# M.TECH. IN MECHANICAL ENGINEERING (PRODUCTION DESIGN & MANUFACTURING)

## CURRICULUM AND SYLLABUS

**(Effect from the Academic Year 2006 – 07)**

# PONDICHERRY UNIVERSITY

## PUDUCHERRY – 605014.

**M.TECH. IN MECHANICAL ENGINEERING (PRODUCT DESIGN AND MANUFACTURING)**
**CURRICULUM AND SCHEME OF EXAMINATION**

**(Total credit requirement for the completion of the Programme :72)**

**Eligibility:**

**M.Tech. in Mechanical Engineering (Product Design and Manufacturing) :** Candidates for admission to the first semester of the four semester M.Tech. Course in Mechanical Engineering with specilisation in Product design and Manufacturing should have passed B.E/B.Tech in Mechanical / Production Engineering or an examination of any University or Authority accepted by the Pondicherry University as equivalent thereto, with at least 55% marks in the degree examination or equivalent CGPA.

## SEMESTER – I

| Sl. No. | Code | Subject | Hours / Week | | | Credits | Evaluation (marks) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Internal | External | Total |
| 1. | ME 911 | Computational Methods | 4 | 0 | 0 | 4 | 40 | 60 | 100 |
| 2. | ME 912 | Computer Aided Design | 4 | 0 | 0 | 4 | 40 | 60 | 100 |
| 3. | ME 913 | Design for Manufacture and Assembly | 4 | 0 | 0 | 4 | 40 | 60 | 100 |
| 4. | ME 914 | Computer Aided Manufacturing | 4 | 0 | 0 | 4 | 40 | 60 | 100 |
| 5. | | Elective - I | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6. | ME917 | CAD Laboratory | 0 | 0 | 3 | 2 | 50 | 50 | 100 |
| | | | | | | 21 | 250 | 350 | 600 |

## SEMESTER – II

| Sl. No. | Code | Subject | Hours / Week | | | Credits | Evaluation (marks) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Internal | External | Total |
| 1. | ME 915 | Product Design | 4 | 0 | 0 | 4 | 40 | 60 | 100 |
| 2. | ME 916 | Advanced Materials and Processing | 4 | 0 | 0 | 4 | 40 | 60 | 100 |
| 3. | | Elective - II | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 4. | | Elective - III | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 5. | | Elective - IV | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 6. | | Elective - V | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 7. | ME 918 | CAM Laboratory | 0 | 0 | 3 | 2 | 50 | 50 | 100 |
| | | | | | | 22 | 290 | 410 | 700 |

S**EMESTER – III**

| Sl. No. | Code | Subject | Hours / Week | | | Credits | Evaluation (marks) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Internal | External | Total |
| 1. | | Elective - VI | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 2. | | Elective - VII | 3 | 0 | 0 | 3 | 40 | 60 | 100 |
| 3. | ME 971 | Directed Study | 0 | 0 | 3 | 3 | 100 | - | 100 |
| 4. | ME 919 | Major Project (Phase – I) | 0 | 0 | 18 | 8 | 200 | 100 | 300 |
| | | | | | | 17 | 380 | 220 | 600 |

**SEMESTER – IV**

| Sl. No. | Code | Subject | Hours / Week | | | Credits | Evaluation (marks) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | | Internal | External | Total |
| 1. | ME 920 | Major Project (Phase – II) | 0 | 0 | 24 | 12 | 250 | 150 | 400 |
| | | | | | | 12 | 250 | 150 | 400 |

## LIST OF ELECTIVES*:*

| Sl.No. | Code | Subject |
|---|---|---|
| 1 | ME 941 | Advanced Finite Element Analysis |
| 2 | ME 942 | Advanced Mechanism Design |
| 3 | ME 943 | Composite Materials Technology |
| 4 | ME 944 | Computer Aided Inspection and Quality Control |
| 5 | ME 945 | Finite Element Method |
| 6 | ME 946 | Fuzzy Logic and Neural Networks |
| 7 | ME 947 | Industrial Automation |
| 8 | ME 948 | Industrial Robot Technology |
| 9 | ME 949 | Integrated Materials Management |
| 10 | ME 950 | Logistics & Supply Chain Management |
| 11 | ME 951 | Maintenance and Safety Engineering |
| 12 | ME 952 | Materials Sciences |
| 13 | ME 953 | Micro- Electro- Mechanical Systems |
| 14 | ME 954 | Optimization in Design |
| 15 | ME 955 | Optimization Techniques in Manufacturing |
| 16 | ME 956 | Product Reliability Engineering |
| 17 | ME 957 | Project Management |
| 18 | ME 958 | Quality Engineering And Robust Design |
| 19 | ME 959 | Rapid Prototyping |
| 20 | ME 960 | Simulation and its Applications in Manufacturing |
| 21 | ME 961 | Total Quality Management |
| 22 | ME 962 | Tribology in Design |

## ME 911 COMPUTATIONAL METHODS

**Unit - I**

Variational and Weighted Residual Methods - Introduction, functional - Euler's equation – Solutions of Euler's equations-Functional dependent on first and higher order derivatives –Approximate solution to boundary value problems- Rayleigh - Ritz method, Weighted residual Method – Gelerkin Method..

**Unit - II**

Numerical Methods - Solution of Linear Simultaneous equations- direct methods of solution- Gauss elimination method, Gauss Jordon method, Crout's method - iterative methods of solution – Jacobi's method Gauss Seidal method. Determination of Eigen value by iteration – power method.

**Unit - III**

Curve fitting – Method of least squares, fitting straight line, parabola and exponential, polynomial of degree N, applications.

Statistical methods - Statistical Inference- sampling distribution of statistics, standard error, point and internal estimation for population, mean, variance and least square estimate.

**Unit - IV**

Test of Hypothesis, Inference concerning means, variances and proportions for small and large samples, t, F, chi square tests, goodness of fitness, and test of independence.

**Unit - V**

Design of experiment – Analysis of variance, one way and two way classification, latin square design, factorial design, test of significance of main and interaction effects.

**REFERENCE BOOKS**


1. Miller and Freund, - Probability and statistics for Engineers, Prentice Hall of India, 1995.
2. Douglas C. Montgomery and George C. Runger - Applied Statistic and Probability for Engineers, Wiley Higher Education,1998
3. Elsgolts, L. - Differential equation and calculus of variations, Mir Publishers, Moscow, 1966.
4. Dr, B.S. Grewal - Higher Engineering Mathematics, Khanna Publishers, 2000

## ME 912 COMPUTER AIDED DESIGN

**Unit - I**

Principles of Computer Graphics - Point plotting, drawing of lines, Bresenham's circle algorithm. Transformation in Graphics: co-ordinate system used in Graphics and windowing , view port, views, 2D transformations – rotation, scaling, translation, mirror, reflection, shear - homogeneous transformations – concatenation, 3D Transformation – Perspective Projection – Technique (Description of techniques only).

**Unit - II**

Geometric Modeling Classification of Geometric Modelling – Wire frame, Surface and Solid Modeling, applications – representation of curves and surfaces – Parametric form – Design of curved shapes- Cubic spline – Bezier curve – B-spline – Design of Surfaces - features of Surface Modelling Package - Solid Primitives, CSG, B-rep and description of other modelling techniques like Pure primitive instancing, cell decomposition, spatial occupancy enumeration, Boolean Operations (join, cut, intersection), Creating 3D objects from 2D profiles (extrusion, revolving etc)

**Unit - III**

Graphics standard & Data storage - Standards for computer graphics GKS, PHIGS. Data exchange standards – IGES, STEP - Manipulation of the model - Model storage - Data structures - Data base considerations - Object oriented representations - Organizing data for CIM applications - Design information system.

