Form: **MP 06 (i)**
(Clause 9.5.1)

## Motilal Nehru National Institute of Technology Allahabad

**1. Course Structure of M. Tech. Mechanical Engineering (Computer Aided Design and Manufacturing)**

**I Semester:**

| S. No. | Subject Name | Code | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | Computer Aided Design | ME21101 | 4 | 0 | 0 | 4 |
| 2. | Finite Element Method in Engineering | ME21131 | 4 | 0 | 0 | 4 |
| 3. | Elective I | | 4 | 0 | 0 | 4 |
| 4. | Elective II | | 4 | 0 | 0 | 4 |
| 5. | Elective III | | 4 | 0 | 0 | 4 |

**Total Credits = 20**

**II Semester:**

| S. No. | Subject Name | Code | L | T | P | Cr |
|---|---|---|---|---|---|---|
| 1. | Computer Aided Manufacturing | ME22132 | 4 | 0 | 0 | 4 |
| 2. | CAD/CAM Lab | ME22231 | 0 | 0 | 6 | 4 |
| 3. | Elective IV | | 4 | 0 | 0 | 4 |
| 4. | Elective V | | 4 | 0 | 0 | 4 |
| 5. | Elective VI | | 4 | 0 | 0 | 4 |

**Total Credits = 20**

**III Semester:**

| S. No. | Subject Name | Code | Credits |
|---|---|---|---|
| 1. | State of the art Seminar / Special Study / Term Project | ME23681 | 4 |
| 2. | Thesis | ME23631 | 16 |

**IV Semester:**

| S. No. | Subject Name | Code | Credits |
|---|---|---|---|
| 1. | Thesis | ME24631 | 20 |

**Note: The distribution of thesis evaluation marks will be as follows**.

1. Supervisor (s) evaluation component: 60%
2. Oral Board evaluation component: 40%

**List of Electives for M. Tech Mechanical Engineering (Computer Aided Design and Manufacturing)**

| **Elective-I** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME21391 | Concurrent Engineering |
| 2 | ME21392 | Computer Integrated Manufacturing Systems |
| 3 | ME21393 | Surface Engineering |

| **Elective-II** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME21394 | Modal Analysis of Mechanical System |
| 2 | ME21395 | Modeling and Simulation of Manufacturing Systems |
| 3 | ME21396 | Robotics and Robot Applications |

| **Elective-III** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME21317 | Product Design and Development |
| 2 | ME21397 | Production and Operations Management |
| 3 | AM213XX | Computational Fluid Dynamics |

| **Elective-IV** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME22398 | Mechanical System Design |
| 2 | ME22399 | Materials, Manufacturing and Design |
| 3 | ME22309 | Design of Micro-Electro-Mechanical Systems |

| **Elective-V** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME22363 | Optimization Methods in Engineering |
| 2 | ME22401 | Design of Experiments |
| 3 | ME22402 | Artificial Intelligence in Engineering |

| **Elective-VI** | | |
|---|---|---|
| **Sl. No.** | **Subject Code** | **Subject Name** |
| 1 | ME22403 | Mechatronics and Control Systems |
| 2 | ME22318 | Reverse Engineering |
| 3 | ME22404 | Rapid Prototyping and Manufacturing |

**Mechanical Engineering Department**

Course Code: **ME21101**
Course Name: **Computer Aided Design**

1. **Introduction:** Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.
2. **Design of Curves:** Fundamental of Curve Design, Parametric Space of a Curve, Reparametrization, Parametric cubic curve, Blending functions, Truncation, extention, and subdivision, composite curve: continuty requirements, Spline Curves, Bezier Curves, B-Spline Curve, Rational Polynomials, Rational curves,NURBS.
3. **Geometric Transformations:**Translation, Rotation, Scaling Symmetry and Reflection, Homogeneous Transformations. Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformation.
4. **Design of Surfaces:** Fundamental of Surface Design, Parametric Space of a Surface, Reparametrization of aSurface patch, Sixteen point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfacesof Revolutions, Bezier Surface, B-Spline and NURBS Surface.
5. **Design of Solids**: Parametric Solid, Tricubic Solid, Curves and surfaces embedded in a Solid, Generalized notion scheme and higher dimension elements. Instances and parametric shpaes, Sweep Solids, Controlled Deformable solids.Complex model construction: Topology of Models: Euler's formula, connectivity number, genus, Euler-Poincare formula, topological atlas, Orientation, non-orientable surface, topology of closed curved surfaces, Gauss-Bonnet theorem, Euler operators, Euler object, topological disc, nets.Graph based models, Boolean algebra, Boolean model construction, Constructive Solid Geometry, Boundary Models, Data transfer in a collaborative environment.
6. **Geometric Properties:** Local and global properties of a curve, Local and global properties of a surface, Global properties of complex solids, Relational properties, intersections.Applications in Product Development and other areas.

**References:**


1. Geometric Modeling: Michael E. Mortenson, Third Edition, Industrial Press Inc.2006.
2. Mathematical Elements of Computer Graphics, Rogers and Adams, McGraw Hill. 1994
3. CAD CAM Theory and Prectice: I. Zeid, Tata-McGraw Hill, 2006
4. Computer-Aided Engineering Design, B Sahay and ASaxena, Springer, 2005.
5. Differential Geometry of Curves and Surfaces, Thomas F. Banchoff and Stephen T. Lovett, Thomas Banchoff-Stephen Lovett, 2010.
6. Computational Geometry for Design and Manufacture, I.D. Faux and M.J. Pratt, John Wiley, 1980.
7. Lectures on Classical Differential Geometry, Dirk J. Struick, Addison Wesley, 1980.

