Department of Production Engineering

Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

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

Institute Mission

To educate students at Undergraduate, Post Graduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.

- To provide excellent research and development facilities to take up Ph.D programs and research projects.
- To develop effective teaching and 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 center of repute striving continuously towards providing quality education, research and innovation in the field of production engineering

Department Mission

- To provide quality education at both undergraduate and post graduate levels
- To provide opportunities and facilities for research and innovation
- To produce engineering graduates to meet the demands of manufacturing industries and R&D organizations
- To emphasize on integrating Manufacturing technology with management
- To impart latest technological knowledge to students by continuous development of curricula and faculty

Program Educational Objectives (PEOs)

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, team work and professionalism

PROGRAM OUTCOMES (POs)

M. Tech. in Production Engineering (Automated Manufacturing Systems)

Compulsory PO

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An 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 automation 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.

COURSE INFORMATION SHEET

Course code: PE 501
Course title: MANUFACTURING AUTOMATION
Pre-requisite(s): None
Co- requisite(s): PE 502
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech.
Semester / Level: I/5
Branch: Production Engineering (A.M.S)
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	Able to implement concepts of automation in machine tools and plant
CO2	Students will understand the fundamentals of control in automation as they apply to manufacturing.
CO3	Design of Pneumatic Circuit for manufacturing application
CO4	Design of Hydraulic Circuit for manufacturing application
CO5	Ability to apply PLC timers and counters for the control of industrial processes

SYLLABUS

Module 1: [8L]
Fundamentals of Manufacturing; Production system facilities; Manufacturing support systems; Different types of manufacturing systems; Automation in Production Systems

Module 2: [8L]
Manufacturing operations; Product, Production relationships; Production Concepts & Mathematical Models, Costs of Manufacturing Operations, Case studies

Module 3: [8L]
Automation Principles & Strategies, Concept of automation; Basic elements and types of automation; flexibility, degree, levels and yardstick of automation;
Components of Automation: Sensors, Actuators, ADC, DAC and Input/output devices.

Module 4: **[8L]**

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.

Module 5: **[8L]**

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)**

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

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

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

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: PE 502
Course title: COMPUTER AIDED MANUFACTURING LAB
Pre-requisite(s): None
Co- requisite(s): PE 501
Credits: 02 L:0 T:0 P: 4
Class schedule per week: 4
Class: M.Tech.
Semester / Level: I/5
Branch: Production Engineering (A.M.S)
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 Engineering (A.M.S.)
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: MODELING AND SIMULATION
Pre-requisite(s): None
Co- requisite(s): PE 505
Credits: 03 L:3 T:0 P:0
Class schedule per week: 3
Class: M.Tech
Semester / Level: I/5
Branch: Production Engineering (A.M.S)
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): PE 504
Credits: 02 L:0 T:0 P:4
Class schedule per week: 4
Class: M.Tech.
Semester / Level: I/5
Branch: Production Engineering (A.M.S)
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 506
Course title: MANUFACTURING TECHNOLOGY
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 Engineering (A.M.S)
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Learn the concepts of casting
2.	Understand the various types of forming methods
3.	Know about tool life, MRR, Cutting forces and surface finish in different machining process
4.	Understand the concept of joining processes
5.	Realize the importance of NTM in present manufacturing scenario.

Course Outcomes

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

CO1	Classify the different types of casting process
CO2	Explain principles and process of Forging, Rolling, Extrusion, drawing and designing of die
CO3	Analyse the tool life, MRR, Cutting forces and surface finish
CO4	Categorize welding processes according to welding principle and material
CO5	Select a proper NTM method for given component

SYLLABUS

Module 1: Introduction to manufacturing and Foundry [8L]
Classification of different manufacturing processes, application areas and limitations, basic engineering materials.
Sand casting process- Patterns, Core; Molding Processes, Solidification Process, Melting Furnaces,
Special casting methods - centrifugal casting and continuous casting; Permanent mold casting; Hot chamber and cold chamber die casting; Investment casting; Shell mold casting; Plaster mold casting.
Basic design considerations in casting, Casting defects and remedies.