**Unit - IV**

Finite Element Modeling - Introduction, Mesh Generation – mesh requirements, Semi-Automatic Methods-Node-based approach, Region based approach, Solid-modeling-based methods. Fully Automatic Methods-Element-based approach, Application. Modeling Hints- utilizing symmetricity – symmetric and anti symmetric B.C, proper and effective usage of different types of elements, - warping limit, corner angle, aspect ratio, Acceptable and Unacceptable Distortion, Mesh Refinements using Isoparametric Finite Elements, Meshing in high gradient areas, Transition Regions. Sub modeling Concept

**Unit - V**

Extending the Capabilities of CAD Parametric and variational modeling - Feature recognition - Design by features - Assembly and Tolerance modeling - Tolerance representation - specification, analysis and synthesis - Analysis - Rapid prototyping - Al in Design.
An overview of modeling softwares like PRO-E, CATIA, IDEAS, SOLID EDGE etc.

**REFERENCE BOOKS**


1. Chris Mcmahon and Jimmie Browne - CAD/CAM – Principle Practice and Manufacturing Management, Addision Wesley England , Second Edition,2000.
2. Dr.Sadhu Singh - Computer Aided Design and Manufacturing, Khanna Publishers, New Delhi, Second Edition,2000.
3. P.Radhakrishnan, S.Subramanayan and V.Raju - CAD/CAM/CIM, New Age International (P) Ltd., New Delhi.
4. Groover M.P. and Zimmers EW. - CAD/CAM; Computer Aided Design and Manufacturing, Prentice Hall International, New Delhi, 1992.
5. Ibrahim Zeid - CAD/CAM theory and Practice, Tata McGraw Hill Publishing Co. Ltd., Company Ltd., New Delhi, 1992.
6. R.D. Cook, - Concepts and applications of Finite Element Analysis, John Wiley and Sons, New York, Second Edition, 1981,.
7. Ibrahim Zeid - Mastering CAD/CAM – Tata Mc Graw Hill Publishing Co. Ltd., New Delhi, 2005.

## ME 913 DESIGN FOR MANUFACTURE AND ASSEMBLY

**Unit - I**

General design principles, Effect of material properties on design, Effect of manufacturing process on design, mechanisms selection, evaluation method, Process capability

**Unit - II**

Working principle, Material, Manufacture, Design - Possible solutions - Materials choice - Influence of materials on form design - form design of welded members, forgings and castings.

**Unit - III**

Design features to facilitate machining - drills - milling cutters - keyways - Doweling procedures, counter sunk screws - Reduction of machined area - simplification by separation - simplification by amalgamation - Design for machinability - Design for economy - Design for capability - Design for accessibility - Design for assembly.

**Unit - IV**

Redesign of castings based on parting line considerations - Minimizing core requirements, machined holes, redesign of cast members to obviate cores.

**Unit - V**

Feature tolerances - Geometric tolerances - Assembly limits – Datum features - Tolerance stacks. Introduction to design for assembly, General approach to design for assembly- case studies.

**REFERENCE BOOKS**


1. Boothroyd - Design for Manufacture
2. Robert Matousek - Engineering Design - A systematic approach, Blackie & Sons Ltd., 1963.
3. James G. Bralla - Hand Book of Product Design for Manufacturing, McGraw Hill Co., 1986.
4. Swift K.G. - Knowledge based design for manufacture, Kogan Page Ltd., 1987.
5. Daniel E. Whitney - Mechanical Assemblies - Their Design, Manufacture and Role in Product Development.
6. - Casting Design Hand Book.
7. Farag.M - Materials Selection for Engineering Design, Prentice Hall, 1997
8. Spotts.M.F. - Dimensioning and Tolerance for Quantity Production, Prentice Hall, 1983
9. James G Bralla - Hand Book of Product Design for Manufacturing, McGraw Hill, 1983.

## ME 914 COMPUTER AIDED MANUFACTURING

**Unit - I**

CAM – Scope and applications – NC in CAM – Principal types of CNC machine tools and their construction features – tooling for CNC – ISO designation for tooling – CNC operating system – FANUC, SINUMERIK – LINUMERIK – Programming for CNC machining – coordinate systems – manual part programming – computer assisted part programming – CNC part programming with CAD system.

**Unit - II**

Material handling in CAM environment – types – AGVS – AS/RS – Swarf handling and disposal of wastes – single and mixed mode assembly lines – quantitative analysis of assembly systems.

Robotics – classification and specification – drives and controls – sensors - end effectors - grippers- tool handling and work handling – machine vision – robot programming concepts – case studies in assembly.

**Unit - III**

Quality Function Deployment – Process Planning – CAPP – Variant and Generative systems- Concurrent Engineering and Design for Manufacturing – Advanced manufacturing Planning

Computer Aided Production Planning and Control – Aggregate production planning and master production schedule – MRP – MRP II – ERP - Capacity planning

**Unit - IV**

Rapid prototyping: Need for rapid prototyping, Basic principles and advantages of RP, General features and classifications of different RP techniques with examples, Introduction to three representative RP techniques: Fusion Deposition Modeling, Laminated Object Manufacturing and Stereo-lithography.

**Unit - V**

Flexible manufacturing cells, systems – characteristics – economics and technological justification – planning, installation, operation and evaluation issues – role of group technology and JIT in FMS – typical case studies future prospects

**REFERENCE BOOKS**


1. Mikell P.Groover - Automation , Production Systems and Computer Integrated Manufacturing, Second edition, Prentice Hall of India, 2002
2. S.Kant Vajpayee - Principles of Computer Integrated Manufacturing, Prentice Hall of India, 1999
3. David Bed worth - Computer Integrated Design and Manufacturing, TMH, 1998
4. Ranky, Paul.G, - Computer Integrated Manufacturing, Prentice Hall International, 1986
5. Amitabha Ghosh, - Rapid Prototyping – A Brief Introduction, Affiliated East West Press Pvt. Ltd., 1997
6. Radhakrishnan.S Subramanian.S - CAD/CAM/CIM", Prentice Hall of India, 2000

**ME 917 CAD LABORATORY**

**I.PROGRAMMING**

Computer aided design of machine elements - Development of programs using FORTRAN/C language for design, drawing & plotting of Machine Elements and Interfacing with packages like AutoCAD

1.Shaft
2.Couplings

Output of the program should create Auto CAD Script file. Run the Script file to show Design Drawing in the computer screen.

**II.DRAFTING**

Using Auto CAD Software draw

1. Orthographic views of the given 3D blocks
2. 3D blocks for the given orthographic views.

**III.MODELLING**

Using any modeling Softwares like ProE/CATIA/IDEAS generate

1. Solid modelling of given 3D blocks

**IV. FE ANALYSIS**

Using any FEA software packages like ANSYS / NISA etc solve for

1. Plane Stress Analysis on tooth profile.
2. 2D Asymmetric analysis to determine Hoop and longitudinal stress on thick cylinder

**V . SIMULATION USING MATLAB**

1.Effect of damping on a single degree damped vibrating system.
2.Transient heat transfer problem

## ME 915 PRODUCT DESIGN

**Unit - I**

Definition - Design by Evolution and by Innovation - factors to be considered for product design - Production-Consumption cycle - The morphology of design - Primary design Phases and flow charting. Role of Allowance, Process Capability, and Tolerance in Detailed Design and Assembly.

Product strategies, Market research - identifying customer needs - Analysis of product - locating ideas for new products, Selecting the right product, creative thinking, curiosity, imagination and brain storming - product specification.

**Unit - II**

Task - Structured approaches - clarification - search - external and internal -systematic exploration - concept selection – methodology and benefits.

The value of appearance - principles and laws of appearance - incorporating quality, safety and reliability into design. Man machine considerations - ergonomic considerations - Designing for ease of maintenance.

**Unit - III**

Modeling and simulation - the role of models in product design, mathematical modeling similitude relations - weighted property index.

