College of Engineering, Pune
(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Manufacturing Engineering and Industrial Management

Curriculum Structure & Detailed Syllabus (UG Program)

B. Tech. (Production Engineering S/w)
(Revision: A.Y. 2020-21, Effective from: A.Y. 2022-23)

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Program Education Objectives (PEOs):

The Undergraduate students will demonstrate:

I. **PEO1**: Advance professionally as a result of his/her ability to solve complex technical problems using the knowledge of mathematics, science, engineering and humanities and to work in multidisciplinary areas whose solutions lead to significant societal benefits.

II. **PEO2**: Demonstrate professional engineering competence to real life problems and compete successfully using principles of manufacturing and time and quality management in the design and manufacture of products and services.

III. **PEO3**: Exhibit professionalism, ethical attitude, communication skills, teamwork in their profession and adapt to current trends by engaging in lifelong learning.

Program Outcomes (POs):

The Undergraduate Students will demonstrate:

a. Graduates will apply the basic knowledge of mathematics, science, engineering and humanities to Production Engineering field
b. Graduates will have the ability to define the problems and provide solutions by designing and conducting experiments, interpreting, and analyzing data for manufacturing.
c. Graduates will design manufacturing systems that would encompass machining science and technology, production processes, metal forming, tool and die design with the fully acquaintance with engineering thermodynamics and heat transfer, theory of machines, strength of material and would meet specifications and requirements as demanded by the customers.
d. Graduates will apply design and tooling for manufacturing, Kinematics of Machine Elements, Quality Control, modeling of manufacturing systems to solve production engineering problems.
e. Graduates understand manufacturing technologies like computer-controlled processes and Industrial Engineering, production management, SCLM, and Total Quality Management concepts.
f. Graduates will have the confidence to apply engineering solutions in global and societal contexts.
g. Graduates will understand quantitative modeling and analysis of a broad array of systems-level decision problems concerned with economic efficiency, work design, productivity and quality with environmental focus.
h. Graduates should be capable of self-education and clearly understand the value of achieving perfection in their professional endeavors.
i. Graduates will participate as members of engineering and science laboratory teams, as well as members of multidisciplinary design teams.
j. Graduates will be proficient in English language in both verbal and written forms which will enable them to compete with graduates of international engineering institutions.
k. Graduates will have the ability to choose and apply appropriate resource management technique/s so as to optimally utilize resources in manufacturing systems.
l. Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.

Correlation between the PEOs and PO's/PSO's

Program Objectives		Program Outcome												Program Specific Outcomes		
		a	b	c	d	e	f	g	h	i	j	k	l	PSO1	PSO2	PSO3
PEO's	I	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓
	II	✓	✓	✓	✓	✓	✓					✓	✓	✓		
	III	✓	✓				✓		✓	✓	✓		✓			✓

Program Specific Outcomes:

After completion of the program, the graduates should be able to:

PSO1: Apply knowledge of manufacturing systems, Industrial Engineering and analytical techniques to solve real world problems.

PSO2: Apply knowledge of machine tool design,

measurement systems, quality control and management systems to identify, formulate and solve complex engineering problems.

PSO3: Design, develop and manufacture innovative products using emerging manufacturing and computing technologies like CAD/CAM/CIM, Rapid prototyping, machine learning, artificial intelligence etc.

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
BSC	**Basic Science Course**	**9**	**27**	16.27
ESC	**Engineering Science Course**	**5**	**18**	10.84
MLC	**Mandatory Learning Course**	**3**	**0**	0.00
SLC	**Self-Learning Course**	**2**	**4**	2.41
HSMC	**Humanities/Social Sciences/Management Course**	**6**	**7**	4.22
LLC	**Liberal Learning Course**	**1**	**1**	0.60
SBC	**Skill Based Course**	**7**	**26**	15.66
IFC	**Interdisciplinary Foundation Course**	**2**	**4**	2.41
IOC	**Interdisciplinary Open Course**	**2**	**4**	2.41
DEC	**Department Elective Course**	**2**	**6**	3.61
PCC	**Program Core Course**	**17**	**49**	29.52
LC	**Laboratory Course**	**19**	**20**	12.05
		75	**166**	

Semester VII : Scheme A

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	MLC		Intellectual Property Rights	1	0	0	0
2	LLC		Liberal Learning Course	1	0	0	1
3	MLC		Environmental Studies	1	0	0	0
4	IOC		Interdisciplinary Open Course-III Artificial Intelligence	2	0	0	2
5	DEC		Department Elective-II [Option among minimum 3 courses]	3	0	0	3
6	PCC		Machine Tool Design	3	0	0	3
7	PCC		CAD/CAM/CIM	2	1	0	3
8	PCC		Manufacturing Automation	2	1	0	3
9	PCC		Operations Research	3	0	0	3
10	LC		CAD/CAM/CIM Lab	0	0	2	1
11	LC		Manufacturing Automation Lab	0	0	2	1
12	LC		Modelling and simulation lab	1	0	2	1
13	LC		Process Planning and Tool Selection Lab	1	0	2	2
				20	**2**	**8**	**24**
			Total Academic Engagement and Credits				

Available Credits for the Program Core: 10

Interdisciplinary Open Course -III: A Set of Management related courses to be offered by Humanities/Production Engineering Department for all Students.

- ONE Minor course [To be offered to the Students from Other Departments]
- ONE Honors course [To be offered to Students of Host Department]

For other departments

			Interdisciplinary Open Course-III	L	T	P	Credits
1	IOC		Total Quality Management	2	0	0	2
2	IOC		Operations Research	2	0	0	2
3	IOC		Project Planning and Control	2	0	0	2

Department Elective-II [Option among minimum 3 courses]

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	DEC		Product Design and Manufacture	3	0	0	3
2	DEC		Total Quality Management	3	0	0	3
3	DEC		Micro Electro Mechanical Systems	3	0	0	3
4	DEC		Tribology in Manufacturing	3	0	0	3
5	DEC		Mechatronics	3	0	0	3
6	DEC		Robotics	3	0	0	3

7	DEC		Artificial Intelligence	3	0	0	3
8	DEC		Advanced Joining Technology	3	0	0	3

Semester VIII:

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	SBC		Industrial Inplant Training	0	0	0	10
2	PCC		Seminar II	0	0	0	1
3	SLC		Department Elective-III [Option among minimum 3 courses] Project and Production Management/Equivalent MOOC Course	0	0	0	3
				0	**0**	**0**	**14**
			Total Academic Engagement and Credits				**Max. 17**

Available Credits for the Program Core: 00

Yellow Highlighted Text: AICTE recommended titles/Changed Title; Blue Highlighted Text: New Course

Of the four Department Elective courses, the student shall be taken at least two courses in MOOCs mode

- ONE Minor course [To be offered to the Students from Other Departments]
- ONE Honors course [To be offered to Students of Host Department]

Minors- Manufacturing Technology (Mechanical)

Semester	Course Code	Course offered	Teaching Scheme			Credits
			L	T	P	
V	PE(MI)-21001	Metrology and Quality Control	3	-	-	3
VI	PE(MI)-21002	Engineering Economics and Operations Research	3	-	-	3
VII		Manufacturing Automation	3	-	-	3
VIII		Industrial Design of Products	3	-	-	3

Minors- Manufacturing Technology (Civil/ENTC/Electrical/Instru/Comp/IT/Meta)

Semester	Course Code	Course offered	Teaching scheme			Credits
			L	T	P	
V	PE(MI)-21003	Production Processes	3	-	-	3
VI	PE(MI)-21002	Engineering Economics and Operations Research	3	-	-	3
VII		Manufacturing Automation	3	-	-	3
VIII		Industrial Design of Products	3	-	-	3

Honors- Manufacturing Systems Engineering

Semester	Course Code	Course offered	Teaching scheme			Credits
			L	T	P	
V	PE(HO)-21001	Precision Engineering	3	-	-	3
VI	PE(HO)-21002	Reliability and Maintenance Engineering	3	-	-	3
VII		Performance Modeling of Production Systems	3	-	-	3
VIII		Machine Tool Systems	3	-	-	3

Honors- Mechatronics

Semester	Course Code	Course offered	Teaching scheme			Credits
			L	T	P	
V	PE(HO)-21003	Principles of Electronics	3	-	-	3
VI	PE(HO)-21004	Industrial Instrumentation and Control	3	-	-	3
VII		Mechatronics System Design	3	-	-	3
VIII		Fluid Power Systems and Factory Automation	3	-	-	3

Interdisciplinary Open Course-III

Artificial Intelligence

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1 and T2 – 20 marks each,
End-Sem Exam - 60

Course Outcomes:

At the end of the course students will be able to:

- Knowledge of what constitutes "Artificial" Intelligence and how to identify systems with Artificial Intelligence.
- Ability to apply Artificial Intelligence techniques for problem solving.
- Implement classical Artificial Intelligence techniques, such as search algorithms, minimax algorithm, neural networks, tracking, robot localization.

Syllabus Contents:

Unit 1 **(6 hrs)**
Overview: foundations, scope, problems, and approaches of AI.
Intelligent agents: reactive, deliberative, goal-driven, utility-driven, and learning agents, Artificial Intelligence programming techniques.

Unit 2 **(8 Hrs)**
Problem-solving through Search: forward and backward, state-space, blind, heuristic, problem-reduction, alpha-beta pruning, minimax, constraint propagation, neural, stochastic, and evolutionary search algorithms, sample applications.

Unit 3 **(8 Hrs)**
Knowledge Representation and Reasoning: ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications.

Unit 4 **(6 Hrs)**
Planning: planning as search, partial order planning, construction, and use of planning graphs.
Representing and Reasoning with Uncertain Knowledge: probability, connection to logic, independence, Bayes rule, bayesian networks, probabilistic inference, sample applications.

Unit 5 **(8 Hrs)**
Decision-Making: basics of utility theory, decision theory, sequential decision problems, elementary game theory, sample applications.

Machine Learning: basic concepts, linear models, perceptron, K nearest neighbors, advanced models, neural networks, SVMs, decision trees and unsupervised learning

Unit 6 **(4 Hrs)**

Applications of AI(vision/robotics etc.), student project presentations

Text Books:

- Russell, Stuart and Norvig, Peter, "Artificial Intelligence: A Modern Approach" Prentice Hall, 2003.

Reference Books:

- Aleksander, Igor and Burnett, Piers "Thinking Machines" Oxford, 1987.
- Bench-Capon, T. J. M., "Knowledge Representation: An approach to artificial intelligence" Academic Press, 1990.
- Genesereth, Michael R. and Nilsson, Nils J. "Logical Foundations of Artificial Intelligence", Morgan Kaufmann,1987.
- Michael Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems (3rd Edition),
- VINOD CHANDRA S.S., ANAND HAREENDRAN S, " ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING"
- Luger " Artificial Intelligence", Edition 5, Pearson, 2008

MACHINE TOOL DESIGN

Teaching Scheme

Lectures : 3 hrs/week
Tutorial :

Examination Scheme

100 marks: Continuous evaluation- Assignments /Quiz/T1/T2 - 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Knowledge about Design of various elements of machine tools and their structures.
- Knowledge of drives in machine tools.
- Learn the methods of acceptance tests for machine tools.
- Knowledge of NC-CNC machine & their controls.
- Information about recent trends in machine tools

Syllabus Contents:

Unit 1 **(10 hrs)**

Introduction and Drives

Recent trends in machine tool design, Classification and kinematic structure of machine tool, Consideration for machine tool speed drive, Structural and ray diagram, etc., Electric motor selection, Feed drive types, Friction variator- Principle and types.

Unit 2 **(14 hrs)**

Elements of machine tool

Design of bed- Optimum design criteria, Cross-sections, stiffness, Materials, Column design methodology for radical drilling and milling machine.

Design of guides-materials, Requirements, Types, Average pressure, stability, wear and its

compensation, Combination guide, stick-slip.
Design of spindle- Material, spindle ends and supports, Spacing between supports.
Design of power screws-Design methodology, Pitch error, Specific pressure on thread, Recirculating ball screw, Axial load and dynamic load carrying capacity, Rigidity, etc.

Unit 3 **(4 hrs)**

Rigidity of machine tool
Static and dynamic rigidity, Source of vibration, chatter, static compliance of lathe, Dynamic rigidity analysis.

