BIRLA INSTITUTE OF TECHNOLOGY

CHOICE BASED CREDIT SYSTEM (CBCS) CURRICULUM

(NEW COURSE STRUCTURE – To be effective from Academic Session 2022-23)

M.TECH IN PRODUCTION AND INDUSTRIAL ENGINEERING

PRODUCTION AND INDUSTRIAL ENGINEERING DEPARTMENT

INSTITUTE VISION

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

INSTITUTE MISSION

- To educate students at Undergraduate, Postgraduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching 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 post graduate 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

Programme Educational Objectives (PEOs) – Production And Industrial Engineering

- ✓ **PEO 1:** Graduates will develop into independent researchers and academicians in the broad area of production and industrial engineering
- ✓ **PEO 2:** Graduates will demonstrate a high level of competency and problem-solving aptitude to find innovative solutions for theoretical and practical problems
- ✓ **PEO 3:** Developing a practice of continuously updating with latest knowledge and information in their relevant field of specialization
- ✓ **PEO 4:** Graduates should engage with engineering profession and understand the importance of ethics, teamwork, and professionalism

Graduate Attributes (GAs)

GA1: Scholarship of Knowledge

Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse, and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

GA2: Critical Thinking

Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

GA3: Problem Solving

Think laterally and originally, conceptualise, and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

GA4: Research Skill

Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

GA5: Usage of modern tools

Create, select, learn, 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.

GA6: Collaborative and Multidisciplinary work

Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

GA7: Project Management and Finance

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.

GA8: Communication

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

GA9: Life-long Learning

Recognise the need for and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

GA10: Ethical Practices and Social Responsibility

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

GA11: Independent and Reflective Learning

Observe and examine critically the outcomes of one's actions and make corrective measures subsequently and learn from mistakes without depending on external feedback.

PROGRAM OUTCOMES (POs) for M.TECH. (AUTOMATED MANUFACTURING SYSTEMS)

Compulsory PO

- ✓ **PO1:** An ability to independently carry out research /investigation and development work to solve practical problems.
- ✓ **PO2**: Ability to write and present a substantial technical report/document.
- ✓ **PO3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

Optional PO (Program Specific)

- ✓ **PO4:** Application of engineering and technological knowledge to solve a wide range of Production and Industrial problems.
- ✓ **PO5:** Developing expertise in manufacturing related subjects both at the theory and practical level.
- ✓ **PO6:** Developing the ability and expertise in the students to apply latest data analytics tools and techniques for computing and engineering practice.

PROGRAMME COURSE STRUCTURE

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
REVISED COURSE STRUCTURE - Effective from academic session 2022-23
Based on CBCS & OBE Model
Recommended scheme of study for M.Tech in PRODUCTION & INDUSTRIAL ENGINEERING

SEMESTER / Session of Study (Recommended)	Course Level	Category of Course	Course Code	Courses	Mode of delivery & Credits *L-Lecture; T-Tutorial; P-Practical*			Total Credits *C- Credits*
					L (*Periods/ week*)	T (*Periods/ week*)	P (*Periods/ week*)	C
	THEORIES							
FIRST / Monsoon	**Fifth**	**Programme Core (PC)**	**PE 503**	**Planning & Control of Production System**	**3**	**0**	**0**	**3**
			PE 511	**Computer Integrated Manufacturing**	**3**	**0**	**0**	**3**
			PE 522	**Optimization Techniques**	**3**	**0**	**0**	**3**
			PE 523	**Manufacturing Strategies**	**3**	**0**	**0**	**3**
			PE 524	**Advanced Manufacturing Technologies**	**3**	**0**	**0**	**3**
	LABORATORIES							
	Fifth	**Humanities and Social Science (HSS)**	**MT 132**	**Communication Skills - I**	**0**	**0**	**3**	**1.5**
		(PC)	**PE 502**	**Computer Aided Manufacturing Lab**	**0**	**0**	**4**	**2**
			PE 525	**Advanced Manufacturing Technologies Lab**	**0**	**0**	**4**	**2**
		TOTAL						**20.5**
THEORIES								
SECOND/ Spring	**Fifth**	**Electives of Production & Operations Management Specialization (Any 5 courses)**	**PE 504**	**Modelling and Simulation**	**3**	**0**	**0**	**3**
			PE 508	**Operations & Supply Chain Management**	**3**	**0**	**0**	**3**
			PE 518	**Data Analytics**	**3**	**0**	**0**	**3**
			PE 521	**Quality Engineering and Robust Design**	**3**	**0**	**0**	**3**
			PE 526	**Advanced Topics in Operations Research**	**3**	**0**	**0**	**3**
			PE 527	**Soft Computing in Manufacturing**	**3**	**0**	**0**	**3**
		Electives of Production Technology Specialization (Any 5 courses)	**PE 510**	**Robotics & Robot Applications**	**3**	**0**	**0**	**3**
			PE 521	**Quality Engineering and Robust Design**	**3**	**0**	**0**	**3**
			PE 527	**Soft Computing in Manufacturing**	**3**	**0**	**0**	**3**
			PE 528	**Manufacturing Automation**	**3**	**0**	**0**	**3**
			PE 529	**Advanced Machining Technologies**	**3**	**0**	**0**	**3**
			PE 530	**Materials for Engineering Applications**	**3**	**0**	**0**	**3**
			PE 531	**Analysis of Material Deformation Processes**	**3**	**0**	**0**	**3**
			PE 532	**Additive Manufacturing**	**3**	**0**	**0**	**3**
			ME 506	**Applied Tribology**	**3**	**0**	**0**	**3**

SECOND/ Spring	**LABORATORIES**							
	Fifth	**(HSS)**	**MT 133**	**Communication Skills - II**	**0**	**0**	**3**	**1.5**
		(PC)	**PE 505**	**Manufacturing Simulation Lab**	**0**	**0**	**4**	**2**
			PE 517	**Computer Aided Design & Drafting Lab**	**0**	**0**	**4**	**2**
		TOTAL						**20.5**

THIRD / Monsoon	**Sixth**	**THEORIES**						
		(PC)	**PE 600**	**Thesis (Part I)**				**8**
		Open Elective (OE)		**Open Elective - I / MOOC - I**	**3**	**0**	**0**	**3**
				Open Elective – II / MOOC - II	**3**	**0**	**0**	**3**
		TOTAL						**14**
FOURTH/ Spring	**Sixth**	**(PC)**	**PE650**	**Thesis (Part II)**				**16**
		TOTAL						**16**
GRAND TOTAL FOR M. TECH PROGRAMME (41 + 30)								**71**

OPEN ELECTIVE COURSES

LEVEL / SESSION	Code no.	Name of the OE courses	Prerequisites courses with code	L	T	P	C
SISTH / (MO)	**PE 601**	**Automated Manufacturing**	**None**	**3**	**0**	**0**	**3**
SIXTH / (MO)	**PE 602**	**Smart Manufacturing**	**None**	**3**	**0**	**0**	**3**

*** OPEN ELECTIVES TO BE OPTED ONLY BY OTHER DEPARTMENT STUDENTS**

COURSE INFORMATION SHEET

Course code: PE 502
Course title: COMPUTER AIDED MANUFACTURING LAB
Pre-requisite(s): None
Co- requisite(s): None
Credits: 02 L:0 T:0 P: 4
Class schedule per week: 4
Class: M.Tech.
Semester / Level: I/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives:
This course enables the students to:

1	To learn the concepts and principles of Computer aided Manufacturing (CAM)
2	To understand the various types of CAM Software's like Fanuc, Siemen's, etc. and their practical usage in manufacturing applications
3	Understand concepts of machining for selection of appropriate machining parameters, and cutting tools for CNC milling and turning jobs
4	Develop industrial components by interpreting 3D part models/ part drawings
5	Understand the concepts of CAM Software, CNC technology, to convert a CNC-lathe into a CNC-Milling machine and vice-versa

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	Produce an industrial component by interpreting 3D part model/ part drawings using Computer Aided Manufacturing technology through programming, setup, and ensuring safe operation of Computer Numerical Control (CNC) machine tools.
CO4	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.
CO5	Develop prototype models by interpreting 3D part model/ part drawings

List of experiments

Experiment No. 1
Write a manual part program for step turning operation for a given drawing. Write the program and simulate in FANUC/SIEMENS CNC lathe simulator.

Experiment No. 2
Write a manual part program for radius cutting and taper turning operation for a given drawing. Write the program and simulate in FANUC/SIEMENS CNC lathe simulator.

Experiment No. 3
Write a manual part program for grooving operation for a given drawing. Write the program and simulate in FANUC/SIEMENS CNC lathe simulator.

Experiment No. 4
Write a manual part program for thread cutting operation for a given drawing. Write the program and simulate in FANUC/SIEMENS CNC lathe simulator.

Experiment No. 5
Convert a modular CNC-mill Unimat machine into CNC-Lathe Unimat machine and write a manual part program for step turning operation for a given drawing in Unimat CNC Lathe.

Experiment No. 6
Write a manual part program for taper turning operation for a given drawing in Unimat CNC Lathe.

Experiment No. 7
Write a manual part program for profile milling operation using linear and circular interpolation cutting for a given drawing. Write a program and simulate in FANUC/SIEMENS CNC milling simulator.

Experiment No. 8
Write a manual part program for Profile cutting with sub-program and right compensation for given drawing. Write a program and simulate in FANUC/SIEMENS CNC milling simulator.

Experiment No. 9
Write a manual part program for circular and rectangular pocketing for a given drawing. Write a program and simulate in FANUC/SIEMENS CNC milling simulator.

Experiment No. 10
Write a manual part program for drilling operation for a given drawing. Write a program and simulate in FANUC/SIEMENS CNC milling simulator.

Experiment No. 11
Convert a modular CNC-lathe Unimat machine into CNC-mill Unimate machine and write a manual part program for contouring operation for a given drawing in Unimat CNC Milling.

Experiment No. 12
Write a manual part program for contouring operation with tool compensation right for a given drawing.

Experiment No. 13
To study and learn how to operate CNC milling (VMC 300) machine-Siemens controller.

Experiment No. 14
To machine a mill part for a given drawing on a CNC milling machine (VMC 300).

Books recommended:

TEXT BOOK

1. Mikell P. Grover "Automation, Production Systems and Computer-Integrated Manufacturing" Pearson Education, New Delhi. ISBN: 0132393212.**(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)**

EFERENCE 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)**

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 (es)	10				
Viva-voce	20				
Semester End Examination	**% Distribution**				
Examination: Experiment Performance	30				
Quiz	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

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

Design of real-time industrial projects.

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	2	1	3	2	2
CO3	2	3	3	2	3	2
CO4	3	2	2	3	2	3
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES 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 503
Course title: PLANNING & CONTROL OF PRODUCTION SYSTEM
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech.
Semester / Level: I/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives

This course enables the students:

A.	To introduce to various inherent concepts of production systems, planning and control systems of Manufacturing Industry.
B.	To introduce of forecasting models, plant layout.
C.	To make routine process, scheduling process and identify different strategies employed in manufacturing industries to production planning.
D.	To give basic concept of inventory control and its technique.
E.	To give concept of Production monitoring & control

Course Outcomes

After the completion of this course, students will be:

CO1	Identify Various types of production systems
CO2	Understand the fundamentals of facility locations, demand forecasting.
CO3	Obtain knowledge about production planning, capacity planning.
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	Know production monitoring and control techniques.

