDY AND ERGONOMICS 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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	1	2	3
CO1	3	3	3	2	2	1	1		1	2	2	3	3	2	3
CO2	3	3	2	2	2	1	1		1	2	2	2	3	2	3
CO3	3	3	3	2	3	1	1		1	2	2	3	3	2	3
CO4	3	3	2	2	2	1	1		1	2	2	2	3	2	3
CO5	3	3	2	3	3	1	1		1	2	2	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: PE 346
Course title: WORK STUDY AND ERGONOMICS 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 draw process chat and learn best way of assembly.
2	Expose the students to various work sampling methods and performance evaluation.
3	Understand to evaluate multi activity chart.
4	Measure the effect of posture.
5	Evaluate the physical working capacity of various machine.

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

CO1	Draw different process chart and do time study.
CO2	Find idle time of operation and evaluate performance by different rating methods.
CO3	Prepare flow process chart as per given narrative.
CO4	Draw multi activity chart for any assembly.
CO5	Analyze the effect of posture in any operation by cycle ergometer and Wireless EMG

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**
   Objective: To find the idle tome by work sampling method.

6. **EXPERIMENT – 6: Performance evaluation**
   Objective: Performance evaluation by card rating.

7. **EXPERIMENT – 7: Time study**
   Objective: Time study for drilling and chamfering operations.

8. **EXPERIMENT – 8: Preparation of flow process chart**
   Objective: To prepare 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: Multiple activity chart**
    Objective: To make multiple activity chart from the given operations.

11. **EXPERIMENT – 11: Effect of posture**
    Objective: Effect of posture on the response to cycle ergometer exercise.

12. **EXPERIMENT – 12: Physical working capacity-I**
    Objective: Evaluation of physical working capacity by bio-mechanic machine like wireless EMG.

13. **EXPERIMENT – 13: Physical working capacity-II**
    Objective: Evaluation of physical working capacity by bio-mechanic machine like wireless EMG.

14. **EXPERIMENT-14: Physical working capacity-III**
    Objective: Evaluation of body temperature by thermal scanning camera.

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 work study and ergonomics.

POs met through Topics beyond syllabus/Advanced topics/Design:
PO-5, 6, 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 Faculty
2. 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	1	2	3
CO1	3	2		3					3			2	2	3	3
CO2	3	2		3					3			2	2	3	3
CO3	3	2		3					3			2	2	3	3
CO4	3	2		3					3			2	2	3	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	CD3, CD6
CO2	CD3, CD6
CO3	CD3, CD6
CO4	CD3, CD6
CO5	CD3, CD6

COURSE INFORMATION SHEET

Course code: PE 323
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)**

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

Small Projects and practical application for Human factor engineering in product design

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

POs 1-3, 12

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

AR AND VR application for Product design for reverse engineering and Maintenance

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

POs 1-3, 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	Case based learning	

Course Evaluation:

Direct Assessment-

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

Progressive Evaluation	% Distribution				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2			2			2		2	3	3	3
CO2	3	3	3	2						2		2	3	3	3
CO3	3	3	3	2						2		2	3	2	3
CO4	3	3	3	2			3			2		2	3	2	3
CO5	3	3	3	2						2		2	3	3	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: PE 324
Course title: SURFACE ENGINEERING AND LASER ADDITIVE MANUFACTURING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L: 03 T: 00 P: 00
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 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 [4]
Introduction to structure of solids: structure, morphology, energy, types and classification.
Surface dependent engineering properties: physical, chemical and mechanical – their definition, origin and importance.

Module 2: Mechanisms of Surface Degradation and Failures **[8]**

Common surface-initiated engineering degradation/failures and their mechanism: wear, friction, fatigue, corrosion, oxidation.

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 and Surface Coating Techniques **[16]**

Conventional surface modification methods: shot peening, flame and induction hardening, carburizing, nitriding, diffusion aided surface alloying

Surface coating techniques by chemical/electro-chemical routes: electro/electroless deposition, anodizing, galvanizing, etc.

