ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. MANUFACTURING ENGINEERING
(FULL TIME AND PART TIME) (R-2023)
CHOICE BASED CREDIT SYSTEM

VISION
To develop educational avenues for the students to emerge as disciplined, researchers technocrats and entrepreneurs making transformative impact on establishing a world class society in the domain of Production Engineering and Automation.

MISSION
1. To impart students with knowledge on modern manufacturing and automated systems by incorporating critical thinking, leadership qualities and communication with interpersonal skills.
2. To create a conducive environment for exchange of multi disciplinary ideas towards research, creativity, innovation and entrepreneurship to meet societal needs with optimal solutions.
3. To follow the values of integrity and honesty through curricular, co-curricular and extracurricular activities.
ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. MANUFACTURING ENGINEERING
(FULL TIME AND PART TIME) (R-2023)
CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

| I. | Successful career practicing modern manufacturing techniques and tools, adapting to emerging trends in industries or as an entrepreneur. |
| II. | Excel scholarly in academics and research organization, by demonstrating analytical and problem solving skills for complex engineering problems. |
| III. | Sustainable solution provider for societal needs through innovative and interdisciplinary approaches using modern tools. |
| IV. | Lead and engage diverse teams through effective communication, collaboration and managerial skills, by following ethics and professional standards. |

PROGRAMME OUTCOMES (POs):

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<td>1</td>
<td>Graduates shall be able to independently carry out research/investigation and development work to solve practical problems.</td>
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<td>Graduates shall be able to write and present a substantial technical report/document.</td>
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<td>Graduates shall be familiar with modern concepts of manufacturing techniques and principles.</td>
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<td>Graduates shall be able to adapt to real time manufacturing systems, materials processing and quality systems.</td>
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<td>Graduates shall be able to analyse and provide optimum solution to manufacturing challenges using intelligence tools.</td>
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<td>Graduates shall be able to develop and work with interdisciplinary problems as professional engineers of organisations, innovators or entrepreneurs, catering to industrial and societal needs.</td>
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PEO/PO Mapping:

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Attested

[Signature]

Director
Centre for Academic Courses
Anna University, Chennai-600 025
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(FULL TIME) (R - 2023)

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ANNA UNIVERSITY, CHENNAI  
UNIVERSITY DEPARTMENTS  
M.E. MANUFACTURING ENGINEERING (FULL TIME)  
REGULATIONS - 2023  
CHOICE BASED CREDIT SYSTEM  
CURRICULUM AND SYLLABI FOR SEMESTER I TO IV

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# M.E. Manufacturing Engineering (Part Time) (R - 2023) | Choice Based Credit System

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**TOTAL NO. OF CREDITS** 14.5+13.5+11+10+10+16= 75

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**TOTAL** 14.5 13.5 12 10 13 12 75

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*Attested*

**Director**

Centre for Academic Courses
Anna University, Chennai-600 025
### PROFESSIONAL CORE COURSES (PCC)

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Director
Centre for Academic Courses
Anna University, Chennai-600 025
# Professional Elective Courses (PEC)

## All Courses Common to Professional Electives I-VI

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### PRODUCT ORIENTED MANUFACTURING

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### EMPLOYABILITY ENHANCEMENT COURSES (EEC)

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COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To enumerate the fundamental knowledge of Integer programming
2. To solve problems using dynamic programming
3. To understand and solve non-linear programming problems
4. To familiarize on factorial design and Taguchi’s design of experiments
5. To have knowledge of decision-making tools in manufacturing

UNIT – I INTEGRAL PROGRAMMING
Branch and bound technique – Cutting plane algorithm method – Travelling Salesman Problem – 0/1 Knapsack Problem – Chinese Postman Problem – Vehicle Routing Problem.

UNIT – II DYNAMIC PROGRAMMING

UNIT – III NONLINEAR PROGRAMMING
Types of Nonlinear Programming Problems - One-Variable Unconstrained Optimization - Multivariable Unconstrained Optimization - The Karush-Kuhn-Tucker (KKT) - Quadratic Programming - Separable Programming

UNIT – IV DESIGN OF EXPERIMENTS
Fundamentals – fractional, factorial experiments – 2^k factorial design – 3 level and mixed level factorials – Response Surface Methods and Designs, Robust Parameters Design and Process Robustness Studies

UNIT – V DECISION MAKING

TOTAL: 60 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to

CO1 Explain the fundamentals of optimization through integer, dynamic and nonlinear programming
CO2 Identify appropriate optimization methods to solve complex problems involved in various industries.
CO3 Explain the methods of implementing design of experiments
CO4 Find appropriate trade-off solutions for multi-objective decision making problems in production systems, supply chain systems and specific operational problems
CO5 Compare the techniques of decision making under different environmental conditions.

REFERENCES:

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1 – Slight, 2 – Moderate, 3 - Substantial
OBJECTIVES:
1. To gain knowledge on evolution of Solid Freeform Manufacturing (SFM) and the importance of DfAM in improving the quality.
2. To acquaint with various SFM Technologies and hybrid processes, along with their material science and applications in different fields.

UNIT I INTRODUCTION
Introduction to solid freeform manufacturing (SFM) - Need- SFM evolution, Distinction between SFM & CNC machining - Development of SFM systems — Hierarchical structure of SFM - SFM process chain — Classification. SFM Supply chain - Economics aspect: Strategic aspect- Operative aspect

UNIT II DESIGN FOR ADDITIVE MANUFACTURING (DfAM)

UNIT III VAT POLYMERIZATION, MATERIAL EXTRUSION & SHEET LAMINATION TECHNOLOGIES

UNIT IV POWDER BED FUSION, BINDER JETTING, MATERIAL JETTING & DIRECT ENERGY DEPOSITION TECHNOLOGIES
UNIT V MATERIALS AND APPLICATIONS OF SFM


TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be able to
CO 1: Explore the importance in the evolution of SFM/AM, proliferation into the various fields and its effects on supply chain
CO 2: Recognize the importance of DfAM in improving the quality of fabricated parts and understand the guidelines of DfAM
CO 3: Acquire knowledge on principles and applications of vat polymerization, material extrusion and sheet lamination processes with case studies.
CO 4: Acquire knowledge on principles of powder bed fusion, jetting, direct energy deposition and hybrid processes
CO 5: Understand the properties and characteristics of materials used in SFM/AM and explore the applications in various fields.

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REFERENCES:
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To learn the analysis and fabrication methods of polymer matrix composites.
2. To study the processing methods of metal matrix composite and its applications.
3. To learn the processing methods of ceramic matrix composite with their properties.
4. To introduce to mechanics of composites.
5. To familiarize on advanced materials and its processing.

UNIT – I PROCESSING OF POLYMER COMPOSITES

UNIT – II MANUFACTURING OF METAL MATRIX COMPOSITES

UNIT– III FABRICATION AND TESTING OF CERAMIC COMPOSITES

UNIT– IV MECHANICS OF COMPOSITES

UNIT – V ADVANCED MATERIALS AND PROCESSING

TOTAL: 45 PERIODS
COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Define composites, fibers, and matrix materials used in polymer composites.
CO2 Explain the various manufacturing processes involved in the production of metal matrix composites.
CO3 Design a novel method or modification to enhance the interfacial bonding and mechanical properties of ceramic matrix composites.
CO4 Evaluate the laminate structural module and their significance in predicting the mechanical response of composite laminates.
CO5 Develop and optimize manufacturing processes for high entropy alloys, bulk metallic glasses, and amorphous materials to achieve desired properties and microstructures.

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1 – Slight, 2 – Moderate, 3 – Substantial

Attested

Director
Centre for Academic Courses
Anna University, Chennai-600 025
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students to
1. Comprehend the characteristics and selection of high-speed cutting tools and tool materials
2. Recall the concept of precision machining and its importance in machining hard and brittle materials.
4. Analyze industry case studies to understand the practical applications and challenges in modern metal forming
5. Comprehend the material selection and behavior in advanced bulk forming processes and the importance of surface treatments and coatings.

UNIT – I HIGH-SPEED MACHINING METHODS

UNIT – II PRECISION MACHINING

UNIT – III MACHINING OF DIFFICULT-TO-MACHINE MATERIALS
Overview - high-strength alloys, hardened steels, superalloys, composites, etc. - Challenges and characteristics - Importance and applications - Tool materials - Coatings and surface treatments for improved tool life and performance - Analysis of cutting forces, heat generation, and chip formation - Industry case studies, Future trends and challenges in machining of difficult-to-machine materials.

UNIT – IV MODERN METAL FORMING

UNIT – V ADVANCED BULK FORMING
Introduction - different types, Equipment and tooling considerations, Material selection and behaviour, Process parameters and control - Surface treatments and coatings - Hot Forging and Warm Forging - Precision Forging - Roll Forming - Profile Extrusion - Hybrid Bulk Forming - Industry case studies, Future trends and challenges in advanced bulk forming.

TOTAL: 45 PERIODS
COURSE OUTCOMES
Upon successful completion of the course, students should be able to

**CO1** Apply advanced machining methods such as high-speed cutting, trochoidal milling, and adaptive milling to achieve efficient and precise machining operations.

**CO2** Utilize precision machining techniques including ultra-precision grinding, electrolytic in-process dressing, and diamond turn machining to achieve high-quality surface finishes and dimensional accuracy.

**CO3** Develop the ability to machine difficult-to-machine materials, such as high-strength alloys and composites, by selecting suitable tool materials, coatings, and machining parameters.

**CO4** Apply modern metal forming processes, such as incremental sheet forming and superplastic forming, to produce complex shapes with improved material utilization and dimensional accuracy.

**CO5** Evaluate and analyze industry case studies to understand the practical applications, challenges, and future trends in advanced machining and metal forming processes and propose innovative solutions to address these challenges.

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1 – Slight, 2 – Moderate, 3 - Substantial
OBJECTIVES:
To impart knowledge on
- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I  RESEARCH PROBLEM FORMULATION
Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II  RESEARCH DESIGN AND DATA COLLECTION
Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III  DATA ANALYSIS, INTERPRETATION AND REPORTING
Sampling, sampling error, measures of central tendency and variation.; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV  INTELLECTUAL PROPERTY RIGHTS
Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V  PATENTS
Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
OBJECTIVES:
The main learning objective of this course is to prepare the students to
1. Analyze and evaluate the effects of different machining parameters on the quality of machined components, such as dimensional accuracy and surface finish.
2. Apply appropriate techniques and instruments to measure and analyze surface roughness of machined components, demonstrating proficiency in using surface roughness testers or profilometers.
3. Evaluate the quality, dimensional accuracy, and mechanical properties of the printed parts and propose improvements.