SYLLABUS

Module 1 **[8 L]**
Generalized model of a production system, decisions in the life cycle of a production system, risk analysis using decision trees, different kinds of production systems.

Module 2 **[8 L]**
Mathematical models for facility location and layout, Importance of forecasting – Types of forecasting, their uses – General principles of forecasting – Forecasting techniques– qualitative methods and quantitative methods.

Module 3 **[8 L]**
Routing, Scheduling, Loading, dispatching, Production Planning Models, Hierarchical Production Planning, Aggregate planning, Desegregation of Aggregate Plan.

Module 4 **[8 L]**

Inventory planning and control, Material Requirements Planning and Lot Sizing, manufacturing resource planning & ERP.

Module 5 **[8 L]**

Production monitoring & control, Production Control principles and techniques, performance criteria & evaluation, resource balancing, PPC in Process Industries, Planning and Control of JIT Systems.

Books recommended:

TEXT BOOKS

1. Jay H Heizer, Barry Render, Production and operations management, Prentice Hall Publication**.(T1)**
2. Elsayed E.A. and Boucher T. O. Analysis and Control of Production systems, Prentice Hall**.(T2)**
3. King J. R., Production Planning and Control, Pergamon Press, Oxford**.(T3)**

REFERENCE BOOKS:

1. Production and operations management, S. N. Chary **(R1)**
2. Production and Operations Management Manufacturing and Services, Nicholas J. Aquilano and Richard B. Chase **(R2)**
3. Quantitative Production Management,Bestwick, P.F. and Lockyer, K **(R3)**
4. O. R. in Production Planning, Scheduling and Inventory Control Johnson, L. A. and Momtgomergy, D. C **(R4)**
5. Production and Inventory Management, Hax, A. C. and Candea, D**,.(R5)**

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2			
CO2	2	1	2	3		3
CO3	1		1	1		
CO4	2		1	3		2
CO5	1			3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 504
Course title: MODELLING AND SIMULATION
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech
Semester / Level: II/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives

This course enables the students:

A.	To learn the concepts of modelling and simulation
B.	To understand the various types of simulation models and their practical use
C.	To know about software for modelling and simulation in various application areas
D.	Understand the statistical aspect of simulation
E.	To comprehend the verification and validation approaches for simulation models

Course Outcomes

After the completion of this course, students will be:

CO1	Develop model frameworks for discrete-event simulation
CO2	Apply pseudo-random number based manual simulation to discrete-events
CO3	Construct software models for manufacturing, logistic and material handling problems
CO4	Generate random distributions of various probability distributions for queuing systems
CO5	Analyse the simulation output for validation

SYLLABUS

Module 1 **[8L]**

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 **[8L]**

Event verses activity, General principles of event-driven simulation, Use of Pseudo-Random numbers in simulation of queuing systems, Simulation of manufacturing systems and other examples

Module 3 **[8L]**

Simulation of manufacturing and material handling systems, Modeling downtime and failures, Case studies, Introduction to simulation software and languages for manufacturing and material handling

Module 4 **[8L]**

Statistical models in simulation, Terminology and concepts, Useful statistical models: Discrete and continuous distribution, Poisson, Uniform, Exponential and Normal distribution, Empirical distribution

Module 5 **[8L]**

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 recommended:

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)**

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2			
CO2	2	1	2	3		3
CO3	1		1	1		
CO4	2		1	3		2
CO5	1			3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 505
Course title: MANUFACTURING SIMULATION LAB
Pre-requisite(s): None
Co- requisite(s): None
Credits: 02 L:0 T:0 P:4
Class schedule per week: 4
Class: M.Tech.
Semester / Level: II/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives

This course enables the students:

A.	To apply the concepts of modelling and simulation to real problems
B.	To develop various types of simulation models
C.	To use some software for modelling and simulation
D.	To understand the statistical aspect of simulation
E.	To apply the verification and validation approaches for simulation models

Course Outcomes

After the completion of this course, students will be:

CO1	Able to develop models for discrete-event simulation
CO2	Apply pseudo-random number based manual simulation to discrete-events
CO3	Develop software models for manufacturing, logistic and material handling problems
CO4	Apply various probability distributions for queuing systems
CO5	Analyse the simulation output for validation

List of experiments

Experiment No. 1
Modelling & Simulation Concepts and Simulation software
Aim: To understand and make a list of the basic terms, concepts and software related to modelling and simulation

Experiment No. 2
Discrete Event Simulation (Using Random Numbers) of a Bank
Aim: Consider the operation of a one-teller bank where customers arrive for service in 1 ± 10 minutes. The customers are served in time 1 ± 6 minutes. Simulate the bank operation until twenty customers are served assuming customer 1 arrives at time 0, and compute measures of performance such as the percentage of idle time and the average waiting time per customer.

Experiment No. 3
Simulation of a Robotic work cell, Aim: Simulate a robotic work cell to find the cycle time of job and production rate. Assuming a 90% efficient and 8 hours shift, find the per day production. Also give your suggestion for improving the system productivity.

Experiment No. 4
Simulation of a Drill press operation
Aim: Parts are machined on a drill press. They arrive at a rate of one every 5 ± 3 minute and it takes 3± 2 minute to machine them. Every 60 ± 60 minutes, a rush job arrives which takes 12 ± 3 minute to complete. The rush job interrupts the present job. When the regular job returns to the machine, it stays only for its remaining process time. Simulate the mean system response time for each type of part. Response time is the total time that a part spends in the system.

Experiment No. 5
Simulation of a Grocery shop
Aim: A small grocery has only one checkout counter. Customers arrive at this checkout counter at random in the interval of [1, 8] minutes. The service time vary from 1 to 6 minutes with the probabilities shown. Simulate the problem/system for arrival and service of 20 customers.

Experiment No. 6
Discrete Event Simulation (Using a GPSS© software) of a Food Store
Aim: Use aGPSS© software to construct the model for simulation

Experiment No. 7
Simulation of a Self-Service Cafeteria Using a GPSS© software
Aim: Use aGPSS© software to construct the model for simulation

Experiment No. 8
Simulation of Ambulance Dispatch
Aim: Use aGPSS© software to construct the model for simulation

Experiment No. 9
Simulation of Factory Maintenance
Aim: Use aGPSS© software to construct the model for simulation

Experiment No. 10
Simulation of Ships (Un)Loading Cargo at a Harbor
Aim: Use aGPSS© software to construct the model for simulation

Experiment No. 11
Simulation of Hospital's Emergency Room
Aim: Use aGPSS© software to construct the model for simulation

Experiment No. 12
Monte Carlo Simulation (Using MINITAB©)
Aim: Use MINITAB© to conduct a Monte Carlo simulation for finding the distribution of machining time in a lathe when the probability distribution for length of job, feed rate and rotational rpm are known

Books recommended:
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)**

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 (es)	10				
Viva-voce	20				
Semester End Examination	**% Distribution**				
Examination: Experiment Performance	30				
Quiz	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

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

1. Design of real-time industrial projects.
2. POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

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

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors
CD2	Hands on training on computers
CD3	Self- learning advice

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	1	**2**	**3**	**4**	**5**	**6**
1		2	1		2	
2		1	1		3	
3	1	2	1	2	1	1
4		1			2	
5			1		2	

< 34% = 1, 34-66% = 2, > 66% = 3

COURSE INFORMATION SHEET

Course code: PE 508
Course title: OPERATIONS & SUPPLY CHAIN MANAGEMENT
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech
Semester / Level: II/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives

This course enables the students:

A.	To provide the student the knowledge of strategic importance of supply chain design and planning of an organisation
B.	The role of inventory management and forecasting in a supply chain
C.	Knowledge of facility planning and scheduling models
D.	Knowledge of various distribution and transportation networks and their applications
E.	The role of sourcing, information technology, pricing and revenue management, and coordination in a supply chain.

Course Outcomes

After the completion of this course, students will be:

CO1	Define the goal of a supply chain and analysis the impact of supply chain decisions on the success of a firm
CO2	Analyse demand forecasts and supply for both an enterprise and a supply chain
CO3	Apply operations planning, MRP, and aggregate planning concepts
CO4	Design a supply chain network for a firm or organisation
CO5	Judge and select the best supplier for a firm or organisation

SYLLABUS

Module 1 [8L]

Introduction to Supply Chain Management: Understanding the supply chain, Supply Chain Performance- Achieving strategic fit and scope, complexity, key issues, Supply Chain Drivers and Metrics, Centralized vs. decentralized systems

Module 2 [8L]

Planning Demand and Supply in a Supply Chain: Forecasting- Need for forecasting, Quantitative methods. Inventory Management- Various costs in inventory management and need, Deterministic models and discounts, Probabilistic inventory management. Aggregate Planning- The Role of Aggregate Planning, Aggregate Planning Strategies.

Module 3 [8L]

Facility Planning and Scheduling models: Facility layout and location- Qualitative aspects, Quantitative models for layout decisions, Product, process fixed position, group layout, Location decisions-quantitative models. Scheduling models- Scheduling in MRP system, Sequencing rules and applications, Batch production sequencing and Scheduling.

Module 4 [8L]

Designing the Supply chain network: 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, Supply Chain Optimization.

Module 5 [8L]

Managing Cross-Functional Drivers in a Supply Chain: Sourcing Decisions- Make or buy decisions, Third- and fourth-party logistics providers, Sourcing Processes. Pricing and Revenue Management in a Supply Chain, Information Technology in a Supply Chain, Coordination in a Supply Chain.

Books recommended:

TEXT BOOKS:

1. Chopra, S., and Meindl, P. "Supply Chain Management, strategy, planning, and operation" 6/e – PHI, second edition, 2014. (**T1**)
2. Operations Management by Evans and Collier. (**T2**)
3. R. Panneerselvan, Production and operations Management, Prentice Hall of India, Delhi (2000). (**T3**)

REFERENCE BOOKS:

1. Christopher, "Logistics and Supply Chain Management", Pearson Education Asia, New Delhi. (**R1**)
2. Taylor and Brunt, "Manufacturing Operations and Supply Chain Management (The Lean Approach)", Business Press Thomson Learning, NY. (**R2**)
3. Arjan J. Van Weele, "Purchasing and Supply Chain Management (Analysis Planning and Practice)", Engineering, Business Press, Thomson Learning NY. (**R3**)
4. Shah, J. "Supply Chain Management, text and cases", Pearson Education South Asia,2009. (**R4**)
5. Donald B., "Logistic Management - The Integrated Supply Chain process", McGraw Hill. (**R5**)
6. Operations Management by Heizer and Render. (**R6**)

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
1	2	1	2	3	1	
2	2	1	2	3		2
3	2	1	2	3		1
4	2	1	2	3	1	1
5	2	1	2	3		1

< 34% = 1, 34-66% = 2, > 66% = 3

	Mapping between CO and CD	
CD	**Course Delivery methods**	**Course Outcomes**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO2, CO3, CO4, CO5
CD3	Seminars	CO3, CO4, CO5
CD4	Self- learning advice using internets	CO4, CO5

COURSE INFORMATION SHEET

Course code: PE 510
Course title: ROBOTICS & ROBOT APPLICATIONS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech
Semester / Level: II/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives

This course enables the students:

A.	To understand robot structures and their workspace
B.	To perform spatial transformations associated with rigid body motions
C.	To perform forward and inverse kinematics analysis of robot manipulator
D.	To carry out robot dynamic analysis and trajectory planning
E.	To perform programming of robots.