Surface coating by physical routes: thermal/plasma spray, physical/chemical vapor deposition, sputtering, etc.

Module 4: Advanced Surface Modification Techniques **[6]**

Advanced surface modification methods: laser, plasma, ion and electron beam assisted surface engineering.

Module 5: Laser Additive Manufacturing **[6]**

Additive manufacturing vis-à-vis subtractive manufacturing, Advantages and challenges, recent trend and innovation, 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>:

<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
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	2	2	3	2	1	1	1	1	1	3	2	3	3
CO2	3	3	3	2	3	2	1	1	1	1	1	3	2	3	3
CO3	3	3	3	2	3	2	1	1	1	1	2	3	3	3	3
CO4	3	3	3	3	3	2	1	1	1	1	1	3	3	3	3
CO5	3	3	3	2	3	2	1	1	1	1	1	3	3	3	3

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

<u>Mapping Between Course Outcomes (COs) and Course Delivery Method</u>

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 333
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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2								2	3	2	3
CO2	3	3	3	2						1		2	3	2	3
CO3	3	3	3	2						1		2	3	2	3
CO4	3	3	3	2						1		2	3	2	3
CO5	3	3	3	2						1		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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 336
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 learn about materials of tooling and their properties and to learn about the economic aspects of tools.
2	Understand the basic principles and types of location & clamping and Learn about various types of jigs and fixtures and their design.
3	Understand the concept of die set assembly and types of dies, design of blanking and piercing die, drawing dies and forging die.
4	The procedure for design of single point cutting tool, drill bits, form tools and milling cutter to be explained to students.
5	Understand the different types of linear measurement systems and gauges used in measurement and their design.

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

CO1	Understand the types and choice of tool materials and perform economic analysis of using tools.
CO2	Design various jig and fixture for industrial requirement through creative thinking.
CO3	Demonstrate the process of designing blanking & piercing die, drawing dies and forging die.
CO4	Design single point cutting tools, form tools, drills and milling cutters.
CO5	Understand the different types of linear measurement systems and design gauges used for various components and purposes.

SYLLABUS

Module 1: Introduction **[6]**
Introduction to tool design, Materials for tooling: Materials for cutting tools, dies and punches; Economics of Tooling.

Module 2: Jigs & Fixtures **[10]**

Jigs & Fixtures: Principal of design and construction, Location and clamping; Basic concept for design of Turning, Milling, Drilling and Indexing Jigs and fixtures.

Module 3: **Cutting Die and Forming Die** **[10]**

Components of dies assembly, Classification of dies; Blanking and piercing die: Shearing action, Punch and die clearance, centre of pressure, cutting force, design of die elements.
Drawing Die: Calculation of blank diameter, number of draws.

Module 4: Cutting tool **[8]**

Design of tools to produce holes, and surfaces of revolution, and flat surfaces like single point tools, form tools, drills, milling cutters.

Module 5: Tooling Metrology **[6]**

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, slip gauges and angle gauges.

Types of gauges - plain gauges, taper gauges, thread ring gauges, snap gauge, limit gauge, gauge materials, considerations of gauge design, Taylor's principle of gauging, wear allowance on gauges.

Text Book

1. Production Engineering Design (Tool Design) by Surender Kumar, Umesh Chandra and S.C. Srivastava, Satya Prakashan **(T1)**
2. Tool Design by C. Donaldson**,** G.H.Lecain, V.C.Goold, and Joyjeet Ghose, Tata McGraw Hill **(T2)**
3. R.K. Jain, Engineering Metrology Khanna Publications, New Delhi **(T3)**
4. R K Rajput, Mechanical Measurements and Instrumentations, Kataria Publication **(T4)**