LIST OF EXERCISES
1. CNC Machining Experiment: Perform a machining operation using a CNC (Computer Numerical Control) machine, such as milling or turning.
2. Surface Roughness Measurement: Measure the surface roughness of machined components using instruments like a profilometer or surface roughness tester.
3. Tool Wear Analysis: Analyze the wear characteristics of cutting tools used in machining operations.
4. Metal Forming Experiment: Perform a metal forming operation, such as bending, deep drawing, incremental forming and superplastic forming.
5. EDM (Electrical Discharge Machining) and WEDM (Wire Electrical Discharge Machining): Perform EDM experiments to understand the principles of material removal through electrical discharges.
7. Laser engraving process
8. Cutting of different materials during water jet machining
9. Experiments on Ultrasonic Machining
10. Experiments on hydroforming
11. Micro hole drilling in ECM
12. Experiments on incremental forming

(Any 10 for Conduct of end semester examination) TOTAL = 45 PERIODS

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO1 Demonstrate a high level of competence in operating CNC machines, including programming, tool selection, and machining parameter optimization. They will be able to produce accurate and precise machined components.
CO2 Acquire the skills to accurately measure and analyze surface roughness using appropriate instruments. They will be able to assess and interpret surface roughness data to ensure the desired quality of machined surfaces.
CO3 Interpret the tool wear characteristics in machining operations. They will be able to analyze tool wear patterns, measure tool wear parameters, and propose effective strategies to minimize tool wear and prolong tool life.

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1 – Slight, 2 – Moderate, 3 - Substantial
OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To understand various Mechanical, Chemical, Thermal and Electrical based modern materials processing techniques through practical skill sets.
2. To analyse and observe the principles and its importance
3. To study the major applications in manufacture

LIST OF EXERCISES
2. Squeeze casting.
5. Chemical vapour deposition of coating.
8. Sandwich structure fabrication metallic foam fabrication.
9. Injection moulding of a bush (typical component)
10. Additive manufacturing using FDM.
11. Pin on Disc - wear measurement.
(Any 10 for Conduct of end semester examination)

TOTAL = 45 PERIODS

COURSE OUTCOMES
Upon completion of this course, the students will be able to
CO1 Understand and grasp the significance of modern materials processing and its applications through hands-on experience
CO2 Identify the selection of materials processes and its process parameters
CO3 Express and perform project related works.

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1 – Slight, 2 – Moderate, 3 - Substantial
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students to
1. Understand and apply mathematical models for one-dimensional problems and employ
   numerical methods to solve them effectively.
2. Analyze and solve two-dimensional scalar and vector variable problems to determine field
   variables, using appropriate mathematical techniques.
3. Apply iso-parametric transformation and numerical integration methods to accurately evaluate
   element matrices in finite element analysis.
4. Utilize various solution techniques to effectively solve eigenvalue problems encountered in
   finite element analysis.
5. Demonstrate knowledge of key factors, pre-processing and post-processing steps, and the
   utilization of computer tools in the implementation of finite element analysis.

UNIT – I    INTRODUCTION

Historical Background – Weighted Residual Methods - Basic Concept of FEM – Variational
Formulation of B.V.P. – Ritz Method – Finite Element Modelling – Element Equations – Linear
and Higher order Shape functions – Bar, Beam Elements – Applications to Heat Transfer
problems.

UNIT – II    FINITE ELEMENT ANALYSIS OF TWO-DIMENSIONAL PROBLEMS

Basic Boundary Value Problems in two-dimensions – Linear and higher order Triangular,
quadilateral elements – Poisson’s and Laplace’s Equation – Weak Formulation – Element
Matrices and Vectors – Application to scalar variable problems - Introduction to Theory of
Elasticity – Plane Stress – Plane Strain and Axisymmetric Formulation – Principle of virtual work –
Element matrices using energy approach.

UNIT– III ISO-PARAMETRIC FORMULATION

Natural Coordinate Systems – Lagrangian Interpolation Polynomials – Iso-parametric Elements
– Formulation – Shape functions - one dimensional, two dimensional triangular and quadrilateral
elements - Serendipity elements - Jacobian transformation - Numerical Integration – Gauss
quadrature – one-, two- and three-point integration.

UNIT – IV EIGENVALUE PROBLEMS

Dynamic Analysis – Equations of Motion – Consistent and lumped mass matrices – Free Vibration
analysis – Natural frequencies of Longitudinal, Transverse and torsional vibration – Solution of
Eigenvalue problems - Introduction to transient field problems.

UNIT – V COMPUTER IMPLEMENTATION AND FE ANALYSIS

Pre Processing, mesh generation, elements connecting, boundary conditions, input of material
and processing characteristics – Solution and post processing – Overview of application
packages – Development of code for one dimensional analysis and validation - FE analysis of
metal casting – special considerations, latent heat incorporation, gap element – Time stepping
procedures – Crank – Nicholson algorithm – Prediction of grain structure – Basic concepts of
plasticity and fracture – Solid and flow formulation – small incremental deformation formulation –
Fracture criteria – FE analysis of metal cutting, chip separation criteria, incorporation of strain rate
dependency – FE analysis of welding.

TOTAL: 60 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to:

**CO1** Apply mathematical models and numerical methods to solve one-dimensional problems, demonstrating proficiency in analyzing and solving engineering problems.

**CO2** Analyze and solve two-dimensional scalar and vector variable problems using appropriate mathematical techniques, showcasing the ability to determine field variables accurately.

**CO3** Apply iso-parametric transformation and numerical integration methods to evaluate element matrices in finite element analysis, demonstrating competence in handling complex structural and mechanical systems.

**CO4** Utilize various solution techniques to effectively solve eigenvalue problems encountered in finite element analysis, showcasing the ability to determine natural frequencies and modes of vibration.

**CO5** Compare proficiency in utilizing finite element methods and computer tools for modeling, analysis, and simulation in manufacturing processes, highlighting the ability to tackle real-world engineering challenges.

**REFERENCES:**

COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students to
1. Acquiring a comprehensive knowledge on the basics of thin films technology
2. Introduce various types of physical vapour deposition techniques for thin film
3. Introduce various types of chemical vapour deposition techniques for thin film
4. Means to control and monitor thin film and properties of thin film.
5. Applications of thin films in various fields.

UNIT – I INTRODUCTION TO THIN FILMS AND VACUUM TECHNOLOGY 9
Definition of thin films - Formation of thin films (sticking coefficient, formation of thermodynamically stable cluster - nucleation) - Environment (Gas phase and plasma) for thin film deposition; Deposition parameters and their effects on film growth, Substrates – overview of various substrates utilized - Concept of different vacuum pumps: rotary, diffusion, Turbo molecular pump, Cryogenic-pump, Ti-sublimation pump, Concept of different gauges: Pirani, penning, Pressure Control – Mass flow controllers.

UNIT – II PHYSICAL VAPOUR DEPOSITION (PVD) TECHNIQUES 9

UNIT– III CHEMICAL VAPOUR DEPOSITION (CVD) TECHNIQUES 9
Advantages and disadvantages of Chemical vapour deposition (CVD) techniques over PVD techniques, Different kinds of CVD techniques: Metallo Organic (MO) CVD, thermally activated CVD, Plasma enhanced CVD, Atomic layer deposition (ALD)- Importance of ALD technique. Epitaxy – Introduction: Epitaxial growth- Growth kinetics of epitaxy, Growth modes – illustration of crystallographic relations with thin film to substrate, characterization of epilayers (in situ and ex situ)

UNIT – IV DEPOSITION MONITORING, CONTROL AND PROPERTIES OF THIN FILM 9

UNIT – V APPLICATION OF THIN FILMS 9

TOTAL: 45 PERIODS
COURSE OUTCOMES
Upon successful completion of the course, students should be able to

CO1  Explain the fundamentals of thin film technology.
CO2  Compare the various PVD techniques of preparation of thin films
CO3  Compare the various CVD techniques of preparation of thin films and epitaxial growth
CO4  Explain the process of deposition monitoring and its film growth as well as unique properties of thin film.
CO5  List the thin film application in various fields of engineering

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1 – Slight, 2 – Moderate, 3 – Substantial
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To study the approaches and techniques to assess quality by statistical process control.
2. To study the methodology to assess and sampling of parameters
3. To Impart knowledge in reliability concepts and assess the various configurations
4. To Impart knowledge in reliability monitoring methods
5. To analyze effectively various techniques to improve reliability of the system.

UNIT – I QUALITY AND STATISTICAL PROCESS CONTROL  9

UNIT – II ACCEPTANCE SAMPLING  9
Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling plans – OC curves – Producer’s risk and consumer’s risk. AQL, LTPD, AOQL, Concepts – standard sampling plans for AQL and LTPD – use of standard sampling plans

UNIT– III RELIABILITY CONCEPTS AND ASSESSMENT  9

UNIT – IV RELIABILITY MONITORING  9

UNIT – V RELIABILITY IMPROVEMENT  9

COURSE OUTCOMES
Upon successful completion of the course, students should be able to

CO1 Apply quality principles, process variation, and control charts for effective quality management.
CO2 Discuss different sampling plans.
CO3 Explain reliability concepts and assess the various configurations.
CO4 Build knowledge in reliability monitoring methods.
CO5 Examine effectively various techniques to improve reliability of the system.

REFERENCES:

QUALITY SYSTEMS LABORATORY

LIST OF EXERCISES
1. One-way ANOVA and Two-way ANOVA testing
2. Linear Regression and Multiple Regression
3. Full Factorial Design of Experiments
4. Fractional Factorial Design of Experiments
5. Response Surface Methodology analysis
6. Multiple response Optimization
7. Taguchi Methodology

TOTAL = 60 PERIODS

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1 – Slight, 2 – Moderate, 3 - Substantial

Attested

Director
Centre for Academic Courses
Anna University, Chennai-600 025
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To introduce basic of machine learning techniques
2. To learn about classification methods
3. To familiarize about clustering methods
4. To summarize the basics of neural networks
5. To impart knowledge on Deep learning and Reinforcement learning.

UNIT – I INTRODUCTION TO MACHINE LEARNING 6
Learning – Types of Machine Learning, Classifications vs Regression, Evaluation metrics and loss functions in Classification, Linear Regression, Evaluation metrics and loss functions in Regression, Applications of AI in Robotics.

