

DEPARTMENT OF MECHANICAL ENGINEERING, NIT, Hamirpur (HP)
M. Tech. (CAD/ CAM)

SCHEME (from July 2011)

Semester 1:

Course No.	Name	L – T – P	Credit	Remarks
ME – 610	Optimization Techniques	3 – 0 – 0	3	
ME – 611	Computer Aided Design	3 – 0 – 0	3	
ME – 612	CNC Machine Tools and Programming	3 – 0 – 0	3	
	Programme Elective I	3 – 0 – 0	3	
	Programme Elective II	3 – 0 – 0	3	
ME – 613	Laboratory-1	0 – 0 – 3	2	
Total Credits =			17	

Programme Elective I

- a). ME-721 Mechatronics
- b). ME-722 Computer Aided Inspection and Testing
- c). ME-723 Data Base Management Systems

Programme Elective II

- a). ME-726 Friction and Wear
- b). ME-727 Machine Tool Design
- c). ME-728 Modelling and Simulation

Semester 2:

Course No.	Name	L – T – P	Credit	Remarks
ME - 614	Industrial Robotics	3 – 0 – 0	3	
ME – 615	Rapid Prototyping and Manufacturing	3 – 0 – 0	3	
ME – 616	Flexible Manufacturing Systems	3 – 0 – 0	3	
	Programme Elective III	3 – 0 – 0	3	
	Open Elective	3 – 0 – 0	3	
ME - 617	Laboratory-2	0 – 0 – 3	2	
Total Credits =			17	

Programme Elective III

- a). ME-731 Bearing Design
- b). ME-732 Finite Element Method
- c). ME-733 Data Communication and Networking

Open Elective

- a). ME-760 Robotics
- b). ME-761 Management Information System

Semester 3:

Course No.	Name	L – T – P	Credit	Remarks
ME - 799	Self Study		2	
ME - 800	Seminar	0 – 0 - 3	2	
ME – 801	Dissertation		12	
Total Credits			16	

Semester 4:

Course No.	Name	L – T – P	Credit	Remarks
ME – 801	Dissertation		20	
Total Credits			20	

OPTIMIZATION TECHNIQUES

ME – 610

L T P C
3 0 0 3

1 **OPTIMIZATION PROBLEM FORMULATION:** Design variables, constraints, objective function and variable bounds. Single – variable.

2 **SINGLE VARIABLE OPTIMIZATION ALGORITHM:** Bracketing, Melliotls Exhaustive Search Method and bounding phase Method.

3 **REGION ELIMINATION METHODS:** Fibonacci Search method and Golden section search method. Gradient based methods, Newton -Raphson method, Bisection Method, Secant Method, and Cubic Search Method. Computer programs for bounding phase method and golden section search method.

4 **MULTIVARIABLE OPTIMIZATION ALGORITHMS:** Direct search methods. Simplex search method and Hooke-Jeeves pattern search method. Gradient based methods- Cauchy's, (steepest descent) method and Newton's method. Constrained Optimization Algorithms-Kuhn-Tucker conditions, penalty function method, method of multipliers, cutting plane method, Generalized Reduced Gradient method, computer program for penalty function method. Integer programming -penalty function method. Global optimization using the steepest descent method, genetic algorithms and simulated annealing.

BOOKS RECOMMENDED:

- 1 Optimization in Engineering Design -KalyanInoy Deb, PHI.
- 2 Optimization Methods -S. S.Rao, PHI.

COMPUTER AIDED DESIGN

ME – 611

L T P C
3 0 0 3

- 1 **INTRODUCTION:** Definitions, Historical Development. Geometric Modeling, Nameable and Unnamable shapes, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.
- 2 **DESIGN OF CURVES:** Algebraic and Geometric Forms, Parametric space of a curve, Blending functions, Reparametrization, Truncating, Extending and subdividing, Space curve, Four point form, Straight lines, Spline Curves, Bezier Curves, B-spline Curves, Rational Polynomials, introduction to NURBS
- 3 **DESIGN OF SURFACES:** Algebraic and Geometric form, Tangent and Twist Vectors, Normal, Parametric space of a surface, Blending Functions, Reparametrization of a surface patch, subdividing, Sixteen Point form, Four Curve Form, Plane surface, Cylindrical Surface, Ruled surface, Surface of Revolution. Bezier Surface, B-Spline Surface.
- 4 **SOLID MODELING FUNDAMENTALS:** Topology of Closed Paths, Piecewise flat surfaces, topology of closed curved surfaces, Generalized Concept of boundary, Set theory, Boolean operators, Set-membership Classification, Euler operators, Formal Modeling Criteria.
- 5 **SOLID MODEL CONSTRUCTION:** Graph Based methods, Boolean models, Instances and Parameterized Shapes, Cell Decomposition and spatial-Occupancy Enumeration, Sweep Representation, Constructive Solid Geometry, Boundary Representation
- 6 **TRANSFORMATIONS:** Translation, Rotation, Scaling Symmetry and Reflection, Homogeneous Transformations. Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Transformation.
- 7 **Introduction to Assembly-modeling,** Analytical Properties, Relational Properties and intersections, Data transfer formats.
- 8 **Applications:** Implementation of the algorithms on MATLAB, Construction of Solid and Surface Models on any of the high end solid modelers (IDEAS / ProE and Imageware Surfacr), Course Project