Material selection: problems of material selection-performance characteristics of materials - the material selection process-economics of materials-cost versus performance relations-weighted property index.

**Unit - IV**

Strength Consideration : Principal Stress Trajectories - Balanced Design – Criteria and Objectives of Design – Designing for Uniform Strength – Tension vis –a-vis Compression.

Stiffness and Rigidity consideration: Mapping of Principal Stresses – Buckling and Instability – Plastic Design – Practical Ideas for Material saving in Design – Ribs, Corrugations, Laminates and Membranes.

Design for Production : Forging Design – Pressed Components Design – Casting Design – Design for Machining Ease – Design for PM Parts – Approach to Design with Plastics, Rubber, Ceramics.

**Unit - V**

Case studies – based on materials and manufacturing of Automobiles Components and Home appliances.

Classes of exclusive rights - Patents - Combination versus aggregation - Novelty and Utility - Design patents - Paten disclosure - Patent application steps-Patent Office prosecution-Sales of paten rights- Trade marks-Copy rights.

**REFERENCE BOOKS**


1. Karl.T.Ulrich and Steven D.Eppinger - Product Design and Development, McGraw-Hill International Edn., 2004.
2. Benjamin W.Niebel and Alanb.Draper - Product Design and Process Engineering, McGraw Hill Book Co.,
3. A.K.Chitale and R.C.Gupta - Product Design and Manufacturing, Prentice Hall, 2002.

## ME 916 ADVANCED MATERIALS AND PROCESSING

**Unit - I**

Introduction: Conventional materials, limitation, need for composites, classification and characteristics of composites, resin matrices, reinforcements, other constituents of fiber, fiber reinforced plastics, ceramics and metal matrix composites – manufacturing of metal matrix composites, solid and liquid state processing-testing of composites- applications

**Unit - II**

Introduction to powder metallurgy (P/M) Processes – Design considerations for P/M tooling – Types of compaction – Sintering at different atmospheres – Liquid Phase sintering – Secondary processes – P/M applications specifically to cutting tool, bearing and friction materials – Nano materials and their applications.

**Unit - III**

Newer forming processes specifically with reference to applications – Super plastic forming, rubber forming, explosive, electro – hydraulic and magnetic pulse forming. Special metal joining processes – Ultrasonic welding, Friction welding, Explosive Welding, Electron Beam welding, Diffusion bonding.

**Unit - IV**

Special material removal processes – Chemical machining, Electro chemical machining, Electrical Discharge machining, wire EDM, Water Jet machining – High speed machining – Micro machining Casting of Non-Ferrous metals.

**Unit - V**

Surface Structure and properties – Surface coatings, Hard facing, Thermal spraying, Vapor deposition, Ion implantation, Hot dipping – Coating of Cutting and forming tools.

**REFERENCE BOOKS**


1. Serope. Kalpakjian and Steven.R.Schmid - Manufacturing Engineering and Technology, Addison Wesley Longman (Singapore) Pvt. Ltd., New Delhi, 2000.
2. L. Carl Love - Welding Procedures and Applications, Prentice Hall Inc., 1993.
3. H.M.T. - Production Technology, Tata McGraw Hill Publishing Co, 2002.
4 R.W..Heine,C.R.Loper and P.C. Rosenthal - Principles of Metal Casting, Tata McGraw Hill Publishing Co., 1991.

## ME 918 CAM LABORATORY

**List of Exercises**

1. CNC part programming for simple turning operation
2. CNC part programming for box turning operation
3. CNC part programming for facing operation
4. CNC part programming for box facing operation
5. CNC part programming for step turning operation
6. CNC part programming for taper turning operation
7. CNC part programming for thread cutting operation
8. CNC part programming for end milling operation
9. CNC part programming for profile cutting in milling
10. CNC part programming for machining holes in milling
11. Generating G & M codes for the model created using solid edge package
12. Tool and die design for a plastic component
13. Pattern design for a casting component
14. Simple robot part programming for material handling
15. FMS programming for a simple layout

## ME 941ADVANCED FINITE ELEMENT ANALYSIS

**Unit - I**

3D problems in stress Analysis – Introduction, Finite element formulation for Tetrahedral elements, stress calculations-Application and Examples

**Unit - II**

Bending of plates and shells **-**Review of Elasticity Equations-Bending of Plates and Shells-Finite Element Formulation of Plate and Shell Elements-Conforming and Non Conforming Elements - Co and C1 Continuity Elements - Application and Examples

**Unit - III**

Dynamic analysis - Equation of motions - Mass matrices- lumped and consistent mass matrices - Free vibration analysis - Natural frequencies of Longitudinal –Introduction to Eigen buckling analysis-Application and Examples

**Unit - IV**

Introduction to 2D transient field problems.- element formulation Two point and three point recurrence schemes, -Application and Examples.

**Unit - V**

Non-linear problems- Introduction- Incremental and Iterative Techniques-Material non-Linearity-Elasto Plasticity-Plasticity-Visco plasticity-Geometric Non linearity-large displacement Formulation, Introduction to non linear buckling analysis -Application and Examples

**REFERENCE BOOKS**


1. Frank L. Stasa - Applied Finite Element Analysis for Engineers,CBS International Edition, 1985
2. Reddy J.N. - A Introduction to Finite Element Method, McGraw Hill, International Edition, 1993
3. Krishnamoorthy C.S - Finite Element Analysis - Theory and Programming, Tata McGraw Hill Publishing Company Ltd., 1998
4. Rao.S.S, - Finite Element Method in Engineering, Pergamon Press, 1989
5. Cook,Robert Devis - Concepts and Application of finite Element Analysis, Wiley John & Sons,1999
6. Buchaman,G - Schaum's Outline of finite Element Analysis, McGraw Hill, 1994

## ME942 ADVANCED MECHANISM DESIGN

**Unit - I**

Introduction - Review of fundamentals of kinematics - Mobility Analysis - Formation of one D.O.F. multi loop Kinematic chains, Network formula - Gross motion concepts.

Kinematic Analysis - Position Analysis - Vector loop equations for four bar, slider crank, inverted slider crank, geared five bar and six bar linkages. Analytical Methods for velocity and acceleration Analysis - Four bar linkage jerk analysis.

**Unit - II**

Path curvature theory - Fixed and moving centrodes, inflection points and inflection circles - Euler Savary equation, graphical constructions - Cubic stationary curvature.

**Unit - III**

Synthesis of mechanisms - Type synthesis - Number synthesis - Associated Linkage Concepts - Dimensional synthesis - function generation, path generation, motion generation. Graphical methods - Cognate linkage - Coupler curves synthesis, design of six-bar mechanisms- Algebraic methods - Application of instant center in linkage design. Cam Mechanisms –Determination of optimum size of Cams.

**Unit - IV**

Dynamics of mechanisms - Static force analysis with friction - Inertia force analysis - Combined static and inertia force analysis, shaking force, Kinetostatic analysis. Introduction to force and moment balancing of linkages.

**Unit - V**

Spatial mechnisms and robotics - Kinematic Analysis of Spatial RSSR mechanism - Denavit - Hartenberg Parameters - Forward and inverse Kinematics of Robotic Manipulators - Study and use of mechanism software packages

**REFERENCE BOOKS:**


1. Sandor G.N. and Erdman A.G. - Advanced Mechanism Design Analysis and Synthesis, Prentice Hall, 1984.
2. Shigley, J.E. and Uicker, J.J. . - Theory of Machines and Mechanisms, McGraw Hill, 1995
3. Amitabha Ghosh and Ashok Kumar Mallik - Theory of Mechanism and Mechines, EWLP, Delhi, 1999.
4. Norton R.L., - Design of Machinery, McGraw Hill, 1999.
5. Kenneth J, Waldron, Gary L.Kinzel - Kinematics, Dynamics and Design of Machinery, John Wiley &Sons, 1999.