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. P. H. Joshi, Jigs and Fixtures Design Manual, Mc Graw Hill, 2003 **(R3)**
4. Handbook, Fundamentals of Tool Design, ASTME **(R4)**
5. E. Osterguard, Basic Die Making, Mc-Graw Hill Book Co, 2013. **(R5)**
6. F. W. Wilson, Fundamentals of Tool Design, Literary Licensing, LLC, 2012. **(R6)**
7. N V Raghavendra and Krishnamurthy, Engineering Metrology and Measurement, Oxford University Press **(R7)**
8. Bentley, Engineering Metrology and Measurements, Pearson Education **(R8)**

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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√	√		
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	2			3	2	1	1	1	1	2	3	3	2	2
CO2	3	3	1	1	1	2	1	1	1	1	2	2	3	2	3
CO3	3	3	3	1	1	2	1	1	1	1	2	2	2	2	3
CO4	3	3	1	1	1	2	1	1	1	1	2	2	2	2	3
CO5	3	2	2	1	3	1			1	2	2	3	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 337
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	3	1					1		3	3	3	3
CO2	3	3	3	2	1					1		3	3	3	3
CO3	3	3	3	3	1							3	3	2	3
CO4	3	3	3	2	1							3	3	2	3
CO5	3	3	3	3	1							3	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 348
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

<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	√

Course Evaluation:

Direct Assessment-

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

Progressive Evaluation	% Distribution
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	1	1		1					2	3	3	3	3
CO2	3	2	2			1	1	1	2		3	3	3	3	3
CO3	3	2	3			1	1	1	2		3	3	3	3	3
CO4	3	2	3			1	1	1	2		3	3	3	3	3
CO5	3	3	2	2	3			1	2		2	3	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, CD7

COURSE INFORMATION SHEET

Course code: PE 349
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	

<u>Course Evaluation:</u>

Direct Assessment-

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

Progressive Evaluation	**% Distribution**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	2	3
CO1	3	2	1	1						1	1	2	3	1	2
CO2	3	3	3	1	2	1	1	1	2	1	2	3	3	3	3
CO3	3	2	2	2	2	1		1	2	1	2	3	3	3	3
CO4	3	2	1	1		1		1		1	1	2	3	2	3
CO5	3	3	2	3	2	1	1	1	2	1	3	3	3	3	3

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

<u>Mapping Between Course Outcomes (COs) and Course Delivery Method</u>

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 350
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]**

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

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

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**
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	1	1		1	1						1	3	1	2
CO2	3	2	2	1	1							1	3	1	3
CO3	3	3	2	3								1	3	2	3
CO4	3	3	1	3								1	3	2	3
CO5	3	3	2	3	1							1	3	3	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, 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 332
Course title: OPERATION 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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	12
CO1	3	3	3	1		1		1			1	3
CO2	3	3	3	1		1	1	1	2		2	2
CO3	3	3	2			1	1		2		1	3
CO4	3	2	1			1	1	1	2		2	2
CO5	3	2	1			1			2		2	2

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: PE 347
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**
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment-

1. Student Feedback on Faculty
2. 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	12
CO1	1	2		3	2		1	1	1			1
CO2	1	3	1	2					2			1
CO3	1		2	1		1			1			
CO4		2	2	1	2		1		1	2		
CO5	1	3		1	1		1		2	1		1

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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: MC 300
Course title: SUMMER INTERNSHIP
Pre-requisite(s):
Co- requisite(s):
Credits: 2 L: T: P:
Class schedule per week: NA
Class: B. Tech
Semester / Level: VI / Third
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

<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	15
CO1	1	1	1	1		2					1	2	2	2	2
CO2	2	1	1	2	2	2						2	3	3	2
CO3	2	1	1	1	1	1			3				3	3	2
CO4	1	1	1	1		3	3	3			2	2	3	3	3
CO5	1	1	1	1	1	3	1			3	1		2	2	3