Unit 4 **(4 hrs)**

Control system in machine tool
Electrical control- Push button system, selective and pre selective control.
Adaptive control- ACO/ACC etc. control involving thermal relay, Directional control valves, Quick braking etc., Hydraulic control, use of stepper motor and servo motor.

Unit 5 **(6 hrs)**

NC- CNC AND FMS
Introduction, Block diagram of NC, Tool motion, Axes designation, CNC block diagram,
Open/ Close loop control, Sensors, FMS- definition, Classification, Automatic tool changer, Machining centers.

Unit 6 **(4 hrs)**
Micro movement and reliability of machine tool
Micro movement method- Magnetostrictine, Thermodynamic, etc, Reliability of component, Condition based maintenance and reliability centric maintenance.

Text Books:

- D.K. Pal and S.K.Basu, Design of Machine Tools (6th Revised Ed), Oxford-IBH 2014.
- A. Bhattacharya and G.C. Sen, Principles of Machine Tools, New Central Book Agency, Calcutta

Reference Books:

- Acherkan, N.S. et al Machine Tools Vol. I to Vol. IV, :, MIR Publications
- Martin, S.J. NC Machine Tools,: ELBS
- Koenigsburger, A., Design Principles of MCMT Pergamon press, 1964.
- Mehta, N.K., Machine Tool Design, Tata McGraw Hill
- T Kundra, Rao, P.M., Tiwari, N.K. Numerical Control and Computer Aided Manufacturing, Tata McGraw Hil

CAD /CAM /CIM

Teaching Scheme	Examination Scheme
Lectures: 2 hrs/week	T1 and T2 – 20 marks each,
Tutorial: 1 hrs/week	End-Sem Exam - 60

Course Outcomes:

The student will show their ability at a professional level to:

- CO1: Solve the problems based on transformations of geometrical entities and develop its representation in a CAD system to validate the results.
- CO2: Represent the mathematical expression of geometrical entities to Evaluate and Validate developed curves, surfaces, and solids.
- CO3: Classify and Illustrate the various additive manufacturing techniques to understand the process chain of manufacturing the mechanical parts using state of the art CAD System and Rapid Prototyping Process.
- CO4: Explain and Classify NC machines and its working principles to Prepare NC programs using manual part programming techniques.
- CO5: Discuss the various concepts of CIM such as Production Planning and Control, Process Planning, MRP, and ERP to Solve the problems based on MRP during its implementation in large scale manufacturing.
- CO6: Explain the Group technology to Apply the concepts of Production Flow Analysis and Rank Order Clustering to Formulate Machine Cells

Syllabus Contents:

Unit 1 **(4 hrs)**

Introduction to CAD/CAM

Introduction: Trends in Modern Manufacturing, Product Cycle and CAD/CAM, Functional relationship, Elements of CAD Hardware.

Computer Graphics: Transformation- Introduction, Formulation, Translation, Rotation, Scaling, Reflection, Homogenous Representation, Concatenated Transformation, Inverse Transformations.

Unit 2 **(7 hrs)**

Modelling

Curves:- Introduction, Analytic Curves, Parametric representation, Line, Circle, Parabolas, Hyperbolas, Ellipses, Conics. Geometric continuity (C0, C1, C2) and Visual continuity (G0, G1, G2), Synthetic Curves, Hermite Cubic Spline, Bezier Curve, B-Spline Curve and NURB

Surface:- Introduction, Surface Representation, Analytic Surface, Synthetic Surfaces, Hermite bicubic Surface, Bezier surfaces, B-spline Surfaces, Coons Surface, Reverse Engineering

Solids:- Introduction, Geometry & Topology, Solid Representation, Boundary Representation, Constructive Solid Geometry, Sweeps, Solid Manipulations, Feature Based Modelling.

Unit 3 **(7 hrs)**

Rapid Prototyping

Importance and overview of Rapid Prototyping, Classification of Rapid Prototyping (RP) Process (FDM, LOM, SLA, SLS, Stereolithography etc.), Typical Process Chain for RP, Introduction to CAD and Data exchange format, data format details, conversion, validation, repairing, Part Slicing and Orientation and its importance, application and case studies.

Unit 4 **(6 hrs)**

NC Programming

Machine Tool Co-ordinate System, Machine zero, Job zero, Cutter Programming, Tool Offsets, Programming Steps, NC Programming Languages, G-codes and M-codes. Turning Center programming, Machining Center programming, Advance features of Controller.

Unit 5 **(6hrs)**

Computer Integrated Manufacturing (CIM)

Computer application in manufacturing, computer aided inspection and quality control. Computer integrated production management system, inventory material requirement planning, manufacturing resource planning, enterprise resource planning

Computer aided process planning (CAPP): Retrieval CAPP, generative CAPP and computer assisted shop floor control.

Unit 6 **(2 hrs)**

Group Technology

Part Families, Part classification and coding, production flow analysis, Rank Order Clustering Algorithm, machine cell design and Cellular manufacturing.

Text Books:

- Mikel P. Groover and Emory W. Zimmers: Computer Aided Design and Manufacturing, Prentice Hall.
- T. Kundra, Rao P.M., Tiwari N.K. : Numerical Control and Computer Aided Manufacturing, Tata McGraw Hill
- Nanua Singh: Systems Approach to Computer-Integrated Design and Manufacturing, John Wiley and Sons, Inc.
- P. Radhakrishnan and Subramaniam: CAD / CAM / CIM, Wiley Eastern Ltd.
- Venuvinod, PK., MA. W., Rapid Prortotyping – Laser Based and Other Technologies, Kluwer, 2004.

Reference Books:

- Paul C. Bave: CAD Principles and Applications
- Mikell P. Groover: Automation, Production systems & Computer Integrated Manufacturing, Prentice Hall.
- Ibrahim Zeid: Mastering in CAD-CAM, Tata McGraw Hill Publication.

OPERATIONS RESEARCH

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz/T1/T2- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Develop a general understanding of the Operational Research (OR) approach to decision making
- Develop network planning procedures for solving logistic and scheduling problems.
- Formulate inventory and queuing problems and generate optimal solutions.
- Identify best techniques to solve a specific problem

Syllabus Contents:

Unit 1 **(6hrs)**

Introduction

Operations Research: Development, history, definitions, objectives, characteristics, limitations, phases, and applications. Optimization models and their classifications.

Linear Programming

Formulation of LP problem, Simplex method (minimization/maximization cases). Degeneracy in LP, Duality in LP, Sensitivity analysis.

Unit 2 **(6hrs)**

Transportation

Introduction. Methods for finding initial solution. Test of optimality Maximization Transportation problem. Tran-shipment problem. Degeneracy.

Assignment Problem

Introduction. Solution methods. Variations of the assignment problem. Traveling Salesman Problem.

Unit 3 **(7hrs)**

Sequencing Models

Scheduling and sequencing. Assumptions in sequencing models. Processing “n” jobs on “m” machines. Graphical Method

Scheduling

Multiple jobs single machine sequencing methods- FCFS, EDD, LFT, etc.

Inventory Control System (Quantitative Approach)

Introduction. Meaning of Inventory Control. Functional classifications of Inventories. Advantages of Inventory Control. Deterministic Inventory Models: economic lot size with instantaneous replenishment with and without shortage costs, economic lot size models with quantity discount.

Unit 4 **(7hrs)**

Queuing Theory

Queuing Systems: Introduction, cost associated with, Classification of queuing models. Kendall’s notations. Models: {(M/M/1): (α / FSFS)}. Single server models.

Simulation

Introduction to discrete event Simulation. Monte -Carlo Simulation. Problems related to Monte-Carlo Simulation.

Dynamic Programming

Distinguishing characteristics of D.P. Deterministic DP problems.

Unit 5 **(7hrs)**

Replacement Models

Replacement of capital equipment that deteriorates with time, Replacement of items that fail without deteriorating.

Theory of Games

Introduction, two–person zero-sum game. Minimax and Maximin principle. Saddle point. Methods for solving game problems with mixed strategies. Introduction to graphical, and iterative methods for solving game problems.

Unit 6 **(7hrs)**

Network Models

Introduction to PERT / CPM. Concepts and construction of network diagrams. Critical path and project duration, floats, network crashing, optimum project duration and cost, PERT activity, time estimate, probability of completion of a project on before specified time, Resource allocation and load smoothening.

Minimal Spanning tree, shortest route and Maximal Flow problems.

Text Books:

- Gupta P. K. and Hira D. S. : Operations Research, S Chand & Company Ltd.

- Sharma S. D., KedarNath: Operations Research, Ram Nath& Co.

Reference Books:

- Sharma J. K.: Mathematical Models in Operations Research, Tata McGraw – Hill Publishing Company Limited.
- Taha H. A.: Operations Research: An Introduction, Prentice Hall of India Pvt. Ltd.
- Wagner H. N. : Principles of Operations Research with applications to Managerial Decisions, Prentice Hall of India Pvt. Ltd.
- R. Panneerselvam : Operations Research, Prentice Hall of India Pvt. Ltd
- Wiest J. D. & Levy F. K.: Managerial Guide to PERT/CPM, Prentice Hall of India Pvt. Ltd.
- Srinath L.S "PERT & CPM principles & Applications" Affiliate East West Press (P) Ltd., New Delhi, 1975.

CAD / CAM / CIM LABORATORY

Teaching Scheme
Practical: 4 hrs/week

Examination Scheme
Term Work : 50 Marks
Oral : 50 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Learn the CAD modelling commands like extrusion, protrusion, etc. to develop 3D CAD Model
- Understand and execute the advance technologies like Additive Manufacturing Technology to solve complex real-life problems
- Learn the concept of FEA and its implementation. Evaluate and interpret FEA analysis results for design and evaluation purposes to solve industry-based problems.
- Understand the concepts of CNC machine tools using CAM Programming to develop the G-code program manually and using software.

Syllabus Contents:

1. To Study of Solid Modeler and Modeling of Simple machine parts
2. Study of Rapid Prototyping Techniques by Using Additive Manufacturing Technologies as FDM Technology
3. To study Simulation of cutting/milling operations using CAM packages
4. Introduction to FEA, Advantages & Disadvantages of FEA & its Applications, What is FEA, Functional Approximation method, Finite Difference Method, Steps involved in FEA, Stiffness matrix & its properties, Derivation of Stiffness matrix, Types of Elements.
5. Introduction to ANSYS, ANSYS Interface & Environments, Problem solving methodology in ANSYS.
6. Analysis of various problems using ANSYS software.

Note: Oral shall be based on above assignments.

(PE 497) MANUFACTURING AUTOMATION LABORATORY

Teaching Scheme
Lectures : 3 hrs/week
Tutorial: -

Examination Scheme
Term Work : 50 Marks
Oral : 50 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Identify and select the fluid power component required for fluid power automation
- Implement the electrical/PLC based control strategy for fluid power systems
- Analyze the fluid power circuits and applications
- Understand basic hydraulic/pneumatic elements required in an automated production system
- Evaluate basic fluid power circuits
- Write basic PLC Ladder Logic programmes

Syllabus Contents:

The term work shall consist of record of any eight assignments on following topics:

1. Study & Design of basic hydraulic and pneumatic circuits: such as Standard ON-OFF and Pneumatic Latch.
2. Study & Design of Pneumatic or Hydraulic circuit for Two Push Button Control and Clamping of Workpiece.
3. Study & Design of Pneumatic or Hydraulic circuit for material handling.
4. Study & Experiments in 8051 Microcontroller & its applications in Production Engineering.
5. Study & experiments in Programmable Logic Controllers (PLC).
6. Study of Displacement, Level, Pressure controls.
7. Measurements & Design of circuit for Speed & Temperature measurements.
8. Study & Design of Simple Hydraulic or Pneumatic and Electro-Hydraulic or Electro-Pneumatic Automatic Control Circuit Problem.
9. Study & Design of Electro-hydraulic or Electro-pneumatic Control Circuit Problem.
10. Study of Maintenance and Troubleshooting of Fluid Power Systems.

Note: Oral shall be based on above assignments.

