MECHANICAL ENGINEERING DEPARTMENT
MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY
ALLAHABAD-211004
M. TECH. ALL COURSES
LIST OF PROFESSIONAL ELECTIVES I & II

1.	ME	901	Finite Elements Method	(PDD)
2.	ME	902	Computer Aided Design	(PR)
3.	ME	903	Computer Aided Manufacturing	(D+PDD)
4.	ME	905	Mechatronics	(D+PDD+PR)
5.	ME	906	Computer Integrated Manufacturing	(D+PDD+PR)
6.	ME	917	Product design and development	(D+CC+PR)
7.	ME	920	Advanced Manufacturing Technology	(CC+D+PDD)
8.	ME	924	Design for Manufacturing and Assembly	(CC+D+PR)
9.	ME	950	Measurement System Design	
10.	ME	951	Rapid Prototyping and Manufacturing	(CC+D+PR)
11.	ME	952	Product Development	(CC+D+PR)
12.	ME	953	Reverse Engineering	
13.	ME	954	Nano Technology	
14.	ME	955	Precision Engineering	
15.	ME	956	Concurrent Engineering	
16.	ME	957	Artificial Intelligence in Engineering	
17.	ME	958	Evolutionary Algorithms in search and optimization	
18.	ME	959	Systems Dynamics and control	
19.	ME	960	Flexible Manufacturing System	(D+PDD+PR)
20.	ME	961	Design Against Fatigue and Fracture	(CC+PDD+PR)
21.	ME	962	Noise and Vibration	
22.	ME	963	Computer Graphics	(PR)
23.	ME	964	Turbo Pumps Design	
24.	ME	965	Design of Mechanical Systems	(CC+D+PDD)
25.	ME	966	Tool Design	
26.	ME	967	Logistics and Supply Chain Management	(PDD+PR)
27.	ME	968	Machine Tool Dynamics	
28.	ME	969	Advance Welding Technology	(D+PDD+CC)
29.	ME	970	Modeling and Simulation in Engineering	
30.	ME	971	Total Quality Management	
31.	ME	972	Ergonomics	D+CC+PR)
32.	ME	974	Micro Electrical Mechanical Systems	
33.	ME	975	Market Research and Forecasting	
34.	ME	976	Management of Technology and Innovation	
35.	ME	977	Neural Network and Fuzzy Logic	
36.	ME	978	Design of Robotic Systems	(D+PDD)
37.	ME	979	Tribology	
38.	ME	980	Fatigue damage and life prediction of Engineering Materials	(CC+PDD+PR)
39.	ME	981	Thermo-fluid dynamics	
40.	ME	982	Advanced Gas Dynamics	
41.	ME	983	Fans, Blowers& Compressors	
42.	ME	984	Gas Turbine and Jet Propulsion	
43.	ME	985	Automobile Systems – Designer's Approach	
44.	ME	986	Forensic Engineering	
45.	ME	987	Design of Experiment	

46.	ME	988	Wave Propagation
47.	ME	989	Design and analysis of Rotor Bearing System
48.	ME	990	Principles of Engineering Design
49.	ME	991	Design of Pressure Vessels
50.	ME	992	Experimental Stress Analysis
51.	ME	993	Creativity Engineering
52.	ME	994	Laser Material Processing
53.	ME	995	Advanced Mechanism Design
54.	ME	996	Control of Automotive Systems

CC: Computer aided Design and Manufacturing; D: Design; PDD: Product Design and Development; PR: Production

ME- 901: FINITE ELEMENT METHOD

Introduction and Direct Approach FEM: Concept of FEM, History, Packages, Range of applications, Steps in FEM, Approaches of FEM, Development of Elemental Equations for simple systems (i) Single dof problems-Spring Network, Hydraulic Network and Resistance Network (ii) Two dof problems-Plane Trusses and Frame structures; Assembly Procedure, Application of Boundary Conditions; Solver Technology: Linear direct solver, Iterative solvers, Eigen solver, Non-linear equation solver

Galerkin's and Rayleigh-Ritz FEM for 1-D and Radially Symmetric Scalar Field Problems: Concept of Galerkin's and Raleigh-Ritz Mathematical Approaches, Governing Equation and Boundary Conditions for Heat Transfer-Rod and Fin, Solid Mechanics-Bar extension and Beam bending; Fluid Dynamics-parallel wall flow; Electrostatics and Magnetostatic problems; Weak Formulation and Functional, Polynomial Approximation, Standard 1-D Shape Functions of C0 and C1 Continuity Elements, Derivation of Element Matrices and Vectors, Assembly, Imposition of Boundary Conditions and Nodal Solution; Co-ordinate Transformation and Numerical Integration. Transient and Eigen Value Problems

Galerkin's and Rayleigh-Ritz FEM for Plane (2-D) and Axisymmetric SINGLE VARIABLE Problems: Governing Equation and Boundary Conditions-Heat Transfer, Solid mechanics-Rod Torsion, Fluid Dynamics-Stream function and Velocity potential formulation, Electrostatics and Magnetostatic Problems, Weak Formulation and Functional, Polynomial Approximation, Standard 2-D Shape Functions of C0 Continuity Elements, Derivation of Element Matrices and Vectors, Assembly, Imposition of Boundary Conditions and Nodal Solution; Mapping and Numerical Integration; Transient and Eigen Value Problems

Galerkin's and Rayleigh-Ritz FEM for Plane (2-D) and Axisymmetric MULTI-VARIABLE Problems: Governing equation and Boundary conditions- Stress Analysis and Fluid Flow Analysis Problems: Weak Formulation and Functional, Polynomial Approximation, Derivation of Element Matrices and Vectors, Assembly, Imposition of Boundary Conditions and Nodal Solution, Post processing of solutions

Galerkin's and Rayleigh-Ritz FEM for 3-D Problems: Governing equation and Boundary conditions-Heat Transfer and Elastic Stress Analysis Problems, Weak Formulation and Functional, Polynomial Approximation, Standard 3-D Shape Functions of C0 Continuity Elements, Derivation of Element Matrices and Vectors, Assembly, Imposition of boundary conditions and Nodal Solution; Mapping and Numerical Integration

ME-902: COMPUTER AIDED DESIGN

Introduction: Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.