Module 2: Metal forming **[8L]**

Hot and cold working. Forming operation~-Forging, rolling, extrusion, drawing processes, sheet metal operations.

Powder metallurgy processing: Production of metal powders, compaction and sintering processes.

Module 3: Metal Removal Processes **[8L]**

Classification of machining processes and machine tools. Tool's materials, different types of cutting tools, tool geometry and nomenclature of single point cutting tool, Concept of cutting speed, feed and depth of cut.single and multipoint cutting operation. Turning, Drilling, shaper, grinding, milling operations.

Module 4: Joining processes **[8L]**

Classification of welding processes, electric arc, special welding methods: MMAW, GTAW, GMAW, GMAW-CO2 welding, submerged arc welding, electro-slag welding, electron beam welding, laser beam welding, ultrasonic welding, resistance welding, welding defects, and arc blow heat affected zone, testing of welded joints, brazing and soldering.

Module 5: Non conventional manufacturing **[8L]**

Theory and application of machining by Abrasive Jet, Water Jet, Abrasive Flow, Ultrasonic. Electrochemical Machining and grinding. Thermal energy methods of material processing by Electro-discharge, High Energy Rate Forming.

Books recommended:

TEXT BOOKS:

1. Kalpakjian, S. and Schmid, S. R, "Manufacturing Engineering andTechnology", Pearson Education, 2000. **(T1)**
2. Groover, M. P., "Fundamentals of Modern Manufacturing", John Wiley and Sons Inc.,2002. **(T2)**
3. Rao, P. N., "Manufacturing Technology (Vol. 1&2)", Tata McGraw Hill 2009. **(T3)**
4. Choudhry, S.K.H., Choudhry, A.K.H., and Roy N., "Elements of Work Shop Technology", Vol I & II, Media Promoters & Publishers, 1994. **(T4)**

REFERENCE BOOKS:

1. Ghosh A., Malik A. K., "Manufacturing Science" East West Press, 2010. **(R1)**
2. DeGarmo, E. P, Black, J. T., Kohser, R. A. "Materials and Processes in Manufacturing", Prentice Hall of India Pvt. Limited, 1997. **(R2)**
3. Lindberg, R. A., "Processes and Materials of Manufacture", Prentice Hall India Limited, 1990. **(R3)**
4. Khanna, O.P., and Lal, M., A Text Book of Production Technology, Vol I & II, Dhanpat Rai & Sons, 1992. **(R4)**
5. Jain R K ., "Production Technology: Manufacturing Processes, Technology and Automation" Khanna Publication 2004. **(R5)**

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	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
1	1	1	1	2	1	1
2	1	1	1	2	1	1
3	1	1	2	3	1	2
4	1	1	1	3	1	1
5	1	1	2	3	2	2

< 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: PE 507
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: I/5
Branch: Production Engineering (A.M.S)
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:

CO1	Able to define the various process used in Additive Manufacturing
CO2	Able to analyse and select suitable process and materials used in Additive Manufacturing.
CO3	Able to identify, analyse and solve problems related to Additive Manufacturing.
CO4	Able to apply knowledge of additive manufacturing for various real-life applications
CO5	Able to apply technique of CAD and reverse engineering for geometry transformation in Additive Manufacturing.

SYLLABUS

Module 1 **[7L]**
Introduction
Overview, Basic principle need and advantages of additive manufacturing, Procedure of product development in additive manufacturing, Classification of additive manufacturing processes, Materials used in additive manufacturing, Challenges in Additive Manufacturing.

Module 2 **[9L]**

Additive Manufacturing Processes

Z-Corporation 3D-printing, Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS), Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).

Module 3 **[8L]**

Additive Manufacturing Machines and Systems

Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors. Introduction to NC/CNC/DNC machine tools, CNC programming and introduction, Hardware Interpolators, Software Interpolators, Recent developments of CNC systems for additive manufacturing.

Module 4 **[8L]**

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, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.

Module 5 **[8L]**

Post-Processing in Additive Manufacturing

Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Brief information on characterization techniques used in additive manufacturing, Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.