Course Outcomes

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

CO1	Describe and explain the various robot classification and their characteristics.
CO2	Analyse gravity force of simple robot manipulators.
CO3	Solve forward and inverse kinematics of simple robot manipulators
CO4	Plan and generate joint trajectory for robot motion.
CO5	Code fundamental programs for robot applications.

SYLLABUS

Module 1 **[8L]**

Introduction: Brief history of robot technology, Basic terminologies, Robot Anatomy, Degree of Freedom, classification and characteristics, Robot selection, structure of industrial robot, Robots in Automation.

Module 2 **[8L]**

Robot End Effectors and Sensors: Types of End Effectors, Mechanical Grippers, Gripper Force Analysis, Other Types of Gripers, Special-Purpose Gripers, Gripper Selection and Design. Robot Sensors, Different types of Robot Sensors.

Module 3 **[8L]**

Robot Kinematics: Transformations and Kinematics, Vector operations - Properties of Transformation matrices and their arithmetic link and joint description -Homogeneous transformations and Manipulator – Forward solution -Inverse solution, Denavit-Hartenberg parameters, frame assignment to links, Jacobian Transformation in Robotic Manipulation

Module 4 **[8L]**

Robot Dynamics: Dynamics of Robotic Manipulators, Euler Equations, The Lagrangian Equations of motion. Application of Lagrange–Euler (LE), Dynamic Modeling of Robotic Manipulators. Trajectory Planning and generations, Join-Interpolated Trajectories, Cartesian Path Trajectories.

Module 5 **[8L]**

Robot Programming and Applications: Robot Programming, Programming Methods, Programming Languages. Robot application in Manufacturing- Material handling, Processing operations, Assembly and Inspection Operations.

Text books:

1. M. P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey, Industrial Robotics Technology, Programming and Applications, McGraw Hill, Int. 2008.
2. Keramas, J., G., Robot Technology Fundamentals, DELMAR, Cengage learning.
3. Mittal, R., K., Robotics and Control, McGraw Hill publication, 2015.
4. K.S. Fu, R. C. Gonzalez and C.S.G. Lee, Robotics Control, Sensing, Vision and Intelligence, McGraw Hill, 2008.

Reference books:

1. Introduction to Robotics Analysis, Systems, Applications by Saeed B Niku PHI.
2. Fundamentals of Robotics Analysis and Control, Robert J Schilling, PHI.
3. J. J. Craig, Introduction to Robotics: Mechanics and Control, 3/e, Pearson Education, 2009
4. S. K. Saha, Introduction to Robotics, Tata McGraw Hill Education Private Limited, 2008.
5. D. Richard, Klafter, and A. Thomas, Chmielewski, Michael Negin, Robotics Engineering-An Integrated Approach, Prentice-Hall of India Pvt. Ltd., 2009.
6. A. Ghosal, Robotics Fundamental Concepts and Analysis, Oxford University Press India, 2006.
7. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw -Hill, 2009.

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets
CD5	Industrial visit

Mapping between Course Outcomes and Program Outcomes

Course Outcome	**Program Outcomes**					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		1	1	2	
CO2			2	2	2	
CO3	1		2	3	3	
CO4	1		2	3	3	1
CO5	2	1	2	3	3	

<34% =1, 34-66% = 2, >66% = 3

	Mapping between Course Outcomes and Course delivery method	
CD	**Course Delivery methods**	**Course Outcomes**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO2, CO3, CO4, CO5
CD3	Seminars	CO3, CO4, CO5
CD4	Self- learning advice using internets	CO2, CO3, CO4, CO5
CD5	Industrial visit	CO2, CO5

COURSE INFORMATION SHEET

Course code: PE 511
Course title: COMPUTER INTEGRATED MANUFACTURING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L: 03 T:0 P:0
Class schedule per week: 03
Class: M.Tech
Semester / Level: I/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives
This course enables the students:

A.	To acquire knowledge in recent advances in the CIM.
B.	Design and develop CIM systems using the knowledge of mathematics, science, engineering and IT tools
C.	Apply modern computational, analytical, tools and techniques to face the challenges in CIM.
D.	Communicate ideas effectively with diversified groups to become lead professionals in academia and industry in advanced areas of manufacturing.
E.	To inculcate students with professional and ethical attitude, and an ability to relate CIM issues to broader engineering and social context.

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

1.	Understand the effect of manufacturing automation strategies and know the basics of Computer Integrated Manufacturing (CIM)
2.	Analyse automated flow lines and assembly systems and balance the line.
3.	Design automated material handling and storage systems for a FMS
4.	Design manufacturing cells and apply automatic inspection methods in CIM environment.
5.	Analyze the role of OSI model in the design of communication protocols and comprehend the importance of data communications in CIM environment.

Syllabus

MODULE-I

Manufacturing Automation: Automated Manufacturing Systems, Computerized Manufacturing Support Systems, Reasons for Automation and Process Improvement, CIM, Computer based integration between various functions - manufacturing, sales, design, materials, shop floor & computer process monitoring.

MODULE-II

Manual Assembly Lines: Assembly Workstations and Work Transport Systems

Automated Flow lines: System Configurations, Work part Transfer Mechanisms, Storage Buffers, Control of Production Line, Analysis of Transfer Lines-Transfer Lines with No Internal Parts Storage, Transfer Lines with Internal Storage Buffers. The Line Balancing Problem.

MODULE-III

Flexible Manufacturing Systems: Flexibility, Types of FMS and its Components. FMS Applications and Benefits, Machine loading problems in FMS, Production scheduling, scheduling rules, Routing and sequencing decisions.

Automatic Material Handling and Storage systems: Design Considerations in Material Handling, Material Transport Equipment- Automated Guided Vehicles, Design of Automated Storage/Retrieval Systems.

MODULE-IV

Cellular Manufacturing Systems: Part Families, Parts Classification and Coding, Features of Parts Classification and Coding Systems, Opitz of Parts Classification and Coding Systems, Production Flow Analysis, Machine Cell Design, Applications of GT Quantitative analysis of Cellular Manufacturing, Grouping of parts and Machines by Rank Order Clustering, Arranging Machines in a GT Cell.

Automated Inspection systems: Overview of Automated Identification Methods, Bar Code Technology, Radio Frequency Identification,

MODULE-V

Computer Networks for Manufacturing

Introduction to Data Communications: Data Communications, CIM data Files and report formats for data management.
Networks, The Internet – History, Protocols and Standards. Network Models: Layered Tasks, The OSI model, Layers in the OSI model,
Network Layer: logical addressing and Internet Protocol. MAP/TOP,
Physical Layer and Media: Bandwidth Utilization, Multiplexing, Spread Spectrum, Transmission media
Data Link Layer: Error Detection and Correction, Data Link Control, Multiple Access, Wired LANs: Ethernet, Wireless LANs.
Transport and Application Layer: Process-to-Process Delivery: UDP, TCP and SCTP. Domain Name System, File Transfer.

Books:

Text books:

1. Groover, M.P., “Automation, Production Systems and Computer Integrated Manufacturing ",Third Edition, Prentice-Hall, 2007
2. P.N.Rao, "CAD/CAM Principle and Applications", Tata McGraw Hill Publishing Company Limited.
3. Viswanadham N. and Narahari Y., Performance Modelling of Automated Manufacturing Systems, Prentice Hall India, 1994.

Reference books:

1. Kamrani, A.K, Parsaei, H.R and Liles, D.H. (Eds), "Planning, design and analysis of cellular manufacturing systems", Elsevier, 1995.
2. Burbidge, J.L., “Group Technology in Engineering Industry", Mechanical Engineering pub.London, 1979.
3. Rani, S.A., " Hand Book of Cellular Manufacturing Systems", John Wiley & Sons, 1999.
4. Askin R. G. and Standridge C. R., Modelling and Analysis of Manufacturing Systems, John Wiley and Sons, 1994.
5. Ranky P. G., Flexible Manufacturing Cells and Systems in CIM, CIM Ware Ltd., Guildford, Surrey, England, 1990.
6. B. Scholz and Reiter, C.I.M.Interfaces, Chapman Hall, 1992.
7. D. Bedworth et al., Computer Integrated Design and Manufacturing, McGraw Hill, 1991.

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

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

Indirect Assessment –

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

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets
CD5	Industrial visit

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	3		
CO2	3		1	3	2	3
CO3	3	1	2	3		2
CO4	3	2		3	3	2
CO5	3	3		3		1

<34% =1, 34-66% = 2, >66% = 3

	Mapping between CO and CD	
CD	**Course Delivery methods**	**Course Outcomes**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO2, CO3, CO4, CO5
CD3	Seminars	CO3, CO4, CO5
CD4	Self- learning advice using internets	CO2, CO3, CO4, CO5
CD5	Industrial visit	CO1, CO4, CO5

COURSE INFORMATION SHEET

Course code: PE 517
Course title: COMPUTER AIDED DESIGN AND DRAFTING LAB
Pre-requisite(s): None
Co- requisite(s): None
Credits: 02 L: 0 T: 0 P: 4
Class schedule per week: 4
Class: M.Tech.
Semester / Level: II/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn the concepts and principles of Computer aided Design & Drafting (CADD)
2	Understand the various types of CAD Software's like CATIA V5, Unigraphics NX etc.
3	Understand concepts of designing and drafting of various manufacturing components.
4	Understand the concepts of parametric 3D part modelling/Assembly
5	Understand the concepts of CAD Software, Design & Assemble various parts of Manufacturing 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, etc.
CO3	Produce models of an industrial component by interpreting 3D part drawings using Computer Aided Design, Drafting software.
CO4	Apply the concepts of CAD Drawings and Assemble various components of Manufacturing with focus on Industrial Applications
CO5	Will be able to generate part/assembly drawings.