Curves: Fundamental of Curve Design, Parametric Space of a Curve, Reparametrization, Space Curves: Spline Curves, Bezier Curves, B-Spline Curve, Rational Polynomials, Rational curves, NURBS.
Surfaces: Fundamental of Surface Design, Parametric Space of a Surface, Reparametrization of a Surface patch, Sixteen point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B-Spline Surface.
Solids: Fundamental of Solid Design, Parametric Space of a Solids; Continuity and composite Solids, Surface and Curves in a Solid.
Solid Modeling: Topology and Geometry, Set theory, Euler Operators, Regularized Boolean Operators, Construction Criteria, Graph Based Models, Instances and Parameterized Shapes, Cell-decomposition and Spatial Occupancy Enumeration, Sweep representation, CGS, BRep, Wireframe Analytical properties, Relational properties and Intersection. Applications in Mechanical Engineering Design.

M E 903: COMPUTERS AIDED MANUFACTURING

Fundamentals of Numerical Control: Need and future of NC Systems, Principles and Types of NC, Design Features of NC M/c Tools; Machining Centre; **NC Part Programming:** Manual, computer Assisted-APT, EXAPT, ADAPT and CAD based Part Programming; **Feedback Devices-**Resolvers, Encoders, and Inductosyns; **Actuation Systems-** Hydraulic, Pneumatic and Electromechanical**; Computer Control and Adaptive Control System-**CNC, DNC and AC; **Flexible Manufacturing Systems-**Concept and Classification, Types of Flexibility, pallets, fixtures, work handling systems, simulation and analysis in the design of FMS; **Concurrent Engineering-**Objectives, tools and applications; **Automated Quality Control Systems-**Working, Programming and Applications of CMM

ME- 905: MECHATRONICS

Fundamentals of Mechatronics, definitions and concepts. Conventional vs. Mechatronics Systems. Need of Mechatronics in Mechanical Engineering. Sensors and transducers with special reference to mechatronics. Signals system and actuating devices, real time interfacing. Application of mechatronics in manufacturing and automation case studies.

ME -906: COMPUTER INTEGRATED MANUFACTURING

Fundamentals of Automation in Manufacturing Systems: Manufacturing Systems: Concept Objectives, Types and Trends; Concepts of Mechanization, Automation and Integration**; Functions and Components of CIM System:** Concept of CAD/CAM and CIMS**; Software Technology for CIM System:** Business Database System: File processing, Data Processing and Database Design, File Organization and Relational Analysis; Decision Support System, Personal/Distributed Computing and Local Area Network**; Group Technology and Cellular Manufacturing:** Concept of Group Technology and its Application, classification and Coding Techniques; Clustering Techniques and Cellular Manufacturing**; 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); **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**; Automated Material Handling Systems:** Industrial Robots, Conveyors, AGVs, Automatic Storage and Retrieval Systems**; Advanced Manufacturing Systems:** Lean Manufacturing systems, Agile Manufacturing systems, Reconfigurable Manufacturing Systems, Holonic Manufacturing Systems and Agent-Based Manufacturing Systems

ME-917: PRODUCT DESIGN AND DEVELOPMENT

Introduction

Significance of product design, product design and development process, sequential engineering design method, the challenges of product development,

Product Planning and Project Selection: Identifying opportunities, evaluate and prioritize projects, allocation of resources

Identifying Customer Needs: Interpret raw data in terms of customers need, organize needs in hierarchy and establish the relative importance of needs.,

Product Specifications: Establish target specifications, setting final specifications,

Concept Generation: Activities of concept generation, clarifying problem, search both internally and externally, explore the output,

Industrial Design: Assessing need for industrial design, industrial design process, management, assessing quality of industrial design,

Concept Selection: Overview, concept screening and concept scoring, methods of selection.

Theory of inventive problem solving (TRIZ): Fundamentals, methods and techniques, General Theory of Innovation and TRIZ, Value engineering Applications in Product development and design, Model-based technology for generating innovative ideas

Concept Testing: Elements of testing: qualitative and quantitative methods including survey, measurement of customers' response,

Intellectual Property: Elements and outline, patenting procedures., claim procedure,

Design for Environment: Impact, regulations from government, ISO system.,

Text books and references:

1. Ulrich K. T, and Eppinger S.D, Product Design and Development, Tata McGraw Hill
2. Otto K, and Wood K, Product Design, Pearson
3. Engineering of creativity: introduction to TRIZ methodology of inventive Problem Solving, By Semyon D. Savransky, CRC Press.
4. Inventive thinking through TRIZ: a practical guide, By Michael A. Orloff, Springer**.**
5. Systematic innovation: an introduction to TRIZ ; (theory of inventive Problem Solving), By John Terninko, Alla Zusman, CRC Press.

ME 924: DESIGN FOR MANUFACTURING AND ASSEMBLY

Introduction: Design philosophy steps in Design process — General Design rules for manufacturability — basic principles of design Ling for economical production — creativity in design. Materials: Selection of Materials for design Developments in Material technology -- criteria for material selection — Material selection interrelationship with process selection process
selection charts.

MACHINING PROCESS: Overview of various machining processes -- general design rules for machining - Dimensional tolerance and surface roughness — Design for machining — Ease — Redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

METAL CASTING: Appraisal of various casting processes, selection of casting process, - general design considerations for casting — casting tolerances — use of solidification simulation in casting design — product design rules for sand casting.

METAL JOINING: Appraisal of various welding processes, Factors in design of weidments — general design guidelines — pre and post treatment of welds — effects of thermal stresses in weld joints — design of brazed joints. Forging — Design factors for Forging — Closed die forging design — parting

lines of die5 drop forging die design — general design recommendations. Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing — Keeler Goodman Forming Line Diagram — Component Design for Blanking.

ASSEMBLE ADVANTAGES: Development of the assemble process, choice of assemble method assemble advantages social effects of automation.
AUTOMATIC ASSEMBLY TRANSFER SYSTEMS : Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine.

DESIGN OF MANUAL ASSEMBLY: Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and
size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.