## ME943 COMPOSITE MATERIALS TECHNOLOGY

**Unit - I**

Definition – Need – General Characteristics , Matrices – Polymer, Metal, Carbon and Ceramic Matrices, Reinforcement – Types – fibers, whiskers and particles, Reinforcement materials, Selection, advantages and limitations.

**Unit - II**

Polymer Matrix Composites – Matrix Resins – Thermosetting resins, Thermoplastic resins, Polyacryl ethers (PAE), Thermoplastic Polyimides (TPI), Polyacrylene Sulfide, Molecularly ordered liquid Crystals (MOLC), Polyblends Alloys, Fibers and Laminar Composites.

**Unit - III**

Metal Matrix Composites – Matrix selection, Reinforcement and reinforcement selection, Matrix reinforcement interface, Interaction zone, Interface bond strength.

**Unit - IV**

Polymer Matrix Production Methods – Bag Moulding, Compression Moulding, Pultrusion, Filament Winding, Metal Matrix Composites - Fabrication methods – Solid State Techniques and Liquid State Techniques

**Unit - V**

Micro mechanics and macro mechanics of composites, monotonic strength and fracture, Fatigue and Creep, Applications of composites. Composites Processing.

**REFERENCE BOOKS**


1. Krishan K.Chawla - Composite Materials : Science and Engineering, Springer, 2001.
2. F.L.Mathews and R.D.Rawlings - Composite Materials - Engineering and Science, RC Press, 2002.
3. Mallic P.K. - Fiber - Reinforced Composites : Materials, Manufacturing and Design, Marcel Dekker Inc, 1993.
4. Sanjay K.Mazumdar - Composites Manufacturing : Materials, Product and Process Engineering, CRC Press, 2002.

## ME944 COMPUTER AIDED INSPECTION AND QUALITY CONTROL

**Unit - I**

Quality – definition- Traditional and modern QC – ISO 9000 and ISO 14000 standards- CAQC- Software required- Automatic Inspection: Inspection Fundamentals – Sampling versus 100% inspection - Contact Inspection techniques: CMM –Types- construction, operation and programming – software- applications and benefits- Flexible Inspection systems- Inspection probes on machine tools- Automatic shaft inspection.

**Unit - II**

Machine Vision, Image Processing and its Application in Inspection-optical inspection - Linear Array Devices, Optical Triangulation Techniques - Non Contact Sensors For Surface Finish Measurements- non contact non optical inspection technologies- Electrical field- radiation techniques- ultrasonic methods.

**Unit - III**

Optical projection comparator- Bosch and lomp projector – laser viewer for production profile checks- opto-electronic dimensional gauging, operations and applications- co-ordinate measuring robots- process control robot- digital height gauge with SPC- air gauging with electronic sensors.

**Unit - IV**

Laser Interferometer, Speckle Measurements, Laser Scanning Systems- - Testing of Machine Tools Using Laser Interferometer- Robotic gauging and inspection systems- expert knowledge based real time inspection system.

Computer Aided Quality Assurance Records- Calibration Control -Automatic Quality Data Acquisition.

**Unit - V**

Computer Aided Quality Control–Objectives of CAQC- Computers in QC- CAQC Charts for Attributes and Variables – Study of CAQC Software like STAT- Introduction to six sigma - 6σ Methods and Tools - 6σ for manufacturing - 6σ for product development.

**REFERENCE BOOKS**


1. Geoff Vorley and Fred Tickle - Quality management, Principles & Techniques",QMT Ltd., Guilford, UK, 2004
2. Mikell P.Groover, - Automation , Production Systems and Computer Integrated Manufacturing, Second Edition, Prentice Hall of India, 2002
3. Douglus C. Montgomery - Statistical Quality Control, John Wiley and sons, 1998
4. Sadhu Singh - CAD/CAM, Khanna Publishers, 2000
5. O.P.Khanna, - Engineering Metrology', Khanna Publishers, 1998

## ME945 FINITE ELEMENT METHOD

**Unit - I**

Basic Concept, comparison with FDM advantages and disadvantages, history of development, application. Direct stiffness method (DSM)- Fundamental steps in DSM, Plane Truss, Idealisation, joint forces and displacements, Master stiffness Equation- formulation of element stiffness equations – Assembly and solution, co-ordinate transformation –Assembly Rules – BC implementation – Calculation of Reaction, Internal forces and stresses.

**Unit - II**

Finite Element Analysis of 1D Problems - One dimensional second order equations, discretisation, weak formulation, element equations, assembly, boundary conditions, solution of equations- post processing, fourth order equations and their solutions – convergence criteria, examples from solid mechanics, heat transfer

**Unit - III**

Element Shape Functions:- Classification of $C^0$, $C^1$ continuous problems-Parameter functions, its properties- completeness and compatibility condition, One-dimensional elements, Global coordinates, Two-dimensional elements, three noded triangular elements and four noded quadrilateral elements.
Natural co-ordinate systems –Lagrangian Interpolation Polynomials- Serendipity Formulation- Difference between Superparametric, Subparametric and Isoparametric Elements, Isoparamatric Elements Formulation, length coordinates– 1D bar elements, $C^0$ cintinuous shape function, beam elements, $C^1$ continuous shape function - 2D Triangular elements, Rectangular elements. – Area coordinates- Numerical integration – simple Problems using Gauss quadrature Technique

**Unit - IV**

Finite Element Analysis of Plane Elasticity 2D Problems - Introduction to Theory of Elasticity – Plane Stress –Plain Strain and Axisymmeteric Formulation – Principle of virtual work –Element matrices using energy approach. -Triangular, Quadrilateral elements - Simple problems using three noded triangular element only

**Unit - V**

Finite Element Analysis of 2D Steady State Thermal Problems - Green-Gauss Theorem-Element equation formulation – Variational calculus approach- Galerkin approach – General Two-Dimensional Heat Conduction – Axisymmetric Heat conduction -Triangular, Quadrilateral elements - Simple problems using three noded triangular element only.

**REFERENCE BOOKS**


1. Frank L. Stasa - Applied Finite Element Analysis for Engineers,CBS International Edition, 1985
2. Reddy J.N. - A Introduction to Finite Element Method, McGraw Hill, International Edition, 1993
3. Krishnamoorthy C.S - Finite Element Analysis : Theory and Programming, Tata McGraw Hill Publishing Company .Ltd 1998
4. Rao.S.S, - Finite Element Method in Engineering, Pergamon Press, 1989
5. Cook,Robert Devis etal, - Concepts and Application of finite Element Analysis, Wiley John & Sons,1999
6. Buchaman,G - Schaum's Outline of finite Element Analysis, McGraw Hill Company, 1994

## ME946 FUZZY LOGIC AND NEURAL NETWORKS

**Unit - I**

Knowledge Representation and processing – knowledge and Intelligence – logic – Frames – production systems. Fundamentals of Fuzzy logic – Fuzzy sets – Fuzzy Relation – composition and Inference.

**Unit - II**

Membership Function Estimation – Importance – Fuzzy to crisp conversion – methods – Fuzzy extension principle – Fuzzy tautologies – Implication operation Composition operation

**Unit - III**

Basics of Fuzzy Control – Architecture of Fuzzy Control – examples of Fuzzy Control system Design – Robotic Control system – Industrial applications.

**Unit - IV**

Hybrid Intelligence – Basic concepts of neural network – Inference and learning – Classification Models – Association models, Optimization models – Neural Network learning.

**Unit - V**

Rule Based Neural Networks – Network Training – Application of Neural Network in Mathematical Modeling – knowledge based approaches – applications in Mechanical Engineering– Fuzzy – Neural, examples, Neuro – Fuzzy examples – Intelligence in Automation.