SOFTWARE LABORATORY

Teaching Scheme
Practical: 2hrs/week
Tutorial: 1 hr/week

Examination Scheme
Term Work: -- 50 Marks
Oral/Practical Exam: --50 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Develop a basic understanding of the Java platform
- Able to develop classes for mathematical operators

- Assign Work Resources to Tasks, Assign Material Resources to Tasks and Assign Cost Resources to Tasks, track progress on tasks usage and resource utilization and monitor project execution compared with the planned schedule.
- Simulate Processes and Networks regarding production facility to reduce the work in process inventory and optimize resource optimization
- To select the layout having optimum productivity and resources.

Syllabus Contents:

1. Introduction to scheduling of a project in MS Project 2010, Fine-Tuning Task Details, Fine-Tuning the Project Plan, Creating Summary tasks and Milestones, defining Task Dependencies, Constraint types and Task types, Studying Gantt Chart view.
2. Introduction to CPM/PERT using MS Project 2010, Assigning resources, Resource Levelling, cash flow and Project overview analysis by generating reports.
3. Introduction to production facility planning and scheduling using WITNESS software, Defining Location, Entities, Arrivals, Processing and Attributes related to the facility, introduction to What-If scenarios, Assigning Machine downtimes and setup times.
4. Introduction to WITNESS software. Simulating multiple iterations of a layout and comparative analysis of different layouts using WITNESS Manufacturing Edition software.
5. Overview to Java Platform

   Compiler Vs Interpreter, JVM and Byte code concept, JNI concept, Security in Java.

6. Basic Language components of Java
   Variable, operators, Expressions, Statements and Block, Control structures, Arrays, Functions.

7. Object Oriented Concepts in Java
   Creating Classes, Managing Inheritance, Polymorphism and other COP concepts, Interfaces and Packages, Enumerated Types, Annotations, Nested Classes, Inner classes and Anonymous classes

8. Essential Java Classes
   String class, other classes in java. Lang, Classes for mathematical operations, Exception Handling, Collections

9. File and other I/O Handling
   Overview of I/O streams, java.io package classes overview, Reading/Writing standard I/O, Reading/Writing in File

10. GUI programming
    AWT Classes, Event Handling, Introduction to SWING, Introduction to Advanced Core Java: Threads, Socket Programming, 2D-3D programming, Image Handling API, RMI, Reflection, JNI programming, Applets

List of Assignments

1. Write programs for

a. Fibonacci Series up to given number of terms.
b. Prime Number within a given range.
c. That reads a String from the command line and writes it backward

2. Write a program that continues to read a line from user and print all the characters back in reveres. The program terminates when the user write "End'

3. Write a program to count the number of tokens, given a string and a separator.

4. Number Generator is class that generates random numbers continuously while Running Average class calculates the average of a set of numbers generated. Write These Classes. Write a program that uses tile piped stream to pipe the number generator with the average calculator.

5. Create a Circle class that contains a radius field. Give it a constructor where you pass in the radius. Have your test routine create a few circles, assign a value to the radius, then print out some information about the circles. Give your Circle a get Area method that calculates its area, and a print Info method that prints out the radius and area. Make a program that creates an array of 100 circles, each with a random radius. Print out the sum of the areas of the 100 circles. Also print the biggest and smallest areas.

6. Write a program for rectangle as in Assignment 5. Have your Circle and Rectangle inherit from a common Shape class. Change all your existing classes so that the fields are private, and you have getXxx and setXxx methods to look up and change the values of the fields. If you haven't already made a square class, do so. Make your Square inherit from Rectangle, but still enforce the restriction that the width and the height are the same. Hint: override some method(s). Make a method that will take an array of Shape objects and sum their areas. Where is the best place to put this method? Make a test case consisting of an array of mixed shapes.

7. Write a program to count the numbers of characters entered through stdin. The program exits upon entering Ctrl+Z. Also write all these characters in to given file.

8. Write a program to append a set of files to a given file.

9. Design a calculator in AVVT and SWING.

Note: Oral shall be based on above assignments.

PROCESS PLANNING AND TOOL SELECTION LAB

Teaching Scheme	Examination Scheme
Practical : 2 hrs/week	Term Work : 50 Marks
Tutorial: -	Oral : 50 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Analyze the dimensions, tolerances, and control of various features of parts.
- Students can be able to select and assign sequence of machining processes from basic to principal processes.
- Students can identify and select the appropriate tools and tooling for major machining operations to be performed on workpiece.
- Students can prepare process plan and flow diagram for given component.

Syllabus Contents:

The term work shall consist of record of any Six assignments on following topics:

1. Preliminary part print analysis for given components which includes study of part, its dimensions and tolerances and control of its features of parts.
2. Preparation of tolerance chart for any two components also students have to describe handling, basic processes for manufacturing, sequence of operations. Study of Special processes, if necessary, related surfaces to be machined, Assembly Process if any for the given parts.
3. Analysis of Part Dimensions of given component: Shape of part as flatness, straightness, roundness, geometrical shapes, symmetry, job requirement of finish on part.
4. Drawing of arrangement of locators, for standard shaped components like rectangular prism, pyramids, cylinder, tube, cones and any one nonstandard component for good geometric control Manufacturing Processes:
5. Identification and list our sequence of various manufacturing processes to be performed on a given component/workpiece, from a drawing such as Basic Processes, Principal Processes, Major Operations and Auxiliary Processes, Supporting Operations.
6. Study and Selection of Tooling: Standard and Special Tooling. Use of Jigs and Fixtures, Selection of Equipment, Tooling. Economics of Tooling.
7. Study of conventional tooling methods for commonly Machined Surfaces, Tooling ideas for Typical features on a job. Multi tooling setups, new tools and tooling methods
8. Study of the machined parts and initial data required for process design from the point of manufacture:
    a. Planning the sequence of machining operations along with selection of machining operations along with selection of machine tools, cutting tools, jigs and fixtures, cutting variables as well as fixing in process dimensions and gauging.
    b. Datum features/surfaces and their selection.
    c. Stock preparations and blank selection with material estimate.
    d. Time estimates and time standards.
    e. Process sheet design for the complete manufacture of the machined parts.

Note: Oral shall be based on above assignments

For other departments

Interdisciplinary Open Course-III

TOTAL QUALITY MANAGEMENT

Teaching Scheme	Examination Scheme
Lectures : 2 hrs/week	Test 1 – 20, Test 2 – 20,
Tutorial: -	End-Sem Exam- 60.

Course Outcomes:

- Understanding of quality management philosophies and frameworks.
- In-depth knowledge on various tools and techniques of quality management.
- Learn the applications of quality tools and techniques in both manufacturing and service industry.
- Develop strategies for continuous process improvement.

Syllabus Contents:

Unit 1 **(6 Hrs)**

Introduction To Quality Management

Definitions – TOM framework, benefits, awareness and obstacles. Quality – vision, mission and policy statements. Customer Focus – customer perception of quality, Translating needs into requirements, customer retention. Dimensions of product and service quality. Cost of quality. Historical review, Ten principles of quality management. Overview of the contributions of Deming, Juran, Crosby, Masaaki Imai, Feigenbaum, Ishikawa, PDSA cycle, Taguchi techniques – introduction, loss function, parameter and tolerance design, signal to noise ratio. Concepts of Quality circle, Japanese 5S principles and 8D methodology.

Unit 2 **(9 Hrs)**

Statistical Process Control and Process Capability

Meaning and significance of statistical process control (SPC) – construction of control charts for variables and attributed. Process capability – meaning, significance and measurement. Acceptance Sampling by variables, some aspects of specifications and tolerances, Process capability. Sampling inspection, OC Curves and Sampling Plan, 100% Inspection and Selective Inspection, Statistics in Selective inspection. Measurement system capability, Gauge R&R study, Machine Capability study, statistical tolerances. Control charts for individual measurements, X chart, moving average and moving range charts, exponential weighted moving average chart, cumulative sum chart.

Unit 3 **(9 Hrs)**

Quality Improvement Through Design of Experiments

Data analysis, Analysis of variance, t test, f test, Normal probability plot, box plot, full factorial experiments, main effects of a factor, two factor experiments. Regression, Taguchi method, Design of orthogonal experiments, data analysis by response graph method and analysis of variance

Unit 4 **(5 Hrs)**

Six Sigma Approach to Quality and Concepts of Reliability

Six sigma introduction, Sigma Quality level, Six sigma methodology, DMAIC, DMADV, tools used in six sigma projects. Sigma case Six studies. Reliability concepts – definitions, reliability in series and parallel, product life characteristics curve, maintainability

Unit 5 **(6 Hrs)**

Tools and Techniques for Quality Management

Quality functions development (QFD) – Benefits, Voice of customer, information organization, House of quality (HOQ), building a HOQ, QFD process. Failure mode effect analysis (FMEA) – requirements of reliability, failure rate, FMEA stages, design, process and documentation. Seven old (statistical) tools. Seven new management tools. Zero defect concept, Bench marking and POKA YOKE. Selection of sources of supply, evaluation of suppliers. Kaizen, JIT

Unit 6 **(5 Hrs)**

Quality Systems Organizing and Implementation

Total productive maintenance (TMP) – relevance to TQM, Terrotechnology. Business process re-engineering (BPR) – principles, applications, reengineering process, benefits and limitations. Introduction to IS/ISO 9001:2015 – quality management systems – guidelines for performance improvements. Quality Audits. TQM culture, Leadership – quality council, employee involvement, motivation, empowerment, recognition and reward- Benefits of implementing ISO 9000 standard.

Text Books:

- Dale H. Besterfield et al, Total Quality Management, Third edition, Pearson Education (First Indian Reprints 2004).
- L Suganthi, Anand A. Samuel, Total Quality Management, PHI learning Pvt. Ltd., Sixth Edition 2010.
- K. Krishnaiah, Applied Statistical Quality Control and Improvement, PHI learning Pvt. Ltd., First Edition 2014.

Reference Books:

- Roger C. Swanson, "The Quality Improvement Hand Book", Publisher Vanity Books International, New Delhi.
- Williarn. C. Johnson and Richard J. Chavia, "Encyclopedia of Total Quality Management", New Delhi.

(IOC) OPERATIONS RESEARCH

Teaching Scheme	**Examination Scheme**
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz/T1/T2- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Develop a general understanding of the Operational Research (OR) approach to decision making
- Develop network planning procedures for solving logistic and scheduling problems.
- Formulate inventory and queuing problems and generate optimal solutions.
- Identify best techniques to solve a specific problem

Syllabus Contents:

Unit 1 **(4 hrs)**

Introduction

Operations Research: Development, history, definitions, objectives, characteristics, limitations, phases, and applications. Optimization models and their classifications.

Linear Programming

Formulation of LP problem, Simplex method (minimization / maximization cases). Degeneracy in LP, Duality in LP, Sensitivity analysis.

Unit 2 **(4 hrs)**

Transportation

Introduction. Methods for finding initial solution. Test of optimality Maximization Transportation problem, Degeneracy.

Assignment Problem

Introduction. Solution methods. Variations of the assignment problem. Traveling Salesman Problem.

Unit 3 **(3 hrs)**

Sequencing Models

Scheduling and sequencing. Assumptions in sequencing models. Processing "n" jobs on "m"machines. Graphical Method

Inventory Control System (Quantitative Approach)

Introduction. Meaning of Inventory Control. Functional classifications of Inventories. Advantages of Inventory Control. Deterministic Inventory Models: economic lot size with instantaneous replenishment with and without shortage costs, economic lot size models with quantity discount.

Unit 4 **(4 hrs)**

Queuing Theory

Queuing Systems : Introduction, cost associated with, Classification of queuing models. Kendall's notations. Models : {(M/M/1) : (α / FSFS)}. Single server models.

Simulation

Introduction to discrete event Simulation. Monte -Carlo Simulation. Problems related to Monte-Carlo Simulation.

Unit 5 **(4 hrs)**

Replacement Models

Replacement of capital equipment that deteriorates with time, Replacement of items that fail without deteriorating.

Theory of Games

Introduction, two–person zero-sum game. Minimax and Maximin principle. Saddle point. Methods for solving game problems with mixed strategies. Introduction to graphical, and iterative methods for solving game problems.

Unit 6 **(4 hrs)**

Network Models

Introduction to PERT / CPM. Concepts and construction of network diagrams. Critical path and project duration, floats, network crashing, optimum project duration and cost, PERT activity, time estimate, probability of completion of a project on before specified time.