REFERENCE BOOKS:

1. Geoffrey Boothroyd, "Assembly Automation and Product Design", Marcel Dekker Inc., NY, 1992.
2. Engineering Design – Material & Processing Approach – George E. Deiter, McGraw Hill Intl. 2nd Ed. 2000.
3. Geoffrey Boothroyd, "Hand Book of Product Design" Marcel and Dekken, N.Y. 1990.
4. A Delbainbre "Computer Aided Assembly London, 1992.

ME 950: MEASUREMENT SYSTEM DESIGN

Introduction and Measurement Fundamentals

Performance Characteristics of Instruments:

Static Characteristics and Static Calibration, Dynamic Characteristics

Measuring Device:

Motion and Dimensional Measurement, Force, Torque and Shaft Power Measurement, Pressure and sound Measurement, Flow Measurement, Temperature Measurement

Manipulating, Computing, and Compensating Devices:

Bridge Circuits, Amplifiers, Filters, Integration and Differentiation

Virtual Instrumentation:

LabVIEW/Simulink Programming. Case studies on the following:

a) Virtual oscilloscope.
b) Thermal measurement using RTD and thermocouple.
c) Strain based measurement
d) Vibration measurement
e) LVDT based measurement

Data Acquisition & Signal Conditioning:

Introduction**,** Quantizing Theory**,** Hardware for Analog to Digital Conversion**,** Analog to Digital (A/D) Conversion**,** Digital to Analog (D/A) Conversion

References:

1. Measurement Systems E.O. Doebelin and D. N. Manik TMH
2. Mechanical Measurements Beckwith and Buck Addison Wesley

3. Experimental Methods for engineers J.P.Holman McGraw Hill
4. Virtual Instrumentation Using Lab View Sannjay Gupta, John Joseph TMH
5. LabView style book Peter A Blume Virtual Instrument Series Prentice Hall

ME-951: RAPID PROTOTYPING AND MANUFACTURING

Introduction: Phases of Prototyping. Fundamentals of R.P. Classification of R.P. Processes.
Rapid Prototyping Process: Automated Processes, Difference between Additive and Subtractive Processes, Process Chain, steps in involved in R.P.
Types of R.P. systems: Liquid Based, Solid Based & Powder Based. Data Formats in R.P. Application of R.P. in Manufacturing and Rapid Tooling. Evaluation and Benchmarking, Modeling practice on softwares such as IDEAS, UNIGRAPHICS, ProE, etc.

ME-952: PRODUCT DEVELOPMENT

Ideonomics: Introduction, Elements of ideonomics, method of accumulating ideas, individual approach, Team approach, Brain Storming, Research Method, Approach and Survey Methods.
Ideonomics in Engineering design: Introduction, Important Facts about information, categories of information Rationality about information. Sources of information and collection of information.
Need Heedolgy: Introduction, Variety of needs. Analysis of statement of need, Need Analysis.
Structure and Morphology of Design: Morphology of Design: Morphology of design. The design process, Flow of work during the design process.
Design: Design by Evolution, Design by Innovation, Creative design routes, Design by Scientific logic and prepositional calculus.
Identification: Introduction, Aids and identification of problem. Conversion of Goals to engineering Problem. Problem identification and Systematic design. Testing techniques, Specifications technical and standard. Techniques of Decision Making in Designing from large number of feasible alternatives. Considerations of social and environmental factors, Reliability and maintainability.
Ergonomics and Human factors.
Qualifying of Design by applying comprehensive test programme and probabilistic approaches in design. Economics in Engineering Design and Optimization. Economics in Engineering Design, value analysis and Economics Evolution Formulae.
Aesthetic: Concepts of Aesthetics for engineering and Aesthetic elements for Design. Consideration of Production Aspects.

ME-953: REVERSE ENGINEERING

Introduction of Reverse and concurrent engineering. Elements of concurrent engineering. Advantage and applications.
Theory of measurements: Linear, angular, curved surfaces, methods of advanced Measuring devices, Coordinate Measuring machine. Elements to CMM. Data accumulation, retrieval.
Geometric Modeling: 2D and 3D Graphics, concepts of various transformations of Geometric Models, Wireframe surface and solid modeling techniques, representation of parametric and non-parametric curves and surfaces, Mathematical representation of solid and solid modeling- based applications. CAD/CAM data exchanges. Visual realism and Graphics Tools.
Applications: Auto-CAD, Auto surt, Auto Mil., and UNIGRAPHICS. CAD/CAM interfaces, process planning, computer aided production planning systems. Capacity planning. Part Programming. APT, CAPPS programming, Geometry definition, Tool Path generation.
Rapid Prototyping: Concurrent Engineering, Need of Rapid Prototyping. Techniques, Resins, (Laser engines) Laser, Laser production and control. Post curing, Data retrieval from CAD, MIC codes generation, Apparatus for quality measurement. (CMM) .

ME-954: NANOTECHNOLOGY

Introduction: Background and Fundamentals of Nanotechnology
Methods of Measuring Properties: Structure, Microscopy, Spectroscopy
Properties of Individual Nanoparticles: Metal Nanoclusters, Semiconducting Nanoparticles, Rare Gas and Molecular Clusters, Methods of Synthesis

Carbon Nanotubes: Fabrication, Structure, Electrical Properties, Vibration Properties, Mechanical Properties, Applications of Carbon Nanotubes
Bulk Nanostructured Materials: Solid Disordered Nanostructures, Nanostructured Crystals
Nanomachines and Nanodevices: Microelectromechanical Systems (MEMs) and Nanoelectromechanical Systems (NEMs) Technology, Fabricating MEMS and NEMs, Advantages of MEMs and NEMs.
Thin Film Deposition Processes: Chemical Vapor Deposition (CVD), Electrodeposition, Epitaxy, Thermal oxidation, Physical Vapor Deposition (PVD), Evaporation, Sputtering, Casting. Lithography
Etching Processes: Wet etching and Dry etching
Mirco/ Nano Tribology: Measurement Technique, Friction and Adhesion: Atomic scale friction, Micro scale friction; Scratching, Wear, Local Deformation and Fabrication/ Machining, Indentation, Lubrication, Challenges and advances in Nanomaterials processing techniques

ME-955: PRECISION ENGINEERING

History, Basic concepts, Dynamic characteristics of device Elements like bearings, locks and stops, coupling clutches, energy storing elements etc. Gear, Wedge, Screw and linkage mechanism Instruments for displacement, velocity acceleration, force and torque. Precision systems like video discs and d rives, laser printer etc. Design considerations for environments cooling electronic equipment. Systematic approach for design.