Books RECOMMENDED:

- 1 Geometric Modeling: Michael E. Mortenson, John Wiley, 1992
- 2 Mathematical Elements of Computer Graphics: Roger and Adams, McGraw Hill, 1994.
- 3 CAD CAM Theory and Practice: I. Zeid, McGraw Hill, 1994.
- 4 Computer Aided Engineering Design, Saxena and Sahay, Anamaya N. Delhi, 2005.

CNC MACHINE TOOLS and PROGRAMMING

ME – 612

L T P Cr
3 0 0 3

- 1 **INTRODUCTION:** Basis and need of CNC machines: NC, CNC and DNC systems. Applications of CNC machines in manufacturing, advantages of CNC machine.
- 2 **CONSTRUCTIONAL DETAILS, OF CNC MACHINES:** Machine structures, slide ways, motion transmission elements swarf removal and safety considerations. Automatic tool changers and multiple pallet systems Sensors and feedback devices in CNC machines, Constructional" details of CNC turning center.
- 3 **CNC MACHINING CENTER:** Classification of CNC control systems.
- 4 **CNC PART PROGRAMMING:** Axis identification and coordinate systems, structure of CNC part program, Programming formats, NC programming codes.
- 5 **PROGRAMMING FOR 2 AXIS CONTROL SYSTEMS:** Manual part programming for a turning center, programming using tool nose radius compensation, do loop, sub routines and fixed cycles. Programming for CNC wire-cut machines.
- 6 **PROGRAMMING FOR 3 AXIS CONTROL SYSTEM:** Manual part programming for CNC machining center programming using tool radius compensation tool offsets, doloop, subroutines and fixed cycles.
- 7 **COMPUTER AIDED CNC PART PROGRAMMING:** Using ApT language CAD/CAM aided CNC part programming.
- 8 **TOOLING FOR CNC MACHINES:** Tooling requirements of CNC machine, preset and qualified tools, work .and tool holding devices in CNC machines.

BOOKS RECOMMENDED:

- 1 Pabla E S & Adithan M. "CNC Machines", New Age publishers, New Delhi.
- 2 Ploywka, John & Gabrel, Stanley, "Programming of Computer Numerically Controlled Machines" Industrial Press Inc. New York.
- 3 Raello Ralph "Essentials of Numerical Control" Prentice Hall, NJ.
- 4 Pollack Herman W. & Robinson T., "Computer Numerical Control", Prentice Hall NJ.
- 5 Seams Warren "Computer Numerical Control: Concepts, Programming", Delmar Publisher Inc. New York.

- 1. Introduction to Mechatronics systems and components.** Principles of basic electronics -Digital logic. Number system logic gates. Sequence logic flip Hop system. JK flip Hop, D-flip flop.
- 2. Microprocessors and their applications** - Microcomputer computer structure/microcontroller. Integrated circuits-signal conditioning processes, various types of amplifiers, low pass and High pass filters.
- 3. Sensors-** Sensors and transducers, displacement. Position proximity sensors. Velocity, force sensors Fluid presence temperature. Liquid level and light sensors. Selection of sensors. Actuators, Pneumatic and Hydraulic systems. Mechanical actuation system. Electrical actuation system. Other Electrical/ electronic hardware in mechatronics system.
- 4. Principles of Electronic system communication-** Interfacing. AD and DA converters. Software and hardware principles and tools to build mechatronic systems. Basic system models. Mathematical models. Mechanical and other system building blocks.
- 5. System models-** Engg. Systems. Rotational, translation. Electro mechanical: Hydraulic mechanical system. System transfer functions, first - second order system in series.
- 6. Design and selection of Mechatronics** Statements namely sensors line encoders and revolvers, stepper and servomotors ball screws, solenoids, line actuators and controllers with application to CNC system. Robots. Consumer electronics products etc. Design of a mechatronic product using available software CAD packages. MATLAB and SIMULINK.