UNIT – II CLASSIFICATION METHODS 6

UNIT – III CLUSTERING 6
Introduction to clustering, Types of Clustering, Agglomerative clustering, K-means clustering, K-means clustering application study, Principal component analysis (PCA), PCA Application case study in Feature Selection for Robot Guidance.

UNIT – IV NEURAL NETWORKS 6

UNIT – V DEEP LEARNING AND REINFORCEMENT LEARNING 6

Lab Experiments:
1. Basic programs in python
2. Implementation of Linear regression
3. Implementation of SVM model
4. Implementation of Decision tree model
5. Implementation of K-means clustering algorithm
6. Implementation of MLP model
7. Implementation of CNN model
8. Implementation of Q-Learning algorithm

TOTAL: 30 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to

**CO1** Understand the basics of machine learning techniques.

**CO2** Able to classify the various methods.

**CO3** Understand the various clustering methods.

**CO4** Build about the basics of neural networks.

**CO5** Understand about deep learning and reinforcement learning.

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1 – Slight, 2 – Moderate, 3 – Substantial
OBJECTIVES
The main learning objective of this course is to prepare the students to
1. Apply the principles of finite element analysis to design and analyze elements used in manufacturing processes, demonstrating proficiency in utilizing finite element techniques for engineering design.
2. Develop skills in the application of finite element analysis for designing and evaluating manufacturing components, structures, and systems, including the ability to design and optimize elements through numerical simulations.
3. Evaluate and interpret the results obtained from finite element analysis simulations, critically analyzing the performance and behavior of manufacturing systems, and making informed decisions based on the simulation outcomes.

LIST OF EXERCISES
1. One Dimensional FEA Problem like beam, Truss etc.
2. Two Dimensional FEA Problems like plane stress, plane strain, axisymmetric and vibration.
3. Three Dimensional FEA Problems like shell and contact.
4. FEA Application in metal forming like superplastic forming, deep drawing etc
5. FEA Application in Metal cutting
6. FEA Application in casting process
7. 3D Modelling and Assemble of Engine
8. Modelling of Crack Shaft
9. Modelling of Connecting Rod
10. Modelling of Cotter Joint
11. Modelling of Plummer Block and Coupling
(Any 10 for Conduct of end semester examination) TOTAL = 60 PERIODS

COURSE OUTCOMES
Upon completion of this course, the students will be able to

CO1 Apply the principles of Finite Element Analysis to solve complex problems encountered in the field of production engineering

CO2 Design and analyze manufacturing problems using Finite Element Analysis, to optimize designs and improve manufacturing processes.

CO3 Identify and assess engineering problems in the manufacturing domain and simulate them using Finite Element Analysis, demonstrating the ability to model real-world scenarios and predict their behavior.

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COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To enable students to select and define a problem/need for analysis in the field of manufacturing engineering.
2. To review and analyse literature/data of selected problems for study and propose objective and scope of project work.
3. To develop hypothesis and identify methodology based on ethical, scientific and systematic application of knowledge in the field of problem.
4. To design, model and experiment/develop optimal solution for problem being investigated.
5. To analyse and interpret data, and synthesis of the information to provide valid conclusions and submit project.

EVALUATION:
- A project topic may be selected based on the literature survey and the creative ideas of the students themselves in consultation with their project supervisor. The topic should be chosen so that it will improve and develop the skills to design, fabricate, analyse, test and research. Literature survey and a part of the project work be carried out in project I.
- The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.
- A project report for project I is to be submitted at the end.
- Project work evaluation is based on the Regulations of the Credit system for the Post graduate programmes of Anna University.

COURSE OUTCOMES:
Upon completion of this project, the students will be able to

CO1 Apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative and get trained in planning, organising and coordinating various components of project work.

CO2 Design, model and experiment/develop optimal solutions for problems being investigated.

CO3 Analyse and interpret the experimental data from various machining methods and synthesis of the information to provide valid conclusions and submit reports.

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1 – Slight, 2 – Moderate, 3 - Substantial
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To correlate the concepts and principles of various domain of knowledge
2. To interpret and analyze typical problems, case studies etc.
3. To evaluate, review and comprehensively propose the solution to the questions.

EVALUATION:
The students shall be evaluated by written and/or oral examination on selected topics spread across the semester and reviewed by a three-member committee approved by the Head of the Department. The topics shall cover fundamental concepts of manufacturing techniques, management principles and techniques, basics materials processing and behaviour, analysis and testing etc.

TOTAL = 30 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be able to
CO1 Summarise logically the problem by comprehending various domain of knowledge
CO2 Examine typical problems, case studies etc. and identify relationship between various components/concepts
CO3 Justify a solution for a question on the basis of comprehensive review and evaluation of various alternatives.

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1 – Slight, 2 – Moderate, 3 - Substantial
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To propose and define a problem/need for analysis in the field of manufacturing engineering based on practical experience in project-I work.
2. To comprehensively review and analyse literature/data to develop hypothesis and identify methodology based on ethical, scientific and systematic application of knowledge in the field of problem.
3. To design experiments, develop models and conduct experiments/simulations for development of sustainable and economical solutions for problem being investigated.
4. To analyse and interpret data, and synthesize of the factual information to arrive at valid conclusions
5. To enable students to communicate technical information in the form of oral presentation and technical report in the form of project.

EVALUATION:
- The progress of the project is evaluated based on a minimum of three reviews.
- The review committee may be constituted by the Head of the Department.
- A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Division based on oral presentation and the project report.
- Project work evaluation is based on the Regulations of the Credit system for Post graduate programmes of Anna University

COURSE OUTCOMES:
Upon completion of this project, the students will be able to

CO1 Apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organised, coordinated project outcome of the aimed work.

CO2 Design, model and experiment/develop optimal solutions for problems being investigated.

CO3 Analyse and interpret the experimental data from various machining methods and synthesis of the information to provide valid conclusions and submit reports.

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OBJECTIVES:
1. To impart knowledge on welding Metallurgy, Design and Special welding processes.
2. To elaborate gating system design and casting metallurgy and to provide knowledge on Special casting processes.
3. To familiarize the students with automation and environmental aspects and standards.

UNIT I          WELDING DESIGN 9

UNIT II          SPECIAL WELDING PROCESSES 9
Micro joining And Nano joining, Wire Bonding; Fundamentals and Types of Laser Welding Including Hybrid Processes, Laser Properties; Stud Welding And Mechanical Fasteners; Magnetically Impelled Arc Welding; Advanced Gas Tungsten Arc Welding; Flux Cored Arc Welding; Electron Beam Welding; Cold Pressure Welding; Ultrasonic Welding; Explosive Welding; Diffusion Bonding; Friction Stir Welding; Electromagnetic Pulse Welding; High Velocity Projectile Impact Welding - Under water welding-Diffusion bonding.

UNIT III         CASTING DESIGN AND SOLIDIFICATION 9
Introduction - - Pattern allowances - Introduction of gating design - Types of gate - Pouring time calculation - Aspiration effects in gating system - Problem solving on gating design - Solidification analysis - Risering methods - Shape factor - Feeding & Chills effect - Problem related to riser design - Design of thin and unequal sections - mechanism of solidification - Rapid solidification processing (RSP) - Melt spinning - Roll quenching - Vibratory solidification - Splat cooling - Thixoforming - Rheocasting - Single crystal growing - Casting defects, inspection, diagnosis and rectification - Case studies.

UNIT IV          SPECIAL CASTING PROCESSES 9
Evaporative Pattern Casting Process and full mould process - Vacuum sealed moulding - vacuum casting - Magnetic Moulding - Squeeze Casting-types - Mega Casting-Plaster mould casting - Ceramic mould casting.

UNIT V          AUTOMATION ENVIRONMENTAL ASPECTS, SPECIFICATION AND STANDARDS 9

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be able to
CO 1: Use design knowledge to overcome defects in welding  
CO 2: Select suitable welding process for the given applications.  
CO 3: Use design knowledge to produce quality casting.  
CO 4: Select suitable casting process for the given applications.  
CO 5: Implement automation principles with environment consciousness techniques in welding and casting plants and learn to follow standards.

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**REFERENCES:**

COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students to
1. Obtain an overview type of laser and optics
2. Acquire knowledge about all the possible interaction of materials with laser.
3. Get an insight to the joining of materials by laser.
4. Study the process of laser surface modification and forming
5. Get an exposure to laser optics and control for texture, marking, drilling and cutting.

UNIT – I INTRODUCTION TO LASERS AND OPTICS 9


UNIT – II LASER MATERIAL INTERACTION 9


UNIT– III LASER JOINING 9

Laser Welding Parameters: Beam Power, Spot diameter and Traverse Speed; Effect of Beam Characteristics: Beam Mode, Beam Stability, Beam Polarization, Pulsed Beams, Plasma Formation, Gas Shielding, and Effect of Ambient Pressure, Beam Size and Focal Point Location, Joint Configuration; Welding Efficiency; Mechanism of Laser Welding: Conduction Mode Welding, Keyhole Welding; Material Considerations; ferrous, Nonferrous alloys, Ceramics, Polymers, Dissimilar Materials; Weldment Discontinuities: Porosity, Humping, Spiking; Advantages and Disadvantages of Laser Welding; Special Techniques; Heat Treatment; Specific Applications.

UNIT – IV LASER SURFACE MODIFICATIONS AND FORMING 9

Laser Surface Heat Treatment: Process parameters; Temperature Field; Microstructural Changes in Steels; Nonferrous Alloys; Hardness Variation; Residual Stresses; Advantages and Disadvantages of Laser Surface-Treatment; Laser Surface Melting; Laser Direct Metal Deposition: Processing Parameters, Methods for Applying the Coating Material, Dilution; Advantages and Disadvantages of Laser Cladding; Laser Physical Vapor Deposition (LPVD); Laser Shock Peening: Analysis, Advantages and Disadvantages of Laser Shock Peening. Laser Forming: Principle of Laser Forming, Process Parameters; Laser Forming Mechanisms: Temperature Gradient, Mechanism, Buckling Mechanism, Upsetting Mechanism; Process Analysis; Advantages and Disadvantages; Applications

UNIT – V LASER MACHINING 9
Forms of Laser Cutting: Fusion Cutting, Sublimation Cutting, Photochemical Ablation- Laser instrumentation for cutting and drilling, cut quality and process characteristics methods of cutting material consideration, practical performance, process variations, Dot matrix marking, Engraving, Image micromachining- Micromachining

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to

CO1 Explain the laser source and its parameters.
CO2 Describe the material- laser interaction.
CO3 Summarise laser joining of materials.
CO4 List the various surface modification and forming using lasers
CO5 Interpret laser process parameters for machining.