ME-956: CONCURRENT ENGINEERING

Meaning and Purpose of Concurrent Engineering, Techniques of Concurrent Engineering - Quality Function Deployment (QFD), Design for manufacture (DFM), Design for assembly (DFA), Taguchi method for Robust design (TMRD), Failure mode and effect analysis (FMEA), Design for reliability, maintainability and serviceability, Implementation of Concurrent Engineering

ME-957: ARTIFICIAL INTELLIGENCE IN ENGINEERING

Introduction to expert system, Introduction to Artificial intelligence, Expert system, Overview, Development of expert systems, Problem presentation, Expert system structure, knowledge basis and representation, inference mechanism, introduction to PROLOG, data structure, Backtracking and cut, input-output, predates.
Equipment selection, Layout design, Material handling, CAPP.
Feature extraction and Recognition, Bar code and coding of components.
Automatic storage and Retrieval
Qualitative reasoning, Fuzzy logics, neural nets, application from manufacturing.

ME-958: EVOLUTIONARY ALGORITHMS IN SEARCH AND OPTIMIZATION

Traditional Optimization Methods
Role of biologically inspired optimization techniques: Brief introduction
Difficulties in search; Optimization and machine learning
Overview of natural evolution and its abilities

Genetic algorithms: reproduction, crossover and mutation. Analysis of GA-operators. Reproduction, Crossover, Mutation, Shape Modeling. Choice of Probabilities for GA operators, Termination Criterion, Implementation. Examples: Deception; Multimode and multi- objective optimization; engineering applications.
Ant colony optimization, Swarm intelligence, Tabu Search and their applications like TSM
Introduction with applications for evolution strategy and simulated annealing: Examples in various fields in engineering practices
Neural networks Bayesian learning: adaptive resonance theory, operations in ART networks, ART-I training algorithm

ME-960: FLEXIBLE MANUFACTURING SYSTEMS

Introduction, purpose and definition, architecture of FMS, CNC, DNC, Hardware and of software's auxiliary devices in FMS, MS operation control. Production scheduling in FMS. FMS scheduling rules, FMS capacity planing and control. Part programming, computer assisted part programming methods, robotics, introduction, classification, Hardware details of robot elements, Principles of robot programming, Automated Guided vehicles, classification and elements supervisory systems, Application on welding assembly, material handling, Economics of FMS technology.

ME-961: DESIGN AGAINST FATIGUE FRACTURE

FRACTURE MECHANICS:
Fracture Mechanics approach to design
Linear Elastic Fracture Mechanics (LEFM): stress concentration effect of flaws, Cracks as stress raisers**;** The Griffith energy balance, The energy release rate, Crack growth instability analysis and R-curve, Stress analysis of cracks: Generalised In-plane Loading (Williams approach), Westergaard stress function, Behaviour at Crack Tips in Real Materials**;** Effects of Cracks on Strength**;** Effect of Cracks on Brittle versus Ductile Behaviors, The stress Intensity factor K, Effect of size, Principle of superposition, Weight functions, Crack tip plasticity, Fracture toughness, K as a failure criterion, Trends of K_{IC} with material; Effects of Temperature and loading rate.; Microstructural Influences on K_{IC}; Mixed mode fracture.
Elastic-Plastic Fracture Mechanics (EPFM): Crack tip opening displacement, The J-contour integral, J as a nonlinear energy release rate, The HRR singularity, J as a Path-Independent Line Integral, J as a Stress Intensity Parameter, The large strain zone, Laboratory measurement of J, Relationship between J and CTOD
FATIGUE OF MATERIALS: Micromechanism of fatigue, Introduction, Fatigue Design Criteria : Infinite life design, safe life design,fail-safe design, Damage Tolerant Design, Fatigue Tests and the stress-life (S-N) Approach, Cyclic deformation and the strain-life (ε-N) approach, Fundamentals of LEFM and application to fatigue crack growth : LEFM concepts, Cyclic plastic zone size, fatigue crack growth, mean stress effect, Experimental measurement of fatigue crack growth, Fatigue from variable amplitude loading: Spectrum loading, Cumulative damage theories, Load interaction and sequence effects, cyclic counting method, crack growth and life estimation methods.

REFERENCE:

1. Fracture Mechanics: Fundamentals and Applications T.L.Anderson CRC Press
2. Fundamentals of Fracture Mechanics J.F.Knott Butterworths
3. Metal Fatigue in Engineering Stephens, Fatemi, Fuchs and Stephens John Wily
4. Fatigue Damage, Crack Growth and Life Prediction F.Ellyin Chapman & Hall
5. Elementary Engineering Fracture Mechanics. D. Broek Kluwer Academic

ME-962: NOISE AND VIBRATION

Noise: Random aspects of noise, traffic noise community noise, automobile noise, jet noise, aircraft noise. Sonic bang, acoustic fatigue. Industrial noise, noise in piping system. Noise in machines and components of reciprocating and rotating machines.
Noise control systems, types and design of exhaust mufflers, sound absorbing materials.
Noise measurement and instrumentation. Effect of noise on human beings.
Vibration: Introduction: Systems with one degree of freedom, Free and forced vibration, torsional vibration. Analysis by Rayleigh's method. Stodola method and iterative method of Holtzer. Analysis and application of forced vibration in steady state as well as transient state, self excited vibrations. Free vibrations of systems with several degrees of freedom. Free vibration of elastic bodies, Free longitudinal vibrations of Prismatic bar, orthogonality principle.

ME-963: COMPUTER GRAPHICS

Recent development in Computer Graphics, Scope, Graphic standards and hardware requirements for interfacing. Raster scan graphics, fundamental requirement and plotting of a point, line drawing, DDA and Breaseenham's line algorithm, circle generation using bresenham's algorithm. Two-dimensional transformation, basic and inverse geometric transformations, clipping and clipping algorithms.
Elements of 3-D Graphics, Projections, representations of polygons and solid modeling.
Development of curves and surface using Bazier, Hermiyte and B-spline algorithms. Evaluation of Curves length, surface area and volume of objects of visual realism. Hidden line removals. And shading algorithms
Use of application software packages for drafting and Used of plotters, scanners drawing of simple.
Assembly drawing using drafting packages.