**REFERENCE BOOKS**


1. Clarence W.de Silva - Intelligent Control Fuzzy Logic Applications, CRS Press, 1995.
2. Timothy J.Ross - Fuzzy Logic with Engineering Applications, McGraw Hill Inc., 1995.
3. Limin Fu - Neural Networks in Computer Intelligence, Tata McGraw Hill Publishing Company Ltd., 2003.
4. Stamations and V.Kartalopoulos - Understanding Neural Networks and Fuzzy Logic, Basic Concepts Applications, IEEE Neural Networks Council Prentice Hall of India Pvt., Ltd., 2001.
5. James A.Freeman and David M.Skapura - Neural Networks Algorithms, Applications & Programming Techniques, Pearson Education Asia, 2001.
6. Yegnarayane.B - Artificial Neural Networks, Prentice Hall – 2001.

## ME947 INDUSTRIAL AUTOMATION

**Unit - I**

Principles of automatic controls: Basic concepts of open and closed loop feedback control systems, block diagram representation of physical system, spring mass system, torsion system, hydraulic system, transfer function from block diagram for mechanical, electro-mechanical and hydraulic system. Controls and sensors used in machine tools.

**Unit - II**

Automation in hydraulic systems: Hydraulic systems components – constructional details and characteristics of pumps – actuator – control and regulation elements.

**Unit - III**

Hydraulic circuits: reciprocation operation of multi cylinder unit – quick return – sequencing, synchronizing circuits – accumulator circuits – safety circuits – circuits for press, drilling, milling and grinding – servo system – selection of components.

**Unit - IV**

Automation in pneumatic system: Pneumatic principles – elements of pneumatic system – control valves – basic pneumatic and hydro pneumatic circuits – logic circuits – pneumatic sensors – maintenance of pneumatic systems.

**Unit - V**

Architecture of Microprocessor – interfacing – data transfer schemes – application of microprocessor in hydraulic and pneumatic systems – use of microprocessor for sequencing – PLC – low cost automation.

**REFERENCE BOOKS**


1. A.Esposito - Fluid Power with applications, Prentice Hall, 2001.
2. Andrew Par - Hydraulics and Pneumatics for Technicians, Jaico Publishing, 1980.
3. SR Majumdar - Pneumatic System Principles and Maintenance, Tata McGraw Hill, 1995.
4. Goankar - Microprocessor Architecture, Programming and Applications, Wiley Eastern Limited, 1993.

## ME948 INDUSTRIAL ROBOT TECHNOLOGY

**Unit - I**

Robotics and Automation - Robot Definition, Classification of Robots, Robot System components, Functions of Robot System, Specification of Robot System, Robot Drives and Power transmission systems, Remote Centered Compliance devices.

**Unit - II**

Robotic Sensory Devices, Non optical Position sensors, Optical position sensors, Velocity sensors, Accelerometers, Proximity sensors, Touch and Slip Sensors, Force and Torque sensors – Robot vision system.

**Unit - III**

Methods of Robot programming – Lead through programming methods – capabilities and limitations, Textual Robot languages – Robot language structure – motion commands, end effectors and sensor commands, Robot programming functions, robot programming environment, On-Line and Off Line programming Languages

**Unit - IV**

Robot cell layouts – multiple Robots and machine interface, consideration in work cell design, interlocks, error detection and recovery, Robot cycle time analysis, simulation of Robot work cells.

**Unit - V**

Applications of robots in material transfer, machine loading and unloading, welding, assembly and inspection, safety, training, maintenance and quality aspects, Economics and social aspects of robotics

**REFERENCE BOOKS**


1. Richard D.Klafter, Thomas A.Chmielewski and Michael Negin - Robotic Engineering – An Integrated Approach, Prentice Hall of India Pvt Ltd, 2002.
2. Mikell P.Groover, Mitchell weiss,Roger N.Nagel and Nicholas G.Odrey - Industrial Robotics – Technology, Programming and Applications, McGraw Hill International Edition, 1996.
3. Shimon Y.Nof - Hand Book of Robotics, John Wiley sons, 1985.

## ME949 INTEGRATED MATERIALS MANAGEMENT

**Unit – I**

Integrated Materials Management Concept - materials planning and budgeting - Quality specification – source selection - creative purchasing - purchase systems – negotiation –delivery conditions - Make or Buy - Buying seasonal commodities – purchasing under uncertainty – purchasing of capital equipment – international purchasing – import substitution – public buying – legal aspects - contracts – vendor rating – buyer-seller relationship and ethics.

**Unit – II**

Stores Management – stores systems and procedures – incoming materials control – stores accounting and stock verification – obsolete, surplus and scrap management – codification and standardization - value analysis – material handling – storing and material handling equipments.

**Unit – III**

Inventory Control : inventory models - purchase model with instantaneous replenishment and without shortages, manufacturing model without shortages, purchase model with shortage and manufacturing model with shortages – operation of inventory systems – quantity discounts - P & Q systems of inventory replenishment – multiple item model with shortage limitation – determination of stock level of perishable items under probabilistic condition – MRP I and II.

**Unit – IV**

Concepts of Physical distribution – need, importance and management – Warehouses - location and layout types - receiving and shipping procedures - Application of OR techniques (Transportation problems only).

Common carriers – Insurance coverage – Transportation documents – railway / lorry receipts – Bill of lading – clearing, forwarding and demurrage - evaluation of materials management performance – computers in materials management.

**Unit – V**

Creating the logistics vision – problems with conventional organizations – developing logistics organizations - need for integration – managing supply chain as a network – process integration and ECR – comakership and logistics partnerships – supplier development.

New organizational paradigm – managing supply chain of the future – role of information in the virtual supply chain – route map to integrated supply chain.

**REFERENCE BOOKS**


1. P.Gopalakrishnan and M.Sundaresan - Materials Management – An integrated approach, Prentice Hall of India Pvt. Ltd., 2000.
2. Donald M Dobler, Lamar Lee Jr and David N. Burt - Purchasing and Materials Management – Texts and Cases, Tata McGraw Hill Publishing Co. Ltd., 1985.
3. Martin Christopher - Logistics & Supply Chain Management, Pitman Publishing, 2000.
4. J.R.Tony Arnold and Stephen N Chapman - Introduction to Materials Management, IV Edition, Pearson Education Asia Ltd.,2001.
5. A.K.Dutta - Materials Management – Procedures, Text and Cases, II Edition, Prentice Hall of India Pvt. Ltd., 2001.
6. R.Panneerselvam - Operations Research, Prentice Hall of India, New Delhi, 2002.

## ME950 LOGISTICS AND SUPPLY CHAIN MANAGEMENT

**Unit - I**

Logistics and Competitive Strategy: Competitive advantage – gaining competitive advantage through logistics – mission of logistics management – supply chain and competitive performance – changing logistics environment.

Customer Service Dimension: marketing and logistics interface – customer service and customer retention – service driven logistics systems – setting customer service priorities – setting service standards.

**Unit - II**

Measuring Logistics Cost and Performance: concept of total cost analysis – principles of logistics costing – logistics and the bottom line – logistics and shareholder value – customer profitability analysis – direct product profitability – cost drivers and activity-based costing.

Benchmarking the Supply Chain: benchmarking the logistics process – mapping supply chain processes – supplier and distribution benchmarking – setting benchmarking priorities – identifying logistics performance indicators.

Managing the global pipeline: trend towards globalization in the supply chain – challenge of global logistics - organizing for global logistics.

**Unit - III**

Strategic Lead-Time Management: time based competition – concept of lead-time – logistics pipeline management – logistics value engineering – lead-time gap.

Just-in-time and Quick Response Logistics – Japanese philosophy – implications for logistics – quick response logistics – vendor managed inventory – logistics information systems – logistics systems dynamics – production strategies for quick response.

**Unit - IV**

Managing the Supply Chain: creating logistics vision – problems with conventional organizations – developing logistics organizations - logistics as a vehicle for change – need for integration – managing supply chain as a network – process integration and ECR – co-makership and logistics partnerships – supplier development.