Books RECOMMENDED:

1. Mechatronics by W. Bolton; Addison Wesley Longman Pvt. Ltd.
2. Automation Production System and CIMS by Mikel P Groover; Prentice Hall.
3. Mechatronics by Hegde; Jones and Bartlett
4. Applied Mechatronics by Samili and Mrad Oxford University Press
5. Design with Microprocessors for Mechanical Engineers by Stiffler McGraw-Hill

COMPUTER AIDED INSPECTION AND TESTING

ME – 722

L T P Cr
3 0 0 3

- 1 **INTRODUCTION:** Computer aided testing (CAT) and computer aided inspection (CAI), computer aided quality control (CAQC), on-line inspection and quality control, technology of automation Gauging, automatic inspection machines, in-process gauging,
- 2 **CO-ORDINATE MEASURING MACHINES:** Basic Types of Measuring Machines, probe types, operating modes, programming software's, accessories, measurement and inspection capabilities, flexible inspection systems, inspection problems. '
- 3 **MACHINE VISION:** Functions of machine vision system, evaluating the performance of machine vision system, machine vision applications.
- 4 **SCANNING LASER BEAM DEVICES:** Laser interferometer, laser, alignment devices, X-ray optics, CCD (Charge-coupled Devices) Array, ultrasonic system.
- 5 **MACHINE TOOL SENSING:** Part measurement, Tool wear, Axial, motion, Sequence of functions, tool Identification. Computer aided surface roughness measuring systems, High accuracy profile measuring systems.
- 6 **PROXIMITY SENSING:** Photoelectric Transducers, Image processing for vision sensor, 3 dimensional object recognition.

BOOKS RECOMMENDED

- 1 Machine Vision-Nello Zueh and Richard K.Miller prentice hall,1987
- 2 Roberts Sensor -Pugh, IFS Publication, 1986
- 3 Transducers and Interfacing -Bannister and Whitehead~ Von Nostrand. 1986
- 4 Computer Control of Manufacturing Systems -Koren, McGraw Hill, 1983

DATABASE MANAGEMENT SYSTEMS

ME 723

L T P C

3 0 0 3

1. **INTRPRODUCTION OF DATBASE MANAGEMENT SYSTEMS (DBMS)** Concept of DBMS, characteristics, frontend and backend actors, advantages, database applications
2. **DATABASE SYSTEM ARCHITECTURE** Data models, instances, schemas, three schema architecture, database system environment, centralised and client server architecture of DBMS, classification of DBMS.
3. **DATA MODELLING** High level conceptual data models for database design, example of database application, entity types, entity sets, attributes and keys, relationship types, relationship sets roles and structural constraints, weak entity, ER diagram conventions, total participation, partial participation, extended ER features, specialization, generalization, attribute inheritance, design constraints, aggregation, primary key, super key, foreign key, trigger.
4. **RELATIONAL DATA MODEL** Relational model concepts, domain attributes, tuples and relations, characteristics of relations, relational model constraints, relational database schema
5. **RELATIONAL ALGEBRA** Relational algebra and expression, relational calculus, types of operators: Urinary operator (select, projection and rename operator), binary operator (union intersectional and minus operator), Cartesian product, binary relational operation, joint operation, division operation.
6. **DATABASE DESIGN THEORY AND METHODOLOGY** Problems with DBMS, functional dependencies, closure of a set of functional dependency, canonical curve, decomposition, Normalization, 1NF, 2NF, 3NF and BCNF, 4NF, 5NF. Test for lossless decomposition,
7. **SQL : SCHEME DEFINITION, CONSTRAINTS AND QUERRIES** SQL data definition and data types, schema and catalogue concept for SQL, create table demand, attribute data type, constraints, schema change statement, basic queries in SQL, ambiguity, use of asterisk and key word "distinct", aggregate functions, grouping, insert, delete and update statement.

BOOKS RECOMMENDED

1. Fundamentals of database systems by Elamsari and Navathe
2. Database System Concepts by Silberschatz, Korth, Sudarshan, Mc Graw Hill

Elective II

FRICION AND WEAR

ME- 726

L T P C
3 0 0 3

1. FUNDAMENTAL REVIEW: Surface Topography and contacts, Measurement of surface topography, Surface roughness and its quantification, Topography of surfaces, Contact between surfaces

2. FRICTION: Definition, Sliding Friction: Quantitative Laws of sliding friction, magnitude of the friction force, criticism of the adhesive theory, other contributions to the friction force, rolling Force, sliding friction, Models of asperity deformation, friction of metals ceramics and Polymers.

3. ROLLING FRICTION: Laws of rolling friction, the measurement of friction.

4. TYPES OF WEAR: Uses of Wear, types of wear the measurement of wear.

5. ADHESIVE WEAR: Introduction, mechanism of adhesive wear, the sizes and shapes of transferred fragments, the size distribution of wear fragments, quantitative laws of adhesive wear, alternative forms of wear equation, equilibrium distribution of transferred particles and the minimum load for transfer materials to be used in adhesive wear situations.

6. ABRASIVE WEAR: Introduction quantitative expression for abrasive wear, experimental evidence for the abrasive wear equation, effect of hardness on abrasive wear rate, influence of abrasive particle, size on abrasive wear rate, effect of moisture contents and lubrication.