Future scope in Additive Manufacturing

Modelling and Simulation: Thermal model to predict size of deposition such as width and height of deposition, Finite element simulation of additive process.

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: PE 508
Course title: OPERATIONS AND 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: I/5
Branch: Production Engineering (A.M.S)
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 509
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: I/5
Branch: Production Engineering (A.M.S)
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 510
Course title: ROBOTICS & ROBOT APPLICATIONS
Pre-requisite(s): PE 501
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 Engineering (A.M.S)
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): PE 503
Co- requisite(s): None
Credits: 03 L: 03 T:0 P:0
Class schedule per week: 03
Class: M.Tech
Semester / Level: II/5
Branch: Production Engineering (A.M.S)
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.

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.
4. Kumar Surender, U.Chandra,and S.C.Srivasatava, "Computer Integrated Manufacturing", Satya Prakshan Pvt. Ltd., New Delhi

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 512
Course title: SOFT COMPUTING IN MANUFACTURING AUTOMATION
Pre-requisite(s): PE 501
Co- requisite(s): None
Credits: 03 L:3 T: P:
Class schedule per week: 03
Class: M.Tech
Semester / Level: II/5
Branch: Production Engineering (AMS)
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 513
Course title: MANUFACTURING SYSTEM DESIGN
Pre-requisite(s): None
Co- requisite(s): None
Credits: 3 L:03 T: 00 P: 00
Class schedule per week: 3
Class: M. Tech
Semester / Level: II/5
Branch: Production Engineering (AMS)
Name of Teacher:

Course Objectives

This course enables the students:

A.	To learn the concepts of manufacturing systems
B.	To know the fundamentals of design system, components and processes
C.	To estimate optimizing parameters of product
D.	To redesign the manufacturing systems
E.	To understand the optimization techniques in Manufacturing

Course Outcomes

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

CO1	Evaluate the manufacturing systems and its components
CO2	Design the manufacturing system according to need.
CO3	Analyze the optimization parameter for particular product
CO4	Redesign manufacturing system
CO5	Solve problems on optimization and designing of manufacturing system.

Syllabus

Module 1 **[8L]**

Introduction of manufacturing systems; Elements of manufacturing systems and their interaction; Recent Manufacturing strategies; Dynamics of manufacturing systems; Performance evaluation of manufacturing systems.

Module 2 **[8L]**

Design requirements of manufacturing system, Architecture and methodologies of manufacturing system, Framework of Manufacturing Systems, performance measurement and tools of Manufacturing Systems.

Module 3 **[8L]**

Design of Information system for manufacturing, Parts oriented production information system Development of Knowledge Based manufacturing system. Production control strategies, the importance of Optimization in manufacturing.

Module 4
[8L]

Redesign Methodology, case study of system redesign; Miltenburg's manufacturing system worksheet. System element used for system redesign. Sensitivity analysis of stochastic parameters.

Module 5 **[8L]**

Concept of artificial intelligence and its application for optimization. Human centered manufacturing system; Role of Manufacturing systems in Industry; Social system for manufacturing system

Text books:

1. Robert E Stein, "Re-Engineering the Manufacturing System" Marcel, Dekker
2. Product Design & Development - Karl. T. Ulrich and Steven D. Eppinger – TMH,Delhi
3. Ulrich Rembold, Christan Blume, Ruediger Dillmann, "Computer Integrated Manufacturing Technology and Systems", Marcel, Dekker.
4. Introduction of work study - ILO, Geneva - Universal Publishing Corporation, Bombay.
5. Motion and Time Study - Ralph M. Bannes - John Wiley & Sons
6. Work Study and Ergonomics - H.S. Shan – Dhanpat Rai& Sons

Reference books:

1. David O' Sullivan, "Manufacturing System Redesign- Creating the Integrated Manufacturing Environment", PTR Prentice Hall
2. Gideon Malevi, "Restructuring the Manufacturing Process Applying the Matrix Method", APICS.