Text Books:

- Gupta P. K. and Hira D. S. : Operations Research, S Chand & Company Ltd.
- Sharma S. D., KedarNath : Operations Research, Ram Nath& Co.

Reference Books:

- Sharma J. K. : Mathematical Models in Operations Research, Tata McGraw – Hill Publishing Company Limited.
- Taha H. A. : Operations Research : An Introduction, Prentice Hall of India Pvt. Ltd.
- Wagner H. N. : Principles of Operations Research with applications to Managerial Decisions, Prentice Hall of India Pvt. Ltd.
- R. Panneerselvam : Operations Research, Prentice Hall of India Pvt. Ltd
- Wiest J. D. & Levy F. K.: Managerial Guide to PERT/CPM, Prentice Hall of India Pvt. Ltd.
- Srinath L.S “PERT & CPM principles & Applications” Affiliate East West Press (P) Ltd., New Delhi, 1975.

Department Elective-II [Option among minimum 3 courses]

(DEC) PRODUCT DESIGN AND MANUFACTURING

Teaching Scheme
Lectures : 3 hrs/week
Tutorial: -

Examination Scheme
100 marks: Continuous evaluation- Assignments /Quiz/T1/T2 - 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Learn basics of product design process and morphology of design.
- Students understand design for manufacturing and assembly (DFMA) concepts.
- To understand optimization tools and ergonomic principles applied on typical product design as well as concept of value engineering in new product design.
- Students will learn about Design for safety, Environment, and Product cost
- At the end of course students should be aware of different stages of product design

Syllabus Contents:

Unit 1 **(5 hrs)**

Introduction To Product Design

Asimow's Model: Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle, Flow and Value Addition in the Production-consumption Cycle, The Morphology of Design (The sever phases), Primary Design

Phases and flowcharting, Role of Allowance Process Capability, and. Tolerance in Detailed Design and Assembly.

Unit 2 **(8 hrs)**

Product Design Practice and Industry

Introduction, Product Strategies Time to Market, Analysis of the Product, The Three S's, Standardization Renard Series (Preferred Numbers), Simplification, The Designer and it's Role, The Designer: Myth and Reality, The Industrial Design Organization Basic Design Considerations, Problems faced by Industrial Designer. Procedure adopted by Industrial Designers, Types of Models designed by Industrial Designers, What the Designer contributes, Role of Aesthetics in Product Design, Functional Design Practice.

Unit 3 **(10 hrs)**

Design for Manufacturing, Assembly, and Maintenance : Engineering Materials, Properties of Materials, Selection of Materials – I, Selection of Materials – II, Applications of Engineering Material.

Robust Design, Design for X, Product Design for Manual Assembly, DFMA Guidelines, Ergonomics in Product Design

Selection of Processes-I, Selection of Processes-II, Process Capabilities, Design Guidelines for Sand Casting, Design Guidelines for Die Casting Process.

Product Design Guidelines: Compression Molding and Extrusion, Design Guidelines for Extrusion and Injection Molding, Design Guidelines for Sheet Metal Working, Design Guidelines for Machining, Design Guidelines for Powder Metal Processing.

Assembly Processes: Introduction, Adhesive Joining: Guidelines, Design Guidelines for Mechanical Fasteners, Design Guidelines for Welding, Design Guidelines: Brazing and Soldering

Unit 4 **(6 hrs)**

Optimization in Design

Introduction, Siddal's Classification of Design Approaches, Optimization by Differential Calculus, Lagrange Multipliers, Simplex search Method, Geometric Programming, Johnson's Method of Optimum Design.

Unit 5 **(8 hrs)**

Design for safety, Environment, and Product cost, Design for Environment, Design for Environment: Steps, Product Architecture Design for Safety and Reliability. Elements of visual needs, translating customer needs. Cost and Price Structure, Information Need Sources, Estimating Direct and Indirect Costs, Design and Manufacturing Costs, Ways to Model Manufacturing Costs, Human Engineering Considerations in Product Design.

Introduction, Human being as Applicator of Forces, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Unit 6 **(8 hrs)**

Value Engineering and Product Design

Introduction, Historical& Perspective, What is Value? Nature and Measurement of Value,

Maximum Value, Normal Degree of Value, Importance of Value, The Value Analysis, Job Plan, Creativity, Steps to Problem-solving and Value Analysis, Value Analysis Tests, Value Engineering Idea Generation Cheek-list, Cost Reduction through Value Engineering Case Study on Tap Switch Control Assembly, Material and Process Selection in Value Engineering.

Modern Approaches to Product Design

Concurrent Design, Quality Function Deployment (QFD) for design.

Text Books:

- A.C. Chitale and R.C. Gupta, Product Design and Manufacturing by PHI.
- Karl T. Ulrich & Steven D., Product Design & Development Eppinger Tata McGraw Hill, 3rd Edition, 2003

Reference Books:

- Tim Jones, Butterworth Heinmann, New Product Development by Oxford, *TAC*- 1997.
- Roland Engene Y.,Inetoviez, New Product Development: Design & Analysis, John Wiley and Sons Inc., N.Y. 1990.
- Geofferry Boothroyd, Peter Dewhurst and Winston Knight. Product Design for Manufacture and Assembly, Amherst, 1983.
- Bill Hollins, Stwout Pugh, Butterworth, Successful Product Design by London 1990.
- Boothroyod & DewburstP.,Design for Assembly, a Designer's Hand book, University of Massachusets, Amherst, 1983.
- Keyinotto & Kristini Wood, Product Design Pearson Education 2004.

TOTAL QUALITY MANAGEMENT

Teaching Scheme
Lectures : 3 hrs/week
Tutorial: -

Examination Scheme
Test 1 – 20, Test 2 – 20,
End-Sem Exam- 60.

Course Outcomes:

- Understanding of quality management philosophies and frameworks.
- In-depth knowledge on various tools and techniques of quality management.
- Learn the applications of quality tools and techniques in both manufacturing and service industry.
- Develop strategies for continuous process improvement.

Syllabus Contents:

Unit 1 **(6 Hrs)**

Introduction To Quality Management

Definitions – TOM framework, benefits, awareness and obstacles. Quality – vision, mission and policy statements. Customer Focus – customer perception of quality, Translating needs into requirements, customer retention. Dimensions of product and service quality. Cost of quality. Historical review, Ten principles of quality management. Overview of the contributions of Deming, Juran, Crosby, Masaaki

Imai, Feigenbaum, Ishikawa, PDSA cycle, Taguchi techniques – introduction, loss function, parameter and tolerance design, signal to noise ratio. Concepts of Quality circle, Japanese 5S principles and 8D methodology.

Unit 2 **(9 Hrs)**

Statistical Process Control and Process Capability

Meaning and significance of statistical process control (SPC) – construction of control charts for variables and attributed. Process capability – meaning, significance and measurement. Acceptance Sampling by variables, some aspects of specifications and tolerances, Process capability. Sampling inspection, OC Curves and Sampling Plan, 100% Inspection and Selective Inspection, Statistics in Selective inspection. Measurement system capability, Gauge R&R study, Machine Capability study, statistical tolerances. Control charts for individual measurements, X chart, Moving average and moving range charts, exponential weighted moving average chart, cumulative sum chart.

Unit 3 **(9 Hrs)**

Quality Improvement Through Design of Experiments

Data analysis, Analysis of variance, t test, f test, Normal probability plot, box plot, full factorial experiments, main effects of a factor, two factor experiments. Regression, Taguchi method, Design of orthogonal experiments, data analysis by response graph method and analysis of variance

Unit 4 **(5 Hrs)**

Six Sigma Approach to Quality and Concepts of Reliability

Six sigma introduction, Sigma Quality level, six sigma methodology, DMAIC, DMADV, tools used in six sigma projects. Sigma case Six studies. Reliability concepts – definitions, reliability in series and parallel, product life characteristics curve, maintainability

Unit 5 **(6 Hrs)**

Tools and Techniques for Quality Management

Quality functions development (QFD) – Benefits, Voice of customer, information organization, House of quality (HOQ), building a HOQ, QFD process. Failure mode effect analysis (FMEA) – requirements of reliability, failure rate, FMEA stages, design, process and documentation. Seven old (statistical) tools. Seven new management tools. Zero defect concept, Bench marking and POKA YOKE. Selection of sources of supply, evaluation of suppliers. Kaizen, JIT

Unit 6 **(5 Hrs)**

Quality Systems Organizing and Implementation

Total productive maintenance (TMP) – relevance to TQM, Terrotechnology. Business process re-engineering (BPR) – principles, applications, reengineering process, benefits and limitations. Introduction to IS/ISO 9001:2015 – quality management systems – guidelines for performance improvements. Quality Audits. TQM culture, Leadership – quality council, employee involvement, motivation, empowerment, recognition and reward- Benefits of implementing ISO 9000 standard.

Text Books:

- Dale H. Besterfield et al, Total Quality Management, Third edition, Pearson Education (First Indian Reprints 2004).
- L Suganthi, Anand A. Samuel, Total Quality Management, PHI learning Pvt. Ltd., Sixth Edition 2010.
- K. Krishnaiah, Applied Statistical Quality Control and Improvement, PHI learning Pvt. Ltd., First Edition 2014.

Reference Books:

- Roger C. Swanson, "The Quality Improvement Hand Book", Publisher Vanity Books International, New Delhi.
- Williarn. C. Johnson and Richard J. Chavia, "Encyclopaedia of Total Quality Management", New Delhi.

TRIBOLOGY IN MANUFACTURING

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1 and T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. The course will enable the students to know the importance of Tribology in Industry.
2. The course will enable the students to know the basic concepts of Friction, Wear, Lubrications and their measurements.
3. This course will help students to know the performance of different types of bearings and analytical analysis thereof.
4. This course will help students to learn and discuss different metal forming processes from tribological point of view.

Syllabus Contents:

Unit 1 **(8 hrs)**

Tribology

Introduction, Importance of Tribology in Design, Tribology in Industry, Economic Considerations, effects of surface preparation on Tribology.

Friction

Introduction, Laws of friction, kinds of friction, causes of friction, area of contact, friction measurement, theories of friction.

Wear

Types of wear, various factors affecting wear, cutting tool wear & coating, measurement of wear, wear between solids and flowing liquids, theories of wear.

Unit 2 **(6 hrs)**

Lubricants and Lubrication

Introduction, Lubricant properties- physical and chemical, basic modes of lubrication, types of lubricants, Seals-Static and dynamic.

Unit 3 **(8 hrs)**

Hydrostatic and Aerostatic Lubrication

Basic concept, operations, advantages and limitations. Flow of viscous fluid through rectangular slot, Circular pad bearing and conical bearing, load carrying capacity and flow of lubricants. Bearing power, energy losses in bearing and film thickness, bearing temperature. Optimum design of step bearing, Introduction to Aerostatic Bearing and its application.

Unit 4 **(10 hrs)**

Hydrodynamic Lubrication

Theory of hydrodynamic lubrication. Mechanism of pressure development in oil film. Two-dimensional Reynolds equation, pressure distribution in journal bearings - long & short, Load Carrying capacity, Somerfield number, importance of radial clearance, eccentricity ratio minimum oil film thickness etc., Heat Balance equations.

Hydrodynamic Thrust Bearing

Introduction, flat plate thrust bearing, pressure distribution equation, load, centre of pressure. Tapered land thrust bearing, step-thrust bearing, and tilting pad thrust bearing. Friction in tilting pad thrust bearing, Heat Balance equations.

Unit 5 **(6 hrs)**

Hydrostatic Squeeze Film

Introduction, parallel rectangular plate, Circular plate approaching each other and cylinder near plane, pressure distribution, squeeze load and time of approach.

Unit 6 **(4 hrs)**

Lubrication in metal processing

Lubricants in Forging, wire drawings, drawing, extrusion, rolling etc. Lubricants used for wire ropes, pulley and chains, introduction to Nano-Tribology.

Text Books:

- Basu S.K., Sengupta S. N. and Ahuja B.B. “Fundamentals of Tribology” PHI Learning, Ltd. India.
- Majumdar B. C. "Introduction to Tribology and Bearings", S. Chand and Company Ltd., New Delhi.