**Mechanical Engineering Department**

Course Code: **ME21131**
Course Name: **Finite Element Method in Engineering**

**Introduction:** Concept of Finite Element Method (FEM), History, FEM based Packages, Applications of FEM, Approaches of FEM-Galerkin's and Raleigh-Ritz, Step by Step Procedure of FEM Applications

**FEM for 1-D and Radially Symmetric Scalar Field Problems:** General Governing Equation and Boundary Conditions for descibing steady state problems of Heat Transfer, Solid Mechanics, Fluid Dynamics, Electrostatics and Magnetostatic; Finite Element Formulation following the steps of Integral Formulation, Descritization and Polynomial Approximation using Standard 1-D elements; Development and Evaluation of Elemental Matrices; Assembly of Matrices using Assembly Rules, Imposition Procedure for application of Essential Boundary Conditions and Numerical Solution of Finite Element Equations; Post Computation of the Solutions; Finite Element Formulation

of Transient Problems

**FEM for Plane (2-D) and Axisymmetric SINGLE VARIABLE Problems:** General Governing Equation and Boundary Conditions for descibing steady state problems of Heat Transfer, Solid mechanics, Fluid Dynamics, Electrostatics and Magnetostatics; Finite Element Formulation following the steps of Integral Formulation, Descritization and Polynomial Approximation using Standard 2-D elements; Development and Evaluation of Elemental Matrices; Assembly of Matrices using Assembly Rules, Imposition Procedure for application of Essential Boundary Conditions and Numerical Solution of Finite Element Equations; Post Computation of the Solutions; Finite Element Formulation of Transient Problems

**FEM for Plane (2-D) and Axisymmetric MULTI-VARIABLE Problems:** Governing Equation and Boundary Conditions for describing steady state Plane and Axisymmetric Elastic Stress Analysis Problems: Finite Element Formulation following the steps of Integral Formulation, Descritization and Polynomial Approximation using Standard 2-D elements; Development and Evaluation of Elemental Matrices; Assembly of Matrices using Assembly Rules, Imposition Procedure for application of Essential Boundary Conditions and Numerical Solution of Finite Element Equations; Post Computation of the Solutions

**FEM for 3-D Problems:** Governing equation and Boundary conditions for describing steady state Heat Transfer and Elastic Stress Analysis Problems, Finite Element Formulation following the steps of Integral Formulation, Discretization and Polynomial Approximation using Standard 3-D elements; Development and Evaluation of Elemental Matrices; Assembly of Matrices using Assembly Rules, Imposition Procedure for application of Essential Boundary Conditions and Numerical Solution of Finite Element Equations; Post Computation of the Solutions

**Software Practices:** Finite Element Analysis on a software system for finding solution of FEM based real life Problems

**References:**


1. An Introduction to Finite Element Method by J.N. Reddy, TMH, New Delhi
2. The Finite Element Method in Engineering by S.S. Rao, Butterworth Heinemann, Boston
3. Introduction to Finite Elements in Engineering by Chandrupatla and Belegundu, PHI ND
4. The Finite Element Method for Engineers by Huebner, Dewhirst, Smith, and Byrom, John Wiley and Sons, Singapore
5. The Finite Element Method Using MATLAB by Kwon and Bang,CRC Press, New York

**Mechanical Engineering Department**

# Course Code: **ME22132**
## Course Name: **Computer Aided Manufacturing**

1. **Features of CNC Machine tools, Machining Centers**
2. **NC Part Programming:** Manual, Computer Assisted-APT, and CAD/ CAM integration.
3. **Flexible Manufacturing Systems and Automated Guided Vehicles:** Concepts, classification, types of flexibility, pallets fixtures, work handling systems, AS/RS
4. **Concurrent Engineering:** Objectives, tools and applications
5. **Shop Floor Control and Computer process monitoring**
6. **Automated quality Control Systems:** Computer-aided quality control, Programming and applications of CMM

**References:**


1. Automation, Production System & Computer Integrated Manufacturing by M.P. Groover, PHI
2. Computer-Aided Manufacturing by T.C. Chang, R.A. Wysk and H.P. Wang, Pearson Prentice Hall.
3. Computer Integrated Design & Manufacturing by David D. Bedworth, Mark R. Henderson, & Philip M. Wolfa, McGraw Hill Inc.
4. Computer Integrated Manufacturing Technology & Systems by U. Rambold, C. Blume & R. Dilman, Marcel & Dekker.

**Mechanical Engineering Department**

Course Code: **ME22231**
Course Name: **CAD/CAM LAB**

1. Study of HMT CNC TRAIN MASTER Lathe.
2. Study of HMT CNC TRAIN MASTER Machining Centre.
3. Study of PMT CNC Lathe.
4. Study of various types of Automatic Tool changers.
5. Study of different components of robot.
6. Preparation of small programmes in C for robot for motions (#6 periods)
7. Programming on HMT Trainer Lathe.
8. Programming on HMT milling machine.

**Mechanical Engineering Department**

Course Code: **ME21391**

Course Name: **Concurrent Engineering**

1 **Introduction-** Basic concepts, sequential Engineering, sequential engineering Vs CE, why CE, mathematical model for understanding interactions between design and manufacturing, examples, benefits of CE, characterization of CE environment, difficulties associated with performing CE, framework for integration of life-cycle phases in a CE environment, CE techniques.