7. CORROSIVE WEAR: Introduction, Brittle Fracture wear, Transition between corrosive & adhesive & abrasive wear, Tribochemical polishing, Oxidative wear,

8. FATIGUE WEAR: Fatigue wear during sliding Surface crack initiated fatigue wear Subsurface crack initiated fatigue wear Effect of lubrication on fatigue wear during sliding, Fatigue wear during rolling

BOOKS RECOMMENDED

1. Friction and Wear of Materials by Rabinowicz
2. Fundamentals of Tribology by Basu, Sengupta, Ahuja
3. Fundamentals of Fluid Film Lubrication by Hamrock, Schmid, Jacobson
4. Applied Tribology Bearing Design and Lubrication by Khonsari and Booser
5. Principles and Applications of Tribology by Bhushan B.
6. Engineering Tribology by Williams
7. Tribology: Friction, Lubrication & Wear by Szeri

MACHINE TOOL DESIGN

ME-727

L T P C
3 0 0 3

1. INTRODUCTION: Kinematics of different types of machine tools; selection of cutting conditions and tools; calculation of cutting force on single point and multipoint tools; hole machining, calculation of power; accuracy requirements and standards.

2. DESIGN OF MACHINE TOOL DRIVES: Selection of Electric Motor, Stepped Regulation of Speed, Laws of Stepped Regulation, Why Geometric Progression is used against Arithmetic, Harmonic & Logarithmic despite shortcomings, Relation between Range ratio, Geometric Progression Ratio and No. of Speed Steps,

Design of Stepped Drives:-Break up of Speed Steps, Structural Formulae, Structural Diagram, Selection of Best Structural Diagram, Ray Diagram, Speed Chart, General recommendations for Developing the Gearing Diagram, Determining the number of teeth of Gears,

a) Speed Gear box : Limiting Transmission Ratio of Speed Gear Box, Design Case Study of Speed Gear Box for Lathe, Classification of Speed Gear Boxes

b) Feed Gear box: Limiting Transmission Ratio of Feed Gear Box, Design Case Study of Feed Gear Box (with Gear Cone & Sliding Key) for Drilling Machine, Classification of Feed Gear Boxes, Study of Application of Norton's & Meander's Mechanism for Thread Cutting
Step less Drives:-Step less Regulation of Speed & Feed Rates through Hydraulic, Electric & Mechanical means, Positively Infinitely Variable Drive, Case Study of CNC Lathe with Electronic Controller for Speed & Feed Step less Regulation

3. CONTROLLERS: Types, characteristics of controllers and their selection; ball screws and friction screws-guide ways; linear motion systems; design calculations of drives; closed- loop operations of feed drives; linear indexing drives; control elements: single and multi axis CNC controllers; hydraulic control, pneumatic control; limit switches; proximity switches; sequencing Control using hard wired and PLC systems.

4. DESIGN OF MACHINE TOOL STRUCTURES: Static and dynamic stiffness; dynamic analysis of cutting process; stability, forced vibration, ergonomics and aesthetics in machine tool design; design of spindle and spindle supports: function of spindles; design

requirements; standard spindle noses; design calculations of spindles; bearing selection and mounting.

5. **DESIGN OF SPECIAL PURPOSE MACHINES:** Modular design concepts; standard modules.

6. **DESIGN OF A TYPICAL SPM MACHINES:** Example; CNC and transfer machines

BOOKS RECOMMENDED

1. Mehta, NK, "Machine Tool Design and Numerical Control" Tata McGraw Hill
2. Koenigsberger F., "Design Principle of Cutting Machine Tools", Pergamon Press
3. Basu, SK and Pal, DK, "Design of Machine Tools", Fourth Ed., Oxford and IBH
4. Acherkan, N, "Machine Tool Design Vol I-IV", Mir Pub Moscow
5. Sen, G C and Bhattacharya, A, "Principals of Machine Tools", New Central Book Agency

MODELLING AND SIMULATION

ME – 728

L T P C

3 0 0 3

1. INTRODUCTION Simulation: a tool, advantages and disadvantages of simulation, areas of application, systems and system environment, components of a system, discrete and continuous systems, discrete event system simulation.

2. GENERAL PRINCIPLES Concepts in discrete event simulation, time advance algorithm, manual simulation using event scheduling, basis properties and operations

3. MODELS IN SIMULATION Terminology and concepts, statistical models: queuing systems; inventory systems; reliability and maintainability, limited data, discrete distributions: Bernoulli distribution; Binomial distribution; Geometric distribution, continuous distribution: Uniform distribution; Exponential distribution; Gamma distribution; Normal distribution; Weibull distribution; Triangular Distribution; Lognormal distribution, poisson process,

4. QUEUEING MODELS Characteristics of queuing systems, the calling population, system capacity, arrival process, service mechanism, queuing notations, long run measures of performance of queuing systems, server utilization in $G/G/1/\infty/\infty$ queues, server utilization in $G/G/C/\infty/\infty$ queues, server utilization and system performance, costs in queuing problems, Larkovian models.