REFERENCES:

Mapping of COs with POs

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MN3002 MANUFACTURING SYSTEMS AND MODELS L T P C
3 0 0 3

Attested

Director Centre for Academic Courses Anna University, Chennai-600 025
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To understand various measure the performance of manufacturing system
2. To Know how to apply DTMC model to a Manufacturing system
3. To Know how to apply CTMC model to a Manufacturing system
4. To understand Queuing networks and to model queuing network for a Manufacturing system
5. To understand and apply the Petri net model to a Manufacturing system

UNIT I MANUFACTURING SYSTEMS - PERFORMANCE MEASURES

UNIT II DISCRETE TIME MARKOV CHAINS
Introduction to Markov Chains, DTMC, Properties of DTMC, Sojourn Times in DTMC Models, Applications of DTMC Models in Manufacturing Systems

UNIT III CONTINUOUS TIME MARKOV CHAINS
Introduction to CTMC, Properties of CTMC, Sojourn Times in CTMC Models, Applications of CTMC Models in Manufacturing Systems

UNIT IV QUEUING MODELS
Birth and death process, performance measures in queuing models, open queuing networks and closed queuing networks- applications in manufacturing systems

UNIT V PETRINET MODELS
Introduction to Petri-net models-Representational powers of Petri-Nets- Reachability graphs, Markings, Applications of Petri-Nets models in manufacturing systems- Timed and Colored Petri-Nets

COURSE OUTCOMES:
Upon successful completion of the course, students should be able to
- CO1 Identify and measure the performance of manufacturing system
- CO2 Apply the DTMC model to a Manufacturing systems
- CO3 Apply the CTMC model to a Manufacturing system
- CO4 Apply the Queuing network model to a Manufacturing system
- CO5 Apply the Petrinet model to a Manufacturing system

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1 – Slight, 2 – Moderate, 3 - Substantial
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To examine and mimic the natural hierarchical structure.
2. To understand nature specific surface characteristics and replicate them.
3. To introduce to toughness mechanism in nature and apply them for composite fabrication
4. To understand the sensors/actuators in nature and bio inspired MEMS
5. To educate the use information flow and functionality of nature for manufacturing systems

UNIT – I MANUFACTURING BIO INSPIRED HIERARCHICAL STRUCTURE 9
Nature hierarchical structure- levels (dense and porous) – improved properties- bone –bamboo-
cellular structure-honeycomb- negative Poisson ratio structure- sandwich structure- hierarchical
order – strength ratio- Manufacturing: Layered manufacturing- Mould and gel casting- Particulate
Leaching-foaming-Compression moulding and hot pressing-Low-pressure injection moulding
and extrusion- ultrasonic cavitation –Applications.

UNIT – II MANUFACTURING BIO INSPIRED SURFACES 9
Nature dry adhesion (Gecko effect -Attaching/detaching mechanisms)- Wet adhesion (tree
frogs)- Super-hydrophobicity (Lotus effect) –super hydrophilic (plant) - Antibiofouling (shark
skin)- Optical tuning (Iridescent peacock feathers) – hard and tough (Teeth) - hydrodynamic drag
(shark skin, boxfish)-Manufacturing: soft lithography-hot-embossing- Plasma etching- Electron-
beam lithography- Porous alumina membrane molding- sputtering- Electrodeposition-Thermal
Evaporation-Electrostatic spray coating-Chemical surface modification-laser texturing- atomic
layer deposition-photocurable resin-uv exposure Applications.

UNIT– III MANUFACTURING BIO INSPIRED COMPOSITES 9
organic interfaces, inter-lamellar mineral bridges, plastic deformation of individual tile –multiple
cracking large-scale crack bridging- Lobster - armadillo’s dermal shells- Sandwich structure of
turtle carapace- Diatoms-plant stem –self healing composites- freeze casting method-clay/polyimide composites fabricated from centrifugal- additive manufacturing- Applications

UNIT – IV MANUFACTURING BIO INSPIRED SENSORS AND ACTUATORS 9
Thermal sensor (beetle, snakes) – Echolocation (crickets, bats) – Vision (Avian eyes, honeybees’
eye) – microelectromechanical system (MEMS) sensor based on piezoresistive, capacitive,
triboelectric, and piezoelectric – display – muscles – artificial muscles- electrothermal-
capacitive- piezoelectric based MEMS actuators.

UNIT – V BIOINSPIRED MANUFACTURING SYSTEMS 9
Multi-Agent Systems (MAS)-Holonic Manufacturing Systems (HMS) –Bionic Manufacturing
Systems (BMS)-swarm intelligence-positive and negative feedback- Self-Organization-Self-
configuration, Self-optimization, Self-healing. Ant Colony Optimization (ACO), Artificial Bee
Colony (ABC)Algorithm and Particle Swarm Optimization (PSO). MAS- Distributed nature-
Division of labor- Emergence from collective simple behavior. Biologicalisation in Manufacturing-
Alternative or fail-safe mechanisms: Modularity Decoupling --Case Studies–Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to
CO1 Summarize the natural hierarchical structure and methods of manufacturing
CO2 Describe the nature specific surface characteristics and method of manufacturing features.
CO3 List the various toughness mechanisms in nature and composite fabrication involving those features.
CO4 Compare the various the sensors/actuators in nature and manufacture them based on MEMS
CO5 Explain basic understanding on information flow and functionality of nature and application to manufacturing systems

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Mapping of COs with POs

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1 – Slight, 2 – Moderate, 3 - Substantial
OBJECTIVES:
1. To introduce Meso, Micro and Nano manufacturing and their respective applications.
2. To familiarize the students with diamond, turn machining, advanced micro machining and nano finishing methods.
3. To familiarize the students with synthesis of nanomaterials and types of characterization techniques to be used.

UNIT I INTRODUCTION

UNIT II DIAMOND TURNING
Diamond turn machining - need, classification, components, material removal mechanisms, Tooling for diamond turning, Process parameters and optimization - Molecular Dynamics simulation to study nanoscale cutting tool path strategies in surface generations - symmetric, asymmetric and freeform, applications of DTM products.

UNIT III ADVANCED MACHINING / FINISHING PROCESSES

UNIT IV SYNTHESIS OF NANOMATERIALS

UNIT V CHARACTERISATION TECHNIQUES

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be able to
CO 1: Recognize the importance of Meso, Micro and Nano manufacturing and their respective applications.
CO 2: Elaborate on Diamond turn machining process
CO 3: Describe the advanced micro machining and nano finishing methods.
CO 4: Acquire knowledge on synthesis of nanomaterials
CO 5: Identify the type of characterization techniques to be used.

CO - PO MAPPING:
REFERENCES:
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To introduce smart and intelligent materials and its principles.
2. To impart knowledge on materials exhibiting piezoelectricity and their applications.
3. To familiarise the synthesis and application of Electro/ Magneto rheological fluids and their applications.
4. To summarise various shape memory alloys and polymers, their production methods and applications.
5. To introduce smart materials that reconfigure structure based on stimulus and other emerging materials.

UNIT – I INTRODUCTION TO SMART AND INTELLIGENT MATERIALS

UNIT – II PIEZOELECTRIC MATERIALS

UNIT– III MAGNETO/ELECTRO-RHEOLOGICAL FLUIDS
Suspensions- Overview of production method- electro-rheological fluids - principal characteristics of electro-rheological fluids (ERF) –mechanism for the dispersed phase – electorheological fluid domain – fluid actuators- design parameter – application of Electro-rheological- fluids – Basics, Principles and instrumentation and application of Magnetorheological fluids (MRF)- applications of ERF/MRF

UNIT – IV SHAPE MEMORY MATERIALS
Shape Memory Alloys, Nickel – Titanium alloy (Nitinol) – classification of SMA alloys-mechanism of magnetic SMA –Shape Memory Polymers- mechanism of shape memory- types and applications - Overview of production method- Primary moulding – secondary moulding-Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control

UNIT – V STIMULI RESPONSIVE MATERIALS AND EMERGING MATERIALS

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to
**CO1** Discuss on the mechanism and structure of various smart materials
**CO2** Select piezoelectric materials, elaborate applications of them.
**CO3** Explain the working of ERF/MRF applications.
**CO4** Explain the various kinds of shape memory materials, their production and applications.
**CO5** List the property and principles of various stimuli response materials and emerging materials

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COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To provide understanding of techniques of microstructure and crystal structure evaluation
2. To introduce electron microscopic tools for analysis of material topography and compare to atomic force microscopy
3. To understand the typical techniques of evaluation of chemical composition and thermal analysis of materials.
4. To familiarise advanced static mechanical testing methods.
5. To summarise the various dynamic mechanical testing methods.

UNIT – I MICRO AND CRYSTAL STRUCTURE ANALYSIS

UNIT – II ELECTRON MICROSCOPY

UNIT – III CHEMICAL AND THERMAL ANALYSIS

UNIT – IV MECHANICAL TESTING – STATIC TESTS
Micro Hardness –Nanoindentation test- Scratch test - Tensile Test – Stress – Strain plot – for plastic deformation under different strain rate and temperature – Instrumented Charpy Test – Fracture Toughness Test- Typical testing of laminate composites.

UNIT – V MECHANICAL TESTING – DYNAMIC TESTS

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to

**CO1** Compare the contrast enhancement by various metallography and derive information from X-ray diffraction for defining material.

**CO2** Describe the principle of image formation in electron microscopy and atomic force microscopy.

**CO3** Select the technique(s) for determining chemical composition and explain properties that can be reported from thermal analysis.

**CO4** Compare typical test results and procedures for static testing of materials.

**CO5** Identify typical test results and procedures for dynamic testing of materials.

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OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To teach the students about the concepts of metrology.
2. To train the students in the field of surface roughness measurement
3. To acquire knowledge on form measurements and interferometry.
4. To introduce some fundamental principles of CAI, Laser metrology
5. To understand Image processing on Machine vision.