Reference Books:

- Bharat Bhushan, “Principles and Applications of Tribology”, John Wiley and Sons.
- Sahu P., “Engineering Tribology”, PHI Learning, Ltd. India
- Fuller D.D. "Theory and Practice of Lubrication for Engineers". John Wiley and Sons.
- Neale M. J. "Tribology hand Book", Butterworths. London.
- Orlov P., "Fundamentals of Machine Design", Vol. IV, MIR Publication.
- Cameron A. "Basic Lubrication Theory", Wiley Eastern Ltd.
- 'Hailing J., "Principles of Tribology", McMillan Press Ltd., 1975.
- Ghosh M.K., Majumdar B.C. and Sarangi M., “Theory of lubrication”, Tata McGraw Hill Education Pvt. Ltd., New Delhi.

PE-461 MECHATRONICS

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1 and T2 – 20 marks each, End-Sem Exam – 60

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

- Know key elements of Mechatronics system and classification of Mechatronics Products.
- Familiar with the Mechatronics System Design Process.
- Analyse transfer function, block diagram representation of control systems, reduction and analysis of block diagrams.
- Evaluate various control actions and controllers used for developing Mechatronics Systems.
- Create PLC based system, PLC programming techniques and industrial applications of PLC.

Syllabus Contents:

Unit 1 **(8 hrs)**

Mechatronics:
Introduction to Mechatronics, Application areas of Mechatronics, Mechatronic Design Concept, Introduction to Measurement Systems, Control Systems

System Response: Introduction, Input-Output model equation and system characterization, Instantaneous, Lagging and Delay Response, Transient Response Specification, Dynamic Characteristics of Measurement Frequency Response of a System,

Signal Conditioning and Signal Processing:
Signal conditioning, Digital Signals, Data Acquisition, Digital Signal Processing, Pulse-modulation. Analog Signal Processing, Analog to Digital Conversion.

Unit 2 **(8 hrs)**

Digital Logic, Circuits, Systems and Hardware:
Digital Logic, Boolean Algebra, Karnaugh Maps, Combinational Logic and Circuits, Timing Diagrams, Design of Logic Networks, Sequential Logic, Devices and Circuits, Integrated Circuit System Design.

Microprocessors, Microcomputers and Microcontrollers:
Introduction, Microprocessor-based Digital Control, Microcomputer Organization, Microprocessor Architecture, Memory, Input/Output Hardware, Microcontrollers, General Requirements for control and their implementation in Microcontrollers, Classifications, Applications.

Unit 3 **(7 hrs)**

Input/Output Systems:
Interfacing, Input/Output Addressing, Interface Requirements, Peripheral Interface Adapters, Serial Communications Interface, Examples of Interfacing.

Unit 4 **(8 hrs)**

Programmable Logic Controllers:
Introduction, Basic Structure, PLC Hardware, Ladder Diagrams, Input/Output Processing, Programming, Selection of a PLC.

Sensors and Transducers:
Introduction to Sensors and Transducers, Performance Terminology, Sensor working Principles, Selection of sensors,

Unit 5 **(7 hrs)**

Actuators:

Introduction to actuation system, Pneumatic and Hydraulic Actuation Systems, Mechanical Actuation Systems, Electromagnetic Principles, Electrical Actuation Systems, Piezoelectric actuators.

Data Acquisition:

Introduction, Elements of a Data Acquisition and Control System, Overview of the Input/Output Process, Analog to Digital (A/D) Conversion, Digital to Analog (D/A) Conversion, Data Acquisition Case Studies, Data Acquisition and Control Case Studies.

Unit 6 **(5 hrs)**

Mechatronics System Design:

Integrated design issues in Mechatronics, Mechatronics Key Elements, Traditional and Mechatronics designs, The Mechatronics Design Process, Possible Mechatronics Design Solutions, AI in Mechatronics, Fuzzy Logic Applications in Mechatronics, Micro sensors in Mechatronics, Case studies in Mechatronics.

Text Books

1. W. Bolton : Mechatronics : Electronic Control Systems in Mechanical and Electrical Engineering, Third Edition, Pearson Education (Low Price Edition).
2. Michael B. Histand and David G. Alciatore : Introduction to Mechatronics and Measurement Systems, McGraw-Hill International Edition.
3. Devdas Shetty and Richard A. Kolk : Mechatronics System Design, PWS Publishing Company (An International Thomson Publishing Company).
4. Nitaigour Premchand Mahalik : Mechatronics : Principles, Concepts and Applications, Tata McGraw Hill Publishing Company Limited, New Delhi.

Reference Books

1. Clarence W. De Silva : Mechatronics : An Integrated Approach, CRC Press.
2. Lawrence J. Kamm : Understanding Electro-Mechanical Engineering : An Introduction to Mechatronics, Prentice – Hall of India Private Limited, New Delhi.
3. HMT Limited : Mechatronics, Tata McGraw Hill Publishing Company Limited, New Delhi.

ROBOTICS

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1 and T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

At the end of the course students will be able to:

- Define basic terms, classify and analyze the robot structure & gripper designs
- Select the drive system with feedback control and sensors.
- Apply the knowledge of kinematics for link transformation.

- Write a program for robotic application
- Analyze the trajectory planning of joints of robot manipulator.
- Select the robots on the basis of application areas and perform economic analysis.

Syllabus Contents:

Unit 1 **(8 hrs)**

Basic Concepts in Robotics:

Automation and robotics, robot anatomy, basic structure of robots, resolution, accuracy and repeatability. Classification and Structure of Robotics System: Point to point and continuous path systems. Control loops of robotic system, manipulators, wrist motions and grippers.

Robot End Effectors / Grippers:

Grippers and tools, Types of end effectors-mechanical, magnetic and vacuum, gripper force analysis and gripper design considerations.

Unit 2 **(8 Hrs)**

Drives and Control Systems: Basic control systems, concepts and models, types of drive system- Hydraulic systems, pneumatic and electrical, DC servo motors, control system analysis, robot activation and feedback components, types of controllers- P, PI, PID controllers.

Sensors in Robotics

Sensors, internal-external sensors, contact and non-contact sensors, position and velocity sensors, Touch and slip sensors, Force and torque sensors, tactile sensors, Proximity and range sensors. Vision Systems: Vision equipment, line scan and area scan sensor, Charge Coupled Device , image processing, and analysis, preprocessing, segmentation and feature recognition, smoothening of binary image

Unit 3 **(8 Hrs)**

Robot Arm Kinematics and Dynamics:

Homogenous coordinates and homogenous transformations, Forward and Inverse kinematics in robot, Denavit Hartenberg convention and its applications Lagrange-Euler formation, Robot dynamics control

Unit 4 **(6 Hrs)**

Interfacing: Interfacing robot with PC, RS232C serial interface

Robot Programming: Methods of robot programming, lead through programming methods, a robot program for generating a path in space, motion interpolation, WAIT, SIGNAL and DELAY commands, branching capabilities and limitations of lead through methods. Robot Language: The textual robot languages, generations of robot programming languages, variables, motion commands, end effectors and sensor commands, computations and operations, Introduction to artificial intelligence

Unit 5 **(6 Hrs)**

Trajectory Planning

Introduction, Joint Space Scheme, Cubic Polynomials with via points, Blending scheme

Unit 6 **(6 Hrs)**

Robot Applications in Manufacturing:

Material transfer and machine loading/unloading, processing operations assembly and inspection. Concepts of safety in robotics, social factors in use of robots, economics of robots.

Introduction to Telechirs& Futuristic Topics in Robotics:
Telechiric machines and its application - handling radioactive materials, work in space mining& under sea operations, Telechiric surgery, collaborative robotics, calibration.

Reference Books:

- S. R. Deb.: Robotics Technology and Flexible Automation, Tata Mc Graw Hill Publishing Co. Ltd.
- P.A. Janakiraman, Robotics and Image Processing, Tata Mcgraw Hill, 1995

Reference Books:

- Yoren Koren: Robotics for Engineers, McGraw Hill Book Co., ISBN 0-07-035341-7.
- M. P. Grover, M. Weiss, R. N. Nagel, N. G. Odrey, : Industrial Robotics Technology, ISBN 0-07-100442-4.
- K. S. Fu, C. G. S. Lee, R. C. Gonzaler, Robotics Control, Sensing, Vision and Intelligence, Tata
  McGraw Hill. 2008, ISBN 13: 9780070226258

Artificial Intelligence

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1 and T2 – 20 marks each,
End-Sem Exam - 60

Course Outcomes:

At the end of the course students will be able to:

- Knowledge of what constitutes "Artificial" Intelligence and how to identify systems with Artificial Intelligence.
- Ability to apply Artificial Intelligence techniques for problem solving.
- Implement classical Artificial Intelligence techniques, such as search algorithms, minimax algorithm, neural networks, tracking, robot localization.
- Ability to apply Artificial Intelligence techniques for problem solving.

Syllabus Contents:

Unit 1 **(6 hrs)**
Overview: foundations, scope, problems, and approaches of AI.
Intelligent agents: reactive, deliberative, goal-driven, utility-driven, and learning agents, Artificial Intelligence programming techniques.

Unit 2 **(8 Hrs)**
Problem-solving through Search: forward and backward, state-space, blind, heuristic, problem-reduction, alpha-beta pruning, minimax, constraint propagation, neural, stochastic, and

evolutionary search algorithms, sample applications.

Unit 3 **(8 Hrs)**

Knowledge Representation and Reasoning: ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications.

Unit 4 **(6 Hrs)**

Planning: planning as search, partial order planning, construction and use of planning graphs.
Representing and Reasoning with Uncertain Knowledge: probability, connection to logic, independence, Bayes rule, bayesian networks, probabilistic inference, sample applications.

Unit 5 **(8 Hrs)**

Decision-Making: basics of utility theory, decision theory, sequential decision problems, elementary game theory, sample applications.

Machine Learning: basic concepts, linear models, perceptron, K nearest neighbors, advanced models, neural networks, SVMs, decision trees and unsupervised learning

Unit 6 **(4 Hrs)**

Applications of AI(vision/robotics etc.), student project presentations

Text Books:

- Russell, Stuart and Norvig, Peter, "Artificial Intelligence: A Modern Approach" Prentice Hall, 2003.

Reference Books:

- Aleksander, Igor and Burnett, Piers "Thinking Machines" Oxford, 1987.
- Bench-Capon, T. J. M., "Knowledge Representation: An approach to artificial intelligence" Academic Press, 1990.
- Genesereth, Michael R. and Nilsson, Nils J. "Logical Foundations of Artificial Intelligence", Morgan Kaufmann,1987.
- Michael Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems (3rd Edition),
- VINOD CHANDRA S.S., ANAND HAREENDRAN S, " ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING"
- Luger " Artificial Intelligence", Edition 5, Pearson, 2008

(DEC) ADVANCED JOINING TECHNOLOGY

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1 and T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

Students should be able to:

- Explain the working of various conventional & advanced Welding Processes.
- Understand advantages & limitations of welding processes and select the appropriate welding process based on application, customer requirement and specifications.
- Demonstrate an ability of inspection and testing of welded components and apply remedial measures to minimize defects in welding.

Syllabus Contents:

Unit I: Gas and Arc welding processes: [7 hrs]
Fundamental principles – Air Acetylene welding, Oxyacetylene welding, Carbon arc welding, shielded metal arc welding, Submerged arc welding, TIG & MIG welding, Plasma arc welding and Electroslag welding processes - advantages, limitations and applications

Unit II:Resistance Welding Processes: [7 hrs]
Spot welding, Seam welding, Projection welding, Resistance Butt welding, Flash Butt welding, Percussion welding and High frequency resistance welding processes - advantages, limitations and applications.

UNIT III:**Solid State Welding Processes**: [7 hrs]
Cold pressure welding, Diffusion bonding, Explosive welding, Ultrasonic welding, Friction welding, Forge welding, Roll welding and Hot pressure welding processes - advantages, limitations and applications, Advances in adhesive bonding, Brazing and soldering, cladding.

UNIT IV:**Advanced Welding Processes**: [9 hrs]
Thermit welding, atomic hydrogen welding, Electron beam welding, Laser Beam welding - principle, working and applications, Friction stir welding, Cold Metal Transfer - concepts, processes and applications, Under Water welding, Welding automation in aerospace, nuclear and surface transport vehicles, Robotic Welding.