2 **Design for Manufacturing and Assembly-** DFA Guidelines- system guidelines, handling guidelines, insertion guidelines, and joining guidelines, theoretical minimum number of parts, design for piece part production, potential conflicts between DFA and DFM, manufacturing cost analysis, basic DFM part cost method, basic assembly method (adapted Xerox producibility index), Boothroyd DFA analysis.

3 **Design for Manufacturing**- Estimation of the manufacturing costs, reduction of costs of components, reduction of costs of assembly, reduction of the costs of supporting production; consider the impact of DFM Decisions on other factors.

4 **Product Development Economics-** Elements of Economic analysis, Build a Base-Case Financial Model, Perform Sensitivity Analysis, Use Sensitivity analysis to understand project Trade-Offs, Consider the influence of the Qualitative factors on project success

5 **CE Techniques -** Quality Function Deployment, The Taguchi Method for Robust Design, Failure Modes and Effects Analysis (FMEA)

**6** Design for reliability, design for maintainability, design for serviceability and their implementation

**References:**


1. Systems Approach to Computer Integrated Design and Manufacturing by Nanua Singh, Wiley India.
2. Concurrent Engineering by Andrew Kusiak - John Wiley & Sons
3. Concurrent Engineering by Chanan S. Syan and Unny Menon - Chapman & Hall
4. Product Design and Development by Karl T. Ulrich, Steven D. Eppinger, and Anita Goyal, McGraw Hill Publication.
5. Product Design for Manufacture and Assembly by G. Boothroyd, P. Dewhurst and W. A. Knight, CRC Press.
6. Product Design: Techniques in Reverse Engineering and New Product Development by Kevin Otto and Kristin Wood, Pearson Publication.

**Mechanical Engineering Department**

Course Code: **ME21392**
Course Name: **Computer Integrated Manufacturing Systems**

1 **Introduction**
Manufacturing Enterprise: External and Internal Challenges, world-class order-winning criteria, CIM- definition, SME manufacturing wheel, CIM benefits and implementation steps.
Manufacturing Systems: Classification, elements or sections of a typical manufacturing organization.

2 **Functions and Components of CIM System**
Design process, concurrent engineering, Concept of CAD/CAM and CIMS.

3 **Database and Communication in CIM System**
Data Communication technologies, Database Management technologies, Automated data collection in shop floor.

4 **Planning and Scheduling Functions in CIM System**
Aggregate Production Planning (APP), Master Production Schedule (MPS), Material Requirement Planning (MRP), Capacity Requirement Panning (CRP), Manufacturing Resource Planning (MRP-II), Just-In-time Production Systems and Concept of Enterprise Resource Planning (ERP).

5 **Group Technology and Cellular Manufacturing**
Concept of Group Technology and its Application, Classification and Coding Techniques; Clustering Techniques and Cellular Manufacturing, Flexible Manufacturing Systems

6 **Computer-Aided Process Planning**
Approaches – Variant and Generative, Feature Classification and Recognition; Process Classifications and Selections, Machines and Tool Selection, Setting Process Parameters, Process Sheet Documentation.

**References:**


1. James A. Rehg and Henry W. Kraebber, 2005. *Computer-Integrated Manufacturing.* Second Edition, Pearson Education (Singapore) private Ltd., Delhi.
2. Mikell P. Groover, 2005. *Automation, Production Systems and Computer-Integrated Manufacturing*. Second Edition, Pearson Education (Singapore) private Ltd., Delhi.
3. Vajpayee, S. K., Principles of computer-integrated manufacturing, Prentice-Hall of India, New Delhi, 2005.
4. Nanua Singh, 1995, Systems Approach to Computer Integrated Design and manufacturing, John Wiley & Sons.
5. U. Rembold; B. O. Nnaji and A. Storr, 1996. *Computer Integrated Manufacturing and Engineering*, Addison Wesley Publishing Company.
6. Paul G. Ranky, 1985. *Computer Integrated Manufacturing- an Introduction with case studies.* Prentice-Hall International.

**Mechanical Engineering Department**

Course Code: **ME21393**
Course Name: **Surface Engineering**

Introduction to surface engineering – importance and scope of surface engineering, conventional surface engineering practices like pickling, grinding, buffing etc., surface engineering by material addition like electroplating, surface modification of ferrous and non-ferrous materials like nitriding, cyaniding, aluminizing etc. Advanced surface engineering practices like laser assisted surface modification, electron beam assisted modification, spraying techniques like flame and plasma spraying, high velocity oxyfuel, cold spray techniques. Sputter deposition processes, PVD and CVD methods of surface coatings, surface modification by ion implantation and ion beam mixing Characterisation of the engineered surface and coatings like thickness, porosity and adhesion of coatings, surface microscopy and spectroscopic analysis of the modified surfaces. Functional coatings and their applications.