UNIT I CONCEPTS OF METROLOGY 9

UNIT II SURFACE ROUGHNESS 9

UNIT III INTERFEROMETRY AND FORM MEASUREMENTS 9

UNIT IV COMPUTER AIDED INSPECTION AND LASER METROLOGY 9

UNIT V MACHINE VISION AND IMAGE PROCESSING 9
Overview of Machine Vision systems-Elements-Image Acquisition, Image enhancement and Analysis-Vision based GD&T- Image processing Software- 3D reconstruction techniques for measurements and their integration with vision systems.

TOTAL: 45 PERIODS
COURSE OUTCOMES:
Upon successful completion of the course, students should be able to

**CO1** Explain the fundamental concepts of measurement, standards, calibration, maintenance of laboratory facilities and handling of metrological equipments

**CO2** Explain roughness and its applications in manufacturing research, learn the important concepts, principles and applications related to interferometry.

**CO3** Discuss the use of interferometry related sophisticated measurement and inspection facilities.

**CO4** Execute the concepts of Computer aided inspection technologies for industrial situations, design and develop new inspection techniques.

**CO5** Describe the importance of image processing techniques and the possibilities of developing new heuristics for image processing related to metrology.

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COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To expose the students to the basics of environmental sustainability and impact assessment objectives
2. To incorporate knowledge about the environmental based improvements towards lean manufacturing systems
3. To analyze various machineries with intent to conserve energy
4. To analyze hazardous and solid wastes with intent to point out areas of adverse environmental impact and how this impact could be minimized or prevented.
5. To impart the knowledge about the need, procedure and benefits of Green-Co-rating

UNIT – I ENVIRONMENTAL SUSTAINABILITY AND IMPACT ASSESSMENT
Environmental impact assessment objectives – Legislative development – European community directive – Hungarian directive. Strategic environmental assessment and sustainability appraisal. Regional spatial planning and environmental policy.

UNIT – II LEAN MANUFACTURING AND GREEN ENERGY SYSTEM

UNIT – III ENERGY SAVING MACHINERY AND COMPONENTS

UNIT – IV HAZARDOUS AND SOLID WASTE MANAGEMENT

UNIT – V GREEN CO-RATING

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to
CO1 Explain the Concepts of environmental sustainability and environmental impact assessment objectives.
CO2 Apply suitable schemes towards design of green manufacturing requirements.
CO3 Analyze manufacturing processes towards conservation of energy.
CO4 Analyze manufacturing processes towards minimization or prevention of hazardous and solid wastes.
CO5 Build the knowledge of green co-rating and its benefits are well known to the students.
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COURSE OBJECTIVES
The main learning objective of this course is to prepare the students
1. To understand the fundamental of characterization of powders and particulates.
2. To understand methods for the production of powder.
3. To introduce to particle interaction, mixing and sintering.
4. To understand the powder transport and rheology of powder solution.
5. To introduce the methods of production of nano sized powders.

UNIT I  POWDER CHARACTERIZATION  9
Powder size – distribution- shape- surface charges – BET surface area analysis- dynamic light scattering – flowability- apparent and tap density- Cohesiveness- internal powder porosity- powder characteristic suitable for additive manufacturing- Powder satellite content

UNIT II  POWDER PRODUCTION  9
Water- Gas- plasma- centrifugal -atomization- hydride-dehydride- rapid spinning cup process (RSC), vacuum (soluble gas) atomization (VA), rapidsolidification rate (RSR) process for rotating disk atomization, (free-fall) gas (Ar)atomization (GA), and rotating electrode process (REP)- induction melting gas atomization (EIGA)- comparison of powder characteristics by various methods- selective laser beam melting of polymers (LBM)

UNIT III  PARTICLE INTERACTIONS  9

UNIT IV  POWDER TRANSPORT AND RHEOLOGY OF SOLUTION  9

UNIT V  NANOSIZED POWDER PRODUCTION  9
Processes for producing ultrafine powders Mechanical grinding; Wet Chemical Synthesis of Nano-materials- sol gel process; Gas Phase synthesis of Nano-materials Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation (CVC)- comparison of powder characteristics by various methods – Safety measures

TOTAL : 45 PERIODS
OUTCOMES:
Upon successful completion of the course, students should be able to

CO1 Identify techniques of characterization of powders and particulates.
CO2 List and brief on the methods for the production of powder
CO3 relate the powder behaviour due particle interaction and describe sintering.
CO4 Explain the powder transport and rheology of powder solution
CO5 Discuss on the methods of production of nano sized powders

REFERENCES
4. ASM Hand Book, vol. 7: Powder Metallurgy, ASM International

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1 – Slight, 2 – Moderate, 3 - Substantial
COURSE OBJECTIVES:
1. To describe the role and drivers of supply chain management in achieving competitiveness.
2. To explain Supply Chain Network Design.
3. To illustrate issues related to inventory in Supply Chain.
4. To appraise transportation and sourcing in Supply Chain.
5. To apply Information Technology and Emerging Concepts in Supply Chain.

UNIT I INTRODUCTION TO SUPPLY CHAIN MANAGEMENT

UNIT II DISTRIBUTION NETWORK DESIGN IN SUPPLY CHAIN

UNIT III INVENTORY IN SUPPLY CHAIN
The Role of Cycle Inventory in a Supply Chain, Economies of Scale to Exploit Fixed costs, Managing Multi-echelon Cycle Inventory. The Role of Safety Inventory in a Supply Chain, Determining appropriate level of Safety inventory, Impact of supply Uncertainty on Safety inventory, Impact of aggregation on safety inventory, impact of replenishment policies on safety inventory, Managing Safety Inventory in a Multi-echelon Supply Chain, The Role of IT in inventory management.

UNIT IV TRANSPORTATION AND SOURCING IN SUPPLY CHAIN
The role of transportation in a Supply chain, Modes of transportation and their performance characteristics, Transportation Infrastructure and policies, Design options for a transportation network, Trade-offs in transportation design, Tailored transportation, The role of IT in transportation, Problems. Sourcing Decisions In A Supply Chain: The role of IT in sourcing, in-house or outsource, Third-and Fourth-party logistics providers, Total cost of Ownership, Supplier selection, Auctions and Negotiations, Sharing Risk and Reward in the supply chain.

UNIT V INFORMATION TECHNOLOGY IN SUPPLY CHAIN
The role of IT in a supply chain, The supply chain IT framework, The supply chain macro processes, Lack of Supply Chain co-ordination and the Bullwhip effect, managerial levers to achieve coordination, continuous replenishment and vendor-managed inventories, collaborative planning, forecasting and replenishment (CPFR).

TOTAL:45 PERIODS

COURSE OUTCOMES:
The students will be able to
CO1. Understand supply chain concepts, systemic and strategic role of SCM in global competitive environment.
CO2. Evaluate alternative supply and distribution network structures using optimization models.
CO3. Develop optimal inventory policies in the supply chain context.
CO4. Develop optimal sourcing and Transportation decisions in the supply chain.
CO5. Select appropriate information technology frameworks for managing supply chain processes.

REFERENCES:

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COURSE OBJECTIVES

1. To understand Lean production principles, eliminate waste, and improve efficiency through case studies.
2. To learn steps for Value Stream Mapping, apply Lean metrics, and implement improvements in value streams.
3. To explore Six Sigma’s relationship with Lean Manufacturing, cultural changes, quality assessment, and cost implications.
4. To gain knowledge of various Six Sigma tools and techniques for problem-solving and project management.
5. To evaluate Six Sigma quality economics, focus on continuous improvement using Lean principles, Kaizen, and 5S methodologies.

UNIT I LEAN MANUFACTURING

UNIT II VALUE STREAM MAPPING
Need for Value Stream mapping; Steps involved in Value stream mapping – Choose value stream – PQ and PR analysis, Current State map, Lean Metrics, Future State Map, Kaizen plans; Lean implementation - Cultural change, Hoshin planning; Lean in the Supply chain.

UNIT III SIX SIGMA
Six sigma - lean manufacturing and six sigma - six sigma and process tolerance – Six sigma and cultural changes – six sigma capability – six sigma need assessments - implications of quality levels, Cost of Poor Quality (COPQ)

UNIT IV SIX SIGMA SCOPE OF TOOLS AND TECHNIQUES

UNIT V EVALUATION AND CONTINUOUS IMPROVEMENT METHODS
Evaluation strategy – the economics of six sigma quality, Return on six Sigma (ROSS), ROI, poor project estimates – continuous improvement – lean manufacturing – value, customer focus, Perfection, focus on waste, overproduction – waiting, inventory in process (IIP), processing waste, transportation, motion, making defective products, underutilizing people – Kaizen – 5S

TOTAL: 45 PERIODS
COURSE OUTCOMES:
The students will be able to

**CO1.** Demonstrate understanding of Lean production principles, waste identification, and efficiency improvement.

**CO2.** Apply Value Stream Mapping steps and Lean metrics to enhance organizational performance.

**CO3.** Analyze the relationship between Six Sigma and Lean Manufacturing, evaluate cultural changes, quality levels, and cost implications.

**CO4.** Acquire knowledge of Six Sigma tools and techniques for effective problem-solving and project management.

**CO5.** Evaluate Six Sigma quality economics and demonstrate commitment to continuous improvement through Lean principles, Kaizen, 5S methodologies, and customer focus.

REFERENCES:

3. Fred Soleimannejed , Six Sigma, Basic Steps and Implementation, AuthorHouse, 2004

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1-low, 2-medium, 3-high, ‘-‘- no correlation
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To describe the concepts in facility planning.
2. To summarize the types of plant layout and capacity planning methods
3. To impart the knowledge about the concepts of Project management.
4. To familiarize the concepts and methods in production planning and control.
5. To study the concepts in Inventory and maintenance management.

UNIT – I FACILITY PLANNING

UNIT – II CAPACITY & LAYOUT PLANNING
Plant layout types, criteria for good layout, Process layout, Assembly line balancing. Computer based solutions to layout problems such as CRAFT, ALDEP, CORELAP and PREP. Capacity planning – Analysis of designed capacity, installed capacity, commissioned capacity, utilized capacity, factors affecting productivity and capacity expansion strategies.

UNIT – III PROJECT MANAGEMENT
Demand forecasting – Quantitative and qualitative techniques, measurement of forecasting errors. Project management – its role in functional areas of management, network representation of a project, CPM and PERT techniques – case study.

UNIT – IV PRODUCTION PLANNING & CONTROL
Aggregate production planning, production planning strategies, Disaggregating the aggregate plan, Materials Requirement Planning (MRP), MRP-II, Supply chain management, Operation scheduling, prioritization.