List of experiments

Experiment No. 1
Introduction to Basics of Computer Aided Design. Sketcher, Drafting & 3D Modeling. **Experiment No. 2**
Exercise on Padding, Pocketing & Revolving.
Experiment No. 3
Exercise on Nut, Bolt & Threads
Experiment No. 4
Exercise on Chamfer, Fillets, Mirror & Offset
Experiment No. 5
Exercise on Hole & Patterns
Experiment No. 6
Exercise on Ribs & Shell
Experiment No. 7
Exercise on Sweep
Experiment No. 8
Exercise on Blend
Experiment No. 9

Exercise on Datum plane & Axis
Experiment No. 10
Exercise on Assembly-I: Foot-step Bearing
Experiment No. 11
Exercise on Assembly-II: Plumber-Block
Experiment No. 12
Exercise on Assembly-III: Bench-Vice assembly

Books recommended:

TEXT BOOK

1. Rao, P.N. "CAD/CAM: Principles and Applications", McGraw Hill Publication, 2nd Edition, 2004. **(T1)**
2. Mikell P. Grover, E. Zimmer, "Computer Aided Design and Manufacturing (CAD/CAM)", Pearson Publication, 2nd Edition, 2006. **(T2)**

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)**

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 (es)	10				
Viva-voce	20				
Semester End Examination	**% Distribution**				
Examination: Experiment Performance	30				
Quiz	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time Industrial projects.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects, Fractional order controller
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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		3	3	3	
CO2	1	2	1	3	2	1
CO3	2	1	3	2	3	2
CO4	2	2	2	3	2	1
CO5	1	2	3	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES 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

COURSE INFORMATION SHEET

Course code: PE 518
Course title: Data Analytics
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L: 03 T: 00 P: 00
Class schedule per week: 3
Class: M. Tech
Semester / Level: II/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives

This course enables the students:

A.	To learn the concepts of Descriptive Statistics
B.	To know the fundamentals of Analysis of variance and Hypothesis test
C.	To understand the various types of statistical approach for identifying clustering of data
D.	To know about supervise learning and support vector machines algorithms
E.	To understand basics of Neural network method

Course Outcomes

After the completion of this course, students will be:

CO1	Analysing data to convert information to useful knowledge
CO2	Designing and testing Hypothesis test and ANOVA
CO3	Solving problems on clustering of data
CO4	Analysing data using, Bias-Variance Dichotomy, Regression and SVM
CO5	Demonstrating the Neural Network for any experimental data

Syllabus

Module 1: [8L]

Data and Statistics

Classification of data, Introduction to big data, data analytics and descriptive statistics. Central Limit Theorem, Normal distribution, distributions of the sample mean and the sample variance for a normal population, Sampling distributions (Chi-Square, t, F, z).

Module 2: **[8L]**

Regression Analysis

Correlation analysis, Regression analysis, Linear and non-linear regression, Bi-variate and multi-variate regression, Logistic and robust regression, Path analysis

Module 3: **[8L]**

Hypothesis Testing

Introduction to Hypothesis testing, testing for Attributes, Mean of Normal Population, One-tailed and two-tailed tests, F-test and Chi-Square test. Analysis of variance ANOVA- One way and two-way classifications.

Module 4: **[8L]**

Clustering

Introduction, hierarchical clustering, Centroid-based clustering: K-means, Distribution-based clustering, Density-based clustering, Clustering using artificial neural network (ANN), Application examples for clustering

Module 5: **[8L]**

Machine Learning

Introduction to Machine Learning, supervise learning and un-supervise learning. Bias-Variance Dichotomy, Support Vector Machines, Applications of Machine learning.

Text books:

1. Douglas C. Montgomery "Design and analysis of experiment" Arizona state university, John wiley & sons INC.
2. Z C Holcomb "Fundamental of descriptive statistics" Routledge (Taylor and Francis).
3. S. Marshland, Machine Learning: An Algorithmic Perspective, CRC Press (Taylor and Francis), 1st edition, 2009, ISBN: 978-1420067187.
4. S. Kumar "Neural Network A classroom approach" Tata McGraw Hill Publication.

Reference books:

1. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006, ISBN: 978-0387-31073-2.
2. Brain S. Everitt, "A Handbook of Statistical Analysis Using R", Second Edition, 4 LLC, 2014.
3. Dalgaard, Peter, "Introductory statistics with R", Springer Science & Business Media, 2008.
4. K. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets
CD5	Industrial visit

Mapping between Course Outcomes and Program Outcomes

Course Outcome	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1		1	1	2	
CO2			2	2	2	
CO3	1		2	3	3	
CO4	1		2	3	3	1
CO5	2	1	2	3	3	

<34% =1, 34-66% = 2, >66% = 3

	Mapping between Course Outcomes and Course delivery method	
CD	**Course Delivery methods**	**Course Outcomes**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO2, CO3, CO4, CO5
CD3	Seminars	CO3, CO4, CO5
CD4	Self- learning advice using internets	CO2, CO3, CO4, CO5
CD5	Industrial visit	CO2, CO5

COURSE INFORMATION SHEET

Course code: PE 521
Course title: QUALITY ENGINEERING AND ROBUST DESIGN
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech
Semester / Level: II/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives
This course enables the students:

A.	To know the fundamentals of quality and quality control charts
B.	To learn the techniques of acceptance sampling, process measurement and control
C.	To find root cause identification and corrective action
D.	To learn Design of Experiments (DOE), Analysis of Variance (ANOVA), and Factorial Experiments
E.	To Know about robust design and Six Sigma

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

CO1	Develop control charts for variables and attributes
CO2	Design acceptance sampling plans
CO3	Analysis the root cause and develop the Quality Function Deployment (QFD)
CO4	Explain the practical implications of design of experiments
CO5	Apply Taguchi techniques to conduct experiments for robust design

Syllabus

Module 1: **[8L]**

Introduction
Quality Planning, Analysis & Control, Control charts for attributes and variables, cumulative sum and exponentially weighted moving average control charts, process capability.

Module 2: **[8L]**

Sampling Procedures & Measurement Techniques:
acceptance sampling for attributes, sampling plan, Dodge-Romig sampling, Acceptance sampling by variables. Inspection principles and strategies**,** Online and off line methods of inspection.

Module 3: **[8L]**

Root Cause Identification and Corrective Action
Seven Basic and Advanced Quality Control Tools-Affinity Diagram, Inter-Relationship diagram, Tree Diagram, Matrix Diagram, Activity Network Diagram, Prioritization Matrices, Process Decision Program Chart. Quality Function Deployment (QFD), Failure Mode and Effect Analysis (FMEA).

Module 4: **[8L]**

The Design of Experiments

Introductions and DOE process steps; orthogonal array selection and utilization. Analysis and Interpretation Methods for Experiments, Analysis of Variance (ANOVA), Confirmation Experiments, Factorial Experiments.

Module 5: **[8L]**

Robust Design

Application and Benefit of Robust Design, off line and online quality control, quality loss function, Taguchi Technique, S/N Analysis, Quality in Design and manufacturing, basic concept of six sigma, DMAIC.

Books:

Text books:

1. Montgomery, D.C. "Design and Analysis of Experiments", John Wiley and Sons, 5th Edition,2002.
2. Montgomery, D.C. "Introduction to statistical Quality control" John Wiley & Sons, Inc
3. Mitra, A., "Fundamentals of Quality Control and Improvement", Pearson Education Asia, First Edition (2004)

Reference books:

1. Ross, P. J., "Taguchi Techniques for Quality Engineering", McGraw-Hill Professional.
2. Bagchi, T. P., "Taguchi Methods Explained: Practical steps to Robust Design" Prentice- Hall of India.
3. Hicks, C. R. "Fundamental concepts in the Design of Experiments", Holt, Rinehort and Winston, 2000.
4. Grant E L and Leavenworth R S, "Statistical Quality Control", McGraw Hill, Sixth Edition (2000).
5. Hansen Bertrand L and Ghare Prabhakar M, "Quality Control and Applications" Prentice Hall of India Pvt. Ltd., First Edition (1993).

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets
CD5	Industrial visit

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	**Program Outcomes**					
	1	2	3	4	5	6
1		√				
2	√	√				
3	√	√	√	√		
4	√	√		√		
5	√	√		√		

	Mapping between CO and CD	
CD	**Course Delivery methods**	**Course Outcomes**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO2, CO3, CO4, CO5
CD3	Seminars	CO3, CO4, CO5
CD4	Self- learning advice using internets	CO2, CO3, CO4, CO5

COURSE INFORMATION SHEET

Course code: PE 522
Course title: OPTIMIZATION TECHNIQUES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L: 03 T:0 P:0
Class schedule per week: 03
Class: M.Tech
Semester / Level: I/5
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives

This course enables the students:

A.	To Impart knowledge to students in recent advances in the Optimization Techniques in Manufacturing and research related professions
B.	Formulate more complex problems, and apply implementations of selected algorithms to solve these problems
C.	Introduction to optimization techniques using both linear and non-linear programming.
D.	Apply search, satisfaction, optimization and learning algorithms to real world problems.
E.	Evaluate analytically the limitations of these algorithms, and assess tradeoffs between these algorithms

Course Outcomes:

After the completion of this course, students will be:

1.	Construct optimization problem formulation from an engineering problem
2.	Solve linear programming problems using simplex method
3.	Apply classical optimization techniques to solve differentiable non-linear optimization problems
4.	Solve non-differentiable non-linear optimization problems by applying a suitable method.
5.	Understand heuristics and metaheuristics to solve an optimization problem

SYLLABUS

Module 1: **[6L]**

Introduction to Optimization

Introduction, Development, Engineering Applications of Optimization, Statement of an Optimization Problem, Classification of Optimization Problems

Module 2: **[10L]**

Linear Programming

Optimization of linear systems: Introduction, Definition & theories; initial feasible basics, simplex method; Duality and sensitivity analysis.

Module 3: **[8L]**

Classical Optimization Techniques

Introduction, Single Variable Optimization, Multivariable Optimization with no constraints, Multi variable Optimization with equality constraints: Lagrangian multiplier, Multi variable Optimization with Inequality Constraints: Karush–Kuhn–Tucker (KKT) conditions

Module 4: **[8L]**

Selected Methods in Non-Linear Optimization

Separable programming, Quadratic programming, Gradient methods, Direct Search 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 5: **[8L]**

Optimization using meta-heuristics

Reasons for using heuristic and metaheuristic approaches, Types of search approaches, Local search heuristics: SWAP, INSERT, genetic crossover, Metaheuristics: Genetic Algorithm, Ant Colony Optimization, Simulated Annealing.

Books recommended:

TEXT BOOKS:

1. Hamady A Taha, "Operation Research", Pearson Education **[T1]**
2. 2.Rao S.S., Engineering Optimization - Theory and Practice, John Wiley & Sons, New York, 903 pp, 1996 .**[T2]**

REFERENCE BOOKS:

1. An introduction to Optimization by Edwin P K Chong, Stainslaw Zak **[R1]**
2. Nonlinear Programming by Dimitri Bertsekas **[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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets
CD5	Industrial visit

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6
1	3	1	2	3		
2	3		1	3	2	3
3	3	1	2	3		2
4	3	2		3	3	2
5	3	3		3		1

< 34% = 1, 34-66% = 2, > 66% = 3

	Mapping between CO and CD	
CD	**Course Delivery methods**	**Course Outcomes**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO2, CO3, CO4, CO5
CD3	Seminars	CO3, CO4, CO5
CD4	Self- learning advice using internets	CO2, CO3, CO4, CO5

COURSE INFORMATION SHEET

Course code: PE 523
Course title: MANUFACTURING STRATEGIES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L: 03 T:0 P:0
Class schedule per week: 03
Class: M.Tech
Semester / Level: I/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives:

This course enables the students to:

1	Understand the concept of manufacturing as a strategy and strategic planning
2	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)
3	Understand the concept of *Cellular manufacturing and Group technology*
4	Understand the concept of JIT and Lean Manufacturing
5.	Learn about the Theory of constraints and Six sigma manufacturing philosophies.