**References:**

1. Introduction to Surface Engineering by P. A. Dearnley, Cambridge University Press
2. Introduction to Surface Engineering and Functionally Engineered Materials by Peter M. Martin,Wiley
3. Surface Engineering of Metals: Principles, Equipment, Technologies by Tadeusz Burakowskiand TadeuszWierzchon, CRC Press
4. Basics of Surface Technology by Kamraj and Radhakrishanan,New Age International Publisher

**Mechanical Engineering Department**

Course Code: **ME21394**
Course Name: **Modal Analysis of Mechanical System**

**Theoretical Basis:** Single-Degree-of-Freedom (SDOF) System, Presentation and Properties of FRF Data for SDOF System, Undamped Multi-Degree-of-Freedom (MDOF) Systems, MDOF Systems with Proportional Damping, MDOF Systems with Structural (Hysteretic) Damping – General Case, MDOF Systems with Viscous Damping – General Case, Modal Analysis of Rotating Structures., Complex Modes, Characteristics and Presentation of MDOF FRF Data, Non-sinusoidal Vibration and FRF Properties, Complete and Incomplete Models, Sensitivity of Models, Analysis of Weakly Non-linear Structures.

**Response Function Measurement Techniques**: Test Planning, Basic Measurement System, Structure Preparation, Excitation of the Structure, Transducers and Amplifiers, Analysers, Digital Signal Processing, Use of Different Excitation Signals, Calibration, Mass Cancellation, Rotational FRF Measurement, Measurements on Non-Linear Structures, Multi-point Excitation Methods, Measuring FRFs and ODSs using the Scanning LDV.

**Modal Parameter Extraction Methods:** Preliminary Checks of FRF Data, SDOF Modal Analysis Methods, SDOF Modal Analysis in the Frequency Domain (SISO), Global Modal Analysis Methods in the Frequency Domain, MDOF Modal Analysis in the Time Domain, Modal Analysis of Non-Linear Structures.

**Derivation of Mathematical Models:** Modal Models, Refinement of Modal Models, Display of Modal Model, Response Models, Spatial Models, Mobility Skeletons and System Models.

**Applications**: Comparison of and Correlation of Experiment and Prediction, Adjustment or Updating of Models, Coupled and Modified Structure Analysis, Response Prediction and Force Determination, Test Planning.

**References**


1. Modal Testing - Theory, Practice & Applicationby D.J**.** Ewin, John Wiley & Sons
2. Modal Analysis by He, J., Fu, Z. F., Butterworth-Heinemann, 2001.
3. Vibration: Fundamentals and Practice, by De Silva, C.W., CRC press, New York
4. Vibration testing: Theory and Practice by McConnell, K. G., John Wiley & Sons, NY

**Mechanical Engineering Department**

Course Code: **ME21395**
Course Name: **Modeling and Simulation of Manufacturing Systems**

1 Introduction to modeling: Concept of system, Continuous and discrete systems, Types of models, Steps in simulation study, Statistical models in simulation, Discrete, Continuous, Poisson and empirical distributions.
2 Simulation programming techniques, Output data analysis for a single system, Comparing alternative system configurations.
3 Statistical procedure for comparing real world observations with simulation output data, Generation of arriving processes, Verification and validation of simulation models.
4 Monte Carlo simulation and its application in queuing models and inventory models.
5 Simulation of manufacturing and material handling system.
6 Case studies on simulation packages.

**References:**


1. Averill M Law, 2007. Simulation Modeling and Analysis. Fourth Edition, Tata McGraw-Hill Publishing Company Limited, Delhi.
2. Geoffrey Gordon, 2011. System Simulation. Second Edition, Prentice-Hall of India Private Ltd., New Delhi, India.
3. Jerry Banks, John S. Carson II, Barry L. Nelson and David M. Nicol. 2005. Discrete-Event System Simulation, Fourth Edition, Pearson Education (Singapore) Private Limited, Indian Branch, Delhi.
4. Chung, A. C., 2004. Simulation Modeling Handbook - A Practical Approach. CRC Press LLC, Florida, USA.
5. Robinson S., 2004. Simulation: The Practice of Model Development and Use, John Wiley & Sons, Ltd., England.
6. Carrie A., 1988. Simulation of Manufacturing Systems. John Wiley & Sons, Ltd., England.

**Mechanical Engineering Department**

Course Code: **ME21396**
Course Name: **Robotics and Robot Applications**

**Introduction:**Definition, Classification and Specification; Automation and Robotics; Over view of Robotics; present and future applications – classification by coordinate system and control system.
**Components of the Industrial Robotics:** Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom – Requirements and challenges of end effectors, determination of the end effectors, comparison of Electric, Hydraulic and Pneumatic types of locomotion devices
**Actuators:**Introduction – Characteristics of actuating systems – Comparison of actuating systems – Hydraulic devices – Pneumatic devices – Electric motors and stepper motors – Microprocessor control of electric motors.
**Robot Manipulator:**Introduction; Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic Manipulator Joint Co-Ordinate System, Euler Angle & Euler Transformations, Roll-PitchYaw(RPY) Transformation, Relative Transformation, Direct & Inverse Kinematics' Solution, D H Representation & Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Robotic Differential Transformation: Introduction, Jacobian Transformation in Robotic Manipulation
**Sensors:** Introduction – Sensor characteristics ,Various Sensors and their Classification, Use of Sensors and Sensor Based System in Robotics, – Position sensors – Velocity sensors – Acceleration sensors – Force and pressure sensors – Torque sensors – Microswitches – Light and Infrared sensors – Touch and Tactile sensors – Proximity sensors – Range-finders – Sniff sensors – Vision systems – Voice Recognition devices – Voice synthesizers – Remote center compliance device. Machine Vision System, Description, Sensing, Digitizing, Image Processing and Analysis and Application of Machine Vision System, Robotic Assembly Sensors and Intelligent Sensors.
**Robot Programming:**Introduction, Various Teaching Methods, Task Programming, Survey of Robot Level Programming Languages, A Robot Program as a Path in Space, Motion Interpolation, WAIT, SIGNAL & DELAY Commands, Branching, Robot Language Structure, various Textual Robot Languages Such as VAL II, RAIL, AML and their Features, Typical Programming Examples such as Palletizing, Loading a Machine Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion straight line motion – Robot programming, languages and software packages. 6(L)
**Robot Applications:** Industrial Applications, Material Handling, Processing Applications, Assembly Applications, Inspection**;** Application, Principles for Robot Application and Application Planning, Justification of Robots, Robot**;** Safety, Non-Industrial Applications, Robotic application for sustainable Development.