Role of Information Systems and Technology in SCM : importance of information in an integrated SCM environment – inter organisational information systems (IOIS) – information requirements determination for a supply chain IOIS – information and technology applications of SCM.

**Unit - V**

Developing and Maintaining Supply Chain Relationships : conceptual model of alliance development – developing a trusting relationship with partners in supply chain – resolving conflicts in supply chain relationship.

Cases in SCM. - Future Challenges in SCM : greening of supply chain – design for SCM – intelligent information systems.

**REFERENCE BOOKS**


1. Martin Christopher - Logistics and Supply Chain Management – Strategies for reducing cost and improving service, Pitman Publishing, II Edition, 1998.
2. Robert B Handfield and Ernest L Nicholas Jr. - Introduction to Supply Chain Management, Prentice Hall,NJ,1999.
3. Donald J Bowersox and David J Closs - Logistical Management, Tata McGraw Hill, New Delhi, 2000.
4. David Taylor and VikaDavid Brunt - Manufacturing Operations and Supply Chain Management, Thomson Learning, 2001.
5. David Simchi and Levi - Designing and Managing the Supply Chain, Mc Graw Hill, 2000.
6. J B Ayers - Handbook of Supply Chain Management, St. Lencie Press, 2000.
7. B S Sahay - Supply Chain Management for Global Competitiveness, Macmillan India Ltd., New Delhi, 2000.
8. P B Scharj and TS Lansen - Managing the Global Supply Chain, Viva Books, New Delhi, 2000.

## ME951 MAINTENANCE AND SAFETY ENGINEERING

**Unit - I**

Objectives of maintenance - types of maintenance – Breakdown, preventive and predictive maintenance - Repair cycle - Repair Complexity, Lubrication and Lubricants. Maintenance of Mechanical transmission systems and process plants-Energy conservation and auditing-Case studies.

**Unit - II**

Predictive Maintenance - vibration and noise as maintenance tool - wear debris analysis - Condition monitoring concepts applied to industries - Total Productive Maintenance (TPM) –Evaluation of O.E.E-Economics of Maintenance-Case studies.

**Unit - III**

Importance of maintenance management-types of maintenance organization- maintenance of stores and spare parts management – ABC analysis – Value analysis – Computer aided maintenance.

**Unit - IV**

Safety and productivity - causes of accidents in industries – accident reporting and investigation - measuring safety performance - Safety organizations and functions - Factories act and rules-ISo 18000 and standards.

**Unit - V**

Safety Codes and Standards - General Safety considerations in Material Handling equipments - Machine Shop machineries-pressure vessels and pressurized pipelines – welding equipments – operation and inspection of extinguishers – prevention and spread of fire – emergency exit facilities.

**REFERENCE BOOKS**


1. H.P.Garg - Industrial Maintenance, S.Chand & Co Ltd., New Delhi, 1990.
2. P.Gopalakrishnan - Maintenance and Spare parts Management, Prentice Hall of India Pvt. Ltd., New Delhi, 1990.
3. Rolland P.Blake - Industrial Safety, Prentice Hall of India Pvt. Ltd., New Delhi, 1973.
4. R.C.Mishra and K.Pathak - Maintenance Engineering and Management, Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
5. Alexandrov - Material Handling Equipment, Mir Publications, 1981.

## ME952 MATERIALS SCIENCES

**Unit - I**

Elasticity in metals and polymers – Mechanism of plastic deformation, role of dislocations, yield stress, shear strength of perfect and real crystals – Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening, poly phase mixture, precipitation, particle, fibre and dispersion strengthening. Effect of temperature, strain and strain rate on plastic behaviors – Super plasticity – Deformation of non crystalline

**Unit - II**

Motivation for selection, cost basis and service requirements – Selection for mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing and case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

**Unit - III**

Basic concepts of fracture mechanics for both Linear elastic and elastic – Plastic regions – crack growth – Deformation and fracture mechanism maps – Fatigue, low and high cycle Fatigue test – Crack initiation and propagation mechanism – Effect of Surface and metallurgical parameters on fatigue – Fracture of non metallic materials.

**Unit - IV**

Dual phase steels, Micro alloyed, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) steel, Maraging steel – Smart materials, shape memory alloys – Quasi crystal and nano crystalline materials. Polymeric materials – Formation of polymer structure – Production techniques of fibres, foams, adhesives and coatings – structure, properties and applications of engineering polymers.

**Unit - V**

Composites – polymer matrix – metal matrix – Lamina stress strain relationship – Analysis of Laminates – Mechanical Testing of composites and their constituent materials – strength, fracture, fatigue and creep – Applications.

**REFERENCE BOOKS**


1. T.L.Anderson, - Fracture Mechanics, Fundamentals and Applications, II Edition CRC Press, Boca Raton, 1995.
2. Ronald F.Gibson, - Principles of composite material mechanics McGraw Hill 1994.
3. Thomas H.Courtney - Mechanical Behaviour of Materials, II Edition, McGraw Hill, 2000
4. Charles J.A. Crane.F.A.A. - Selection and use of Engineering materials and Furness. J.A.G III Edition, Butterworth Heinemann, 1997.
5. Flinnn R.A. and Trojun P.K. - Engineering materials and their Applications, IV Edition, Jaico, 1999.

## ME953 MICRO- ELECTRO- MECHANICAL SYSTEMS

**Unit - I**

Mechatronics in Products – Semi conductor Sensors and micro electro mechanical Devices - Actuators – Hydraulics Actuators – pneumatic Actuators. Programmable Logic Controllers (PLC) – basic structure – input / output processing-programming – Mnemonics Timers – relays and counters – data handling – selection of PLC. Control architecture – Analog – Digital – Examples of Mechatronic systems from Robotics. Manufacturing, Machine Diagnosis.

**Unit - II**

Miniaturization and application- Micro electro mechanical devices and trends in developing them- Miniactuators, Microsensors, and Micromotors-Principles of Operations. Introduction, Absolute and Relative Tolerance in Manufacturing, Human Manufacturing, Top-Down Manufacturing Methods, Bottom-Up Approaches.

Lithography's Origins, Photolithography Overview, Critical Dimension, Overall Resolution, Sensitivity, Resolution Enhancement Technology Emerging Lithography Technologies

**Unit - III**

Dry Etching- Definitions- Plasmas or Discharges- Ion Etching or Sputtering and Ion-Beam Milling- Plasma Etching (Radical Etching)- Physical Etching.

Wet Isotropic And Anisotropic Etching- Alignment Patterns- Chemical Etching Models- Etching with Bias And/Or Illumination Of The Semiconductor- Etch-Stop Techniques- Problems.

**Unit - IV**

Physical and Chemical Vapor Deposition- Silk-Screening or Screen-Printing- Sol-Gel Deposition Technique, Doctors' Blade or Tape Casting, Plasma Spraying-Deposition and Arraying Methods of Organic Layers in BIOMEMS-Thin versus Thick Film Deposition- Selection Criteria for Deposition Method.

Introduction to LIGA and Micro molding- LIGA Background – LIGA and LIGA like process steps.

**Unit - V**

Surface Micromachining Processes, Poly-Si and Non-Poly-Si Surface Micromachining Modifications, Surface Micromachining Modifications- LIGA-Background, LIGA and LIGA-Like Process Steps.

Introduction and exposure to Nanotechnology- - Applications – Basics of nanofabrication, nano machining, nano assembly.