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

COURSE INFORMATION SHEET

Course code: PE 401
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

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

Circular economy

<u>POs met through Gaps in the Syllabus:</u>
PO 5, PO 6, PO 7

<u>Topics beyond syllabus/Advanced topics/Design:</u>
Reconfigurable manufacturing systems, Rapid Manufacturing, Quality control in cyber physical system

<u>POs met through Topics beyond syllabus/Advanced topics/Design:</u>
PO 3, PO 5, PO 7

<u>Course Delivery Methods:</u>

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	√

<u>Course Evaluation:</u>

Direct Assessment-

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

Progressive Evaluation	% Distribution
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√	√		
Quiz 1	√	√			
Quiz 2				√	√
Assignment			√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	1	2	2	3	1			1			1	3	3	3
CO2	3	3	2	2	3	1			1			1	3	3	3
CO3	3	3	3	2	3	1			1			1	3	3	3
CO4	3	3	2	2	3	2			1			1	3	3	3
CO5	3	2	2	2	3	2			1			1	3	3	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; 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 410
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's like Fanuc, Siemen's, etc. and their practical usage in manufacturing applications
2	Learn concepts of machining parameters and cutting tools for CNC milling and turning jobs and Develop industrial components by interpreting 3D part models/ part drawings
3	Gain the concepts of CAM Software, CNC technology, to convert a CNC-lathe into a CNC-Milling machine and vice-versa
4	Be acquainted with standard industrial robot, its sub-systems and prepare a demonstration of a simple programmed task
5	Give a hands-on experience in a rigging an industrial pneumatics and electro-pneumatics circuit and PLCs

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

CO1	Apply the concepts of machining for selection of appropriate machining centers, machining parameters, select appropriate cutting tools for CNC milling and turning equipment, set-up, program, and operate CNC milling and turning equipment.
CO2	Create and validate NC part program data using manual data input (MDI) for manufacturing of required component using CNC milling or turning applications through CAM Software's like Fanuc, Siemen's, Unimat etc.
CO3	Apply the concepts of CNC technology to convert a CNC-lathe into a CNC-Milling machine and vice-versa and also to carry out machining using programmed part programs.
CO4	Calibrate program a standard industrial robot and analyse the control behaviour of a robot controller
CO5	Create a typical pneumatic and electro-pneumatic circuit and program a PLC and create a simple demonstration.

SYLLABUS

LIST OF EXPERIMENT:

1. **EXPERIMENT – 1:**
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:**
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:**
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:**
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:**
Objective: To write a manual part program for taper turning operation for a given drawing in CNC Lathe

6. **EXPERIMENT – 6:**
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:**
Objective: To write a manual part program for circular and rectangular pocketing for a given drawing and simulate in FANUC/SIEMENS CNC milling simulator

8. **EXPERIMENT – 8:**
Objective: To write a manual part program for Profile cutting with sub-program and right compensation for given drawing and simulate in FANUC/SIEMENS CNC milling

9. **EXPERIMENT – 9:**
Objective: To study and learn how to operate CNC milling machine - FANUC/SIEMENS controller.

10. **EXPERIMENT – 10:**
Objective: To machine a part for a given drawing on a CNC milling machine.

11. EXPERIMENT – 11:

Objective: To study the functional details of robots; programm and simulate the pick and place operation of a Robot

12. EXPERIMENT – 12:

Objective: To study the various types of sensors and PLC Programming

Text Books:

1. Mikell P. Grover "Automation, Production Systems and Computer-Integrated Manufacturing" Pearson Education, New Delhi. **(T1)**
2. Rao, P.N. "CAD/CAM: Principles and Applications", McGraw Hill Publication, 2nd Edition, 2004. **(T2)**
3. Mikell P. Grover, E. Zimmer, "Computer Aided Design and Manufacturing (CAD/CAM)", Pearson Publication, 2nd Edition, 2006. **(T3)**

Reference Books:

1. David Bedworth, "Computer Integrated Design and Manufacturing" Tata McGraw Hill, New Delhi, 1998. **(R1**)
2. Radhakrishan P., Subramaniyam S., "CAD CAM and CIM", New Age International, 2002 **(R2)**

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

Design of real-time Industrial projects.