ME-964: TURBO PUMPS DESIGN

Introduction: Classification, Applications, Idea of three dimensional flow through turbo machines, Axi-symmetric flow, Basic quantities-head, discharge, power and efficiencies, Dynamic similarity of impeller pumps physical quantities, specific speed
Flow through Impeller: Velocity triangles, Euler's work, Theoretical head for finite and infinite number of blades, the influence of finite number of blades, pressure and velocity distribution in impeller. Prewhirl, Degree of reaction, Choice of shape of blade forward, Radial and backward, flow through cascades, Axial and radial thrust, Cavitation in axial and centrifugal pumps. Thoma cavitation factor, Materials resistant to cavitation, Method of preventation of cavitation, Characteristics of pumps, testing of pumps.
Design and Drawing of Impeller Pumps:
(a) Centrifugal pumps, Radial impeller shape, Impeller with blades of single and double curvature by (I) circular arc method and (ii) point by point method. Volute casing, U-turn, Vaned diffuser, Return Channel, Inlet elements.
(b) Mixed flow pumps- helical pumps
(c) Propeller pumps-by aerodynamic method
Recent advances in Impeller pumps

ME-965: DESIGN OF MECHANICAL SYSTEMS

Computer Aided Design of one of the following mechanical system with its components. Only one of the sub systems is to be designed.
Refrigeration System: Design of any of the sub-system of compressor condenser or evaporator. Optimum design for minimum cost & maximum performance.
Automobile System: Design of clutch gearbox and brakes for given power and speed requirements.
I.C.Engines: Design of piston, cylinder, connecting rod, Crankshaft, Cam, Camshaft and Valves.
Machine Tools: Power requirement calculations, frame, bed and guide ways, spindle & bearing design.

ME-966 TOOL DESIGN

General consideration in tool design; **Design of Dies**: Upsetting, Forging, and Extrusion, Application of Computer for design of dies; Sheet metal cutting & Farming dies; Design of tooling for deep drawing; Design of Jigs and Fixture- Work holding devices, Location, Clamping and Indexing; Design of gauges; Design of cutting tools-single point & multipoint cutting tools.

ME-967 LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Introduction to Logistics and Supply Chain Management; Concepts, Drivers and obstacles; Planning Demand and supply in a supply chain-Demand forecasting, Aggregate Planning; Management of Inventory in global supply Chain; Role of Information Technology in supply chain. e-Business and the supply chain; Factors influencing logistics and decision; Bench making and performance measurement.

ME-968 MACHINE TOOL DYNAMICS

General features of Chatter. Various theories of machine tool chatter. Experimental investigation of machine tool stability. Dynamic acceptance tests. Damping in machine tool Chatter in turning, grinding , drilling and mailing processes. Static and dynamic analysis of machine tool structure by lumped parameter. Concept of consistent mess and stiffness matrices of machine tool structure and their identification and modifications. Use of modal analysis in machine tool dynamics.

ME-969 ADVANCED WELDING TECHOLOGY

A review of various metal joining techniques such as welding, brazing, soldering and adhesive bonding, welding compared with other processes of fabrication. Classification of welding processes. Application of welding processes; **Fusion Welding**: Mechanism of arc initiation and maintenance, Temperature distribution. Techniques, scope and limitations of manual metal arc. TIG, MIG, submerged arc. Electroslag welding. Plasma Arc and Electro gas welding. Various gas welding processes e.g. oxyacetylene oxy-hydrogen welding processes; **Resistance welding**, Modern welding processes viz. Electron Beam, Ultrasonic; Explosive, laser beam processes and their applications. Solid state welding processes viz. Friction, Diffusion, cold pressure process and their applications; Oxygen cutting Plasma Arc cutting. Laser cutting processes etc; Brazing, soldering and adhesive bonding. Scope and application; Welding defect and remedies. Weld cracking and prevention. Testing and inspection of welds.

ME-970 MODELING AND SIMULATION IN ENGINEERING

Fundamental aspect of modeling: Technical and Commercial aspects, types of modeling-Analytical, experimental, mechanistic, numerical, AI based and stochastic. Model testing, Principles of simulation, Discrete event simulation. Applications in design and manufacturing.

ME-971 TOTAL QUALITY MANAGEMENT

Concept of quality, quality control and quality management; Science of quality, human resources and quality; Quality organization and management: Quality manual, quality cost, quality related tasks;

Quality information system: Planning, hardware-software; Statistical process control and quality deployment techniques; Controlling quality through measurement and through counting.
Quality system and I.S.O. 9000 series; Quality assurance, Reports on quality, quality audit, quality training; Newer quality management approaches; Quality tools.

ME- 972: ERGONOMICS

Introduction to Ergonomics; Elements of Anthropometry; Physiology, Anatomy; Biomechanics; Kinesiology; Workspace Design, Seating Design; Cumulative Trauma Disorders (CTDs); Manual Material Handling; Hand Tool Design; Human Information Processing; Cognitive ergonomics; Man-machine system interface, Displays and Controls, Principles of graphic user interface design; Compatibility environmental factors; Human errors, product safety, product liability.

References:

1. Sanders, S. M. and McCormick, E. J., "Human Factors in Engineering and Design", McGraw Hill.
2. Bridger, R. S., "Introduction to Ergonomics", CRC Press, Taylor and Francis Group.
3. Kroemer, K., Kroemer, H., and Kroemer-Elbert, K. E., "Ergonomics - How to design for ease and efficiency", Prentice Hall.
4. Dix, A., Finlay, J., Abowd, G. D. and Beale, R., "Human – Computer Interaction", Pearson Education.
5. Cacha, C. A., "Ergonomics and safety in hand tool design", CRC Press, Taylor and Francis Group.