Course Outcomes:

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

CO1	Explain the concept of manufacturing strategy.
CO2	Select a proper manufacturing system for a given product and market scenario.
CO3	Design part family and manufacturing cells.
CO4	Comprehend JIT and Lean Manufacturing and perform value stream mapping.
CO5	Comprehend Theory of constraints and Six sigma manufacturing philosophies.

SYLLABUS

Module 1: [8L]

Manufacturing Strategy: Conceptual framework, manufacturing problems, Manufacturing Audit and strategy formulation, Diagnostic review, opportunity assessment, strategic planning. Manufacturing systems and manufacturing philosophies as manufacturing strategy.

Module 2: [8L]

Manufacturing systems: Elementary of Dedicated manufacturing system, Flexible manufacturing system (FMS), cellular manufacturing system (CMS), and Re-configurable manufacturing system (RMS).

Module 3: **[8L]**

Cellular manufacturing and Group technology: Part family, part classification and grouping, classification and coding systems, benefits and economics of grouping, cell formation and scheduling.

Module 4: **[8L]**

Lean Manufacturing: concept, goals, components, tools and techniques, JIT, KANBAN system, Value Stream Mapping, Kizan, and TQC.

Module 5: **[8L]**

Theory of constrain: concept and issues, TOC- Thinking Process, and VAT ANALYSIS. *Six sigma:* Concept, methodology, and applications

BOOKS RECOMMENDED:

1. Skimmar,Wickham, Manufacturing in the corporate Strategy, John Wiley and sons, NewYork.[T1]
2. Manufacturing Excellence in Global Markets W. Euershelm **[T2]**
3. Manufacturing Systems Design & Analysis B. Wa. **[T3]**
4. Computer Automation in Manufacturing T.O.Boucher **[T4]**

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

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

Topics beyond syllabus/Advanced topics/Design:

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS &EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3		3
CO2	3		3	3		3
CO3	3		3	3		3
CO4	3	1	3	3	1	2
CO5	3	1	3	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 524
Course title: ADVANCED MANUFACTURING TECHNOLOGIES
Pre-requisite(s): None
Co- requisite(s): PE 525
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: M.Tech

Semester / Level: I / 5
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the different advanced machining processes and their operational characteristics
2	Learn about the basic construction of the different advanced machining systems, 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 machining techniques and advanced surface finishing processes.

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 advanced casting processes.
CO2	Explain the fundamental principles, techniques, equipment, applications, advantages and limitations of different surface treatment processes.
CO3	Explain the fundamental principles, techniques, equipment, applications, advantages and limitations of different advanced forming processes.
CO4	Apply complex welding problems with the knowledge of latest welding technologies
CO5	Select appropriate advanced machining technique and advanced surface finishing processes based on work materials used and the part features to be produced.

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, strain induced melt activation (SIMA) and thixo-casting -rapid solidification of amorphous alloys.

Module 2: Surface Treatment **[8]**

Surface coating types, and ceramic and organic methods of coating, economics of coating. electro forming, chemical vapor deposition, thermal spraying, ion implantation, diffusion coating, diamond coating and cladding.

Module 3: Advanced Forming Processes **[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, rubber pad forming, explosive forming, hydroforming; vacuum forming; thixoforming;

Module 4: Advanced Welding Processes **[8]**

Cold welding, diffusion welding, friction stir welding, explosive welding, laser beam welding, electron beam welding, ion beam welding, underwater welding; concept of robotized welding and welding automation, welding of polymers and hybrid structures

Module 5: Advanced Machining & Finishing Processes [9]

High Speed Machining: Application of HSM, improved material removal rate, surface finish and integrity, accuracy, economic considerations. hot machining, cryogenic maching. modern grinding technologies, high speed and high performance grinding. hard machining using single point tools.
Abrasive Flow Machining (AFM), Magnetic Abrasive Finishing (MAF), Magnetic Float Polishing (MFP), Magnetorheological Finishing (MRF), Magnetorheological Abrasive Flow Finishing (MRAFF)

Text books:

1. Kalpakjian, Schmid, Manufacturing Processes for Engineering Materials, 6th edition, Pearson Education **[T1]**
2. Serope Kalpakjian and Steven R. Schmid, Manufacturing Engineering and Technology, 8th Edition, ISBN 978-0-13-668165-6, Pearson Education 2020 **[T2]**

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]**

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment	√	√	√	√	√
Semester End examination	√	√	√	√	√

Indirect Assessment –

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

Course Delivery methods

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1	1	3	3	3	1
2	2	1	3	3	3	1
3	2	1	3	3	3	1
4	1	1	3	3	3	1
5	2	1	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 525
Course title: ADVANCED MANUFACTURING TECHNOLOGIES LAB
Pre-requisite(s): None
Co- requisite(s): PE 524
Credits: 02 L:0 T:0 P: 4
Class schedule per week: 4
Class: M.Tech.
Semester / Level: I/5
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	To learn the concepts and principles of Computer aided Manufacturing (CAM)
2	To understand the various types of advanced casting processes
3	Understand concepts of machining for selection of appropriate machining parameters, and cutting tools for CNC machines
4	Develop industrial components by interpreting 3D part models/ part drawings
5	Understand the concepts of robotic welding technology

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

CO1	***Understand*** the fundamental principles, techniques, equipment of different advanced casting processes and ***Create*** such casting to produce industrial components
CO2	***Understand*** the fundamental principles, techniques, equipment of different advanced CNC machining processes and ***Create*** machining to produce industrial components
CO3	***Understand*** the fundamental principles, techniques, equipment of ultrasonic flaw detector and ***Execute*** flaw detection.
CO4	***Understand*** the fundamental principles, techniques, equipment of robotic welding and ***Execute*** a robotic welding.
CO5	***Create*** 3D prototype models/component by additive manufacturing

List of experiments

Experiment No. 1
Understand the working of stir casting and perform an aluminums stir casting.

Experiment No. 2
Understand the working of stir casting and perform an aluminums stir-squeeze casting.

Experiment No. 3
Learn about CNC lathe machine and understand to operate the machine with part programs.

Experiment No. 4
Write a manual part program for CNC lathe as per given job and machine a part drawing.

Experiment No. 5
Learn about CNC Air Plasma cutting machine and understand to operate the machine. Carry out a cutting operation as per given part drawing.

Experiment No. 6
Learn about CNC surface grinding machine and understand to operate the machine. Carry out a surface grinding operation as per given part drawing.

Experiment No. 7
Learn to use ultrasonic flaw detector. Learn to calibrate the equipment. Carryout a test to find defects in a casting or welded component.

Experiment No. 8
Learn about Micromachining machine and understand to operate the machine with part programs.

Experiment No. 9
Write a manual part program for to carry out micro turning operation

Experiment No. 10
Write a manual part program for to carry out micro drilling operation using micro EDM process.

Experiment No. 11
Learn about robotic welding and robot programming.

Experiment No. 12
Carry out a robotic GMAW of two given workpieces as per given drawing.

Experiment No. 13
Carry out a 3D printing of a component from a given drawing.

Experiment No. 14
Carry out a Wire Arc Additive Manufacturing using Robtoic GMAW setup.

Books recommended:

TEXT BOOK

1. Kalpakjian, Schmid, Manufacturing Processes for Engineering Materials, 6th edition, Pearson Education **[T1]**
2. Serope Kalpakjian and Steven R. Schmid, Manufacturing Engineering and Technology, 8th Edition, ISBN 978-0-13-668165-6, Pearson Education 2020 **[T2]**
3. Mikell P. Grover "Automation, Production Systems and Computer-Integrated Manufacturing" Pearson Education, New Delhi. ISBN: 0132393212.**[T3]**
4. Rao, P.N. "CAD/CAM: Principles and Applications", McGraw Hill Publication, 2nd Edition, 2004. **[T4]**
5. V.K. Jain, Introduction to Micromachining, 2nd Edition, Alpha Science, 2014 [T5]

REFERENCE BOOK

1. David Bedworth, "Computer Integrated Design and Manufacturing" Tata McGraw Hill,
   a. New Delhi, 1998. **(R1)**
2. Golam Kibria, Md. P. Jahan and B. Bhattacharya, Micro-electrical Discharge Machining Processes, Springer Verlag, Singapore, ISBN: 9789811330735 [R2]

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 (es)	10				
Viva-voce	20				
Semester End Examination	**% Distribution**				
Examination: Experiment Performance	30				
Quiz	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	3	3
CO2	3	2	1	3	2	2
CO3	2	3	3	2	3	2
CO4	3	2	2	3	2	3
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES 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 526
Course title: Advanced Topics in Operations Research
Pre-requisite(s): PE 522
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03 Class: M. Tech
Semester / Level: II/05
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Apply the techniques of operations research in real world problems.
2.	Solve integer and mixed integer problems
3.	Apply network modeling approaches in various problems and understand various combinatorial optimization problems coming from real world situations
4.	Solve problems of decision theory
5.	Solve problems of queuing theory and also solve problems which consists more than one goal to be achieved simultaneously by applying goal programming

Course Outcomes

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

CO1.	Apply various advanced liner programing methods to solve various integer, mixed-integer linear programing problems
CO2.	Construct network model for various network problems and solve the problem by applying appropriate methodology
CO3.	Implement combinatorial optimization approach to solve various real-life problems
CO4.	Apply decision theory in various managerial decision-making situations
CO5.	Analyze service and manufacturing systems by applying appropriate queueing model and apply goal programing approach to solve problems where simultaneous goals need to be fulfilled

Syllabus

Module 1: Advanced Topics in Linear Programming [8]

Dual simplex algorithm, Integer Programming: Introduction, Branch and bound technique, Solving 0-1 integer problem, Cutting plane method, Cutting stock problem

Module 2: Network Modelling [8]

Introduction: nodes, arcs, graph, tree, forest; Minimum spanning tree problem: Prim's algorithms, Kruskal's algorithm, Shortest path problem: Dijkstra's algorithm, Maximum flow problem: flow augmenting path method, Minimum cost flow problem: network simplex method.

Module 3: Combinatorial Optimization [8]

Introduction, Knapsack problem: mathematical formulation, solution as a 0-1 integer problem, Travelling salesman problem: mathematical formulation, solution using Hungarian method, Vehicle routing problem: mathematical formulation, Chinese postman problem: mathematical formulation, Quadratic assignment problem: mathematical formulation, Heuristic solution approaches for the combinatorial optimization problems

Module 4: Decision theory [8]

Introduction, Decision under certainty, Decision under risk, Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion, savage MiniMax, Regret criterion, Hurwicz criterion, Decision tree, AHP, TOPSIS

Module 5: Queueing Theory and Goal programming [8]

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, various queue disciplines: M/M/1: ∞/∞, M/M/1: N/∞, M/M/C: ∞/∞; Goal programing: introduction, formulation, solution using simplex method.