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

PO 5

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

Design optimization for industrial projects

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

POs 4,5, 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	√

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 Faculty
2. 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	15
CO1	3	2		3					3			2	2	3	3
CO2	2	2		3					3			2	3	2	3
CO3	3	2		2					3			2	2	3	3
CO4	3	2		3					3			2	2	3	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, 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 411
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: VII/ Fourth
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	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 [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]**

<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>

Mathematical Modelling of Supply Chain

Application of meta-heuristics for supply chain optimization

<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
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	**% Distribution**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	2	2	2	2	2	3	2	2	2	1	3	1	3	3	3
CO2	2	2	2	2	2	3	2	2	2	1	3	1	3	3	3
CO3	2	2	3	2	3	3	2	2	2	1	3	2	3	3	3
CO4	2	2	3	2	3	3	3	2	1	1	3	2	3	3	3
CO5	2	2	3	2	3	3	3	2	1	1	3	1	3	3	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: MT 204
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 Constitution of India
2	To explain the provisions related to social problems and issues.
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 the constitutional provisions.

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

CO1	Outline the need and importance of the Indian constitution.
CO2	Explain the fundamental rights and duties of the citizens of India.
CO3	Relate appropriate constitutional provisions with relevant social issues
CO4	Describe the role of different departments of government.
CO5	Critique the Government policies and programmes designed for the society at large.

SYLLABUS

Module 1
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
Union and State Executives: President and Prime Minister, Council of Ministers, Cabinet and Central Secretariat, Lok Sabha, Rajya Sabha. Governor: Role and Position, Chief Ministers and Council of ministers.

Module 3
The Indian Judicial System – The Supreme Court and The High Court's – composition, Jurisdiction and functions, The Role of the Judiciary.

Module 4

Local Government- District's Administration: Role and Importance, The Panchayatas – Gram Sabha, Constitution and Composition of Panchayats, Constitution and Composition of Municipalities

Module 5

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

<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**
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	**% Distribution**
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz 1	√	√	√		
Quiz 2	√	√	√		
Assignment	√	√	√		
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping Between Course Outcomes (COs) and Course Delivery Method

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

COURSE INFORMATION SHEET

Course code: PE 406
Course title: NON-CONVENTIONAL MACHINING PROCESSES
Pre-requisite(s): MACHINING SCIENCE AND MACHINE TOOLS / MANUFACTURING PROCESSES
Co- requisite(s):
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√	√		
Quiz 2	√	√	√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	1								3	3	2	3
CO2	3	3	3	3	1							3	3	2	3
CO3	3	3	3	2	1							3	3	2	3
CO4	3	3	3	2								3	3	2	3
CO5	3	3	3	3	1							3	3	3	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 407
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	1	1	1				1	1	3	3	2	3
CO2	3	2	1			1				1	2	2	3	1	3
CO3	3	3	3			1				1	1	2	2	2	3
CO4	3	2	1			1	1	1		1	2	3	3	2	3
CO5	3	3	1							1	2	2	3	1	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: PE 412
Course title: EXPERIMENTAL METHODS AND MEASUREMENTS
Pre-requisite(s): METALLURGICAL AND 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
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3			2				2				2	1	
CO2	3	3		3	3				3				1	1	
CO3	1	2		2	2				2				2	1	
CO4	2	3		3	3				3				2	1	
CO5	3	3		3	3					1			1	1	