5. RANDOM NUMBER GENERATION Properties of random numbers, Pseudo random numbers, techniques of generating random numbers, tests of random numbers.

6. RANDOM VARIATE GENERATION Inverse transform technique, Direct transformation for the Normal and Lognormal distribution, Convolution Method, Acceptance rejection technique.

7. INPUT MODELLING AND VALIDATION Steps in the development of model, data collection, Distribution identification, Parameter estimation, Goodness of Fit Tests, selecting input models without data, verification and validation of simulation models.

BOOKS RECOMMENDED

1. Simulation Modelling and Analysis by Law and Kelton, Mc Graw Hill, 1991
2. Simulation Model Design & execution by Fishwick, Prentice Hall, 1995
3. Discrete event system simulation by Banks, Carson, Nelson and Nicol

Semester 2: Core subjects

INDUSTRIAL ROBOTICS

ME-614

L T P Cr
3 0 0 3

- 1 **ROBOTICS:** Historical back ground, Definitions, Laws of Robotics, Robotics systematic robot anatomy, Common Robot configurations, coordinate system, work envelop. Elements of robotic system and effector, actuators, controller, teach pendant, sensors Specification of robots. Applications, Safety measures.
- 2 **ROBOT KINEMATICS:** Forward and reverse Kinematics of 3 DOF Robot arms. Homogeneous transformations. Kinematics equation using homogeneous transformations.
- 3 **ACTUATORS:** Hydraulic actuators. Pneumatic actuator, Electrical actuators, Directional control, Servo Control Flow control valves.
- 4 **END EFFECTORS:** Classification, Drive systems. Magnetic, Mechanical, Vacuum and Adhesive Grippers, force analysis in Grippers.
- 5 **SENSORS:** Need for sensing systems, Sensory devices, Types of sensors, Robot vision system.
- 6 **ROBOT LANGUAGES AND PROGRAMMING:** Types of Programming, Motions Programming, Robot Languages -VAL systems.
- 7 **FLEXIBLE AUTOMATION:** Technology, FMS, Function of Robot in FMS flexible manufacturing cell.

BOOKS RECOMMENDED:

- 1 Robotic technology and flexible automation -S.R Deb, TMH.
- 2 Robotics -Lee, Fu, Gonzalez, Mc Graw Hill.
- 3 Industrial Robot -Groover, Mc Graw Hill.
- 4 Robots manufacturing and application -Paul Afonh, John Wiley.

RAPID PROTOTYPING AND MANUFACTURING

ME – 615

L T P Cr
3 0 0 3

1 **INTRODUCTION:** CAD-CAM and its integration, Development of CAD CAM. The importance of being Rapid, The nature of RP/T. The state of RP/T industry. Rapid Prototyping Defined. Time compression Technologies, Product development and its relation ship with rapid prototyping.

2 **PROCESS CHAIN FOR RAPID PROTOTYPING:** Data Preparation (Pre-processing), Part Building, Post Processing. CAD Model Preparation, Reverse Engineering and CAD model, Digitizing Techniques: Mechanical Contact Digitizing, Optical Non-contact Measurement, CT Scanning Method, Data Processing for Surface Reconstruction.

3 **Data interface for Rapid Prototyping:** STL interface Specification, STL data generation, STL data Manipulation, Advantages and limitations of STL file format. Open files. Repair of STL files. Alternative RP interfaces.

4 **Part orientation and support generation:** Factors affecting part orientation, various models for part orientation determination, the function of part supports, support structure design, Automatic support structure generation.

5 **Model Slicing and Contour Data organization:** Model slicing and skin contour determination, Identification of external and internal contours, Contour data organization, Direct and adaptive slicing: Identification of peak features, Adaptive layer thickness determination, Skin contour computation. Tool path generation.

Part Building: Recoating, parameters affecting part building time, part quality.

Post Processing: Part removal, finishing, curing.

Other issues: Shrinkage, Swelling, Curl and distortion, Surface Deviation and accuracy, Build Style Decisions,

6. **RAPID PROTOTYPING MACHINES:** Classification, Description of RP Machines: SLA, SLS, FDM, 3D Printing, LOM, SDM, Contour Crafting, 3D Welding, etc., CNC-machines and hybrid systems.

7 **RAPID TOOLING AND MANUFACTURING:** Classification of RT Routes, RP of

Patterns, Indirect RT: Indirect method for Soft and Bridge Tooling, Indirect method for Production Tooling, Direct RT: Direct RT method for Soft and Bridge Tooling, Direct method for Production Tooling, Other RT Approaches. Rapid Manufacturing: Methods, limitations.

8 **APPLICATION OF RP:** Heterogeneous objects, Assemblies, MEMES and other small objects, Medicine, Miscellaneous areas including art.