3. Peter Bernus, Laszlo Nemes & Theodore J. Williams, "Architectures for Enterprise Integration", Chapman & Hall.

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

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1		2	1	
CO2	2	1			2	2
CO3	3	2	2	2	1	
CO4	3	2	3	3	1	3
CO5	1	2			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
CD3	Seminars	CO4, CO5
CD4	Self- learning advice using internets	CO1, CO2, CO3, CO4, CO5
CD5	Industrial visit	CO3, CO5

COURSE INFORMATION SHEET

Course code: PE 514
Course title: MECHATRONICS SYSTEMS
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 Engineering (A.M.S)
Name of Teacher:

Course Objectives:

This course enables the students to:

A.	Understand the concepts of Mechatronics systems and its Applications
B.	Study various types of Sensors, Actuators & Transducers
C.	Gain knowledge on Hydraulic and Pneumatic systems
D.	Gain Knowledge on Data Acquisition systems
E.	Understand the types of Modelling & Simulation Techniques

Course Outcomes:

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

CO1	Comprehend mechatronic systems, measurement system and control systems
CO2	Select appropriate sensors and transducers for mechatronic applications
CO3	Design hydraulic and pneumatic systems for machine tool automation
CO4	Develop Signal Conditioning and Data Acquisition systems
CO5	Model and Simulate Different types of Mechanical, Electrical & Electronics Systems

SYLLABUS

Module 1: Introduction to Mechatronics [8L]

Introduction to mechatronic systems, measurement system, control systems; Microprocessors and their applications, PLC system, examples of mechatronic system.

Module 2: Sensors and Transducers [8L]

Performance parameters of transducers, photoelectric transducers, flow transducers, optical transducers; Sensors specifications, Different types of sensors, application of sensors, Actuators and its types.

Module 3: Hydraulic and Pneumatic systems [8L]

Hydraulic system, pressure-flow-direction control valves, servo, logic valves. Hydraulic circuit of machine tools; Pneumatic system, Pressure-flow-direction control valves, Pneumatic component symbols, Pneumatic circuit of machine tools

Module 4: Signal Conditioning [8L]

Signal conditioning, Filtering digital signals, Multiplexers, Data acquisition, Signal processing, Pulse modulation, Data presentation systems

Module 5: Modelling and Simulation of systems [8L]

Mechanical, Electrical, Hydraulic and Thermal systems, Dynamic response of system, Mathematical models, Transfer function and frequency response, Closed loop controllers, Simulation and techniques of simulation

Books recommended:

Text Books:

1. Mechatronics 3/e,W, Bolton (Addison Wesley, ISBN 981-235-874-9.
2. Mechatronics (G. K. Vijayaraghavan, K. P. Ramachandran, M. S. Balasundaram),

   Wiley Publication
3. Mechatronics System Design 2nd Edition (Devdas Shetty), Cengage Learning

Reference Books

1. Introduction to Mechatronics and Measurement Systems, David G. Alciatore, McGraw Hill Publications
2. Mechatronics: A Foundation Course 1st Edition, Clarence W. de Silva, CRC Press.

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

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

CO5	3	3	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,CD2, CD3
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD3,CD6,
CO4	CD1, CD2, CD3,CD6
CO5	CD1,CD2,CD3,CD6

COURSE INFORMATION SHEET

Course code: PE 515
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: II/5
Branch: Production Engineering (AMS)
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

COURSE INFORMATION SHEET

Course code: PE 516
Course title: AUTONOMOUS SYSTEMS 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 Engineering (AMS)
Name of Teachers:

Course Objectives:
This course enables the students to:

1	Comprehend a real –time concepts of Manufacturing Autonomous systems
2	Be acquainted with standard Autonomous systems and create application programs for different applications
3	Give a hands-on experience of industrial applications and integrate with PLC
4	Identify real scenario for the kinematic parameters and troubleshoot a given autonomous system
5	Develop simple robot simulations using MATLAB for controlling the robot positions