ME-977: NEURAL NETWORKS AND FUZZY LOGIC

Basic Concepts: Physiology of Human Brain, Machine learning, Models of Neuron; Network Architecture, Artificial Intelligence & Neural Network.
Learning Processes: Error Correction learning, Memory based learning, Hebbian Learning, Competitive Learning, Credit assignment learning; Learning with a teacher, learning without a teacher, Memory Adaptation, Statistical learning theory.
Single Layer Perceptrons: Least mean square algorithm, learning curves learning rate annealing techniques; Perceptron, Perceptron Convergence Theorem.
Multi-Layer Feed Forward Neural Networks: Multi-Layer Perceptrons, Back Propagation Algorithm; Generalization, Cross Validation; Network Pruning Techniques, Accelerated Convergence of Back Propagation Learning.
Radial Basis Function Networks: Radial Basis Function Networks, Cover's Theorem; Regularization Theory, Regularization Networks, Comparison of RBF Networks & Multilayer Perceptron.
Recurrent Networks: Hopfield Networks; Recurrent Networks in System Identification; Recurrent Networks in Control
Principal Component Analysis: Hebbian based Principal Component Analysis Adaptive Principal Component Analysis using lateral inhibition; Kernel based Principal Component Analysis.
Self Organizing Maps: Self Organizing Map, Properties of the feature Map; Learning Vector Quantization, Contextual maps.
Fuzzy Logic: An introduction to fuzzy logic , Operations on fuzzy sets, Fuzzy relations , Fuzzy implications , Linguistic variables; An introduction to fuzzy logic controllers , Construction of data base and rule base of FLC; Defuzzification methods Inference mechanisms; A robustness study of fuzzy logic controller, Applications of fuzzy systems; Neuro-Fuzzy systems.

ME 978: DESIGN OF ROBOTICS SYSTEM

Introduction: Past, Present & Future; Robot Terminology; Applications, Components and Subsystems; Classification of Robot, End Effectors, Different types of grippers and design concepts.
Motion Analysis: Homogeneous transformations as applicable to rotation and translation – problems
Robot Kinematics: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics – problems. Differential transformation and manipulators, Jacobians – problems.
Dynamics: Lagrange – Euler and Newton – Euler formations – Problems.
Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion, straight line motion – Robot programming, languages and software packages.
Robot actuators and Feed back components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Feedback components: position sensors – potentiometers, resolvers, encoders – Velocity sensors.

1. Robotics / Fu K S/ McGraw Hill.
2. An Introduction to Robot Technology, / P. Coiffet and M. Chaironze / Kogam Page Ltd. 1983 London.
3. Robotic Engineering / Richard D. Klafter, Prentice Hall
4. Robot Analysis and Intelligence / Asada and Slow time / Wiley Inter-Science.
5. Introduction to Robotics / John J Craig / Pearson Edu.
6. Robot Dynamics & Control – Mark W. Spong and M. Vidyasagar / John Wiley & Sons (ASIA) Pte Ltd.
7. Robotics and Control / Mittal R K & Nagrath I J / TMH

ME 980: FATIGUE DAMAGE AND LIFE PREDICTION OF ENGINEERING MATERIALS

General concepts of Fatigue: Types of loading: rainflow counting method, Fatigue failure mechanisms, Factors affecting fatigue life, Fatigue design methodology: Safe-life design method, Fail-safe design method and damage tolerant design method.

Cyclic stress-strain response: Material response to cyclic deformation, stable cyclic response: microstructural changes during cyclic loading, determination of the cyclic curve, mathematical description of the stress-strain relationship, Analysis of hysteresis loops, Effect of temperature, environment and strain rate on sable cyclic response.

Fatigue life prediction under uniaxial loading: Stress, strain and energy based approaches**,** Cumulative damage: concept, multilevel cyclic loading, damage function, determination of the critical damage curve, residual stress influence on fatigue life.

Damage tolerant design: Concept, Mechanics of fatigue crack growth: elastic plastic response to cyclic loading, Microstructural mechanisms of Fatigue Growth (FCG); fatigue crack propagation models, Paris Law, Cyclic Plastic Zone Size, Load Ratio Effects, ΔK_{TH} Thresholds Stress/Strain Life Analysis, Low Cycle Fatigue, High Cycle Fatigue, Role of mean stress, crack closure, variable amplitude loading, Analytical methods for fatigue and life assessment in advanced materials.
Fatigue of notched members: Notch analysis: elastic analysis, stress distribution, nonlinear analysis, general approach, initiation and growth of cracks in notched members: fatigue notch factor approach, local strain approach, energy approach,
Environmental fatigue: Corrosion fatigue and fretting fatigue, low temperature and high temperature fatigue.
Fatigue and Failure of Joints and Structure, Methods to enhance fatigue resistance

Experimental Fracture Mechanics: ASTM standard for measurement of fatigue and fracture parameters

Suggested Reading:

1. ASTM Standards,:American Society for Testing and Materials
2. S. Suresh, Fatigue of Materials, Cambridge University Press, 1991.
3. J.Schijve, Fatigue of Structures and Materials, Kluwer Academic publ. 2001
4. D. Broek, Elementary Engineering Fracture Mechanics, Nordhoff Int. Pub.,1983.
5. S. Kocanda, Fatigue Failure of Metals, Sijthoff and Noordhoff Pub., 1978
6. R.I. Stephens , A.Fatemi, R.R. Stephens and H.O. Fuchs, Metal Fatigue in Engineering, 2nd Edition, John Wiley, 2001.
7. R.W. Hertzberg, Deformation and Fracture Mechanics of Engineering, Materials, John Wiley, 1983.
8. N.E. Frost, K.H. Marsh, & L.P. Pook, Metal Fatigue, Oxford University Press, 1974.
9. T.R. Gurney, Fatigue of Welded Structures, Cambridge University Press, 1979.
10. R.B. Heywood, Designing Against Fatigue of Metals, Reinhold, New York, 1962.
11. R.W. Hertzberg & J.A. Manson, Fatigue of Engineering Plastics, Academic Press, 1980.

ME 985: AUTOMOBILE SYSTEMS – DESIGNER'S APPROACH

Introduction to auto vehicles, various systems of automobiles, Power transmission:, Road and aerodynamic resistance calculation, Engine power calculation,
Transmission, systems. Layout.
Suspension systems: type of chassis, dependent and independent suspension, coil and leaf spring suspension, shock absorbers.
Steering systems, Power steering – options.
Braking system: Mechanical, Hydraulic, Vacuum and Pneumatic brake, their merits and demerits
Tires & Wheels requirements,
Vehicle Dynamics
Alternative power sources, electric vehicles, hybrid vehicles.
Road safety, Influence o f vehicle characteristics on accidents, alternative design, safety factors, designs for uncertainty, crash testing
Introduction of traffic engineering – Highway Engineering – geometric design of highways-accident caused. Accident analysis – Case studies.
Testing Automotive Materials & Components – case studies.