Text Books

1. Wayne L. Winston, Operations Research: Applications and Algorithms, Duxbury Press (T1)
2. Hamdy A. Taha, Operations Research: An Introduction, Prentice Hall PTR, Pearson (T2)

Reference Books

1. Operations Research, D.S. Hira, P.K. Gupta, S. Chand & Company Ltd, 2014 (R1)
2. Quantitative Techniques Vol I and Vol II, L. C. Jhamb, Everest Publishing House (R2)

Course Evaluation:
Individual assignment, Seminar, Theory (Quiz and End semester) examinations

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

Topics beyond syllabus/Advanced topics/Design:

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS &EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

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

Indirect Assessment –

3. Student Feedback on Faculty
4. Student Feedback on Course Outcome

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3		3
CO2	3		3	3		3
CO3	3		3	3		3
CO4	3	1	3	3	1	2
CO5	3	1	3	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 527
Course title: SOFT COMPUTING IN MANUFACTURING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T: P:
Class schedule per week: 03
Class: M.Tech
Semester / Level: II/5
Branch: Production and Industrial Engineering.
Name of Teacher:

Course Objectives

This course enables the students:

A.	To differentiate soft computing tools from hard computation
B.	To learn ANN, Fuzzy Logic and GA and their capabilities to solve complex problems
C.	To apply Artificial Neural Network and its various learning/training algorithms
D.	To learn fuzzy sets, their operations and apply fuzzy rule base to complex problems
E.	To understand various hybrid soft computing applications

Course Outcomes

After the completion of this course, students can

CO1	Distinguish controllers based hard and soft computing tools
CO2	Apply ANN tools for optimization, prediction and search applications
CO3	Apply fuzzy logic tools to inference systems
CO4	Apply genetic algorithm for optimization and search
CO5	Develop hybrid soft computing tools using ANN, fuzzy and GA

Syllabus

Module 1 **[8L]**

Introduction to soft computing and comparison with hard computation, capabilities of soft computing tools, practical applications of soft computing.

Module 2 **[8L]**

Basic concepts of Artificial Neural Networks (ANN), Single layer and Multi-layer perceptron, Learning Processes, Fundamentals of back propagation neural networks (BPNN), Learning and tuning parameters. Applications of ANN in manufacturing and automation.

Module 3 **[8L]**

Basic concepts Fuzzy Logic (FL), Fuzzy sets and their operations. Fuzzy memberships and relations, Fuzzification and defuzzification methods, Fuzzy rule generation, Applications of FL in manufacturing and automation.

Module 4 **[8L]**

Genetic Algorithms: An Overview, Introduction to fundamentals of techniques and applications of genetic algorithms, Selection, fitness function, Cross over, Mutation, Reproduction. GA in problem solving, Implementation of GA. Application of GA in optimization and search

Module 5 **[8L]**

Hybridization of soft computing tools, Types of hybridization, Fundamentals of hybrid systems like Neuro-Fuzzy, Neuro-Genetic and Fuzzy Genetic hybrids

Text books:

1. Neural Network, Fuzzy logic and Genetic Algorithm: Synthesis and Applications – S.Rajasekaran, G.A and Vijayalakshmi Pai.

Reference books:

1. Fuzzy Logic- Intelligence control and information – Jhon Yen and Reza Langar, Pearson Education
2. Neural Network A Comprehensive Foundation- Simon Haykin, Person Education
3. Genetic Algorithms in Search, Optimization and Machine Leaning- D.E. Goldberg, Addison-Wesley, 1989.
4. Fuzzy logic with engineering applications - Ross, T. J, 1997, McGraw-Hill, New York.

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

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

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets
CD5	Industrial visit

Mapping between Objectives and Outcomes

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2		2	2
CO2	1		3		2
CO3	1	2	3	2	
CO4	2				2
CO5	1	2	3		2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 528
Course title: MANUFACTURING AUTOMATION
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech.
Semester / Level: II/5
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	To learn the concepts and principle of manufacturing automation
2	To understand the various types of controls, components of automation and their practical use in manufacturing application
3	Automation Using Pneumatic Systems in various application areas
4	Understand the Automation Using Hydraulic Systems
5	To provide knowledge levels needed for PLC programming and operating

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

CO1	implement concepts of automation in machine tools and plant
CO2	select and apply automated material handling system to manufacturing system
CO3	design automated assembly lines for manufacturing
CO4	design automated assembly systems for manufacturing
CO5	understand the fundamentals of control in automation as they apply to manufacturing.

SYLLABUS

Module 1: [8L]
Introduction to Automation:
Automation in Production Systems-Automated Manufacturing
Systems, Computerized Manufacturing Support Systems, Reasons for Automation, Automation Principles and Strategies. Manufacturing operations, Production Concepts and Mathematical Models. Costs of Manufacturing Operations, Basic Elements of an Automated
Systems, Advanced Automation Functions, Levels of automation.

Module 2: [8L]
Introduction to Material Handling
Overview of Material Handling Equipment, Considerations in Material Handling System Design, The 10 Principles of Material Handling. Material Transport Systems, Automated Guided Vehicle Systems, Monorails and other Rail Guided Vehicles, Conveyor Systems, Analysis of Material Transport Systems. Storage Systems, Storage System Performance, Storage Location Strategies, Conventional Storage Methods and Equipment, Automated Storage Systems, Engineering Analysis of Storage Systems. Automatic data capture-overview of Automatic identification methods, bar code technology, other ADC technologies.

Module 3: **[8L]**

Manual Assembly Lines

Fundamentals of Manual Assembly Lines, Alternative Assembly Systems, Design for Assembly, Analysis of Single Model Assembly Lines, Line balancing problem, largest candidate rule, Kilbridge and Wester method, and Ranked Positional Weights Method, Mixed Model Assembly Lines, Considerations in assembly line design.

Transfer lines

Fundamentals of Automated Production Lines, Storage Buffers, and Applications of Automated Production Lines. Analysis of Transfer Lines with no Internal Storage, Analysis of Transfer lines with Storage Buffers.

Module 4: **[8L]**

Automated Assembly Systems

Fundamentals of Automated Assembly Systems, Design for Automated Assembly, and Quantitative Analysis of Assembly Systems - Parts Delivery System at Work Stations, Multi- Station Assembly Machines, Single Station Assembly

Transfer systems; Vibratory bowl feeders – its analysis; Non-vibratory feeders and their analysis; Analysis and design of part orienting devices, feed tracks and part placing mechanisms.

Module 5: **[8L]**

Industrial control:

Industrial Control: Industrial control systems; Mechanical, Hydraulic, Pneumatic, Electrical, Electronic and hybrid systems; Concepts, features and parameters governing the selection of various components of Industrial control systems.

PLC: Discrete Control using PLC & PLC network, Micro PLC, programming a PLC, Logic Functions, input & output Modules, PLC Processors, PLC Instructors, Documenting a PLC System, Timer & counter Instructions, data Handling instructions, Sequencing Instructions, Mask Data representation.

Books recommended:

TEXT BOOK

1. Mikell P. Grover "Automation, Production Systems and Computer-Integrated Manufacturing"Pearson Education, New Delhi. ISBN: 0132393212.**(T1)**
2. Andrew Parr, "Hydraulic and Pneumatics", Butterworth-Heinemann. ISBN:0750644192. **(T2)**
3. Bolton. W. "Pneumatic and Hydraulic Systems" Elsevier Science & Technology Books.ISBN:0750638362. **(T3)**
4. N. Viswanandham, Y. Narhari "Performance Modeling of Automated Manufacturing Systems" Prentice-Hall. ISBN: 0136588247. **(T4)**
5. W Bolton., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" Prentice-Hall. ISBN: 0131216333. **(T5)**
6. Luke H.D, Automation for Productivity, John Wiley & Sons, New York, 1972. (T6)

REFERENCE BOOK

1. Antony Esposito, "Fluid power with Applications" Pearson Education India. ISBN:8177585800. **(R1)**
2. C D Johnson, "Process Control Instrumentation Technology", Prentice Hall of India, New Delhi. ISBN: 8120309871. **(R2)**
3. S. R. Mujumdar, "Pneumatic system", Tata McGraw Hill. ISBN: 0074602314. **(R3)**

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus:

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery Methods

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3		
CO2	3		1	3		2
CO3	2	3	3	2		2
CO4	3	2	2	3	2	3
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

COURSE INFORMATION SHEET

Course code: PE 529
Course title: ADVANCED MACHINING TECHNOLOGIES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: M.Tech

Semester / Level: II / 5
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Learn about the different advanced machining processes and their operational characteristics
2	Learn about the basic construction of the different advanced machining systems, 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 machining techniques and advanced surface finishing processes.

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 advanced 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 machining techniques and advanced surface finishing processes.
CO5	Select appropriate advanced machining technique and advanced surface finishing processes based on work materials used and the part features to be produced.

SYLLABUS

Module 1: Introduction; Mechanical Energy Based Processes [8]
Introduction to advanced machining processes and their classification. 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), Ultrasonic Machining (USM); Calculation of MRR

Module 2: Chemical and Electro-Chemical Energy Based Processes [7]
Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Chemical Machining (ChM), Chemical Milling, Photochemical Milling, Electropolishing, and Electrochemical Machining (ECM); electrolytes; electrochemistry of ECM; kinematics and dynamics of ECM, tools, electrolyte flow and insulation, surface finish and accuracy.

Module 3: Thermal Energy Based Processes [10]
Fundamental principles, application possibilities, process parameters, schematic layout of machine and operational characteristics of Electro Discharge Machining (EDM), Wire Electro Discharge Machining (WEDM), Laser Beam Machining (LBM), Electron Beam Machining (EBM), and Plasma Arc Machining (PAM).

Module 4: Hybrid Machining Processes [8]
Fundamental principles, applications, and operational characteristics of Electrochemical Grinding (ECG), Electrodischarge Grinding (EDG), Electrochemical Discharge Machining (ECDM) and Electrochemical Discharge Grinding (ECDG), Abrasive Electrodischarge Machining (AEDM), EDM with Ultrasonic Assistance (US-EDM), Ultrasonic-Assisted ECM (US-ECM), Laser-Assisted ECM, Laser-Assisted Oxygen (LASOX) cutting.