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

CO1	Develop a basic manufacturing autonomous systems
CO2	Create programs for different autonomous applications (Robots and AS/RS)
CO3	Design and create pneumatic and electro-pneumatic circuits using PLC
CO4	Analyze the kinematic and dynamic parameters of a standard robot

CO5	Simulate a given autonomous system using virtual tools like MATLAB and interpret the results

List of experiments

Experiment No. 1
Basic components and applications of Autonomous systems
Experiment No. 2
Simulation and study the functional details of the various components of the ARISTO robots
Experiment No. 3
Simulation and Writing a program for PTP operation in ARISTO robot software
Experiment No. 4
Robot Workspace Calibration
Experiment No. 5
Simulation and Writing a program for repeatability through ARISTO robot software
Experiment No. 6
Simulation and Writing a program for circle and spline command through ARISTO robot Software
Experiment No. 7
Simulation and study the functional details of the various components of the Automated storage & Retrieval System (AS/RS)
Experiment No. 8
Simulation and Writing a program for rack to conveyor and conveyor to rack through AS/RS software
Experiment No. 9
Introduction to PLC and Ladder Logic Programming
Experiment No. 10
Programming PLC for Pick and Place Tasks
Experiment No. 11
Programming using MATLAB to perform Autonomous Simulations
Experiment No. 12
Simulate a Robot in MATLAB and control its position

Books recommended:

TEXT BOOK

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

REFERENCE BOOK

3. Radhakrishan P., Subramaniyam S., "CAD CAM and CIM", New Age International, 2002 **(R1)**
4. David Bedworth, "Computer Integrated Design and Manufacturing" Tata McGraw Hill, New Delhi, 1998 **(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	1	2	2	
CO2	1	2	1	2	3	
CO3	2	1	3	2	3	2
CO4		2	2	3	3	
CO5	1	1	1	3	1	1

< 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 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 Engineering (AMS)
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 601
Course title: Data Analytics
Pre-requisite(s): NA
Co- requisite(s): PE 605
Credits: 03 L: 03 T: 00 P: 00
Class schedule per week: 3
Class: M. Tech
Semester / Level: III/6
Branch: Production Engineering (A.M.S)
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 602
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: III/6
Branch: Production Engineering (A.M.S)
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.	To cover various optimization techniques and their applications
2.	To explain the optimization of linear systems using simplex method
3.	Understanding optimization of non-linear problems using quadratic and Direct Search Methods.
4.	Cast engineering minima/maxima problems into optimization framework.
5.	To solve sequential systems like scheduling using dynamic programming

SYLLABUS

Module 1: **[8L]**

Introduction to Optimization

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

Module 2: **[8L]**

Classical Optimization Techniques

Introduction, Single Variable Optimization, Multivariable Optimization with no constraints, Multi variable Optimization with Inequality Constraints

Module 3: **[8L]**

Linear Programming

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

Module 4: **[8L]**

Optimization of Non-linear systems

Introduction, Separable programming; Quadratic programming: programming: gradient methods, Direct Search methods.

Module 5: **[8L]**

Optimization using meta-heuristics
Introduction to meta-heuristics like Simulated Annealing, tabu search, ACO, PSO, Immune systems and hybrid systems

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 603
Course title: HYDRAULIC AND PNEUMATIC CONTROLS
Pre-requisite(s): PE 501
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: Production Engineering (A.M.S)
Name of Teacher:

Course Objectives:

This course enables the students to:

A.	To understand the concepts of Power Hydraulics and its applications
B.	To study various controls valves
C.	To gain knowledge on Hydraulic actuators and Servo valves
D.	To Design Hydraulic circuits
E.	To understand the types of Pneumatics and its applications

Course Outcomes:

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

CO1	Recognise the Importance of Hydraulics and Pneumatics Controls

CO2	Explore the control of various types of valves
CO3	Handle real-life projects in various organizations
CO4	Design Hydraulic circuits
CO5	Perform the maintenance of hydraulic systems and fluids

SYLLABUS

Module 1: **[8L]**

Introduction

Power hydraulics & its applications, Hydraulic symbols,
Positive displacement Pumps: Gear, Vane, Piston and other special types of pumps.