UNIT – V INVENTORY AND MAINTENANCE MANAGEMENT
Introduction to EOQ models, Inventory control techniques – ABC, FSN, VED etc. Types of inventory control – Perpetual, two-bin and periodic inventory system – JIT, SMED, Kanban, zero inventory, Maintenance strategies and planning, Maintenance economics: quantitative analysis, optimal number of machines, Replacement strategies and policies – economic service life, opportunity cost, replacement analysis using specific time period.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to
CO1 Extend knowledge on facilities, and problems associated with them.
CO2 Compare the various capacity and layout planning models.
CO3 Illustrate the concepts of demand forecasting and project management with relevant case studies.
CO4 Explain the concepts of production planning and scheduling.
CO5 Explain the concepts of inventory and maintenance management.

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COURSE OBJECTIVES:
1. To Summarize the Overview of Quality
2. To Illustrate the essentials of Quality
3. To Understand and apply Selected Quality Improvement techniques
4. To gain knowledge on research and development (R&D) certification standards
5. To Develop comprehensive knowledge of Quality Management Systems and awards

UNIT I  INTRODUCTION  9

UNIT II  ESSENTIALS OF QUALITY MANAGEMENT  9

UNIT III  QUALITY IMPROVEMENT TECHNIQUES  9

UNIT IV  RESEARCH AND DEVELOPMENT STANDARDS  9

UNIT V  QUALITY MANAGEMENT SYSTEMS AND AWARD  9

TOTAL: 45 PERIODS

COURSE OUTCOMES:
The students will be able to
CO1. Recognition of the importance of Quality

[Attested]

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
CO2. Acquiring Essentials of Quality
CO3. Application of Quality Improvement tools
CO4. Research and Development standards
CO5. Comprehensive Quality Management System

REFERENCES:
6. Research and Development Evaluation in the Aerospace and Defense Industry & quot; by Matthew Z. Liberatore and Brian J. Lunday
7. ISO 13485:2016 - A Complete Guide to Quality Management in the Medical Device Industry & quot; by Itay Abuhav
8. Good Laboratory Practice: A Question & Answer Reference Guide & quot; by David S. Loseke

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1-low, 2-medium, 3-high, ‘-‘-no correlation
COURSE OBJECTIVES:
To introduce and explain the functions, recruitment, selection, and training methods of Human Resource Management, as well as to examine the ideas of remuneration, labour relations, employee security, and quality assurance in HRM.

UNIT I  HUMAN RESOURCE FUNCTION  9

UNIT II  RECRUITMENT & SELECTION  9

UNIT III  TRAINING & DEVELOPMENT  9

UNIT IV  COMPENSATION & MANAGING QUALITY  9

UNIT V  LABOUR RELATIONS & EMPLOYEE SECURITY  9

Total: 45 PERIODS
COURSE OUTCOMES:
At the end of the course, students will be able
CO1: To obtain knowledge of the roles and functions of Human resource management.
CO2: To become familiar with the various techniques used in the recruitment and selection process.
CO3: To understand the concepts of training methods and development techniques.
CO4: To understand the concepts of compensation and benefits.
CO5: To recognize the various employee relations and security.

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COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To study about the elastic deformation of the materials
2. To describe about the plastic deformation of the materials
3. To study the typical techniques of evaluation of fracture and fracture mechanics of materials.
4. To familiarize Fatigue testing methods.
5. To summarize the Creep testing methods.

UNIT – I ELASTIC DEFORMATION
9

UNIT – II PLASTIC DEFORMATION
9
Dislocation theory - dislocations in the FCC, HCP and BCC lattice, stress fields and energies of dislocations, forces on and between dislocations, dislocation climb, intersections of dislocations, Jogs, dislocation sources, multiplication of dislocations, dislocation pile-ups, Slip and twinning- Yield Criterions- Holography – use of laser for structural testing – Brittle coating

UNIT – III FRACTURE AND FRACTURE MECHANICS
9

UNIT – IV FATIGUE
9

UNIT – V CREEP
9

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to
CO1 Explain the elastic behaviour of various materials.
CO2 Summarize essential information about plastic deformation of the materials.
CO3 Compare the fracture types and mechanisms involved.
CO4 Interpret typical test results and procedures for Fatigue testing of materials.
CO5 Identify typical test results and procedures for Creep testing of materials.

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1 – Slight, 2 – Moderate, 3 – Substantial
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students to
1. Gain an understanding of Finite Element Analysis and its application in solving problems involving plate and shell elements.
2. Comprehend the concepts of Finite Element Analysis and its utilization in solving problems that involve geometric and material nonlinearity
3. Apply solution techniques to effectively solve dynamic problems using Finite Element Analysis
4. Analyse the role of numerical modelling in the fields of heat transfer, fluid flow, and combustion, and evaluate its significance in solving complex problems.
5. Develop finite volume discretized forms of the governing equations for diffusion processes, demonstrating the ability to create computational models for heat transfer and fluid dynamics problems.

UNIT – I BENDING OF PLATES AND SHELLS 9
Review of Elasticity Equations – Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements - Conforming and Non-Conforming Elements – C0 and C1 Continuity Elements –Degenerated shell elements - Application and Examples.

UNIT – II NON-LINEAR PROBLEMS 9

UNIT – III DYNAMIC PROBLEM 9

UNIT – IV GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION 9
TECHNIQUES

UNIT – V CONVECTION-DIFFUSION PROCESSES: FINITE VOLUME METHOD 9
One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

TOTAL: 45 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to

**CO1** Apply concept of Finite Element Analysis to solve problems involving plate and shell elements

**CO2** Apply concept of Finite Element Analysis to solve problems involving geometric and material nonlinearity

**CO3** Formulate solution techniques to solve dynamic problems Apply concepts of Finite Element Analysis to solve fluid mechanics and heat transfer problems

**CO4** Analyse the governing equations and boundary conditions.

**CO5** Analyse various discretization techniques for both steady and unsteady diffusion problems.

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**CI3052** DESIGN FOR MANUFACTURING AND ASSEMBLY

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OBJECTIVES:
1. To teach manufacturing issues that must be considered in the mechanical engineering design process.
2. To Discuss on tools and methods to facilitate development of manufacturable mechanical designs.
3. To make the students to Understand the importance of Assembly, Reliability and Quality for improving design process approach.

UNIT I INTRODUCTION

UNIT II SELECTION OF MATERIALS AND SHAPES

UNIT III SELECTION OF MANUFACTURING PROCESSES

UNIT IV DESIGN FOR ASSEMBLY

UNIT V DESIGN FOR RELIABILITY AND QUALITY

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be able to
CO 1: Understand how to formulate the need analysis leading to definition of the design problem and to convert design problem leading to embodiment design.
CO 2: Identify the suitability of materials application and manufacturing considerations
CO 3: Select manufacturing process and to consider design as per the process adopted for the design problem.
CO 4: Apply the principles of assembly to minimize the assembly time.
CO 5: Analyze and apply the concept of reliability and quality in the product design process.
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**REFERENCES:**

COURSE OBJECTIVES:
The main objective of this course is to prepare the students to:
1. Apply concurrent engineering principles in structuring work and deploying teams effectively in product development projects.
2. Analyse the role of customer involvement throughout the stages of the Product Life Cycle (PLC).
3. Utilize analysis tools such as Failure Mode and Effects Analysis (FMEA) to identify and mitigate potential risks in product design.
4. Assess the significance of intellectual property rights (IPR) in protecting new product innovations and conducting patent searches to ensure compliance.
5. Conduct quantitative and qualitative analysis to estimate future cash inflows and outflows in product development projects.

UNIT I PRODUCT DEVELOPMENT PROCESS & METHODOLOGIES

UNIT II INTRODUCTION TO PRODUCT LIFE CYCLE ENVIRONMENT

UNIT III PRODUCT MODELLING AND ANALYSIS TOOLS

UNIT IV PROJECT SELECTION, EVALUATION AND IPR

UNIT V PRODUCT DEVELOPMENT ECONOMICS
Elements of Economics analysis - Quantitative and qualitative analysis-Economic Analysis process- Estimating magnitude and time of future cash inflows and out flows Sensitivity analysis-Project
trade-offs-Trade-offs rules-Limitation of quantitative analysis- Influence of qualitative factors on project success.

COURSE OUTCOMES
Upon successful completion if the course, students should be able to
1. Apply problem-solving strategies and methodologies to address challenges encountered during the product development process.
2. Evaluate the impact of customer involvement at different stages of the product life cycle and propose strategies for effective customer engagement.
3. Apply various product modelling techniques, such as CAD software and simulation tools, to create and optimize product designs.
4. Apply intellectual property rights (IPR) principles and conduct patent searches to protect and manage new product innovations.
5. Analyse and interpret quantitative and qualitative data to assess the economic viability of product development projects.

REFERENCES
4. Karl T. Ulrich and Steven D. Eppinger "Product Design and Development"
5. John Stark "Product Lifecycle Management: Volume 1 - 21st Century Paradigm for Product Realisation"
7. Michael N. Kennedy "Product Development for the Lean Enterprise: Why Toyota's System is Four Times More Productive and How You Can Implement It"
11. Marc Annacchino "New Product Development: Successful Innovation in the Marketplace"

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COURSE OBJECTIVES:
1. To understand the importance of dynamics in analyzing the behavior of mechanical systems.
2. To develop proficiency in using computational methods for dynamic analysis of multibody systems.
3. To apply stability analysis techniques to assess the stability of nonlinear systems.
4. To characterize the behavior of nonlinear systems using phase plane analysis and describing function.
5. To design control strategies to achieve desired performance in nonlinear mechanical systems.

UNIT I INTRODUCTION TO DYNAMICS

UNIT II COMPUTATIONAL METHODS FOR DYNAMIC ANALYSIS

UNIT III NONLINEAR SYSTEMS AND CONCEPTS

UNIT IV SYSTEM CHARACTERIZATION

UNIT V CONTROL OF NONLINEAR MECHANICAL SYSTEMS

TOTAL 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Describe the fundamental concepts and principles of dynamics in mechanical systems.
CO2 Apply computational methods for analyzing and solving dynamic problems in multibody systems.
CO3 Analyze and evaluate the stability and behavior of nonlinear systems using mathematical techniques.
CO4 Characterize and assess the properties of mechanical systems, such as stability, controllability, and observability.
CO5 Design and implement control strategies to achieve desired performance in nonlinear mechanical systems.