**References:**

1. Robotics and Control by R.K. Mittal and I.J. Nagrath, TMH
2. Industrial Robotics-The Application by M.P. Groover, M. Weiss and N.G. Odrey,TMH
3. CAM and Automation by M.P. Groover,PHI Learning
4. Robot Modelling and Control by Spong Mark and Vidyasagar, Wiley India
5. Foundations of Robotics- analysis and Control by Yoshikava, PHI Learning
6. Introduction to AI Robotics by Murphy, PHI Learning
7. Robotics Fundamental concepts and analysis by GhosalAshitava, Oxford
8. Introduction to Robotics by S. Saha, TMH
9. Industrial Robots Handbook by Yu Kozyhev, MIR Publication

**Mechanical Engineering Department**

Course Code: **ME21317**
Course Name: **Product Design and Development**

1. Introduction and Characteristics of Product Development.
2. Who designs & develops products- Industrial & Practical Examples.
3. Creative thinking- Invention- innovation & inventiveness in a society.
4. Development Process & Organization.
5. A Generic Development Process & Concept Development.
6. Identifying Customer Needs.
7. Concept Generation, Concept Selection
8. Product Architecture, Industrial Design.
9. Human Factors & System Information Input- Text graphics, symbols and codes,
10. Work Place Design- case studies.
11. Human Factors Application – case studies.
12. Human Errors – accidents and safety. Techno legal issues
13. Intellectual Property Rights.

**References**:


1. Product Design & Development by Karl T. Ulrich, Steven D Eppinger, McGraw Hill Publishers.
2. The Mechanical Design Process by David G. Ullman
3. Human Factors in Engineering Design by Mark S Sanders & Ernst J. Mc Cornick McGraw Hill Publishers.
4. Product Design and Process Engineering by Benjamin W Nishel& Alan B Draker- McGraw Hill Publishers.
5. Any other reference discussed in class for specific topics.

**Mechanical Engineering Department**

# Course Code: **ME21397**
# Course Name: **Production and Operations Management**

1. **Introduction:** Flexible production era, Evaluation of service organization, learning curves
2. **Forecasting:** Elements and steps in forecasting, Types of forecasting: Qualitative and quantitative types, Errors in forecasting.
3. **Aggregate Planning:** Purpose, inputs of aggregate plan, planning, processes and strategies, Methods and techniques, Mathematical charting and heuristics.
4. **Managing inventory with dependent demands:** MRP, Lot sizing in MRP Implementing MRP systems, MRP II, ERP.
5. **Operation scheduling:** scheduling systems, scheduling methods, in flow and job-shops, assembly lines.
6. **Capacity Planning:** Definition and measurement of capacity, adjusting capacity, capacity strategies.
7. **Facility Location and Layout:** facility location factors and methods, different facility layouts and their optimization: flow shop, Job-shop, Cellular layout, assembly line and project processes.
8. **JIT, lean and synchronous manufacturing and theory of constraints**
9. **Supply-chain Management:** Creating and effective supply chain, supply chain strategy, performance measurement outsourcing.

**References:**


1. Production and Operations Management by Everett E. Adam, Jr. Ronald J. Ebert
2. Production and Operations Management by Joseph S. Martinich
3. Modern Production/Operations Management by E. S. Buffa and R. K. Sarin
4. Operations Management for Competitive Advantage by Chase Jacobs, Aquilano
5. Operations Management by Krajewski and Ritzman

**Mechanical Engineering Department**

Course Code: **ME22398**
Course Name: **Mechanical System Design**

1 **Engineering Process and systems Approach:** Fundamentals of Technical System: System, plant, Equipment, machines,Assemblies and components, Systems approach: structure and steps during life phases of the system, Application of Systems concepts in Engineering. General approach to design, Identification of Engineering functions, Conversion of energy, material and signals, Functional relationship, Working interrelationship: physicaleffects,Design phases, Engineering Activity Matrix, Defining the proposed effort, Role of Engineer, Engineering Problem Solving Concurrent Engineering, A case study.

2 **Problem Formulation: Defining and formulating a design problem** Nature of Engineering Problems, Needs Statement: customer requirements and company requirements, engineering characteristics, Constraints, Quality function deployment/ house of quality, Engineering design specification. **System Theories** General methodology of problem solving, Functional description of system, System analysis view points, black box approach, state theory approach, Function structure, function variants, relocating functions, subdividing functions, combining and eliminating functions, Concept evaluation: absolute and relative, Decision Process Approach, Case study.