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: PE 413
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2	3	2	1	1	1	1	3	1	2	3	3
CO2	3	3	3	2	3	2	1	1	1	1	3	1	2	3	3
CO3	3	3	3	2	3	2	1	1	1	1	3	1	2	3	3
CO4	3	3	3	2	3	2	1	1	1	1	3	1	2	3	3
CO5	3	3	3	2	3	2	1	1	1	1	3	1	2	3	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 414
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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√			
Quiz 2				√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	12
CO1	3	3	1	1								2
CO2	3	3	3	3							2	2
CO3	3	3	3	3							2	2
CO4	3	3	3	2							2	2
CO5	3	3	1	1		3					3	2

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; 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 417
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 4: 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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	12
CO1	2	2		2							3	1
CO2	2	2	1	2	2					2	3	2
CO3	2	2	1	2						2	3	2
CO4	2	2	1	2						1	3	2
CO5	1			1	3	1			2	1	3	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: PE 400
Course title: RESEARCH PROJECT / INDUSTRIAL INTERNSHIP
Pre-requisite(s):
Co- requisite(s):
Credits: 10 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 two (2). More than two students in a group shall be discouraged. Internship shall be independent. 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 Faculty
2. 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	15
CO1	3	3	3	3	3	3			1			2	3	3	3
CO2	3	3	3	3	3	3			1			2	3	3	3
CO3	3	3	3	3	3	3			1			2	3	3	3
CO4	3	3	3	3	3	3	1	3	2		3	2	3	3	3
CO5	2	2	2	2	2	2			1	3		2	3	3	3

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

In-depth Specialization in
"Advanced Manufacturing and Production Management"

Syllabus (CBCS 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 20 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 339
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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	2	3	2	1	3	2	2		1			2	2	3	3
CO2	2	2	3	3	1				2	2		2	2	3	3
CO3	3	2	2	3	3	2	1		2	1		2	2	2	2
CO4	3	2	2	3	3	2	1		2			2	3	2	3
CO5	3	3	2	3	3		2		1			2	1	2	2

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: PE 340
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**
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	1	1	1				1	1	3	3	2	2
CO2	3	2	1			1				1	2	2	3	1	3
CO3	3	3	3			1				1	1	3	2	2	3
CO4	3	2	1			1	1	1		1	2	2	3	2	2
CO5	3	2	1							1	2	2	3	1	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: PE 310
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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	1	1		1	1						1	3	1	2
CO2	3	2	2	1	1							1	3	1	3
CO3	3	3	2	3								1	3	2	3
CO4	3	3	1	3								1	3	2	3
CO5	3	3	2	3	1							1	3	3	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, 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 341
Course title: PROCESSING OF POLYMERS, COMPOSITE AND ADVANCED MATERIALS
Pre-requisite(s): METALLURGICAL AND 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**				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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

COs	**POs**											**PSOs**		
	1	2	4	4	5	6	7	8	9	10	11	12	13	14	15
CO1	3	2	2	2								1	3	2	3
CO2	3	2	2	2								1	3	2	3
CO3	3	2	2	2								1	3	2	3
CO4	3	2	2	2								1	3	2	3
CO5	3	2	2	2								1	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 & CD6
CO2	CD1, CD2 & CD6
CO3	CD1, CD2 & CD6
CO4	CD1, CD2 & CD6
CO5	CD1, CD2 & CD6

COURSE INFORMATION SHEET

Course code: PE 342
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]**

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

Nil

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

Nil

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

Systems engineering

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

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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√	√		
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	2	1		2	1		2	1	2	1	2	2	3
CO2	3	3	3	2	1	2			1	1	1	1	3	3	3
CO3	3	3	3	3		1	1			1	2	1	3	3	3
CO4	3	3	3	3	2	2	1				2	1	3	3	3
CO5	2	2	1										2	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, 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 409
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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2	1							2	2	2	2
CO2	3	3	3	3	1							2	2	3	3
CO3	3	3	3	3	1							2	2	3	3
CO4	3	3	3	3	1							2	2	3	3
CO5	3	3	3	3	1							3	3	3	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, 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: PE415
Course title: MICRO AND NANO MANUFACTURING
Pre-requisite(s): METALLURGICAL AND 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]**

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

Diamond turning.