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Progress Through Knowledge
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To Understand and apply the principles of mechatronics in modern manufacturing
2. To Develop proficiency in selecting and integrating sensors, transducers, drives, and actuators for mechatronic systems
3. To Design and optimize manufacturing processes using mechatronic principles and techniques
4. To Gain practical skills in programming and interfacing microcontrollers for controlling mechatronic systems
5. To Analyze and evaluate the performance of mechatronic systems in manufacturing operations for continuous improvement

UNIT I  INTRODUCTION TO MECHATRONICS IN MODERN MANUFACTURING

UNIT II  SENSORS AND TRANSDUCERS

UNIT III  DRIVES AND ACTUATORS

UNIT IV  MICROPROCESSORS AND MICROCONTROLLERS

UNIT V  INTEGRATION OF MANUFACTURING SYSTEMS

TOTAL : 45 PERIODS
COURSE OUTCOMES:
Upon successful completion of the course, students should be able to

CO1 Recall and identify key concepts in mechatronics for modern manufacturing.

CO2 Describe the principles and relationships of mechatronic system elements in manufacturing processes.

CO3 Apply knowledge of sensors, transducers, drives, and actuators to design and troubleshoot mechatronic systems.

CO4 Analyze and evaluate the performance of mechatronic components for process optimization.

CO5 Design and integrate mechatronic systems for manufacturing automation.

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1 = Slight, 2 = Moderate, 3 = Substantial

Attested

Director
Centre for Academic Courses
Anna University, Chennai-600 025
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To understand the importance of automation in industry and various industrial standard sensors and process parameters to control the production process.
2. To learn PLC hardware and practice PLC programming and simulation in real systems.
3. To get knowledge on industrial standard data communication protocols, SCADA, centralized and decentralized control.
4. To get introduced to factory layout, Total Integrated Automation on factory and Industry 4.0.
5. To get exposure on building automation using sensors, controllers and actuators.

UNIT I INDUSTRIAL INSTRUMENTATION AND CONTROL 9

UNIT II PROGRAMMABLE LOGIC CONTROLLER 9

UNIT III DATA COMMUNICATION AND SUPERVISORY CONTROL 9 SYSTEMS

UNIT IV SYSTEMS FOR FACTORY AUTOMATION 9
Factory Layout – Tools and Software Based Factory Modelling – Case Study on Automated Manufacturing Units, Assembly Unit, Inspection Systems and PLC Based Automated Systems – Introduction to Factory Automation Monitoring Software – Building Automation System – Software

UNIT V SMART TECHNOLOGIES FOR INDUSTRIAL 4.0 9

TOTAL 45 PERIODS

COURSE OUTCOMES
Upon successful completion of the course, students should be able to
CO1 State the need of identifying the control parameters, sensors, controllers, communication and role of advanced technologies in automating the industry.
CO2 Describe the operation of sensors, instrumentation, Logic controller, communication protocol, factory setup and smart technologies.
CO3 Design and simulate system layout develop logic program
CO4 Implement the selected sensor, protocol and logic in controller to automate an application.
CO5 Create industry model and simulate by varying the parameters to do analysis on statistical and management data of the plant.
REFERENCES

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1 – Slight, 2 – Moderate, 3 – Substantial
COURSE OBJECTIVES:
1. To understand the fundamental principles and concepts of digital twin technology.
2. To apply digital twin techniques to analyze and optimize complex systems.
3. To develop skills in designing and implementing digital twin models for real-world applications.
4. To evaluate the benefits and limitations of digital twin technology in various industries.
5. To critically analyze and interpret data obtained from digital twin simulations.

UNIT I INTRODUCTION

UNIT II DIGITAL TWIN IN A DISCRETE INDUSTRY

UNIT III DIGITAL TWIN IN A PROCESS INDUSTRY
Basics of Process Industry, Trends in the process industry, control system requirements in a process industry, Digital Twin of a plant, Digital Thread in process Industry, Data collection and analysis for process improvements, process safety, Automation simulation, Digital Enterprise

UNIT IV INDUSTRY 5.0
Industrial Revolutions, Industry 5.0 – Definition, principles, Application of Industry 5.0 in process & discrete industries, Benefits of Industry 5.0, challenges in Industry 5.0, Smart manufacturing, Internet of Things 5.0, Industrial Gateways, Basics of Communication requirements – cognitive systems 5.0

UNIT V ADVANTAGES OF DIGITAL TWIN
Improvement in product quality, production process, process Safety, identify bottlenecks and improve efficiency, achieve flexibility in production, continuous prediction and tuning of production process through Simulation, reducing the time to market.

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 Recall and explain the key principles and concepts of digital twin technology.
CO2 Apply digital twin techniques to model and simulate complex systems.
CO3 Design and implement digital twin models for specific applications.
CO4 Evaluate the effectiveness of digital twin technology in improving system performance and efficiency.
CO5 Analyze and interpret data generated from digital twin simulations to make informed decisions.
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COURSE OBJECTIVES:
1. To know the basic terminologies, classification, configurations and components of serial manipulator.
2. To understand the mechanical design and robot arm kinematics
3. To learn and understand the various linear control techniques on manipulators
4. To learn and understand the various non-linear control techniques on manipulators
5. To learn the robot programming and demonstrate the robot in various applications

UNIT I INTRODUCTION TO SERIAL MANIPULATORS

UNIT II MECHANICAL DESIGN OF ROBOT SYSTEM

UNIT III ROBOT DYNAMICS AND TRAJECTORY PLANNING
Trajectory planning – joint space, Cartesian space description and trajectory planning – third order, fifth order - Polynomial trajectory planning-control overview, Dynamic equations-control - Types of Programming – Teach Pendant Programming –Robotic Cell Layouts – Inter Locks-control overview

UNIT IV MOBILE ROBOTICS

UNIT V APPLICATIONS OF ROBOTS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:
CO1 State about fundamental concepts of manipulators and mobile robots.
CO2 Describe the robot types, robot elements, numerical computation methods and the applications
CO3 Solve the robot kinematics, dynamics, trajectory and path planning problems.
CO4 Analyze robot kinematics, dynamics, trajectory and path planning problems.
CO5 Create robot architecture, kinematic and dynamic solutions, program the robot for the given application in the environment.
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OBJECTIVES:
1. To teach the concept of system simulation and their importance in industries and the various techniques used for generating the random numbers.
2. To discuss about the generation techniques and the use of the random numbers in simulation, tests, validity, verification, models of simulation and analysis.
3. To train the students to solve the real time problems in the discrete systems by using a simulation software.

UNIT I  PREAMBLE TO SYSTEM SIMULATION
Systems, general systems theory, Functions/Relationship, concept of simulation, Stochastic activities, Types of Models, Principles used in Modeling, simulation as a decision-making tool, types of simulation, Important measures of performance, Advantages and disadvantages of simulation, Steps in simulation model building.

UNIT II  RANDOM NUMBERS
Methods of generating random numbers, Desirable attributes of random numbers, manual methods, computerized methods, Pseudo random numbers and random variates, discrete and continuous random probability distributions, tests for random numbers, Need for testing random numbers, Application of random numbers in simulation models

UNIT III  DESIGN OF SIMULATION
Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation, validation. Monte Carlo method of simulation, Manual simulation techniques

UNIT IV  SIMULATION SOFTWARE AND DATA HANDLING
Study and selection of simulation languages, Animation based Simulation packages, Selection of Simulation language / package, Use of any one of the simulation software for simulation model building, programmable blocks, Creation of database, Data handling and reporting, terminating conditions, Interpretation of results using statistical analysis

UNIT V  ADVANCED HEURISTICS AND AREAS OF APPLICATION
Ear deaf Analysis - Development of simulation models for Manufacturing and production systems, inventory optimization techniques, Advanced Sequencing and Scheduling problems, queuing systems - Problems, Heuristics for scheduling - Single pass heuristics, multipass heuristics, Evolutionary Optimization techniques - Genetic algorithm, Ant Colony algorithm, Particle Swarm optimization - Case studies.

COURSE OUTCOMES:
At the end of the course, students will be able to
CO 1: Discuss various types of systems and identify different elements of a system to build simulation models and to use them.
CO 2: Generate, test and use random numbers in different ways.
CO 3: Explain various steps in building simulation models and how to run them for effective analysis of real life scenarios and obtain superior results.
CO 4: Develop capabilities of taking up consultancy projects and completing them successfully.
CO 5: Describe various cases in system simulation and its approaches

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**REFERENCES:**
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To impart knowledge on types of batteries and their manufacturing as well as characteristics of hydrogen
2. To familiarize with materials involved in fabrication of Lithium batteries.
3. To introduce non lithium batteries.
4. To summarize concepts and devices for Electrical storage.
5. To learn about Fuel Cells and Hydrogen storage, principles and concepts.

UNIT – I  BASICS OF BATTERIES AND HYDROGEN
Introduction to electrochemical energy storage and conversion devices, Fundamental of batteries – Galvanic cells - battery performance metrics, cell voltage, capacity, charging and discharging curves, Columbic efficiency, power density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide, – Mathematical Modelling for Lead Acid Batteries – Flow Batteries - Advantages and disadvantages, physical and chemical properties of electro-active materials, characteristics and properties of sulphuric acid, lead dioxide - constructional features, materials and manufacturing methods, SLI (Automotive) batteries, sealed lead acid or maintenance free batteries fabrication technology and testing- Hydrogen as energy source - Physical and Chemical properties - Phase Diagram - Risks, Challenges and Safety Van’t Hoff plots for absorption desorption enthalpies; Gravimetric capacities; Hysteresis in cycling; Joule-Thomson Effect, Non-ideal treatment of hydrogen gas.

UNIT – II  LITHIUM ION BATTERIES
Advanced anodes and cathodes – theoretical capacity – merits and demerits - Nanomaterials for anodes: carbon nanotubes, graphene, Sn, Al, Si, SnO2, transition metal oxides (ex. CuO, CoO, NiO) and LTO. Nanomaterials for cathodes: LiCoO2, LiMn2O4, LiFePO4, and doped cathodes NMC, NMCA, NCA-. Fabrication of nanostructured LiCoO2, LiMn2O4, LiFePO4, Si, Sn and CNTs.- Polymer and composite-based lithium polymer battery. Preparation and fabrication of solid-state electrolytes. Polymer/composite-based materials synthesis and fabrication Manufacturing of electrolytes, electrode, assembly, packaging and testing— constant current method, SoC& DoD estimation.