BOOKS RECOMMENDED:

- 1 Bjorke, Layer Manufacturing, Tapir Publisher. 1992.
- 2 Jacobs, PF (Ed), Rapid Prototyping and Manufacturing, Society of Manuf. Engrs, 1992.
- 3 Burns, M., Automated Fabrication: Improving Productivity in Manufacturing, 1993.
- 4 Jacobs, P.F. (Ed.), Stereolithography and Other RP&M Technologies: From Rapid Prototyping to Rapid Tooling, Society of Manuf. Engrs. NY, 1996.
- 5 Chua C. k. and L. K. Fai, Rapid Prototyping: Principles and Applications in Manufacturing.
- 6 Gibson, I. (Ed.), Software Solutions for Rapid Prototyping, Professional Engineering Publications, London., 2002.

FLEXIBLE MANUFACTURING SYSTEMS

ME – 616

L T P Cr
3 0 0 3

- 1 **FLEXIBILITY AND AUTOMATION:** Flexibility and automation, different types of flexibilities in manufacturing, . volume variety relationships for understanding manufacturing systems, different types of FMS, building blocks of flexible manufacturing systems; work stations, storage-retrieved systems, material handling systems and computer control system. Machining of FMS; Horizontal & vertical matching centers. Automatic storage and retrieved systems, FMS Control Systems.
- 2 **GROUP TECHNOLOGY AND CELLULAR MANUFACTURING:** Part families formation, Selection of classifications and Coding Systems, production flow analysis, Cellular Manufacturing ,Computer aided process planning.
- 3 **LAYOUT:** Layout consideration for flexible manufacturing, scheduling of flexible manufacturing systems.
- 4 **FMS SIMULATION:** Future developments in FMS, case studies on FMS.

BOOKS RECOMMENDED:

- 1 Systems Approach to Computer Integrated Design and Manufacturing Automation, Production Systems – Nanua Singh
- 2 Automation, Production Systems and Computer Integrated Manufacturing – M.P.Groover
- 3 Flexible Manufacturing Systems – R.A. Maleki
- 4 Hand Book of Flexibile Manufacturing Systems – Nand K. Jha

- 1 **LUBRICATION:** Fundamentals, Types of Lubrication, Viscosity and its Types of Lubrication, Types of Bearings, Equations of Continuity and Motion, Hydrodynamics of Simple Configuration.
- 2 **HYDRODYNAMIC LUBRICATION:** Pertoff's Equation, Generalized Reynolds Equation, Simplification of Full Reynolds Equation, Infinitely Long Bearings Infinitely Short Bearings, Converging-Diverging Channel, Full Sommerfeld Condition, Half Sommerfield and Reynolds, Center of Pressure, Friction.
- 3 **JOURNAL BEARINGS:** Geometry, Pressure, Equation -Short Bearing, Load, Attitude Angle, Friction, Full Journal Bearing, Friction, Pressure Distribution, Load Carrying Capacity, Partial Journal Bearings, Influence of End Leakage on Behaviour of Bearings.
- 4 **THRUST BEARINGS:** Geometry, Pressure, Equation Infinite Bearing, Finite Thrust Bearing, Friction, Pressure Distribution, Center of Pressure, Load Carrying Capacity.
- 5 **HYDROSTATIC BEARINGS:** Applications, Features, Analysis of Footstep Bearing, Compensators, and Practical Considerations.
6. **POROUS BEARINGS:** Introduction, Geometry, Reynold's Equation
Hydrodynamic Gas Bearings, On Newtonian Fluids and Elasto-Hydrodynamic Lubrication: Difference Between Gas And Oil Lubrication, General Conditions, Solution to Gas Lubricated Hydrodynamic Bearings, Hybrid Bearings, Magnetic Bearings
- 6 **BEARINGS MATERIALS:** General Requirements and Different Types of Bearing Materials.

BOOKS RECOMMENDED:

- 1 Fundamentals of Fluid Film Lubrication by Hamrock, Schmid, Jacobson
- 2 Applied Tribology Bearing Design and Lubrication by Khonsari and Booser
- 3 Principles of Lubrication by Cameron
- 4 Principles and Applications of Tribology by Bhushan, B.
- 5 Magnetic Bearings and Bearingless Drives by Fukao, Oshima, Takemoto, Dorell

FINITE ELEMENT METHOD

ME – 732

L T P Cr

3 0 0 3

1 **FUNDAMENTL CONCEPTS:** Introduction, Historical background, stresses and. equilibrium, boundary conditions, strain-displacement relations, stress-strain relations, 'temperature effects, Rayleigh-Ritz Method, Galerkin's Method, Saint Venant's Principle, Matrix algebra, Gaussian Elimination.

2 **FINITE ELEMENT MESHES:** Choice of mesh, mesh data in numerical form, generation of mesh data, mesh modification.