**REFERENCE BOOKS**


1. David G.Alciatore and Mecheal.B.Histand - Introduction of Mechatronics and Measurement Systems, McGraw Hill International Edition, 1999.
2. HMT - Mechatronics, Tata McGraw Hill Publishing Company Ltd., 1998.
3. Lawrence J.Kamm - Understanding Electro – Mechanical Engineering, An Introduction to Mechatronics, Prentice Hall, 2000.
4. Marc Madou - Fundamentals of Micro fabrication, CRC Press, 1997,
5. W.Trimmer (Ed.) - Micromechanics and MEMS, IEEE Press, 1997.
6. M.Elwenspoek - Silicon Micromachining, Cambridge Press, 1998.
7. R.C.Jaeger - Introduction to Microelectronic Fabrication, Wiley, 1989.
8. Bharat Bhushan(Ed.) - Handbook of Nanotechnology, Springer, 2004.

## ME954 OPTIMIZATION IN DESIGN

**Unit - I**

Introduction - General characteristics of mechanical elements, adequate and optimum design, principles of optimization, Formulation of objective function, design constraints-classification of optimization problem. - Single variable unconstraint optimization – Golden section and Brent's method.

**Unit - II**

Optimization with Equality and Inequality constraints-Direct methods-Indirect methods using penalty functions, Lagrange's multipliers, Geometric Programming and Stochastic Programming

**Unit - III**

Multi variable unconstraint optimization- Conjugate gradient with line minimization – Quasi Newton Method with line search. Multi objective optimization, - Goal attainment- Introduction to Genetic algorithms and Simulated Annealing techniques.

**Unit - IV**

Structural applications-Design of simple truss members. Design applications-Design of simple axial, Transverse loaded members for minimum cost, maximum weight-Design of shafts and Torsionally loaded members-Design of Springs

**Unit - V**

Dynamic applications-Optimum design of single ,two degree of freedom systems, Vibration absorbers. Application in Mechanisms-Optimum design of Simple linkage mechanisms

**REFERENCESBOOKS**


1. Johnson Ray,C. - Optimum Design of mechanical elements, Wiley, John & Sons, 1990.
2. Goldberg,D.E. - Genetic algorithms ion search, Optimization and Machine, Barnen, Addison-Wesley, New York,1989
3. Kalyanamoy Deb - Optimization for Engineering Design algorithms and Examples, Prentice Hall of India Pvt., 1995

## ME955 OPTIMIZATION TECHNIQUES IN MANUFACTURING

**Unit - I**

Introduction to Linear programming Formulations and solutions- Graphical, Simplex and Revised Simplex methods- Integer Programming-Algorithms- Cutting plane and Branch and Bound techniques, zero-one implicit enumeration- Non-linear programming- Lagrangean method, Kuhn – Tucker Conditions, Quadratic and separable programming.

**Unit - II**

Inventory- need and problems- Probabilistic models – continuous review, single and multi-period models Decision under certainty, decision under Risk – expected value criterion and expected value – variance criterion, decision under uncertainty – Laplace, Maxmin, minimax, savage minmax regret and Hurwicz chiteria. Decision tree.

**Unit - III**

Scope, Review of Markov chains-Markov processes and Chains – Classification. Finite and infinite – Stage dynamic programming models, exhaustive enumeration and policy iteration methods, linear programming solution.

**Unit - IV**

Monte Carlo Simulation – Types of simulation – Examples - Discrete event simulation – General principles – Generation of Random numbers – Manual simulation and Spreadsheet-Based simulation of single-server model – Statistical observation methods – Introduction to Simulation Languages.

**UNIT - V**

Genetic Algorithms- principle of working – Similarities and differences between GA and traditional methods- Simulated Annealing approach – Applications.

**REFERENCE BOOKS**


1. Handy A Taha - Operations Research – An Introduction, Pearson Education India, Seventh Edition, 2002.
2. Harvey M.Wagner - Principles of Operation Research with applications to managerial decision, Prentice Hall of India, 2001.
3. R.Panneerselvam - Operation Research, Prentice – Hall of India, Pvt., Ltd., 2002.
4. Daniel P. Heyman - Stochastic Models in Operations Research, Vol. I: Dover Publications, 2004
5. Matthew J. Sobel - Processes and Operating Characteristic, Dover Publications, 2003
6. Frederick S Hillier - Introduction to Operations Research, Mc GrawHill, NY, 1990
7. Paul A Jensen - Operations Research Models and Methods, John Wiley & Sons, 2003

## ME956 PRODUCT RELIABILITY ENGINEERING

**Unit - I**

Definition – Importance of Reliability – Introduction to Probability Distributions – exponential, Weibull, normal, lognormal – Gamma – bath tub Curve – reliability and hazard functions – Determination methods.

**Unit - II**

Factor of Safety and Reliability – Reliability when S and L follow normal distribution, log normal distribution – Fatigue Design: deterministic design procedure, Probabilistic design procedure –Reliability analysis of Mechanical Systems.

**Unit - III**

Reliability tests – types – Component reliability from test data – reliability models for series, parallel, stand by and k-out-of-m systems.

**Unit - IV**

Reliability techniques – Reliability allocation - Derating Components – reliability prediction in industries- Cut set / tie set – FTA – Markov models – Monte Carlo Simulation.

**Unit - V**

Significance of availability and maintainability concepts in reliability evaluation – Importance of maintainability in design and manufacturing – reliability and associated costs – economics of reliability - reliability management.

**REFERENCE BOOKS**


1. S.S.Rao - Reliability Based Design, McGraw Hill Inc, New York, 1992.
2. E.Balagurusamy - Reliability Engineering, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2003.
3. A.D.S.Carter - Mechanical Reliability, Macmillan, 1986.
4. L.S.Srinath - Concepts in Reliability Engineering, Affiliated East West Press Private Limited, New Delhi, 2003.

## ME957 PROJECT MANAGEMENT

**Unit - I**

Indian project management scenario, Projects - Project ideas and preliminary screening. Developments - Project planning to Project completion - Pre-investment phase, Investment phase, operational phase - Governmental Regulatory framework. Capital Budgeting : Capital cost-time-value (CTV) system, managing project resources flow.

**Unit - II**

Stages - Opportunity studies - General opportunity studies, specific opportunity studies, pre-feasibility studies, functional studies or support studies, feasibility study expansion projects, data for feasibility study.
Market and Technical Appraisal : Market and Demand analysis, Market Survey, Demand forecasting. Technical analysis- Materials and inputs, Choice of Technology, Product mix, Plant location, capacity, Machinery and equipment.

**Unit - III**

Appraisal process, Concepts and Techniques, Cost and Benefit from Financial angle - Basic principles for measuring costs and benefits, components of cash flow. Time value of money - Present and future value. Appraisal criteria - Urgency, Payback period, Rate of return, Debt service coverage ratio, Net present value, Benefit cost ratio, Internal rate of return, Annual capital charge, Investment appraisal in practice.

**Unit - IV**

Cost of capital - Cost of different sources of finance, Cost of debt, preference capital, and Equity capital, Weighted average Cost of capital, Marginal cost of capital. Risk analysis- Measures of risk, Sensitivity analysis, and Decision tree analysis. Social cost benefits analysis (SCBA) - Rationale for SCBA, UNIDO approach.
Cost of Capital. Means of financing, Term Loans, Financial Institutions. Profitability - Cost of Production, Break-even analysis. Assessing the tax burden and financial projections.

**Unit - V**

Forms of Project Organization, Project Planning, Implementation, and Control - Network construction, CPM, PERT, Development of Project schedule, Crashing of Project Network, Scheduling based on the availability of Resources (Manpower and Release of Funds).
Introduction to Foreign collaboration projects - Governmental policy framework, Need for foreign technology, Royalty payments, Foreign investments and procedural aspects.

**REFERENCE BOOKS**


1. P.Gopalakrishnan and V.E.Rama Moorthy - Project Management, Macmillan India Ltd., New Delhi, 1993.
2. Prasanna Chandra - Projects - Preparation, Appraisal, Budgeting and Implementation, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1980.
3. B.B.Goel - Project Management - Principles and Techniques, Deep & Deep Publications, New Delhi, 1986.
4. UNIDO - Series on Project Management.