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

POs 1,5,6

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

Nanoimprint Lithography for Nanomanufacturing

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

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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	1	2	3
CO1	2	3			1					1	1	1	2	1	1
CO2	2	3	1	3	2			1		1		1	2	2	3
CO3			2	3	3		1		1		1		1		2
CO4		1	3	2	3				2	1	1	1	2		2
CO5	2	2	1		1	1			2	2		1		2	1

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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

MINOR in "Production and Industrial Engineering"

Syllabus (CBCS UG Program)

(OFFERED ONLY TO THE STUDENTS OF OTHER DEPARTMENTS)

Students who have registered for B. Tech Minor in "Production and Industrial Engineering" should complete 20 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 223
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
Mid Semester Examination	25
Quizzes	10 + 10
Assignment	5
End Semester Examination	**% Distribution**
End Semester Examination	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Semester Examination	√	√			
Quiz1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	1		1		1			1	3	3	3	3
CO2	3	3	3	1		1	1	1	2		2	2	3	2	3
CO3	3	3	2			1	1		2		1	3	3	2	3
CO4	3	2	1			1	1	1	2		2	2	3	3	3
CO5	3	2	1			1			2		2	2	3	3	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: PE 224
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.

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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –
1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	3	1					1		3	3	3	3
CO2	3	3	3	2	1					1		3	3	3	3
CO3	3	3	3	3	1							3	3	2	3
CO4	3	3	3	2	1							3	3	2	3
CO5	3	3	3	3	1							3	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

COURSE INFORMATION SHEET

Course code: PE 343
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]**

<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
Progressive Evaluation	50
End Semester Examination	50

Progressive Evaluation	% Distribution				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√	√		
Quiz 2	√	√	√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2								3	3	2	3
CO2	3	3	3	2								3	3	2	3
CO3	3	3	3	2								3	3	2	3
CO4	3	3	3	2								3	3	2	3
CO5	3	3	3	2								3	3	2	3

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

<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 344
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

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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√	√		
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	1	2	3
CO1	3	3	3		1					1	1	3	1	3	2
CO2	3	2	1		2					1	2	2	1	3	3
CO3	3	3	3		2		1			1	1	3	2	2	2
CO4	3	2	1				1	1		1	2	2	1	3	3
CO5	3	2	1							1	2	2	1	3	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: PE 218
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 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]**

<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>

Logistics and supply chain management, Inventory model design

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

POs 1 -4, 9, 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	

Course Evaluation:

Direct Assessment-

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

Progressive Evaluation	% Distribution				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√			
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	3	3	3	2	2		1		1	2	3	3	3	2	3
CO2	3	3	1	2	2		1		1	2	3	2	3	2	3
CO3	3	3	3	2	2		1		1	2	2	3	3	2	3
CO4	3	3	1	2	2		1		1	2	2	2	3	2	3
CO5	3	3	1	3	2		1		1	2	2	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: PE 416
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]**

<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>

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				
Mid Semester Examination	25				
Quizzes	10 + 10				
Assignment	5				
End Semester Examination	**% Distribution**				
End Semester Examination	50				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Semester Examination	√	√	√		
Quiz 1	√	√			
Quiz 2			√	√	√
Assignment	√	√	√	√	√
End Semester Examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty
2. 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	15
CO1	2	2	2	2	2	3	2	2	2	1	3	1	3	3	3
CO2	2	2	2	2	2	3	2	2	2	1	3	1	3	3	3
CO3	2	2	3	2	3	3	2	2	2	1	3	2	3	3	3
CO4	2	2	3	2	3	3	3	2	1	1	3	2	3	3	3
CO5	2	2	3	2	3	3	3	2	1	1	3	1	3	3	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, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6