3 **ONE DIMENSIONAL PROBLEMS:** Introduction, Finite element Modeling, Co-ordinates end Shape Functions. Potential energy approach, The Galerkin Approach, Assembly of Global stiffness matrix and load vector, properties of K, Finite element equations; 'Treatment of boundary conditions, quadratic shape functions, Temperature effects.

4 **TRUSSES:** Introduction, plane trusses, three dimensional trusses, assembly of global stiffness metrix for the banded and skyline solution.

5 **TWO DIMENSIONAL PROBLEMS USING CONSTANT STRAIN TRIAN:** Introduction, finite element modeling, constant strain triangle (CST), Problem modeling and boundary conditions.

6 **AXISYMMETRIC SOLIDS SUBJECTED TO AXISYMMETRIC LOADIN:** Introduction, Axisymmetric formulation, finite element modeling: Triangular elements, Problem modeling and boundary conditions.

7 **TWO DIMENSIONAL ISOPARAMETRIC ELEMENTS AND NUMERICAL INTEGRATION:** Introduction, The four-node quadrilateral, Numerical Integration, Higher-order element, Problem related to beams.

8 **BEAMS AND FRAMES:** Introduction, finite element formulation, load vector, boundary considerations, shear force and bending moment beams on elastic supports, plane frames, three dimensional frames.

9 **FINITE ELEMENT METHODS IN FLUID FLOW &. HEAT TRANSFER:** 1-0 Steady heat conduction, 1o heat conduction in thin fins, 2-D Steady heat conduction, 2-D Fins. 1-0 & 2-D heat disfusion, incompressible inviscid flow (potential flow), acoustic flow, and viscous incompressible fluid flow.

BOOKS RECOMMENDED

- 1 Introduction to FEM in Engineering by Tirupathi, R. . Chandrupatle and Ashoka D.Belegundu,
- 2 An Introduction to Finite Element Method by J.N. Reddy, McGraw-hill, New York.
- 3 Finite Element Analysis -Theory and Programming by C.S. Krishnamurthy, Tata McGraw Hill
- 4 The Finite Element Method in Engineering by S.S. Rao, Pergamon, New York.
- 5 Finite element 'methods for engineers by Roger T.Fennee,Imperial College Press.
- 6 Finite element analysis in Engg. Design by Rajoebaron.

Data Communication and Networking

ME 733

L T P C

3 0 0 3

1. **Computer networks and the Internet** Internet, service description, protocol, network protocols, Network edge, end systems, clients, servers, connectionless and connection oriented service, network core, circuit switching and packet switching, multiplexed in circuit switched networks, message segmenting, packet forwarding in computer networks, virtual circuit networks, datagram networks, network access, company access, mobile access, physical media, delay and loss in packet switched networks, delay and routes in internet, protocol layers, internet protocol stack, network entities and layers

2. **Application Layer** Principles of application layer protocols, client server sides of an application, process communicating across a network, addressing process, user agent, reliable data transfer, timing in transfer, services provided by the internet transport protocols, Web and HTTP, non persistent and persistent connections, HTTP message format, user server interaction, authorization and cookies, HTTP content, File transfer: FTP, FTP commands and replies, SMTP, Mail access Protocols, DNS and records, content distribution, Web catching, cooperative catching, Peer to peer file sharing, centralised and decentralised directory, query flooding

3. **Transport Layer** Transport layer services, relationship between transport and network layer, transport layer in the internet, multiplexing and demultiplexing, connection oriented multiplexing and demultiplexing, web server and TCP, connection less transport: UDP, UDP segment structure, reliable data transfer, positive and negative acknowledgements, duplicate packets, stop and wait protocols, acknowledge fields, pipelining, Go – Back – N, Selective repeat, connection oriented transport: TCP, TCP segment structure, sequence numbers and acknowledgement numbers, round trip time estimation and timeout, reliable data transfer, Doubling the time out interval, flow control, TCP connection management, congestion control, approaches to congestion control, TCP congestion control

4. **Network layer and routing** Network service models, origins of datagram and virtual circuit service, routing principles, Hierarchical routing, Internet Protocol, IPv4 addressing, obtaining a network address, obtaining a host address, moving datagram from source to

destination, datagram format, IP datagram fragmentation, Internet Control Message Protocol, Network address translators, Routing.

5. Link Layer and Local Area Networks Link layer channels, data link layer, services provided by the link layer, adapters communicating, error detection and correction techniques, parity checks, multi-access protocols, channel portioning protocols, code division multiple access, random access protocols, taking turns protocols, Local Area Networks, LAN address and ARP, address resolution protocol.