Module 5: Advanced Finishing Processes [7]
Abrasive Flow Machining (AFM), Magnetic Abrasive Finishing (MAF), Magnetic Float Polishing (MFP), Magnetorheological Finishing (MRF), Magnetorheological Abrasive Flow Finishing (MRAFF) Chemo Mechanical Polishing (CMP), Electrolytic In-Process Dressing (ELID)

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]**

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:
COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment	√	√	√	√	√
Semester End examination	√	√	√	√	√

Indirect Assessment –

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

Course Delivery methods

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
1	1	1	3	3	3	1
2	2	1	3	3	3	1
3	2	1	3	3	3	1
4	1	1	3	3	3	1
5	2	1	3	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 530
Course title: MATERIALS FOR ENGINEERING APPLICATIONS
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: M.Tech

Semester / Level: II / 5
Branch: Production and Industrial Engineering
Name of Teacher:
Course Objectives:
This course enables the students to:

1	Acquire knowledge about the importance of different types of materials, understand the structure property correlation and learn about the structural materials
2	Learn about the processing, properties and applications of different types of ceramics and glasses
3	Understand the processing techniques, properties and applications of different polymers and composites
4	Learn about the structure, properties and processing of materials utilized for electrical and optical applications
5	Gain knowledge about the recently emerging and newer materials, their processing routes and applications

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

CO1	Investigate and analyze different structural materials for specific engineering applications
CO2	Evaluate ceramic and glassy materials for specific emerging applications
CO3	Select and evaluate the specific applications and processing routes of different composites and polymers
CO4	Compare and select materials for different applications in the electrical and optical industries
CO5	Recommend and select materials for newer advanced industrial applications

SYLLABUS

Module 1: Introduction and Structural Materials [10]
Types of materials - metals, ceramics, polymers, composites, semiconductors; Structure property correlation; Material selection and price
Metals and alloys; ferrous and non-ferrous alloys; phase rule; lever rule; common phase diagrams; time-temperature transformation diagram

Module 2: Ceramics and glasses [8]
Types of ceramics, phase diagrams of common ceramic alloys, properties of common ceramics & glasses, their common applications and processing methods; advanced ceramics

Module 3: Polymers and Composites [8]

Types of polymers, polymerizations processes, common polymers, their synthesis, properties, and applications

Types of composites, conventional composites, fiber reinforced composites, nanocomposites, property averaging by Rule of Mixture, common structural composites, their processing, and applications.

Module 4: Electrical and Optical Materials [7]

Electrical Materials - Conductors, Conductivity and its temperature dependency, semiconductors, Superconductors.

Optical Materials: Optical properties, color, luminescence, reflectivity, transparency, opacity, etc., optical systems and devices, Laser materials, optical fibers, liquid crystal displays, photoconductors.

Module 5: Advanced and Emerging Materials [7]

Processing, properties and applications of Nanomaterials, Shape memory alloys, Super alloys, Carbon-Carbon composites, high strength low alloy (HSLA) steel, Transformation induced in plasticity (TRIP) steel

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)**

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous internal assessment	√	√	√	√	√
Semester End examination	√	√	√	√	√

Indirect Assessment –

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

Course Delivery methods

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
1	2	1	3	3	3	1
2	2	1	3	3	3	1
3	2	2	3	2	3	1
4	1	1	3	3	3	1
5	2	1	3	2	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 531
Course title: ANAYSIS OF MATERIAL DEFORMATION PROCESSES
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:3 T: P:
Class schedule per week: 3
Class: M.Tech

Semester / Level: II / 5
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives:
This course enables the students to:

1	Conceptualize the theories on stress strain in three-dimensional state
2	Learn and understand the theories of elasticity
3	Analyze and develop concepts of the theory of plasticity
4	Understand and acquire knowledge about the analysis techniques for rolling and forging processes
5	Apply various methods for analysis of extrusion and drawing processes

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

CO1	Investigate the state of stress acting on a generalized 3D body
CO2	Analyze and apply the theory of elasticity
CO3	Examine and apply the theory of plasticity
CO4	Apply, investigate, and demonstrate the selection of analysis techniques for rolling and forging processes
CO5	Analyze, select and apply acquired knowledge to select appropriate design criteria for extrusion and drawing processes

SYLLABUS

Module 1: Concepts of stress and strain [8L]

State of Stress at a Point; Stress Tensor; Invariants of stress tensor; Principal Stresses; Spherical and Deviator Stress Tensors; Stress Invariants; Octahedral shear stress; Plane stress; Deformation Tensor; Strain tensor and rotation tensor; Principal strains; Plane strain, Engineering and True Stress – Strain.

Module 2: Theory of elasticity [8L]

Stress-strain relationships for an isotropic body for three-dimensional stress space; Stress-strain relation for plane stress and plane strain conditions; Differential equations of equilibrium; Compatibility equations and physical significance; Basic relationship between equilibrium, constitutive and compatibility relations; Von – Mises and Tresca Yield Criterions; Biaxial and Triaxial Yield Surfaces; Experimental Verification of Yield Criterion and Lode – Stress Parameter.

Module 3: Theory of plasticity **[8L]**

Flow Curve and Idealized Stress – Strain Models; Plastic Deformation Equations: Levy – Mises Equations and Prandtl – Reuss Equations; Velocity Field; Concept of Strain Hardening and Work hardening; Strain Rate and Bauschinger Effects; Work of plastic deformation.

Module 4: Analysis of Forging and Rolling **[8L]**

Overview of analysis methods – Uniform deformation energy method; Upper and lower bound methods; Forging – Analysis of plane strain compression, coulomb friction, sticking and slipping friction; Analysis of circular disc compression, effect of sticking friction, slipping friction and combined effect; Strip Rolling – Pressure Distribution, Roll-Separating Force and Roll Load Calculation; Driving Torque

Module 5: Analysis of Extrusion and Drawing **[8L]**

Extrusion – Analysis of punch load by slab method, Formulation of extrusion pressure, Plain strain extrusion through square and inclined dies, Lubrication in Extrusion; Drawing – Analysis of drawing circular wires, Drawing stress, Optimum die angle, Analysis of tube drawing by slab method, Analysis of strip drawing, Analysis of non-circular wires.

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]**

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Slip line theory, finite element method

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment	√	√	√	√	√
Semester End examination	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Course Delivery methods

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
1	2	1	3	3	3	1
2	2	1	3	3	3	1
3	2	2	3	2	3	1
4	1	1	3	3	3	1
5	2	1	3	2	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 532
Course title: ADDITIVE MANUFACTURING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L: 03 T:00 P:00
Class schedule per week: 3
Class: M.Tech
Semester / Level: II/5
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives
This course enables the students:

A.	To exploit technology used in additive manufacturing.
B.	To understand importance of additive manufacturing in advance manufacturing process.
C.	To acquire knowledge, techniques and skills to select relevant additive manufacturing process.
C.	To explore the potential of additive manufacturing in different industrial sectors.
D.	To apply 3D printing technology for additive manufacturing.

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

CO1	apply technique of CAD, design and reverse engineering for geometry transformation in additive manufacturing.
CO2	analyse and select suitable process and materials used in additive manufacturing.
CO3	understand the pre processing & post processing of additive manufacturing
CO4	identify, analyse, and solve problems related to additive manufacturing file format
CO5	analyse and select suitable process and materials used in rapid tooling

SYLLABUS

Module 1 **[7L]**

Introduction
Overview, Basic principle need and advantages of additive manufacturing, Classification of additive manufacturing processes, Materials used in additive manufacturing, Additive Manufacturing Methodology: Procedure of product development in additive manufacturing, Challenges in Additive Manufacturing. Rapid prototyping and additive manufacturing inter-relationships.

Module 2 **[9L]**

Pre-Processing in Additive Manufacturing
Preparation of 3D-CAD model, reverse engineering, reconstruction of 3D-CAD model using reverse engineering, part orientation and support generation.

Additive Manufacturing Processes I
Liquid-Based Additive Manufacturing Systems: 3D Systems' Stereolithography Apparatus (SLA), Cubital's Solid Ground Curing (SGC)

Solid-Based Additive Manufacturing Systems: Cubic Technologies' Laminated Object Manufacturing (LOM), Stratasys' Fused Deposition Modeling (FDM);

Module 3 **[9L]**

Additive Manufacturing Processes II

Powder-Based Additive Manufacturing Systems: 3D Systems' Selective Laser Sintering (SLS), Z Corporation's Three-Dimensional Printing (3DP), Extrude Hone's Prometal 3D Printing Process,

Newer Additive Manufacturing Systems:

Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Wire and Arc Additive Manufacturing Technologies like Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM). Continuous Liquid Interphase Production (CLIP) and **PolyJet process.**

Module 4 **[8L]**

Rapid Prototyping Data Formats:

STL Format, STL File Problems, STL File Repair, STL Conversion, STL error diagnostics and other standard file Formats.

Post-Processing in Additive Manufacturing

Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement.

Module 5 **[9L]**

Design for Additive Manufacturing, Additive Manufacturing Economics

Rapid Tooling

Direct and Indirect Tooling using Additive Manufacturing: Application of various Additive Manufacturing systems in Direct and Indirect Tooling.

Direct/Rapid Manufacturing

Books recommended:

TEXT BOOKS:

1. Gibson, I, Rosen, D W., and Stucker,B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing,Springer, 2010 **(T1)**.
2. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010 **(T2)**.
3. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014 **(T3)**
4. Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003 **(T4)**.

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. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018 **(R3)**.
4. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, "Laser Cladding", CRC Press, 2004 **(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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1		2		3	1	
CO2	2	1	1		3	1
CO3	1	3	2	3		2
CO4			1	3	2	3
CO5			3	2	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

	Mapping between CO and CD	
CD	**Course Delivery methods**	**Course Outcomes**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO2, CO3, CO4, CO5
CD3	Seminars	CO3, CO4, CO5
CD4	Self- learning advice using internets	CO2, CO3, CO4, CO5

COURSE INFORMATION SHEET

Course code: ME 506
Course title: Applied Tribology
Pre-requisite(s): None
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M.Tech
Semester / Level: II/05
Branch: Production and Industrial Engineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Comprehend the concept of tribology for applying lubrication in bearings and other machine elements.
2.	Design the tribological systems consisting bearings.
3.	Apply modern technologies of surface texturing for performance improvements of bearings.
4.	Derive governing equations of all types of bearings using knowledge of fluid mechanics.
5.	Solve general Reynolds equation for lubrication problems using FDM.

Course Outcomes

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

CO1.	Understand the basic concepts of friction, wear, and lubrication.
CO2.	Apply the knowledge of surface texture parameters for selection of bearing materials.
CO3.	Write Reynold's equation for various bearing problems and design thrust bearings.
CO4.	Design journal bearings and squeeze-film bearings.
CO5.	Design hydrostatic and rolling element bearings.

SYLLABUS

Module 1:

Friction, Wear, and Lubrication, Tribology principles, Principles for selection of bearing types, Lubricants and Lubrication, Mineral oils, Synthetic oils, Viscosity, Density and compressibility, Thermal Properties, Oil life, Greases, Solid lubricants, Lubricant supply methods.(8L)

Module 2:

Surface Texture and Interactions, Geometric characterization of surfaces, Surface parameters, Measurement of surface texture, Measurement of surface flatness, Statistical descriptions, Contact between surfaces, Lubrication regime relation to surface roughness, Bearing Materials, Distinctive selection factors, Oil-film bearing materials, Dry and semi-lubricated bearing materials, Air bearing materials, High-temperature materials, Rolling bearing materials.(8L)

Module 3:

Fundamentals of Viscous Flow, Conservation of mass, momentum, and energy, non-dimensionalisation, Reynolds Equation and Applications, Performance parameters, Thrust Bearings, Thrust bearing types, Design factors, Performance analysis, Design procedure**.**(8L)

Module 4:

Journal Bearings, Full-arc plain journal bearing with infinitely long approximation, Boundary conditions, Definition of the Sommerfeld number, Cavitation phenomena, Bearing performance parameters, Finite journal bearing design and analysis, Bearing Stiffness, Rotor Vibration, and Oil-Whirl Instability, General design guides, Squeeze-Film Bearings, Governing equations, Planar squeeze film, Nonplanar squeeze film, Squeeze film of finite surfaces, Piston rings.(8L)

Module 5:

Hydrostatic Bearings, Types and configurations, Circular step thrust bearings, Capillary- compensated hydrostatic bearings, Orifice-compensated bearings, Design procedure for compensated bearings, Hydraulic lift, Rolling Element Bearings, Ball bearing types, Roller bearing types, Thrust bearing types, Load–life relations, Adjusted rating life, Static load capacity.(8L)

Text Books

1. M. M. Khonsari and E. R. Booser. Applied Tribology: Bearing Design andLubrication, Second Edition. John Wiley & Sons, Ltd, 2008.