UNIT V:**Testing and Design of Weldments:** [6 hrs]
Design and quality control of welds. Edge preparation types of joints, weld symbols. Stresses in butt and fillet welds - weld size calculations. Design for fatigue. Destructive and non-destructive testing of weldments. Weldability Testing - tensile, bend hardness. Impact, notch and fatigue tests. Visual examination - liquid penetration test, magnetic particle examination. Radio graphs, ultrasonic testing. Life assessment of weldments. IS codes.

UNIT VI: **Weld Metallurgy:** [6 hrs]
Weld thermal cycles and their effects, effects of pre and post weld heat treatments, concept of HAZ, concept of weldability and its assessment. Welding of different materials, defects in welds, their causes and remedies.

Text Books:

- Parmer R.S., “Welding Engineering and Technology”, Khanna Publishers, New Delhi, 2008.
- Little R.L., “Welding and Welding Technology”, Tata McGraw Hill Publishing Co., Ltd., New Delhi, 34th reprint, 2008.
- Kalpakjian S. "Manufacturing Engineering and Technology" Prentice Hall Pearson Education India; 4th edition, 2002.

References :

- Schwartz M.M. “Metals Joining Manual”. McGraw Hill Books, 1979.
- Tylecote R.F. “The Solid Phase Welding of Metals”. Edward Arnold Publishers Ltd. London, 1968.
- AWS- Welding Hand Book. 8th Edition. Vol- 2. “Welding Process”
- Nadkarni S.V. “Modern Arc Welding Technology”, 1st edition, Oxford IBH Publishers, 2005.
- Christopher Davis. “Laser Welding- Practical Guide”. Jaico Publishing House, 1994.
- Davis A.C., “The Science and Practice of Welding”, Cambridge University Press, Cambridge, 1993.
- Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM,2007.

Minors – Manufacturing Technology (Mechanical)

SEMESTER-VII

MANUFACTURING AUTOMATION

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation- Assignments /Quiz/T1/T2- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- To have an overview of manufacturing, manufacturing operations and automation technologies
- To study the definition and elements of mechatronics and automation system
- To learn how to apply the principles of mechatronics and automation for the development of productive and efficient manufacturing systems.
- To study the hydraulic and pneumatic systems employed in manufacturing industry.
- To study material handling technologies for their identification in automated material control purposes.
- To learn the integration of automation technologies and material handling technologies into manufacturing systems.

Syllabus Contents:

UNIT 1: Overview of Manufacturing **(08 hr)**

Introduction to Production Systems, Automation in Production Systems, Overview of Manufacturing, Manufacturing Operations, Manufacturing Models and Metrics Automation, Mechatronics and Control Technologies:
Introduction to Automation, Definition of Mechatronics, Mechatronics in Manufacturing, Products and Design, Review of Fundamentals of Electronics Industrial Control Systems, Hardware Components for Automation, Mechatronics and Process Control (Data Conversion Devices, Sensors, Micro-sensors, Transducers, Signal Processing Devices, Relays, Contactors and Timers), Data Acquisition, Actuators and Mechanisms

UNIT 2: Material Handling and Identification Technologies **(08 hr)**

Introduction to Material Handling, Principles of Material Handling, Material Transport Systems, Conventional and Automated Storage Systems, Engineering Analysis of Storage Systems, Automatic Identification and Data Capture
Manufacturing Systems
Introduction to Manufacturing Systems, Single Station Manufacturing Cells, Manual Assembly Lines: Single Model and Mixed Assembly Line Balancing, Automated Production Lines, Automated Assembly Systems

UNIT 3: Automation and Principle of Hydraulic and Pneumatic Circuit Design and Analysis(06)
Hydraulic and Pneumatic Controls, Application in Machine Tools and other Mechanical Fields, Hydraulic and Pneumatic Circuit Design Considerations, Functional Diagram in Circuit Design, Pneumatic Circuit Analysis, Electrical Controls for Fluid Power Circuits, Fluid Logic Control Systems, Fluid Power Maintenance and Safety, Synthesis of circuits, circuit optimization techniques.

UNIT 4: Programmable Automation (Processors) **(06 hr)**
Overview of Microcomputer systems, Microcontroller, 8051 Microcontroller Architecture, 8051 Instruction set and interfacing, applications, and assembly language programming of microcontroller

UNIT 5: Control System and Controllers **(08 hr)**
Transfer function and block diagram, Block Diagram Reduction, Controller Principles, Process Characteristics, Control System Parameters, Controller Modes, Control Actions
Discrete Control
Programmable Logic Controllers, Basic Structure, Ladder Logic Programming, Types and Selection of PLC

UNIT 6: Mechatronic Systems – Control Architectures, Design Strategy and Case Studies **(06 hr)**
Introduction, Control Architecture, Traditional and Mechatronics Designs, Possible Mechatronic Design Solutions, Case Studies of Mechatronic Systems

Text Books:

- Mikell P. Groover, Automation, Production Systems, and Computer Integrated Manufacturing, Third Edition, Prentice-Hall of India Private Limited.
- W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education Limited

Reference Books:

- N. P. Mahalik, Mechatronics: Principles, Concepts and Applications, Tata McGrawHill
- S. R. Majumdar, Oil Hydraulic Systems: Principles and Maintenance, Tata McGrawHill
- HMT Ltd. Mechatronics, Tata McGrawHill
- Joji P. Pneumatic Controls, Wiley India
- S. R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGrawHill

Minors – Manufacturing Technology (Non - Mechanical)

SEMESTER-VII
MANUFACTURING AUTOMATION

Teaching Scheme	**Examination Scheme**
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments
Tutorial: hr/week	/Quiz/T1/T2- 40 Marks, End Sem Exam- 60 marks

Course Objectives:

- To explain the production performance of manufacturing systems
- To realize the importance of Mechatronics in Factory Automation
- To get acquainted with the automation and control technologies
- To identify the requirement of material handling and identification technologies
- To carry out performance analysis of various manual and automated manufacturing systems
- To identify, build and design fluid power systems required in factory automation

Syllabus Contents:

UNIT 1: Overview of Manufacturing **(08 hrs)**

Introduction to Production Systems, Automation in Production Systems, Overview of Manufacturing, Manufacturing Operations, Manufacturing Models and Metrics
Automation, Mechatronics and Control Technologies:
Introduction to Automation, Definition of Mechatronics, Mechatronics in Manufacturing, Products and Design, Review of Fundamentals of Electronics Industrial Control Systems, Hardware Components for Automation, Mechatronics and Process Control (Data Conversion Devices, Sensors, Micro-sensors, Transducers, Signal Processing Devices, Relays, Contactors and Timers), Data Acquisition, Actuators and Mechanisms

UNIT 2: Material Handling and Identification Technologies **(08 hrs)**

Introduction to Material Handling, Principles of Material Handling, Material Transport Systems, Conventional and Automated Storage Systems, Engineering Analysis of Storage Systems, Automatic Identification and Data Capture
Manufacturing Systems
Introduction to Manufacturing Systems, Single Station Manufacturing Cells, Manual Assembly Lines: Single Model and Mixed Assembly Line Balancing, Automated Production Lines, Automated Assembly Systems

UNIT 3:**Automation and Principle of Hydraulic and Pneumatic Circuit Design and Analysis (06 hrs)**

Hydraulic and Pneumatic Controls, Application in Machine Tools and other Mechanical Fields, Hydraulic and Pneumatic Circuit Design Considerations, Functional Diagram in Circuit Design, Pneumatic Circuit Analysis, Electrical Controls for Fluid Power Circuits, Fluid Logic Control Systems, Fluid Power Maintenance and Safety, Synthesis of circuits, circuit optimization techniques.

UNIT 4:**Programmable Automation (Processors)** **(06 hrs)**

Overview of Microcomputer systems, Microcontroller, 8051 Microcontroller Architecture, 8051 Instruction set and interfacing, applications and assembly language programming of microcontroller

UNIT 5:**Control System and Controllers** **(08 hrs)**

Transfer function and block diagram, Block Diagram Reduction, Controller Principles, Process Characteristics, Control System Parameters, Controller Modes, Control Actions

Discrete Control

Programmable Logic Controllers, Basic Structure, Ladder Logic Programming, Types and Selection of PLC

UNIT 6: Mechatronic Systems – Control Architectures, Design Strategy and Case Studies **(06 hrs)**

Introduction, Control Architecture, Traditional and Mechatronics Designs, Possible Mechatronic Design Solutions, Case Studies of Mechatronic Systems

Text Books:

- Mikell P. Groover, Automation, Production Systems, and Computer Integrated Manufacturing, Third Edition, Prentice-Hall of India Private Limited.
- W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education Limited

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- S. R. Majumdar, Oil Hydraulic Systems: Principles and Maintenance, Tata McGrawHill
- HMT Ltd. Mechatronics, Tata McGrawHill
- Joji P. Pneumatic Controls, Wiley India
- S. R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGrawHill

Honors – Manufacturing Systems Engineering

SEMESTER-VII

PERFORMANCE MODELING OF PRODUCTION SYSTEMS

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1, T2 – 20 marks each, End-Sem Exam - 60

Course Outcomes:

- Identify the type of Production system and its modelling.
- Perform line balancing and buffer stock simulation.
- Analyse the production system using Markov chain & Petri Net.

UNIT 1 **(8 hrs)**

Dedicated manufacture versus Flexible manufacture, mechanization versus automation, semi-automatic versus automatic systems using 'in-line' transfer, rotary transfer, balancing of assembly line using available algorithms. Transfer line-monitoring system (TLMS) using Line Status, Line efficiency. Buffer stock Simulation.

UNIT 2 **(7 Hrs)**

Hard automation using relays, solenoid operated valves, magnetic selectors, hydraulic and pneumatic systems in automation. 'In travel' control, 'centralized travel' control and 'time sequence' control.

UNIT 3 **(6 Hrs)**

Automatic inspection of parts and loading unloading using Robots and Vision systems with CCD cameras, LED's for three-dimensional On-line inspection.

UNIT 4 **(6 Hrs)**

AGV and its various guiding technologies.

UNIT 5 **(8 Hrs)**

Markov chain analysis for production systems with discrete time and continuous time analysis. Markov chain analysis with zero or with one or more repair facility, Reversible Markov chains in manufacturing, Use of analytical hierarchy process in Cellular Manufacturing Systems.

UNIT 6 **(7 Hrs)**

Uses of Petri Nets. Generalized timed Petri Nets, Extended stochastic Petri Nets and their applications in Production systems.

References Books:

- N. Viswanadhan& Y. Narahari, "Performance Modelling of Automated Manufacturing Systems", Prentice Hall of India (Eastern Economy Edition) 1992.
- Mikell P. Groover, "Automation, Production Systems & Computer Integrated Manufacturing" Prentice Hall India Learning Pvt. Ltd.3rdEdition. 2008
- Benjamin S. Blanchand, "Logistics Engineering and Management (5th Edn.) - Pearson Education Asia - Indian Reprint 2001

Honors –Mechatronics
SEMESTER-VII

Teaching Scheme	**Examination Scheme**
Lectures : 3 hrs/week	T1/T2/ Assignments/ Quiz -40 End-Sem Exam- 60 marks

(PCC) FLUID POWER SYSTEMS AND FACTORY AUTOMATION

Course Outcomes

At the end of the course, students will demonstrate the ability to:

- Understand the importance and the scope of hydraulics and pneumatics in the modern industry.
- Select and size the different components required to design a fluid power system.
- Analyze the fluid power circuits with control
- Design an electrical or PLC control logic system to control the operation of designed fluid power system.
- Design and implement low-cost fluid power automation system.

Syllabus Contents

Introduction to Fluid Power

Physical Properties of Hydraulic Fluids

Energy and Power in Hydraulic Systems

Frictional Losses in Hydraulic Pipelines

Hydraulic Power Generators - Selection and specification of pumps, pump characteristics.

Linear and Rotary Actuators - selection, specification, and characteristics.

Pressure - direction and flow control valves - relief valves, non-return and safety valves - actuation systems.

Hydraulic Circuit Design and Analysis

Pneumatic fundamentals - control elements, position and pressure sensing

Pneumatic logic circuits - switching circuits -fringe conditions modules and these integration - sequential circuits - cascade methods - mapping methods – step counter method - compound circuit design - combination circuit design.