REFERENCES:

1. the Automotive Chassis by J. Reimpell, H Stoll – SAE International
2. The Motor Vehicle: by – Newton and Steed
3. Automotive vehicle safety – George A Peters & Barbara J Peters
4. A Text Book of Highway Engineering.
5. Automotive Engineering Fundamentals – Richard Stone and J K Ball
6. Chassis design – Principles and Analysis.

ME 986: FORENSIC ENGINEERING

Introduction to forensic engineering uses -case studies. to develop the skills you need for the analysis of product failure.
Failure of products and processes provides a 'toolbox' of techniques: observations, scientific and engineering tests that can be used to establish evidence of the causes of a failure in a metallic product or process.

Catastrophic failures –case studies -examines large-scale failures that have caused loss of life. The studies consider the roles of stress concentration in the design of critical components, poor manufacturing and poor design, material failures, and poor communications.
Intellectual property matters considers protection of new designs and inventive concepts. It concentrates on the arguments used for understanding particular patents, and the precedents that lawyers use for assessing construction, infringement and validity. Case studies include trials in which imitators were successfully sued by means of patents, and cases of new designs that were challenged unsuccessfully because the patents were weak or did not define the inventive concept widely enough to catch the alleged infringing product.

REFERENCES:

1. Introduction to Forensic Engineering (The Forensic Library) by Randall K. Noon, CRC Press (1992).
2. Forensic Engineering, By Kenneth L. Carper
3. FORENSIC ENGINEERING INVESTIGATION By: Randall K Noon
4. Understanding How components Fail by: Donald J Wulpi
5. International Journal of Engineering Failure Analysis.

ME 987: 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.

REFERENCE BOOKS:

1. Douglus C.Montgomery, Design and Analysis of Experiments, John Wiley & Sons.
2. Charles R.Hicks, Fundamental concepts in design of experiments, Holt, Rinehort and Winston.
3. Tapan P.Bagchi, Methods Explained: Practical steps to Robust Design, Prentice-Hall.
4. Cochran, WG and Cox, GM, 1957, Experimental Designs, Asia Publishing House.
5. Phadke M. S., Quality Engineering using robust design, Prentice-Hall.
6. Ross P. J., Taguchi Techniques for quality engineering, McGraw-Hill.

ME 988: WAVE PROPAGATION

Sample wave problems and elementary concepts
Taut string, elastic rod; Exponential notation, frequency, wave number, phase velocity, etc.

One-dimensional propagation
The wave equation; transient responses, characteristics; Dispersion; rod on elastic foundation, flexural waves in a beam; Group velocity; dispersion of transient waves, stationary phase; Group velocity and energy transport; Scattering of harmonic waves, radiation condition

Two-dimensional propagation
Plane waves; Nearly plane waves; geometrical acoustics P, SV and SH waves in elastic solids; Rayleigh waves in half space; Reflection and refraction from a plane interface, mode conversion; Scattering of elastic waves; diffraction, parabolic approximation Dispersion of waves in bounded solids. Waves in rods and plates; Solution of transient problems; Waves in anisotropic materials, Love waves in a layered medium; Introduction to waves in viscoelastic and plastic media.

Wave guides
Waves in an elastic layer,Cut-off frequencies,Forced response

References
K.F. Graff, Wave Motion in Elastic Solids, Dover, 1975.
F. S. Crawford, Berkeley Physics Course, Vol. 3: Waves, McGraw-Hill, 1968.
I. Tolstoy, Wave Propagation, McGraw-Hill, 1973.
G. B. Whitman, Linear and Nonlinear Waves, Wiley-Interscience, 1974.
J. A. Hudson, The Excitation and Propagation of Elastic Waves, Cambridge U.P., 1980.
H. Kolsky, Stress Waves in Solids, Dover, 1963.
J. D. Achenbach, Wave Propagation in Elastic Solids, North Holland, 1975.
J. Miklowitz, The Theory of Elastic Waves and Waveguides, North Holland, 1978.
S. Leibovich & A.R. Seebass, eds., Nonlinear Waves, Cornell U.P., 1974.

ME 992: EXPERIMENTAL STRESS ANALYSIS

Strain Gauge, strain rosettes and transducer applications, Case studies.

Photoelasticity, Stress-optic law. Photoelastic coatings Strain-optic law, photoelastic materials and their selection. Introduction to 3-D photoelasticity.

Role of Digital Image processing techniques for automation.

Brittle coating methods, Moire method of strain analysis, Holography, Speckle and Caustics.

Non-destructive testing using xrays and ultrasonic devices.

References:
J.W. Dally and W.F. Riely , Experimental Stress Analysis, McGraw-Hill, 1978
R.C. Dove and P.H. Adams, Experimental Stress Analysis and Motion Measurements, Prentice Hall, 1964 N.I.
Budynas, A. “Advanced Strength and Applied Stress Analysis”, McGraw□Hill

Daniel P, Bongtae H and Peter I, "High Sensitivity Moire: Experimental analysis for mechanics and material", Spriger-Verlag, NY

ME 993: CREATIVITY ENGINEERING

Definitions and the Theory of the Mechanics of Mind
Heuristics and Models: Attitudes, Approaches, and Actions That Support Creative Thinking, Human Processing-Brains and conscious mind, the subconscious mind-dreams, eureka, subconscious action, subconscious learning, solving a problem in the subconscious mind; Two sides of human thinking-use of presentiment, loading the subconscious mind; Intuitive creative work- tension, heuristic points-examples; Incubation; Routine and Inventive Problems, difficulty of a problem, psychological Inertia,
The Directed Creativity Cycle of Plsek:
A Synthesis Model of the Creative Process, Four phases of Preparation, Imagination, Development, and Action to organize the tools of directed creativity in other working.