Reference Books

1. B. J. Hamrock, S. R. Schmid, B. O. Jacobson. Fundamental of Fluid FilmLubrication. Second Edition. Marcel Dekker, Inc., 2004.

2. G. W. Stachowiak, A. W. Batchelor. Engineering tribology. Butterworth-Heinemann, 2001.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Slip line theory, finite element method

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment	√	√	√	√	√
Semester End examination	√	√	√	√	√

Indirect Assessment –

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

Course Delivery methods

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
1	2	1	3	3	3	1
2	2	1	3	3	3	1
3	2	2	3	2	3	1
4	1	1	3	3	3	1
5	2	1	3	2	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 601
Course title: AUTOMATED MANUFACTURING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech
Semester / Level: III/6
Branch: ALL (Open Elective)
Name of Teacher:

Course Objectives

This course enables the students:

A.	Understand the concept of automation and manufacturing systems
B.	Write basic part programme for NC machine
C.	Knowledge about various components of automation like sensors, actuators, PLC
D.	To utilize material handling equipment like AGV, AS/RS, in manufacturing situations
E.	To identify the role of robotics in automated manufacturing systems

Course Outcomes

After the completion of this course, students will be:

CO1	Explain the principles and strategies of automation in different manufacturing systems
CO2	Demonstrate program for NC machining using part programming
CO3	Interpret different types of controller
CO4	Analyze different types of material handling systems
CO5	Apply fundamentals of Robotics, CIMS and FMS in designing manufacturing systems

SYLLABUS

Module 1 Introduction to Automation [8L]

Basic Elements of an Automated Systems, Advanced Automation Functions, Levels of automation, Automation Principles & Strategies, concept of automation; types of automation; flexibility, degree, level and yardstick of automation; Components of automation, Introduction to NC/CNC/DNC

Module 2 CNC Part Programming [8L]

Axes identification, coordinate system, movements and interpolation with other axis, Application of rotary axis, Manual programming for CNC turning and Milling– offline, Programming formats, Tool offsets, Type of compensations and cutting parameters, Introduction to G codes and M codes for CNC Turning and Milling, single and multipass canned cycle in turning, drilling canned cycles in milling, sub programing.

Module 3 Controller **[8L]**

Industrial Control Systems, Mechanical, Electrical, Hydraulic, Pneumatic, Electronic and Hybrid systems. Concepts features & parameters governing the Selection of various components Necessary for Building the elements.

Introduction to Programmable logical controller (PLC): Discrete Control using PLC & PLC network, Introduction, Micro PLC, programming a PLC, Logic Functions, input & output Modules, PLC Processors, PLC Instructors, Documenting a PLC System, Timer & counter Instructions, Comparison & data Handling instructions, Sequencing Instructions, Mask Data representation.

Module 4Automated material handling and quality control **[8L]**

Types of equipment, functions, analysis, conveyor systems, automated guided vehicle systems (AGVs), guidance, routing and control, Automated Storage and Retrieval systems (AS/RS), Components, Controls and applications, Integration of automated material handling and storage systems to manufacturing environment. Introduction to CMM, Non-Contact Inspection Method

Module 5 Robotics CIM and FMS **[8L]**

Introduction, Fundamentals of robot technology, Robot applications in manufacturing, Robot programming Methods - Robot programming languages and ROS.

Elements of CIM, Different modules and information flow, CIM planning & implementation process, requirements of CIM, Computerized production activities, Computerized integrated quality concept.

Definition & concept, flexible automation & productivity, components of FMS, Different types of FMS, Design problem of FMS, Technology required for FMS system. Their function & programming in FMS.

Books recommended:

TEXT BOOKS:

1. Groover M.P., Automation, "Production Systems and Computer Integrated Manufacturing :3 edition PHI,2009 **(T1)**.
2. Asfahl C. R., "Robots and Manufacturing Automation" John Wiley & Sons, 1992 **(T2)**.
3. Viswanandham N., "Performance modeling of automated Manufacturing Systems", PHI, 1992 **(T3)**.
4. Viswanathan,N., and Narahari,Y., "Performance Modeling and Automated Manufacturing Systems", Prentice Hall of India Pvt. Ltd., 2000 **(T4)**.

REFERENCE BOOKS:

1. Deb S. R.,"Robotics Technology & Flexible Automation" Tata McGraw Hill, 2001 **(R1)**.
2. Thomas R. Kurfess, "Robotics and Automation Handbook" 1 ed., CRC Press 2005 **(R2)**.
3. Anthony Esposito," Fluid Power with Applications", Prentice Hall, 1997 **(R3)**.
4. Bolton, W., "Mechatronics: A Multidisciplinary Approach" 4th ed., Pearson 2008 **(R4)**.

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution				
3 Quizzes	30 % (3 × 10%)				
Assignment (s)	10				
Seminar before a committee	10				
Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous internal assessment					
Semester End examination					

Indirect Assessment –

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

Course Delivery methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	2	2	1
2	1	1	1	3	3	1
3	1	1	1	3	2	1
4	1	1	2	3	3	1
5	1	1	2	3	3	2

< 34% = 1, 34-66% = 2, > 66% = 3

	Mapping between CO and CD	
CD	**Course Delivery methods**	**Course Outcomes**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO2, CO3, CO4, CO5
CD3	Seminars	CO3, CO4, CO5
CD4	Self- learning advice using internets	CO2, CO3, CO4, CO5

COURSE INFORMATION SHEET

Course code: PE 602
Course title: SMART MANUFACTURING
Pre-requisite(s): None
Co- requisite(s): None
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M. Tech
Semester / Level: III/6
Branch: ALL (Open Elective)
Name of Teacher:

Course Objectives

This course enables the students:

A.	To learn the concepts of CAD/CAM, CIMS and smart manufacturing
B.	To understand the various types of robots and their applications
C.	To gain knowledge about different types material handling systems
D.	To comprehend the concepts of agile and E- manufacturing system
E.	To realise the importance of Industry 4.0 through industrial case studies

Course Outcomes

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

CO1	Classify automated Manufacturing Systems, CAD/CAM and CIMS and smart manufacturing.
CO2	Identify and select different types of robots based on their applications
CO3	Develop basic design criteria for AGVs and AS/RS systems
CO4	Define the concepts of E-manufacturing, IT based supply chain, Cloud based manufacturing and Agile manufacturing
CO5	Comprehend the concepts of Industry 4.0 and IoT in manufacturing systems

Syllabus

Module 1:
Introduction to Smart Manufacturing [8L]

Automated Manufacturing Systems, Computerized Manufacturing Support Systems, CAD/ CAM and CIMS, Need for Automation, Process Improvement, Computer based integration between various functions - manufacturing, design, materials

Module 2:
Introduction to Robotics [8L]

Introduction of robot technology, Basic Terminologies, Classification, and characteristics, Physical configuration, Structure of industrial robots and its Applications. Case Studies.

Module 3:

Automated material handling [8L]

Introduction of material handling systems, Conveyor systems, Automated Guided Vehicle systems (AGVs): guidance, routing, control and design, Automated Storage and Retrieval systems (AS/RS): Components, Controls and applications. Integration of automated material handling and storage systems.

Module 4:
E- MANUFACTURING . [8L]

Introduction of Agent based manufacturing, Information technology based Supply chain, and cloud based Manufacturing, Concept of agile manufacturing and E-manufacturing.

Module 5:
Industry 4.0 [8L]

Evaluation of industries, Introduction to Industry 4.0, Challenges in industry 4.0, Impact of Industry 4.0, Case studies on industry 4.0, Introduction to Internet of Things (IoT) and its applications, Smart supply chain and Case studies.

Books:

Text books:

1. Bahga and V. Madisetti, Internet of Things, A hands-on approach, Create Space Independent Publishing Platform, 1st edition, 2014, ISBN: 978-0996025515
2. A. Bahga and V. Madisetti, Cloud Computing, A hands-on approach, Create Space Independent Publishing Platform, 1st edition, 2013, ISBN: 978-1494435141
3. M. Skilton and F. Hovsepian, The 4th Industrial Revolution: Responding to the Impact of Artificial Intelligence on Business, Springer Nature, 2017, ISBN: 978-3-319-62479-2
4. M. P. Grover "Automation, Production Systems and Computer-Integrated Manufacturing" Pearson Education, 4th Edition, 2016, ISBN: 978-0133499612
5. M. P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas and G. Odrey, Industrial Robotics Technology, Programming and Applications, McGraw Hill, 2nd Edition, 2017 ISBN: 978-1259006210

Reference books:

1. Gilchirst, Industry 4.0: The Industrial Internet of Things, Apress (Springer), 1st Edition, 2016, ISBN: 978-1-4842-2046-7
2. S. Jeschke, C. Brecher, H. Song, and D. B. Rawat, Industrial Internet of Things: Cyber manufacturing Systems, Springer, 1st edition, 2017, ISBN: 978-3319425580
3. T. Erl, Z. Mahmood, and R. Puttini, Cloud Computing: Concepts, Technology & Architecture, Prentice Hall, 1st edition, 2013, ISBN: 978-0133387520.
4. N. Viswanandham, Y. Narhari "Performance Modeling of Automated Manufacturing Systems" Prentice-Hall, 1st Edition, 1994, ISBN: 978-8120308701
5. S. K. Saha, Introduction to Robotics, Tata Mcgraw Hill Education Private Limited, 2nd Edition, ISBN: 978-9332902800

Gaps in the syllabus (to meet Industry/Profession requirements)
POs met through Gaps in the Syllabus
Topics beyond syllabus/Advanced topics/Design
POs met through Topics beyond syllabus/Advanced topics/Design

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

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

Indirect Assessment –

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

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars
CD4	Self- learning advice using internets
CD5	Industrial visit

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

Course Outcome #	Program Outcomes					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	2	1
CO2	1	1	1	2	3	
CO3	1	1	2	3	3	1
CO4	1	1	1	3	2	1
CO5	1	2	1	3	3	1

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

	Mapping between CO and CD	
CD	**Course Delivery methods**	**Course Outcomes**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, CO2, CO3, CO4, CO5
CD2	Tutorials/Assignments	CO2, CO3
CD3	Seminars	CO4, CO5
CD4	Self- learning advice using internets	CO2, CO3, CO4, CO5
CD5	Industrial visit	CO1, CO4, CO5