Module 2: **[8L]**

Control valves

Pressure Control: relief valve, Unloaded valve, Pressure reducing valve, Counter balance valve, sequence valve, Flow Control: Meter in Meter out, Bleed off, Pressure and Temperature, compensated flow control valve, Direction Control: Check valve, Open centre, closed centre, Tandem centre and others, Cartridge valves, Flow forces on valve spools.

Module 3: **[8L]**

Hydraulic actuators

Linear and rotary, Design of Hydraulic actuators, Accessories in hydraulic systems: Accumulator, Air-breathe valve, Pressure switches etc. Hydraulic power packs.
Servo valves: Torque motor, electro-hydraulic Servo valves: Types and principles of operations.

Module 4: **[8L]**

Design of Hydraulic circuits and its application

Regeneration, Pre-fill, Twin Pump and others. Maintenance of hydraulic systems and working fluid:

Module 5: **[8L]**

Pneumatics

Air Filter, Lubricators and Regulators, Pneumatic control elements: Air Cylinders and their Design, Pneumatic safety circuits, Pneumatic Logic control.

Books recommended:

TEXT BOOK

1. H.E. Merritt, "Hydraulic Control Systems", John Wiley & Sons, New York. **(T1)**
2. D. Mc Cloy and H. R. Martin, "Control of Fluid Power, Analysis, Design and Control", John Wiley & Sons. **(T2)**

REFERENCE BOOKS:

1. Andrew Parr, Hydraulics and Pneumatics, Jaico Publishers. **(R1)**
2. Esposito, Fluid Power by Esposito, Pearson Education. **(R2)**

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

COURSE 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

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

CO3	3	3	3	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,CD2, CD3
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD3,CD6,
CO4	CD1, CD2, CD3,CD6
CO5	CD1,CD2,CD3,CD6

COURSE INFORMATION SHEET

Course code: PE 604
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: III/6
Branch: Production Engineering (AMS)
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 605
Course title: DATA ANALYTICS LAB
Pre-requisite(s): None
Co- requisite(s): PE 601
Credits: 02 L: 0 T: 0 P: 4
Class schedule per week: 4
Class: M.Tech.
Semester / Level: III/6
Branch: Production Engineering (A.M.S)
Name of Teachers:

Course Objectives:
This course enables the students:

1	To learn the concepts of data and their classes
2	To know the fundamentals of various kinds of regression analysis
3	To understand the concepts of Analysis of variance
4	To know about Hypothesis testing
5	To understand basics of Neural network method

Course Outcomes:

At the end of the course, students should be able to:

CO1	Classify data into numerical and categorical types before analysis
CO2	Conduct different regression analysis using MS-Excel© and MINITAB© software
CO3	Design and testing of hypothesis through software
CO4	Analyse data for ANOVA and significance testing through software
CO5	Apply the Neural Network for predictive models

List of experiments

Experiment No. 1

Introduction to data analytics and classification of data

Experiment No. 2

Conduct a Stratification and Pareto Analysis for given set of data using MINITAB©

Experiment No. 3

Construct a correlation and Scatter plot for given set of data using MINITAB©

Experiment No. 4

Conduct Bi-variate Linear Regression Analysis for given set of data using MINITAB©

Experiment No. 5

Multivariate Nonlinear Regression Analysis for given set of data using MINITAB©

Experiment No. 6

Design and conduct Hypothesis testing *(t* test) for given set of data using MINITAB©

Experiment No. 7

Design and conduct Hypothesis testing *(z* test) for given set of data using MINITAB©

Experiment No. 8

Design and conduct Hypothesis testing *(chi* test) for given set of data using MINITAB©

Experiment No. 9

Conduct an ANOVA Test of significance (*F*-test) for given set of data using MINITAB©

Experiment No. 10

Developing an ANN model for prediction using a set of training data in MATLAB©

Books recommended:

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) :
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 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

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	1	2	2	
CO2	1	2		2		
CO3	2	1	3		3	2
CO4			2	3	3	
CO5	1	1	1	3	1	1

< 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