3 **System Modelling and linear graph modelling:** Need for modelling, Modelling types and purposes, Linear graph modelling concepts, relating LGT to lumped element models of physical systems. Graph Modelling and Analysis Process, manipulation of graph theory rules, Path problem, Network flow problem. Case Study;

**Mathematical Modelling Concepts:** Bondgraph approach. Case Study

4 **Optimization Concepts:** Optimisation process, Motivation and freedom of Choice, goals and objectives- Criteria, calculus method of optimization: Lagrange multiplier, Methods of optimisation-analytical: nonlinear optimization. **System Evaluation:** Feasibility Assessment, planning horizon, time value of money, financial analysis. A case study

**Decision Analysis:** Elements of a decision problem, Decision model, probability, Expected monetary value, Utility value, Baye’s theorem. Case Study.

5 **System Simulation**

Simulation Concepts, simulation models, Iconic, Analog, Analytical, Simulation Process Problem definition, input model construction, Waiting line simulation, Solution process, limitations of simulation approach: A case study.

**Axiomatic Approach of Suh:** Problem definition and FRs, Hierarchy of FRs and DPs Suh’s Axioms and corollary, Decomposition of Design process, Design for manufacture,

**References:**


1. Systematic Mechanical Designing: A Cost and Management Perspective by M.S. Hundal, New York, ASME Press
2. Engineering Design: A Materials and Processing Approach by GE Dieter, McGraw Hill.
3. Design Engineering and design for manufacture by J. R. Dixon, Field Stone Pub.
4. The Mechanical Design Process, David G. Ullman, McGraw Hill
5. Engineering Design by R. J. Eggert, Pearson/Prentice Hall.
6. Elements of Engineering Design, Martin S Ray, Prentice Hall
7. Principles of Design by Nam P Suh, McGraw Hill 1999
8. Total Design by Stuart Pugh, Pearson Education
9. Optimisation Techniques by S. S. Rao
10. System analysis and Project Management by Cleland, Willium and King, McGraw Hill
11. Modelling and Simulation of Mechanical Systems using Bondgraph by Amalendu Mukherjee, RanjitKarmakar

**Mechanical Engineering Department**

Course Code: **ME22399**
Course Name: **Materials, Manufacturing and Design**

1. Why study design process- Understanding Mechanical design – Designer's and Design team.
2. Materials in Design –Evolution of Engineering materials –Metals- Plastics -composites Applications – Automotive Industry- Consumer Goods- Construction & Civil Structure- Industrial Applications.
3. Introducing modelling and synthesis for structural integrity- Modeling and Simulation -the Role of Models in Engineering -case studies--Similitude and Scale Models -Simulation -Geometric Modeling on the Computer -Finite-Element Analysis -Computer Visualization-Rapid Prototyping –case studies.
4. Materials Selection -Performance Characteristics of Materials -The Materials Selection Process -Sources of Information on Materials Properties-Economics of Materials - Design Example--Materials Substitution, Recycling and Materials Selection.
5. Embodiment design- Product architecture- Industrial design- Human factors design –design for environment.
6. Design Against Failure- fatigue -corrosion -wear etc.
7. Manufacturing processes & process selection Classifying processes -Shaping- joining-finish- etc.
8. Plastics –different types- manufacturing Processes -case studies.
9. Materials & the environment Life cycle – packaging material –case studies.
10. Economic Decision Making -Cost Comparison - Materials and energy consuming systems – Eco selection -case studies. Methods of Developing Cost Estimates, Life Cycle Costing – case studies.
11. The Origin of Laws -Contracts - Liability -Product Liability -Protecting Intellectual Property -The Legal and Ethical Domains concern for the environment and for individual Case studies.

**References**


1. Engineering Design: A Materials and Processing Approach by George E. Dieter
2. Materials Selection in Mechanical Design by M.F Ashby, Butterworth- Heinmann
3. Handbook of Product Design for Manufacturing by James G Bralla
4. Manufacturing Engineering and Technology by S. Kalpakjian, Prentice Hall
5. Practical Engineering Failure Analysis by HaniMTawancy, Anwar ul- Hamid, Abbas – Marcel Dekker –New York.
6. Introduction to Engineering design-Modeling, Synthesis& Problem solving strategies- by Andrew Samuel & John Weir.
7. Mechanical Design Process by David G Ullman
8. Composites Manufacturing- Materials Products and process manufacturing.
9. Fatigue Design Handbook by Society of Automotive Engineers, Inc.

**Mechanical Engineering Department**

Course Code: **ME22309**
Course Name: **Design of Micro-Electro-Mechanical Systems**

1. **Overview of Micro Electro Mechanical systems (MEMS) and Microsystems:** MEMS and Microsystem products: Microgears, Micromotors, Microturbines, Mirco-optical Components, Application of Microsystems in Automotive Industry, Application of Microsystems in other Industries: Health care, Aerospace, Industrial Products, Consumer Products, Telecommunications; Scaling Laws in Miniaturization

2. **Working Principles of Microsystems:** Microsensors, Microactuation, MEMS with Microactuators, Microactuators with Mechanical Inertia, Microfluidics

3. **Engineering Science for Microsystems Design and Fabrication:** Atomic structure of matter, Ions and Ionization, Molecular theory of matter and Intermolecular forces, Doping of semiconductor, Diffusion process, Plasma Physics, Electrochemistry

4. **Engineering Mechanics for Microsystems Design:** Static bending of thin plates, Design theory of accelerometer, micro accelerometer, thin film mechanics: thermo mechanics, fracture mechanics

5. **Thermo-fluid Engineering and Microsystems Design:** Fluid flow in micro conduits, Heat conduction in multilayered thin films and in solids at sub-micrometer scale