UNIT– III  POST LITHIUM-ION BATTERIES

UNIT – IV  HYBRID ENERGY STORAGE
UNIT – V   HYDROGEN AND FUEL CELLS


TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Identify the performance parameters of batteries and brief on manufacturing methods and characteristics of hydrogen.

CO2 Classify and compare the various lithium based batteries.

CO3 Relate batteries besides lithium and emerging technologies

CO4 Describe the materials and devices for storing electrical energy

CO5 Explain the features of various types of Fuel Cell and concepts of Hydrogen storage.

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1 – Slight, 2 – Moderate, 3 – Substantial
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To introduce to light weight composite structures and behaviour
2. To educate fundamentals of processing of light metal alloys
3. To analyse the mechanics, design and manufacturing of light metallic structures
4. To introduce to ultra-weight materials and their application
5. To familiarise the application of lightweight materials

UNIT – I LIGHTWEIGHT POLYMER COMPOSITE STRUCTURES

UNIT – II LIGHTWEIGHT METALS AND ALLOYS
Introduction to Light Metals and Alloys, Strength to weight ratio- application – lightweight aluminium alloys, magnesium alloys and titanium alloys – physical metallurgy, properties and methods of manufacturing of components – Applications in Automobile, Aerospace, sports and storage

UNIT – III LIGHTWEIGHT METALLIC STRUCTURES IN ENGINEERING
Overview of Open and Closed Box Beams –Shear Center, Torsion - Deflection - Beam Columns-Stability of Thin-Walled Pressure Vessels – bellows -diaphragm— fins – metallic lattice structures – hierarchical structures- order - metallic foams – Origami, folded and deployable structures – structural stiffness through folds and interlock – Overview of manufacturing of lightweight structure

UNIT – IV ULTRA LIGHTWEIGHT MATERIALS

UNIT – V ENGINEERING APPLICATIONS OF LIGHT WEIGHT MATERIALS
Materials used in tennis rackets, golf clubs, etc. Design principles for lightweight and high-performance sports equipment, Impact of material properties on player performance, Lightweight Materials in Transportation-bicycles, automobiles, and aircraft - Materials used in prosthetic limbs and implants, Biocompatibility and bioengineering considerations, Aerospace Materials for Drone blades, space shuttle - Domestic LPG Cylinders- Economic and Environmental Impact of Materials-Life cycle assessment of materials

COURSE OUTCOMES
Upon successful completion of the course, students should be able to
CO1 Discuss on lightweight composites and their behaviour.
CO2 Select alloy and processing of lightweight metal alloys.
CO3 Analyze stress, strain, and deflection etc of light metallic structures.
CO4 Appraise the ultra-weight materials and their application.
CO5 Discuss the applications of lightweight materials in various field of engineering.

TOTAL: 45 PERIODS
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1 – Slight, 2 – Moderate, 3 – Substantial
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To understand the fundamental of material interaction with host and testing
2. To present overview of manufacturing metallic implants
3. To present overview of manufacturing polymeric implants
4. To present overview of manufacturing ceramic implants
5. To introduce the steps of fabrication of medical devices and regulatory

UNIT – I CELL INTERACTION WITH MATERIALS

UNIT – II METALLIC IMPLANTS

UNIT – III POLYMERIC IMPLANTS
Polymethylmethacrylate (PMMA)-Polylactic acid (PLA) and polyglycolic acid (PGA) - Polycaprolactone (PCL) - UV curable resin- PTFE-PEEK- Ultra high-molecular-weight polyethylene- Biopolymers- Collagens- Elastin- Cellulose and derivatives- Stimulus responsive materials- Orthopedics, Cardiovascular, Respiratory Patches and Tubes, eye lens- fabrication-polishing- injection molding- compression molding- additive manufacturing- Porous products - Solvent casting/particulate leaching- Gas foaming- Cryogelation- Freeze drying - electrospinning-scaffold for regeneration – wound- nerve – drug delivery system- adhesives- sutures

UNIT – IV CERAMIC IMPLANTS

UNIT – V BIOMEDICAL DEVICES AND REGULATORY PERSPECTIVES

TOTAL: 45 PERIODS
Upon successful completion of the course, students should be able to

**CO1** List the cascade of events with material interaction with host and types of testing.

**CO2** Explain the manufacturing process metallic implants.

**CO3** Compare the various manufacturing methods of polymeric implants.

**CO4** Explain the manufacturing of ceramic implants.

**CO5** Discuss the fabrication process of medical devices and regulatory.

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1 – Slight, 2 – Moderate, 3 – Substantial

MN3015 SEMICONDUCTOR MANUFACTURING L T P C 3 0 0 3
COURSE OBJECTIVES:
The main learning objective of this course is to prepare the students
1. To introduce single crystal silicon manufacturing, silicon doping and compounds of silicon.
2. To impart knowledge on manufacturing process of Complementary Metal–Oxide–
Semiconductor.
3. To familiarise the technology and challenges in assembly and packaging
4. To introduce tools and testing of microelectronics.
5. To introduce GaAs, bipolar transistors and micro electromechanical systems

UNIT – I INTRODUCTION TO SILICON AND ITS MANUFACTURING
Single crystal manufacturing-silicon ingot growth –directional solidification – Guttering-slicing –
planarization- chemico mechanical polishing- Silicon -doping. Conductivity, charge densities, E-
K relation, Fermi level, continuity equation, Hall Effect and its applications. diffusion – ion
implantation – thermal oxidation – polysilicon coating – precursors for chemical vapour
deposition of silicon components – epitaxial coating. Properties of silicon and its compounds

UNIT – II COMPLEMENTARY METAL–OXIDE– SEMICONDUCTOR
transfer –etching – Back-end Technology – wet – dry – metallization – physical vapour deposition
— plasma science and types of generation – RF Magnetron – electron beam – laser beam-
Atomic Layer Deposition (ALD)of high-k dielectrics – Fabrication of metal oxide semiconductor
field effect transistor (MOSFET) – illustration.

UNIT – III ASSEMBLY AND PACKAGING
Clean room, vacuum technology, short range force interaction, challenges in 2D/3D structures,
isolation – contacts- passive components – process integration - wire bonding – sealing – levels
of packaging – role of fabrication in performance of electronic/electrical/ electromechanical
functions.

UNIT – IV INSTRUMENTS, TOOLS, INSPECTION AND TESTING
Microgrippers/ manipulators – stage/ platform – tools – vision system – electrical testing - Parasitic
components – Future trends and Challenges: Challenges for integration, system on chip.

UNIT – V GaAs TECHNOLOGIES, SILICON BIPOLAR TECHNOLOGIES AND
MICROELECTROMECHANICAL SYSTEMS
Metal–semiconductor field-effect transistor (MESFET) – modulation-doped field effect transistor
(MODFET) – Monolithic Microwave IC (MMIC) – Bipolar Junction Transistors (BJT): basic
principles and models of operation – bulk micromachining – 3D structure – DIRE – LIGA process
– transducer – electro capacitive- micro accelerometer – illustration

TOTAL: 45 PERIODS
COURSE OUTCOMES
Upon successful completion of the course, students should be able to
CO1 Discuss the science of single crystal silicon, doping and properties of silicon and its compounds.
CO2 Explain the manufacturing process involved in fabrication of Complementary Metal Oxide–Semiconductor.
CO3 List the technology and challenges in assembly and packaging
CO4 Discuss an overview of tools and testing of microelectronics.
CO5 Explain the fundamentals of GaAs, bipolar transistors and micro electromechanical systems: device and its fabrication.

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1 – Slight, 2 – Moderate, 3 – Substantial
COURSE OBJECTIVES:
1. To understand the concept, vocabulary, and history of drone technology, and its impact on businesses.
2. To learn the design, fabrication, and programming of drones, including the classification of UAVs, assembling drone parts, and programming methods.
3. To gain practical skills in drone flying and operation, including flight modes, drone controls, sensor usage, and mobile device integration.
4. To explore the commercial applications of drones in various industries such as insurance, logistics, agriculture, inspection, and filmmaking.
5. To discuss the future trends in drone technology, safety risks, aviation regulations, miniaturization, autonomy, and the use of drones in swarms.

UNIT I  INTRODUCTION TO DRONE TECHNOLOGY  9
Drone Concept - Vocabulary Terminology - History of drone - Types of current generation of drones based on their method of propulsion - Drone technology impact on the businesses - Drone business through entrepreneurship - Opportunities/applications for entrepreneurship and employability

UNIT II  DRONE DESIGN, FABRICATION AND PROGRAMMING  9
Classifications of the UAV - Overview of the main drone parts - Technical characteristics of the parts - Function of the component parts - Assembling a drone - The energy sources - Level of autonomy - Drones configurations - The methods of programming drone - Download program - Install program on computer - Running Programs - Multi rotor stabilization - Flight modes - Wi-Fi connection

UNIT III  DRONE FLYING AND OPERATION  9
Concept of operation for drone - Flight modes - Operate a small drone in a controlled environment - Drone controls - Flight operations - Management tool - Sensors - Onboard storage capacity - Removable storage devices - Linked mobile devices and applications

UNIT IV  DRONE COMMERCIAL APPLICATIONS  9
Choosing a drone based on the application - Drones in the insurance sector - Drones in delivering mail, parcels and other cargo - Drones in agriculture - Drones in inspection of transmission lines and power distribution - Drones in filming and panoramic picturing

UNIT V  FUTURE DRONES AND SAFETY  9
The safety risks - Guidelines to fly safely - Specific aviation regulation and standardization - Drone license - Miniaturization of drones - Increasing autonomy of drones - The use of drones in swarms

TOTAL 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students will be able to:

CO1 Recall and explain the concepts, vocabulary, and historical development of drone technology.

CO2 Analyze and evaluate the design, fabrication, and programming aspects of drones, demonstrating technical knowledge of drone components and their functions.

CO3 Demonstrate practical skills in flying and operating drones, including understanding flight modes, controlling drones, utilizing sensors, and integrating mobile devices.

CO4 Apply knowledge of drone technology to identify and discuss the commercial applications of drones in various industries, evaluating their benefits and limitations.
CO5 Evaluate and discuss the future trends and safety considerations in drone technology, demonstrating an understanding of aviation regulations, miniaturization, autonomy, and swarm usage.

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