Methods and Tools for Creativity
Basic principles behind the tools of creativity, Tools that prepare the mind for creative thought, Tools that stimulate the Imagination to come up with new ideas development and action: The bridge between mere creativity and the rewards of innovation

Intuitive methods of creative work: Intuitive solution, intuitive method- Penetrative analysis, Penetrative analysis of ones own work, Description of the whole process- example
Intuitive Engineering Design: Design Work Environment-Adjusting the Drafting Practice on Screen, Use of Colours, 2D- and 3D- drawings, Equipment, The Intuitive method of Creative Work in Engineering Design: Penetrative Analysis of the Task, Heuristic Points, Generation of a Multipurpose Component, Placement in the Intuitive Method
Comparison Between Intuitive and Systematic Methods: Beginning the Planning-Background, Need of the Product; Planning-Generating a List of Demands, Formulation of the Problem, Decomposing the Problem into Subsystems, Evaluating Alternative Solutions for Subsystems, Linking the Solutions of Subsystems, Concretising the Linked Solutions and Evaluation; Critique of Systematic Method; Intuitive Solution of the Task; **Organisation for Intuitive Engineering:** The latest knowledge, Reforming of the knowledge, Association; Creative Team; Knowledge Diffusion-an example; Knowledge Diffusion in Organisation; Product Design Process
Applying creativity to challenges of design
Process design, reengineering and creativity, creativity and customer needs analysis, Innovative product and service design, creative problem solving and incremental improvement
Theory of Inventive Problem Solving (TRIZ),
Designers Personal Growth: Human Capacity Required- Imagination, Humbleness and Cultural Relations, Faults in Progress of Designer-Inventions and Mania for Patenting, Far-reaching Thinking; Taking Advantage of the Subconscious Mind

References:

1. Design engineering: a manual for enhanced creativity, Volume 10, By W. Ernst Eder, Wolfgang Ernst.
2. Engineering of creativity: introduction to TRIZ methodology of inventive Problem Solving, By Semyon D. Savransky, CRC Press.
3. Inventive thinking through TRIZ: a practical guide, By Michael A. Orloff, Springer.
4. Systematic innovation: an introduction to TRIZ ; (theory of inventive Problem Solving), By John Terninko, Alla Zusman, CRC Press.

5. Make and test projects in engineering design: creativity, engagement and learning, By Andrew E. Samuel, Springer.
6. George E. Dieter, Engineering Design, 3 ed. McGraw Hill International Edition.
7. Creativity, Innovation, and Quality. by Paul E. Plsek (ASQC Quality Press, 1997)

ME 994: LASER MATERIAL PROCESSING

INTRODUCTION
Light and Laser – Historical background, Generation of laser beam, Classification, Characteristics and application of lasers. Lasers in engineering.

LASER BEAM MACHINING
Laser processing of materials and process capabilities, Laser beam machining (LBM), Process principle, analysis and applications of laser Drilling, Cutting, Turning, and Milling processes, Laser Micromachining.

LASER FORMING
Process principle, analysis and applications of Laser forming processes such as Bending and Deep drawing.

LASER WELDING AND SURFACE TREATMENT
Process principle, analysis and applications of laser welding, cladding, surface alloying and heat treatment processes.

LASER BASED RAPID PROTOTYPING
Process principle and analysis of laser based rapid prototyping such as Stereolithography, Selective laser sintering, Laminated object manufacturing, and Laser direct casting.

LASER ASSISTED MATERIAL PROCESSING
Laser assisted machining (LAM), Laser cleaning, and Laser hybrid machining processes.

Latest developments in laser material processing.

References:

1. Steen W. M., Laser Material Processing, Springer, 2003.
2. Luxton J.T., Parker D.E, Industrial lasers and their applications, Prentice Hall, 1987.
3. Chryssolouris G., Laser Machining- Theory and Practice (Mechanical Engineering Series), Springer, 1991.
4. McGough J. A., Advanced Methods of Machining, Chapman and Hall Ltd, 1988.
5. Jain V. K., Advanced Machining Processes, Allied Publishers, 2002.
6. Pandey P. C., Modern Machining Processes, Tata McGraw Hill, 1980.

ME 995: Advanced Mechanism Design

1.Mechanism Design Philosophy

Introduction to Kinematics and Mechanisms: stages of engineering design, the mechanism synthesis process, links, joints, and kinematic chains, determination of freedom or mobility, number synthesis, paradoxes, isomers, linkage transformation, intermittent motion, inversion, Grashof condition, linkages of more than four bars, compliant mechanisms, Micro Electro-Mechanical systems (MEMS).

2. Introduction to dynamics of mechanisms

Inertial forces in linkages, Kinetostatic analysis by complex numbers, superposition method, matrix method, design examples.

3. Graphical Linkage synthesis

Tasks of kinematic synthesis, limiting conditions, number synthesis: the associated linkage concept, dimensional synthesis, coupler curves, cognates, straight-line mechanisms, dwell mechanisms, other useful linkages, examples.

4. Position analysis

Coordinate systems, graphical position analysis of linkages, algebraic position analysis of linkages, algebraic position analysis of linkages, examples, transmission angles, toggle positions, circuits and branches in linkages, Newton-Rapson solution method

5. Analytical linkage synthesis

Analytical synthesis techniques, complex number modeling in kinematic synthesis, The Dyad or standard form, Precision points versus number of free choices, Motion, Path, and Function generation, Three prescribed positions for motion, path, and function generation, examples,Freudenstein's equation, loop closure equation technique.

6.CAM Design

SVAJ diagrams, Double-Dwell cam design-choosing SVAJ functions, Single-Dwell cam design-choosing SVAJ functions, Critical path motion (CPM), sizing the cam, cam manufacturing considerations, practical design considerations, CAM dynamics.

7. Balancing: Static balancing, dynamic balancing, balancing linkages, Effect of balancing on shaking and pin forces, Effect of balancing on input torque, balancing the shaking moment in linkages

Reference:

1. Mechanism Design: Analysis and Synthesis	Erdman, Sandoor	PHI
2. Design of Machinery	Norton	TMH
3. Kinematics and linkage design	Hall Jr.	Prentice Hall
4. Kinematic synthesis of linkages	Hartenberg, Denavit	Mcgraw Hill
5. Applied Linkage Synthesis	Tao	Addison Wesley