6. **Materials for MEMS and Microsystems:** Substrates and Wafers, Active substrate materials, Silicon and its compounds, polymers, packaging materials

7. **Microsystems Fabrication and manufacturing Processes:** Photolithography, Ion implantation, Diffusion, Oxidation, Chemical Vapour Deposition, Physical Vapour Deposition, Etching, Bulk micro manufacturing, Surface micro machining LIGA process

8. **Microsystems Design:** Design Constraints: Selection of Materials, manufacturing processes, signal transduction, electromechanical system, packaging. Process Design: Photolithography, Thin film fabrications, Geometry shaping. Mechanical Design: Geometry of MEMS components, Thermo mechanical loading, stress analysis, dynamic analysis, interfacial fracture analysis. Mechanical Design using FEM: FEM formulation, Simulation of micro fabrication processes, Design of Silicon Die of a Micro pressure sensor, Design of micro fluidic network systems, Design of Micro gas turbine rotor, bearings.

**References**


1. MEMS and Microsystems: Design, Manufacture, and Nanoscale Engineering by Hsu, T.R., John Wiley & Sons, Inc. New Jersey
2. Fundamentals of Microfabrication by Madau, M. J., Taylor &Fransis CRC Press, Boca Ratan
3. Handbook of MEMS: Introduction and Fundamentals by Gad-el-Hak, M., Taylor &Fransis CRC Press, Boca Ratan

**Mechanical Engineering Department**

Course Code: **ME22363**
Course Name: **Optimization Methods in Engineering**

Introduction: Terminologies, Design Variables and Constraints, Objective Function, Variable Bounds, and Problem Formulation.

***Linear Programming:*** Simplex Method, Duality in Linear Programming.

Single Variable Optimization Problems: Optimality Criterion, Bracketing Methods: Exhaustive Search Method, Bounding Phase Method, Region Elimination Methods: Interval Halving Method, Fibonacci Search Method, Golden Section Method, Successive Quadratic Estimation Method. Gradient Based Methods: Newton-Raphson Method, Bisection Method, Secant Method.

Multivariable Optimization Algorithms: Optimality Criteria, Unidirectional Search, Direct Search Methods: Box Method, Hooke-Jeeves Pattern Search Method, Powell's Conjugate Direction Method. ***Gradient Based Methods:*** Cauchy's Steepest Descent Method, Newton's method, Marquardt's Method, Conjugate Gradient Method, Variable-metric (DFP) Method.

***Constrained Optimization Algorithms:*** Kuhn Tucker Conditions, Transformation Methods: Penalty Function Method, Method of Multipliers (MOM), and Sensitivity Analysis.

***Specialized Algorithms:*** Integer Programming: Penalty Function Method, Branch and Bound Method, Geometric Programming.

***Non-Traditional Optimization Algorithms***: Genetic Algorithms, Simulated Annealing, Tabu Search, Ant Colony Optimization, Particle Swarm Optimization; Applications to Engineering Optimization Problems

**References:**

1. Optimization for engineering design: algorithms and examples by Kalyanmoy Deb, Prentice-Hall of India Private Limited, New Delhi
2. Multi-Objective Optimization using Evolutionary Algorithms by Kalyanmoy Deb, Wiley India Pvt. Ltd., New Delhi.
3. Engineering optimization: Theory and Practice by S.S Rao, Fourth Edition, New Age International (P) Limited Publishers, New Delhi.
4. Engineering optimization - methods and applications by Ravindran, Ragsdell, and Reklaitis, John Wiley & Sons, Inc.

**Mechanical Engineering Department**

Course Code: **ME22401**
Course Name: **Design of Experiments**

**Basic Concepts:** Fundamentals of experimental design, Selection of an appropriate design, Criteria for evaluation, Factors and levels, Review of statistical inference, Importance of optimized design, Functional design, Parametric design.

**Single Factor Experiments:** Completely randomized design, Analysis of variance (ANOVA), Effect of total sum of Squares, Randomized block design, Randomized incomplete block design, Latin square design.

**Factorial Experiments:** Two way analysis of variance, Fixed, Random and Mixed models, Expected mean square rules, Nested and nested factorial designs, Effect of confounding, Fractional factorial design, Response Surface Methodology – Central composite designs, The method of steepest ascent, response surface designs.

**Robust Design:** Steps in designing performance in to a product, Taguchi‘s definition of quality, Loss functions and manufacturing tolerances, Additivity, Orthogonal arrays vs. classical statistical experiments, Graphic evaluations of main effects, Selecting factors for Taguchi Experiments, Concept of S/N Ratios – its significance in robust design, Case studies of S/N ratios in optimization, Identifying control and noise factors, Ishikawa Diagram, Constrained Robust Design Approach, Applications.

**References:**


1. Design and Analysis of Experiments by DouglusMontgomery, John Wiley & Sons.
2. Fundamental concepts in design of experiments by Charles R.Hicks, Holt, Rinehort and Winston.
3. Methods Explained: Practical steps to Robust Design by Tapan P.Bagchi, Prentice-Hall.
4. Experimental Designs by Cochran, WG and Cox, GM, Asia Publishing House.
5. Quality Engineering using robust design by M.S. Phadke, Prentice-Hall.
6. Taguchi Techniques for quality engineering by P.J. Ross,McGraw-Hill.

**Mechanical Engineering Department**

Course Code: **ME22402**
Course Name: **Artificial Intelligence in Engineering**

Introduction to knowledge-based intelligent systems, Rule-based expert systems, Expert system structure.