Pneumatic equipment - selection of components - design calculations -application - fault finding – hydro pneumatic circuits –

Use of microprocessors/microcontrollers for sequencing - PLC, Low-cost automation - Robotic circuits.
Advanced Electrical Controls For Fluid Power Systems

Reference Books:

- Antony Esposito, "Fluid power with Applications", Prentice Hall India, 7th Edition, 2014.
- Dudleyt, A.Pease and John J.Pippenger, "Basic Fluid Power", Prentice Hall, 1987.
- Andrew Parr, "Hydraulic and Pneumatics", Jaico Publishing House, 1999.
- Bolton. W. “Pneumatic and Hydraulic Systems", Butterworth - Heinemann, 1997.
- Anthon H. Hehn, “Fluid Power Troubleshooting”, 2nd Edition, Marcel Dekker.
- S. R. Majumdar, “Pneumatic Systems: Principles and Maintenance”, Tata

McGrawHillPublishing Company Limited, 1995.

SEMESTER VIII

PE-402 INDUSTRIAL INPLANT TRAINING

Teaching Scheme
Contact Hours: 2 hrs/week/student
Duration of Training in Industry: 6 months

Examination Scheme
Term Work : 50 Marks
Oral Exam : 50 Marks

Course Outcomes:

- Learning the environment of Industry and its organization chart.
- Learning of Manufacturing Machine Tools: Principles and Operations.
- Exposure to different departments of plant which gives them to conceptualize Design, Manufacturing, Production Planning, Quality Control etc.
- Learning about process of Supply Chain Management, Vendor Development, Product Design, concept of Value Engineering in New Product Development etc.
- Comprehensive report writing skills based on his/her observations, training received, and assignments completed.

General guidelines to the institutions running production - Sandwich degree course and to the students opting for sandwich course. Students are expected to learn following things during the Industrial Implant Training of 6 months:
He shall be given training in large or medium size manufacturing unit in various departments.

1. Orientation / Rotational Training:
Organizational Structure of the Company, scale and type of production, types of products, functional departments like Manufacturing, Process Planning & Control, Quality Assurance, Assembly, Testing, Maintenance, Stores, Purchase, Marketing, Human Resources Department, Design and Drawing Department, General Administration, Packing and Dispatching. Tool Engineering, Materials & Material Handling etc.

2. Industrial Design and Drawing Practice:
Design and Drawing standards, study of Mechanical components and mechanical components and introduction to machine element design such as gears, gear boxes, chain and belt drives, electric motor selection, couplings, shafts, keys, bearings, brackets, bolted and welded connections. Sub - assembly and assembly design and drawings. Various ISO and BIS standards for design. Simple assignments based on the above items, selection of materials, material specification, beat treatment, and properties of materials.

3. Study of Manufacturing Processes:
Study of Processes such as casting, forging, sheet metal working, plastic moulding, extrusion, rolling and machining operations on various machines. Study of finishing processes like grinding, lapping, honing, burnishing, buffing, etc. Chipless manufacturing

processes.

4. Study of Various Manufacturing Machine Tools such as lathes, capstan and turret lathes, planer, shaper and milling. Mechanical and Hydraulic Presses, Gear hobbing, shaping and grinding machines.

5. Study of special purpose machines, jig boring machines, NCICNC machines, work centers and transfer lines and automatic machines.

6. Study of single point cutting tools and multipoint tools, form tools, jig and fixtures, special purpose machine tools and Press tools, Tool material and tool selection, study of cutting parameters.
7. Study of material handling methods and equipment.

8. Introduction to Quality and Quality Policy, need for Quality Control, National and International Standards on Quality and Reliability. Study of various inspection gauges, selection of gauges, comparators, calibration of gauges, Standards Room, etc. Product Performance Test Procedures.

9. Study of various Production Planning and Control functions. Process and Operation Planning, Yearly and Monthly Planning, Forecasting, Scheduling, Planning.
10. Study of various Industrial Engineering functions, Work Study, (Motion Study and Time analysis), Ergonomic considerations, Plant Layout, Safety aspects of working, Safety gadgets used on machines and Personal Safety Equipment.

The students shall be asked to do simple assignments in various departments where he is undergoing training.
Industries shall be requested to prepare training program before hand, covering as much as possible from above mentioned topics depending upon the type of industry.

Term Work :
Term Work will consist of a comprehensive report based on his observation, training received and assignments completed during 6 months of training. The report shall also include good drawing figure, process sheets and machine and product specifications.
Students should maintain training project diary and report to internal guide every week. For writing project report, students must follow the format given in the project diary.

Oral Examination
Oral examination will be based on In-plant Training Report (Term Work), which will be conducted jointly by internal examiner from within the institute and external examiner from the industry.

PE-404 SEMINAR – II

Teaching Scheme	Examination Scheme
Practical:- 2 hrs/week	Oral: -- 50 Marks Term Work: -- 50 Marks

Outcomes:
A Students should:

- Explore seminar topic and its importance.
- Acquire excellent presentation & communication skills.
- Develop interest towards research-oriented fields with ability to search the literature from the available resources
- Develop technical writing skills

Seminar shall be based on deep study of any topic related to production engineering; format of the report shall be as follows:
1. Title Page (Refer format given)
2. Certificate (Refer format given)
3. Acknowledgements: - There should not be any mistake in name and initials.
4. Abstract: - A page explaining the Seminar topic in maximum 150 words.
5. Content / Index (Refer format given in the Project Diary)
6. List of Tables/Figures or Nomenclature and Symbols: - List of Tables, Figures, Graphs etc. with respective page numbers.
7. Introduction: - 2-3 pages.
8. Seminar Report: - Description of topic about 12-15 pages.
9. Conclusion
10. References (Refer format given in the Project Diary)

Instructions regarding Seminar Report Printing:-
Page size :- A4.
Page Format :- Left-1.25", Right-1", Top & Bottom 1" – No Border / Frame.
Font :- Arial Regular.
Font Size and Colour :- 12, Black.
Line Spacing :- 1.5
Printing / Typing :- On one side of the paper only.
(No blank sheet be left any where in the report.)
Paragraph :- Justified.
Paragraph Indent :- Nil.
Page numbers :- Right bottom, starting from „Contents" page.
Printing :- Laser.
Binding :- Spiral with front and back cover of card paper neatly cut to size.

Number of Copies of the Seminar Report: - **Two**.
Instructions for figures and tables: -

i. Figures should be drawn on separate sheets or inserted on the page on which the text is typed. The figures are drawn in either permanent black ink or printed on paper. The figures should be numbered.
ii. Tables shall be typed in text. A separate sheet may be used, if necessary. The table shall

be numbered.

iii. Mathematical portion of the text shall be preferably typed. If this is not possible, it should be written in permanent black ink. Lengthy Mathematical derivations shall not be included. Only the important steps and expressions shall be given.

iv. Discussions and conclusions shall form the last paragraph of the text.

Front page (on Binding and Title Page):-

COLLEGE OF ENGINEERING, PUNE

Title Line (Font size to extend across 5" width)

Title should be in one line, if required use two lines.

_____

_____

Submitted by:-

_____

Class:- _____ Roll No.:- _____

DEPARTMENT OF PRODUCTION ENGINEERING & INDUSTRIAL MANAGEMENT

COLLEGE OF ENGINEERING, PUNE

(An Autonomous Institute of Government of Maharashtra)

20 - 20

Certificate Page: -

DEPARTMENT OF PRODUCTION ENGINEERING & INDUSTRIAL MANAGEMENT

COLLEGE OF ENGINEERING, PUNE

(An Autonomous Institute of Government of Maharashtra)

CERTIFICATE

This is to certify that Mr./Miss_____ has completed the Seminar entitled _____in partial fulfillment of the requirement of the VIII semester Production Engineering (Sandwich) Course at the Department of Production Engineering of COLLEGE OF ENGINEERING, PUNE – 411005, during the academic term 20 - 20 .

(Name of Guide)
Guide

Date:- dd/mm/yyyy

(Name of HOD)
Prof. & Head
Department of Production Engg. & Industrial Management ,
College of Engineering, Pune:- 411005.

Place:- Pune-411005.

(Examiner)

Term Work

Term Work shall comprise of Seminar report. Topic of seminar should be pre-approved by guide.

Oral Examination

Seminar Presentation / Oral examination will be assessed by guide and one internal examiner from within the institute.

PROJECT AND PRODUCTION MANAGEMENT

Teaching Scheme
Self study

Examination Scheme
End Semester Exam-100 Marks

Course Outcomes:

- To enable students to learn the basic concepts of Project & Production Management
- To enable students to implement Project Planning in their Industrial In-Plant Training Project work
- To get capable of self-education and clearly understand the value of achieving perfection in Project implementation & completion.
- To study concept of Facility Location & Layout and implement in their Industrial In-Plant Training Project work
- To develop analytical mind for solving demand forecasting and Inventory decisions

Syllabus Contents:

Unit 1
Project Conception and Appraisal: Project Identification, Idea Screening, Project Appraisal, Project Selection

Unit 2
Project Planning
Development of Project Network – Work Breakdown Structure, Project Representation – AOA and AON Networks, Project Scheduling –Critical Path Method, Project Scheduling with Probabilistic Activity Times - PERT, Time/ Cost Trade-offs in Projects Linear Time-Cost Trade-offs in Projects: A Heuristic Approach, Resource Considerations in Projects, Resource Profiles and levelling, Limited Resource Allocation

Unit 3
Project Implementation & Complementation
Project Monitoring and Control with PERT / Cost, Team Building and Leadership in Projects
Project Completion, Review and Future Directions

Unit 4
Production Management
Introduction to Production Systems and a Generalized Model of Production, Life cycle of a Production System and Major managerial Decisions

Financial Evaluation of Production Related Decisions
Performance Measures of a Production System, Financial Evaluation of Capital Decisions, Decision Trees and evaluation of risk.

Designing Products & Services
Introducing New Products and Services, Product Mix Decisions

Unit 5
Facility Location and Layout
Plant Location, Process Layouts, Product Layouts and Assembly Line Balancing, Cellular Layouts, Layouts for Advanced Manufacturing Systems.

Unit 6
Production Planning Over Medium Term Horizon
Demand Forecasting, Aggregate Production Planning

Operational Decisions Over the Short Term
Inventory related Decisions, Material Requirements Planning, Sequencing and Scheduling

References:

- Arun Kanda, S. G. Deshmukh. Project and Production Management (Video Course) From NPTEL, IITD, http://www.nptel.ac.in/video.php?subjectId=112102106
- Prasanna Chandra, Projects Planning, Analysis, Selection, Financing, Implementation, and Review, sevent Edition, Mc Graw Hill Education (India) Pvt. Ltd.
- MartandTelsang, Industrial Engineering and Production Management
- R. L. Francis, John A. White, Facility layout and location:an analytical approach, Prentice-Hall, 1974
- Stephen N Chapman, Fundamentals of Production Planning and Control, Pearson Education, 2006
- William Bolton, ProductionPlanning and Control- Longman Scientific & Technical 1994Geofferry Boothroyd, Peter Dewhurst and Winston Knight. Product Design for Manufacture and Assembly, Amherst, 1983.
- Bill Hollins, Stwout Pugh, Butterworth, Successful Product Design by London 1990.
- Boothroyod&DewburstP., Design for Assembly, a Designer's Handbook, University of Massachusets, Amherst, 1983.
- Keyinotto&Kristini Wood, Product Design Pearson Education 2004.

Minors – Manufacturing Technology (Mechanical)
SEMESTER-VIII

INDUSTRIAL DESIGN OF PRODUCTS

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation- Assignments /Quiz/T1/T2 - 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Students learn basics of product design process and morphology of design.
- Students are exposed to Concept design, detail design, manufacturing, marketing, Introduction strategy of new product. Students learn about process of design for production of metal components.
- To understand optimization tools and ergonomic principles applied on typical product design

as well as concept of value engineering in new product design.

- To understand all phases of product. Concept to final manufacturing.

Syllabus Contents:

Unit 1 Introduction to Product Design(5 hrs)

Asimow's Model: Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle, Flow and Value Addition in the Production-consumption Cycle, The Morphology of Design (The sever phases), Primary Design Phases and flowcharting, Role of Allowance Process Capability, and. Tolerance in Detailed Design and Assembly.