## ME958 QUALITY ENGINEERING AND ROBUST DESIGN

**Unit - I**

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

**Unit - II**

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.

**Unit - III**

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: The method of steepest ascent, response, Surface designs.

**Unit - IV**

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.

**Unit - V**

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.

**REFERENCE BOOKS**


1. Douglus C.Montgomery - Design and Analysis of Experiments, John Wiley & Sons, 1984.
2. Charles R.Hicks, Holt, Rinehort and Winston - Fundamental Concepts in design of experiments,1984.
3. Tapan P.Bagchi, - Methods Explained: Practical steps to Robust Design, Prentice Hall of India Private Limited, New Delhi,1993.

## ME959 RAPID PROTOTYPING

**Unit - I**
Basic concept of design, Practical Issues in Design, Information in Design, Tools for Design, Recent developments in theories of design.

**Unit - II**
Product Development Cycle – Data requirements, Modeling, Data representation, part orientation and support, from CAD / CAM, STL format, Slicing, Post Processing.

**Unit - III**
Engineering Manufacturing, Overview of existing technologies of prototyping and tooling, General features and classification of Generative Manufacturing process (GMP) for Rapid Prototyping.

**Unit - IV**
Two-Dimensional Layer – by Layer Techniques- Steriolithography (SL), Solid Foil Polymerization(SFP), Selective Laser Sintering (SLS), Selective Powder Building (SPB), Ballistic Particle Manufacturing (PM), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Solid Ground curing (SGC)

**Unit - V**
Direct three Dimensional Techniques – Beam Interference Solidification (BIS), Ballistic Particle Manufacturing, Programmable Moulding, Comparison of GMP characteristics, considerations for adopting RP technology.

**REFERENCE BOOKS**


1. Richard Bizmingham, Graham Cleland, Robert Driver and Dwid Maffin - Understanding Engineering design, Prentice Hall of India, 1998.
2. Amitabha Ghosh, - Rapid Prototyping – A Brief Introduction, Affiliated East West Press Pvt. Ltd., 1997.
3. P.Radhakrishnan and S.Subramanian, - CAD/CAM/CIM, New Age International (P) Ltd, Publishers, 1995.

## ME960 SIMULATION AND ITS APPLCIATIONS IN MANUFACTURING

**Unit - I**

Introduction to Simulation - areas of applications - systems – Components – discrete and continuous systems – types of models - simulation study steps – simulation examples – simulation of queuing systems, inventory systems and reliability problem.

**Unit - II**

General Principles – concepts in discrete event simulation - buildings blocks - world view – manual simulation using event scheduling and operations - List processing – basic properties**.**
Introduction to programming languages – simulation in FORTRAN, GPSS, SIMAN, SLAM and MODSIM – Comparison.

**Unit - III**

Simulation of manufacturing systems – models, goals and performance measures issues - some preliminary case studies of simulation of manufacturing - study of Softwares available in the market – SIM FACTORY II.5, ProModel, AutoMod, Arena, AIM, Witress, Taylor - II.

**Unit - IV**

Mathematical and statistical models in Simulation – review of terminology and concepts – useful statistical models – discrete distributions – continuous – empirical distribution - Poisson process.
Basic concepts of queuing models and estimation of performance measures.

**Unit - V**

Analysis of simulation data - nput data models, Collection of data, identification of statistical distribution, estimating parameters and testing for goodness of it.
Verification and validation of simulation models - Face validity, Validation of assumptions, Input - Output validation.

**REFERENCE BOOKS**


1. Jerry Barks et al - Discrete Event System Simulation, Prentice Hall, NJ, 1996.
2. A.M.Law and W.D.Kelton - Simulation Modeling and Analysis, II Edition, McGraw Hill, NY, 1991.
3. Shannon and E.Robert - Systems Simulations -The Art and Science, Prentice Hall, Englewood Cliffs, NJ, 1975.
4. Irwin R.Miller et al - Probability & Statistics for Engineers, PHI Pvt. Ltd, New Delhi, 1992.
5. Barry L.Nelson, - Stochastic Modeling - Analysis & Simulation, McGraw Hill, NY, 1995.

## ME961 TOTAL QUALITY MANAGEMENT

**Unit - I**

Introduction to TQM – Strategies concepts and objectives – Total quality model – TQM as applied to Indian Industries – Quality circle concepts – concepts, objectives and functions of quality circles – Benefits of the organization – Training of quality Circle members – Implementation.

**Unit - II**

Tools and Techniques – The seven management tools - Technique for analyzing a quality process – Statistical process Control

**Unit - III**

Cost of quality – Taguchi's quality loss function – House keeping concepts for industries, tool room, production shop – processing industries.

**Unit - IV**

Quality based product and process Design – Design for reliability – Design for maintainability – Quality Function Deployment (QFD) – QFD and Quality Assurance – QFD Principles, Concepts and applications – case studies.

**Unit - V**

Introduction to SQC concepts- KAIZEN Concepts – Kaizen by TQC – POKA YOKE - IS 9000-QS9000,14000 concepts- certification system – 9001 to 9004 systems – procedures, audits and reviews – Lean manufacturing systems- Toyota production concepts-case studies.

**REFERENCE BOOKS**


1. S.M.Sundara Raja - Total Quality Management Tata Mc Graw Hill, 1998.
2. Patrick.J.Sweeney(Editor) - TQM for Engineering, Quality Resources, Newyork, 1993.
3. John Bank - The Essence of Total Quality Management, Prentice Hall of India, 1998.
4. James I Bossert - Quality Function Deployment, ASQC Quality Press, Wisconsin, 1994.

## ME962 TRIBOLOGY IN DESIGN

**Unit - I**

Surfaces, Friction and Wear- Topography of the surfaces - Surface features - Surface interaction - Theory of Friction - Sliding and Rolling Friction, Friction properties of metallic and non-metallic materials - friction in extreme conditions - Wear, types of wear - Mechanism of wear - Wear resistance materials - Surface treatment - Surface modifications – Surface coatings.

**Unit - II**

Lubrication Theory - Lubricants and their physical properties lubricants standards - Lubrication Regimes Hydrodynamic lubrication - Reynolds Equation, Thermal, inertia and turbulent effects - Elasto hydrodynamic and plasto hydrodynamic and magneto hydrodynamic lubrication - Hydro static lubrication - Gas lubrication.

**Unit - III**

Design of Fluid Film Bearings - Design and performance analysis of thrust and journal bearings - Full, partial, fixed and pivoted journal bearings design - Lubricant flow and delivery - power loss, Heat and temperature rotating loads and dynamic loads in journal bearings - special bearings - Hydrostatic Bearing design.

**Unit - IV**

Rolling Element Bearings - Geometry and Kinematics - Materials and manufacturing processes - contact stresses - Hertzian stress equation -Load divisions - Stresses and deflection - Axial loads and rotational effects, Bearing life capacity and variable loads - ISO standards - Oil films and their effects - Rolling Bearings Failures.

**Unit - V**

Tribo Measurement and Instrumentation - Surface topography measurements - Electron microscope and friction and wear measurements - Laser method - Instrumentation - International standards - Bearings performance measurements - Bearing vibration measurement.

**REFERENCE BOOKS**


1. Cameron, A. - Basic Lubrication Theory, Ellis Herward Ltd. , UK,1981.
2. Hulling , J. (Editor) - Principles of Tribology, MacMillan ,1984.
3. Williams J.A . - Engineering Tribology, Oxford Univ. Press ,1994.
4. Neale M.J , - Tribology Hand Book , Butterworth Heinemann, 1995.
5. B.C.Majumdar - Introduction to Tribology of Bearings, Allied publishers.
6. D.F.Moore - Principles and Application of Tribology, Pergamon Press
7. D.D.Fuller, - Theory and Practice of Lubrication for Engineers, John Wiley & Sons, New York.