Fuzzy expert systems: fuzzy sets, fuzzy relations, fuzzy implications, construction of data base and rule base, inference mechanisms, defuzzification methods.

Artificial neural networks: neurons and neural networks, single layer perceptrons, multi-layer neural networks, learning processes, radial basis function networks, recurrent neural networks.

Hybrid intelligent systems.

**References:**

1. Artificial Intelligence: A Guide to Intelligent Systems by M. Negnevitsky, Addison-Wesley.
2. Neural Networks: A comprehensive Foundation by S. Haykin, Pearson Education.
3. Introduction to artificial neural systemsby Jaico Publishing House.
4. Neural Networks for Modelling and Control of Dynamic Systems, A Practitioner's Handbook by M. Norgaard, O. Ravn, N.K. Poulsen and L.K. Hansen, Springer.
5. An Introduction to Fuzzy Logic for Practical Applications by K.Tanaka and T. Niimura, Springer.
6. Fuzzy logic with engineering applications by T. J. Ross, Wiley India Pvt. Ltd.
7. Fuzzy logic: intelligence, control and information by J. Yen and R. Langari, Pearson Education.

**Mechanical Engineering Department**

Course Code: **ME22403**

Course Name: **Mechatronics and Control Systems**

Introduction to Mechatronic systems and components.
System Modeling, Transfer functions, Block diagrams, Signal flow graphs.
Time Response of first and second order systems, Stability analysis, Steady state analysis.
Root locus analysis, Controller design using root locus: Lead compensation, Lag compensation.
Frequency response analysis, Frequency domain compensation techniques: Lead and lag compensators.
Sensors and their interface, Electric Actuators, Pneumatic and Hydraulic Actuators, Basics of Microcontroller, I/O interfacing, A/D and D/A conversion.

**References:**


1. Bolton, W., *Mechatronics*, Pearson Education Ltd.
2. Necsulescu, D., *Mechatronics*, Pearson Education Ltd.
3. Smaili, A. and Mrad, F., *Mechatronics: Integrated technologies for intelligent machines*, Oxford University Press.
4. Histand, M. B. and Alciatore, D. G., *Introduction to Mechatronics and Measurement Systems*, McGraw-Hill Education (ISE Editions).
5. Ogata, K., Modern Control Engineering, Pearson Education.
6. Nagrath, I. J. and Gopal, M., Control Systems Engineering, New Age International.
7. Kuo, B. C. and Golnaraghi, F., Automatic Control Systems, Wiley India Pvt. Ltd.

**Mechanical Engineering Department**

Course Code: **ME22318**
Course Name: **Reverse Engineering**

1 Introduction: Need of Reverse Engineering, definition, application

2 Data acquisition technique- contact method, coordinate measurement machine and robotic arms
Non-contact methods, triangulation , Structured Light etc.

3 Pre- processing technique – need of pre-processing, import of the point cloud data, registration , data reduction and filtering

4 Triangular mesh modelling – need of triangular mesh model and its definition , topological characteristics, Euler formula for triangular mesh model, various methods of construction of triangular mesh model

5 Segmentation- Definition and need of segmentation , various methods used for segmentation like edge based and face based method of segmentation

6 Curve and Surface modelling- Parametric form of curves and a surfaces , Hermite curve and surface, Bezier curve and Surface, B-spline curve and Surface, Introduction of NURBS

**References:**


1. Reverse Engineering and Industrial Prospective by Raja, Vinesh , Fernandes, Kiran J., Springer Series in advanced Manufacturing
2. Reverse Engineering- Recent Advances and Applications by Alexander C Telea, Intech Janeza trotline
3. Smart Product Engineering by Michael Abramovici , Rainer Stark, Springer Berlin Heidelberg

**Mechanical Engineering Department**

Course Code: **ME22404**
Course Name: **Rapid Prototyping and Manufacturing**

Introduction to rapid prototyping (RP), Need of RP in context of batch production, FMS and CIM and their application, Basic principles of RP, Steps in RP, Process chain in RP in integrated CAD CAM environment, Advantages of RP, Classification of different RP techniques based on raw materials, layering technique (2-D or 3-D) and energy sources: Process technology and comparative study of: Stereo-lithography (SL) with photo-polymerisation, SL with liquid thermal polymerisation, Solid foil polymerisation, Selective laser sintering, Selective powder binding, ballistic particle manufacturing both 2-D and 3-D, Fused deposition modelling, Shape melting, Laminated object manufacturing, Solid ground curing, Repetitive masking and deposition, Beam interference solidification, Holographic interference solidification, Special topic on RP using metallic alloys, Programming in RP, Modelling, Slicing, Internal hatching, Surface skin fills, Support structure.

**References:**

1. Rapid Prototyping and Applications in Manufacturing by Chua and. Fai: John Wiley
2. Rapid Prototyping and Manufacturing, Fundamentals of Stereo lithography by P.F. Jacobs, Society of Manuf. Engineers Dearborn MI
3. Software Solutions for Rapid Prototyping Professional Engineering Publications by I. Gibson Ed., London
4. Rapid Prototyping Laser Base and Other Technologies by P.K. Vennuvinod and Weiyin Ma; Kluwer Academic Press
5. Solid Freeform Fabrication by D. Kochan, Elsevier
6. Rapid Prototyping Technology Selection and Application by K.G. Cooper, Marcel Dekker