BOOKS RECOMMENDED

1. Computer networks by A.S. Tanenbaum, 3rd edition, Prentice Hall India

REFERENCE BOOKS

1. An engineering approach on computer networking by S. Keshav, Addison Wilsey.

2. Data and computer communication by W. Stalling, Macmillan Press.

Open Elective

ROBOTICS

ME-755

L T P Cr

3 0 0 3

- 1 **ROBOTICS:** Historical back ground, Definitions, Laws of Robotics, Robotics systematic robot anatomy, Common Robot configurations, coordinate system, work envelop. Elements of robotic system and effector, actuators, controller, teach pendant, sensors Specification of robots. Applications, Safety measures.
- 2 **ROBOT KINEMATICS:** Forward and reverse Kinematics of 3 DOF Robot arms. Homogeneous transformations. Kinematics equation using homogeneous transformations.
- 3 **ACTUATORS:** Hydraulic actuators. Pneumatic actuator, Electrical actuators, Directional control, Servo Control Flow control valves.
- 4 **END EFFECTORS:** Classification, Drive systems. Magnetic, Mechanical, Vacuum and Adhesive Grippers, force analysis in Grippers.
- 5 **SENSORS:** Need for sensing systems, Sensory devices, Types of sensors, Robot vision system
- 6 **ROBOT LANGUAGES AND PROGRAMMING:** Types of Programming, Motions Programming, Robot Languages -VAL systems.
7. Applications of Robots in Industries

BOOKS RECOMMENDED

- 1 Robotic technology and flexible automation -S.R Deb, TMH.
- 2 Robotics -Lee, Fu, Gonzalez, Mc Graw Hill.
- 3 Industrial Robot -Groover, Mc Graw Hill.
- 4 Robots manufacturing and application -Paul Afonh, John Wiley.

MANAGEMENT INFORMATION SYSTEMS

ME – 756

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1. **INTRODUCTION:** MIS a tool, advantages and disadvantages, areas of application, systems and system environment, components of a system, discrete and continuous systems, discrete event system simulation. Concepts in discrete event simulation. Concept of Computer networking and DBMS.
- 2 **COMPUTER NETWORKS AND THE INTERNET:** Internet, service description, protocol, network protocols, Network edge, end systems, clients, servers, connectionless and connection oriented service, network core, circuit switching and packet switching, multiplexed in circuit switched networks, message segmenting, packet forwarding in computer networks, virtual circuit networks, datagram networks, network access, company access, mobile access, physical media, delay and loss in packet switched networks, delay and routes in internet, protocol layers, internet protocol stack, network entities and layers.
- 3 **APPLICATION LAYER:** Principles of application layer protocols, client server sides of an application, process communicating across a network, addressing process, user agent, reliable data transfer, timing in transfer, services provided by the internet transport protocols, Web and HTTP.
- 4 **TRANSPORT LAYER:** Transport layer services, relationship between transport and network layer, transport layer in the internet, multiplexing and demultiplexing, connection oriented multiplexing and demultiplexing, web server and TCP, connection less transport.
- 5 **NETWORK LAYER AND ROUTING:** Network service models, origins of datagram and virtual circuit service, routing principles, Hierarchical routing, Internet Protocol.
- 6 **LINK LAYER AND LOCAL AREA NETWORKS:** Link layer channels, data link layer, services provided by the link layer, adapters communicating, error detection and correction techniques, parity checks, multi-access protocols, channel portioning protocols, code division multiple access, random access protocols, taking turns protocols, Local Area Networks, LAN address and ARP, address resolution protocol.
- 7 **DATABASE MANAGEMENT SYSTEMS (DBMS):** Concept of DBMS, characteristics, frontend and backend actors, advantages, database applications.

8 DATABASE SYSTEM ARCHITECTURE: Data models, instances, schemas, three schema architecture, database system environment, centralised and client server architecture of DBMS, classification of DBMS.

9 DATA MODELLING: High level conceptual data models for database design, example of database application, entity types, entity sets, attributes and keys, relationship types, relationship sets roles and structural constraints, weak entity, ER diagram conventions, total participation, partial participation, extended ER features, specialization, generalization, attribute inheritance, design constraints, aggregation, primary key, super key, foreign key, trigger.

10 RELATIONAL DATA MODEL: Relational model concepts, domain attributes, tuples and relations, characteristics of relations, relational model constraints, relational database schema. Relational algebra and expression.

11 DATABASE DESIGN THEORY AND METHODOLOGY: Problems with DBMS, functional dependencies, closure of a set of functional dependency, canonical curve, decomposition, Normalization, 1NF, 2NF, 3NF and BCNF, 4NF, 5NF. Test for lossless decomposition, SQL.

TEXT BOOKS

1. Computer networks by A.S. Tanenbaum, 3rd edition, Prentice Hall India
1. Fundamentals of database systems by Elamsari and Navathe

REFERENCE BOOKS

- 1 An engineering approach on computer networking by S. Keshav, Addison Wilsey.
- 2 Data and computer communication by W. Stalling, Macmillan Press.
- 3 Database System Concepts by Silberschatz, Korth, Sudarshan, 4TH edition, McGraw