Unit 2 Product Design Practice and Industry (8 hrs)

Introduction, Product Strategies Time to Market, Analysis of the Product, The Three S's, Standardization Renard Series (Preferred Numbers), Simplification, The Designer and their Role, The Designer: Myth and Reality, The Industrial Design Organization Basic Design Considerations, Problems faced by Industrial Designer. Procedure adopted by Industrial Designers, Types of Models designed by Industrial Designers, What the Designer contributes, Role of Aesthetics in Product Design, Functional Design Practice. Review of Strength, Stiffness and Rigidity Considerations in Product Design Principal Stress Trajectories (Force - Flow Lines), Balanced Design, Criteria and Objectives of Design, Material Toughness: Resilience, Designing for Uniform Strength, Tension vis-à-vis Compression.

Unit 3 Design for Production -Metal Parts (8 hrs)

Producibility Requirements in the Design of Machine Components, Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, The Role of Process Engineer, Ease of Location and Clamping, Some Additional Aspects of Production Design, Die Casting and Special Castings, Design for Powder Metallurgical Parts, Expanded Metals and Wire Forms.

Designing with Plastics, Rubber, Ceramics and Wood

Approach to Design with Plastics, Plastic Bush Bearings, Gears in Plastic, Fasteners in Plastic, Rubber Parts, Design Recommendations for Rubber Parts, Distortion in Rubber, Dimensional Effects, Tolerances, Ceramics and Glass Parts, Production Design Factors for Ceramic Parts, Special Considerations for Design of Glass Parts, Dimensional Factors and Tolerances, Wood. Design for assembly and disassembly.

Unit 4 Rapid Prototyping (8 hrs)

Importance and overview of Rapid Prototyping, Classification of Rapid Prototyping (RP) Process (FDM, LOM, SLA, SLS, Stereo lithography etc.), Typical Process Chain forRP, Introduction to CAD and Data exchange format, data format details, conversion, validation, repairing, Part Slicing and Orientation and its importance, application and case studies.

Unit 5 Economic Factors Influencing Design (8 hrs)

Product Value, value analysis, design for Safety, Reliability and Environmental Considerations, Manufacturing Operations in relation to Design, Economic Analysis, Profit and Competitiveness, Break-even Analysis, Economics of a New Product Design (Samuel Eilon Model).

Human Engineering Considerations in Product Design

Introduction, Human being as Applicator of Forces, Anthropometry: Man as Occupant of Space,

The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Unit 6: Modern Approaches to Product Design **(6 hrs)**

Concurrent Design, Quality Function Deployment (QFD) for design, product design optimization methods.

Text Books:

- A.C. Chitale and R.C. Gupta, Product Design and Manufacturing by PHI.
- Karl T. Ulrich & Steven D., Product Design & Development Eppinger Tata McGraw Hill, 3rdEdition, 2003

Reference Books:

- Tim Jones, Butterworth Heinmann, New Product Development by Oxford, TAC-1997.
- Roland Engene Y.,Inetoviez, New Product Development: Design & analysis, John Wiley and Sons Inc., N.Y. 1990.
- GeofferryBoothroyd, Peter Dewhurst and Winston Knight. Product Design for Manufacture and Assembly, Amherst, 1983.
- Bill Hollins, Stwout Pugh, Butterworth, Successful Product Design by London 1990.
- Boothroyod&DewburstP.,Design for Assembly, a Designer's Hand book, University of Massachusets, Amherst, 1983.
- Keyinotto and Kristini Wood, Product Design Pearson Education 2004.
- Venuvinod, PK., MA. W., Rapid Prortotyping –Laser Based and Other Technologies, Kluwer,2004.

Minors – Manufacturing Technology (Non - Mechanical)

SEMESTER-VIII
INDUSTRIAL DESIGN OF PRODUCTS

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation- Assignments /Quiz/T1/T2 - 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Students learn basics of product design process and morphology of design.
- Students are exposed to Concept design, detail design, manufacturing, marketing, Introduction strategy of new product. Students learn about process of design for production of metal components.
- To understand optimization tools and ergonomic principles applied on typical product design as well as concept of value engineering in new product design.
- To understand all phases of product. Concept to final manufacturing.

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Producibility Requirements in the Design of Machine Components, Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, The Role of Process Engineer, Ease of Location and Clamping, Some Additional Aspects of Production Design, Die Casting and Special Castings, Design for Powder Metallurgical Parts, Expanded Metals and Wire Forms.

Designing with Plastics, Rubber, Ceramics and Wood

Approach to Design with Plastics, Plastic Bush Bearings, Gears in Plastic, Fasteners in Plastic, Rubber Parts, Design Recommendations for Rubber Parts, Distortion in Rubber, Dimensional Effects, Tolerances, Ceramics and Glass Parts, Production Design Factors for Ceramic Parts, Special Considerations for Design of Glass Parts, Dimensional Factors and Tolerances, Wood. Design for assembly and disassembly.

Unit 4: Rapid Prototyping (8 hrs)

Importance and overview of Rapid Prototyping, Classification of Rapid Prototyping (RP) Process (FDM, LOM, SLA, SLS, Stereo lithography etc.), Typical Process Chain forRP, Introduction to CAD and Data exchange format, data format details, conversion, validation, repairing, Part Slicing and Orientation and its importance, application and case studies.

Unit 5: Economic Factors Influencing Design (8 hrs)

Product Value, value analysis, design for Safety, Reliability and Environmental Considerations, Manufacturing Operations in relation to Design, Economic Analysis, Profit and Competitiveness, Break-even Analysis, Economics of a New Product Design (Samuel Eilon Model).

Human Engineering Considerations in Product Design

Introduction, Human being as Applicator of Forces, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Unit6 : Modern Approaches to Product Design (6 hrs)

Concurrent Design, Quality Function Deployment (QFD) for design, product design optimization methods.

Text Books:

- A.C. Chitale and R.C. Gupta, Product Design and Manufacturing by PHI.
- Karl T. Ulrich & Steven D., Product Design & Development Eppinger Tata McGraw Hill, 3rdEdition, 2003

Reference Books:

- Tim Jones, Butterworth Heinmann, New Product Development by Oxford, TAC-1997.
- Roland Engene Y.,Inetoviez, New Product Development: Design & analysis, John Wiley and Sons Inc., N.Y. 1990.
- Geofferry Boothroyd, Peter Dewhurst and Winston Knight. Product Design for Manufacture and Assembly, Amherst, 1983.
- Bill Hollins, Stwout Pugh, Butterworth, Successful Product Design by London 1990.
- Boothroyod&DewburstP.,Design for Assembly, a Designer's Hand book, University of Massachusets, Amherst, 1983.
- Keyinotto and Kristini Wood, Product Design Pearson Education 2004.
- Venuvinod, PK., MA. W., Rapid Prortotyping –Laser Based and Other Technologies, Kluwer,
  2004.

Honors – Manufacturing Systems Engineering

SEMESTER-VIII
MACHINE TOOL SYSTEMS

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation- Assignments /Quiz/T1/T2- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- To learn machine tool structure and their elements
- To understand basic design features of machine elements
- To get up to-date knowledge in machine tool development field

Syllabus Contents:

Unit1: Machine tool configuration **(6 hrs)**

Recent development in machine tool field, Basic concepts and requirements, types of machine tool, structure of machine tool system, Design approach by matrix method, Introduction to CNC and machining centre configuration.

Unit2: Drive system review **(6 hrs)**

Elements of machine tool system, their requirements and design criteria-drive system viz speed/ feed drive, power transmission screw etc

Unit3: Supporting elements and design analysis **(8 hrs)**

Supporting elements in machine tool-like bed, guides and lubrication, and stick slip, spindle,

Machine column etc.

Unit 4: Rigidity & reliability of machine tool **(6 hrs)**

Rigidity of machine tool-static and dynamic, dynamic characterization analysis of cutting process, vibration and chatter, Machine compliance estimation, Tobius curve etc. Reliability of machine tool, Availability etc.

Unit 5: Automation and feedback **(6 hrs)**

Open loop and closed loop control, pre-selective and selective control, micro movements of elements, micro sensors, electrical/electronic control of motor, hydraulic controls, in-process gauging etc.

Unit 6: Introduction to modern machine tool **(8 hrs)**

Principle of automation, multi-axis machining centres, additive manufacturing machines, super finishing machines etc., machine tool power utilization with full tool life, Machine tool performance (Coefficient of merit).

Text Books:

- S K Basu, D. K. Pal - *Design of Machine Tools*, Oxford & IBH Pub., 1995
- Gopal Chandra Sen, Amitabha Bhattacharyya - *Principles of Machine Tools*, New Central Book Agency, 1967
- N. Ignatyev, N. Acherkan et al - *Machine Tool Design*, Volume 4, University Press of the Pacific, 2000.

Reference Books:

- N K Mehta - *Machine tool design and Numerical control*, third edition, Tata McGraw hill publications limited, 2012
- Stanley John Martin-*Numerical Control of Machine Tools*, Hodder and Stoughton, 1970
- T.K. Kundra- *Numerical Control and Computer-Aided Manufacturing*, McGraw-Hill Education, 1987
- JW Gardner, F Udrea- *Microsensors: principles and applications*,2nd John Wiley & Sons, 2009.
- A Gebhardt, A Gebhardt- *Understanding additive manufacturing*,CarlHanserVerlag GmbH & Co.,2012.
- RS Schmid, S Kalpakjian- *Manufacturing engineering and technology*, Pearson Prentice Hall, 2006.
- B Lu, D Li, X Tian- *Development Trends in Additive Manufacturing and 3D Printing*,Engineering, vol-1,issue-1,2015
- Menz et al - *Microsystem technology* - wileyvch verlag,2000

Honors –Mechatronics

SEMESTER-VIII
(PCC) MECHATRONICS SYSTEM DESIGN

Teaching Scheme	**Examination Scheme**
Lectures: 3 hrs/week	T1/T2/ Assignments/ Quiz - 40
	End-Sem Exam- 60 marks

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

- Understand the integration of knowledge from different disciplines into Mechatronics.
- Analyze existence of Mechatronics in engineering and consumer products those are useful in everyday life.
- Select suitable sensors and actuators while designing electro-mechanical systems.
- Create technical requirement while working with Mechatronics Systems.

Syllabus Contents:

- **Rotational drives** - Pneumatic Motors: continuous and limited rotation - Hydraulic Motors: continuous and limited rotation - Brushless DC Motors - Motion convertors, Fixed ratio, invariant motion profile, variators, remotely controlled couplings Hydraulic Circuits and Pneumatic Circuits.
- **Mechanical Systems and Design** - Mechatronics approach - Control program control, adaptive control and distributed systems - Design process - Types of Design - Integrated product design - Mechanisms, load conditions, design and flexibility Structures, load conditions, flexibility and environmental isolation – Man machine interface, industrial design and ergonomics, information transfer from machine from machine to man and man to machine, safety.
- **Real time interfacing** - Introduction Elements of data acquisition and control Overview of I/O Process-Installation of I/O card and software - Installation of application software- Over framing.
- **Case studies on Data Acquisition** - Transducer calibration system for Automotive applications Strain Gauge weighing system - Solenoid force - Displacement calibration system - Rotary optical encoder - Inverted pendulum control - Controlling temperature of a hot/cold reservoir -Pick and place robot - Carpark barriers.
- **Case studies on Data Acquisition and Control** - Thermal cycle fatigue of a ceramic plate - pH control system - De-Icing Temperature Control System - Skip control of a CD Player - Autofocus Camera, exposure control.
- **Case studies on design of Mechatronics products** - Motion control using D.C. Motor, A.C. Motor & Solenoids - Car engine management - Barcode reader.

References :

- W. Bolton, Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering-, 2nd Edition, Addison Wesley Longman Ltd., 1999.
- Devdas Shetty, Richard A. Kolk, Mechatronics System Design, PWS Publishing company, 1997
- Bradley, D.Dawson, N.C. Burd and A.J. Loader, Mechatronics: Electronics in Products and Processes, Chapman and Hall, London, 1991.
- Brian Morris, Automated Manufacturing Systems - Actuators, Controls, Sensors and

Robotics, Mc Graw Hill International Edition, 1995.
- Gopal, Sensors- A comprehensive Survey Vol I & Vol VIII, BCH Publisher.