PTU/BOS/ME/201/27-07-2004

TEACHING SCHEDULE & STUDY SCHEME

M. TECH. PROGRAMME

(Mechanical Engineering Machine Design)

PUNJAB TECHNICAL UNIVERSITY, JALANDHAR

August, 2004

PTU/BOS/ME/201/27-07-2004

DETAILED SYLLABUS AND OTHER CONDITIONS FOR THE PROPOSED COURSE
M.TECH. MECHANICAL ENGINEERING –MACHINE DESIGN

Schedule of Teaching				**Schedule of Examination**				
Lecture	Tutorials (per week)	Total		Time (Hrs.)	Theory Marks	Sessional Marks	Viva	Total
4	0	4	All theory subjects	3	100	50		150
			Project			50	50	100
			Seminar			100		100
			Dissertation			Satisfactory/not Satisfactory		

SEMESTER-I

MEM-501	Advanced Engineering Mathematics
MEM-502	Advanced Material Science
MEM-503	Advanced Mechanics of Solids
MEM-504	Vibration Analysis
MEM-505	Optimization Techniques
MEM-506	Lab-I

SEMESTER-II

MEM-507	Finite Element Method in Design
MEM-508	Computer Aided Machine Design
MEM-509	Industrial Tribology
MEM-	Elective-I
MEM-	Elective-II
MEM-516	Lab -II

SEMESTER-III

MEM-	Elective-III
MEM-	Elective-IV
MEM-580	Project
MEM-590	Seminar

SEMESTER-IV

MEM-500	Dissertation

LIST OF ELECTIVES

ELECTIVE-I

MEM-510	Mechtronics
MEM-511	Machine Tool Design
MEM-512	Automotive Design

ELECTIVE-II

MEM-513	System Design
MEM-514	Design of Experiments
MEM-515	Robotics Engineering

ELECTIVE-III

MEM-517	Design of Machine Frames & Housings
MEM-518	Product Design & Development
MEM-519	Computational Numerical Techniques
MEM-520	

ELECTIVE-IV

MEM-521	Modelling & Simulation
MEM-522	Composite Materials
MEM-523	Engineering Fracture Mechanics

MEM 501 APPLIED ENGINEERING MATHEMATICS

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

1. FOURIER TRANSFORMS: Introduction, Fourier Integral Theorem, Fourier Sine and Cosine Integral, Complex form of Fourier Integrals, Fourier Transforms, Inverse Fourier Transform, Properties, Modulation Theorem, Convolution Theorem for Fourier Transforms, Parseval's Identity, Fourier Transforms of derivative of functions, Relation between Fourier and Laplace transform.

2. MATRICES AND LINEAR SYSTEM OF EQUATIONS: Solution of linear simultaneous equations by Gaussian elimination and its modification, Crout's triangularization method, Iterative methods-Jacobi`s method, Gauss-Siedel method, Determination of eigen values by iteration.

3. CONFORMAL MAPPING: Conformal mapping, Linear transformations, Bi-linear transformations, Schwarz's-Christoffel transformations.

4. TENSOR ANALYSIS**:** Introduction, Curvilinear co-ordinates, Summation convention, Transformation of coordinates, ,Contravarient and Covariant vectors, Tensor of order zero, Tensor of higher order ,Symmetric and Skew symmetric Tensors, Algebra of Tensors, Riemannian space .Line element and Metric Tensor, Conjugate Tensor, Associated Tensor,Physical components,Christoffel symbols, Covariant differentiation of Covariant and Contravarient Tensors.

Books Recommended

1. Higher Engineering Mathematics by Dr. B.S. Grewal; Khanna Publishers
2. Fourier Series and Boundary Values Problems by Churchill; McGraw Hill.
3. Complex Variables & Applications by Churchill; McGraw Hill.
4. The Use of Integral Transforms by I.N. Sneddon., Tata McGraw Hill.
5. Vector Analysis By Murry Spegiel **;** S. Series

MEM 502 ADVANCED MATERIAL SCIENCE

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

Plastic Deformation of Single Crystals- Concept of crystal geometry, Lattice defects, Deformation by slip, slip in a perfect lattice, slip by dislocation movement, critical resolved shear stress for slip, deformation of single crystal, deformation of face centered cubic crystals, deformation by twinning, stacking faults, deformation bands and kink bands, micro strain behaviour, strain hardening of single crystal

Dislocation Theory- Introduction, observation of dislocation, Berger's vector and dislocation loop, dislocations in face centered cubic lattice, dislocations in hexagonal close packed lattice, dislocation in the body centered cubic lattice, stress fields and energies of dislocations, dislocation climb, intersection of dislocation Jogs, dislocation sources, multiplication of dislocations, dislocation point defect interactions, dislocation pile up.

Strengthening Mechanisms- Grain boundaries and deformation strengthening from grain boundaries, low angle grain boundaries, yield point, phenomenon of strain aging, solid solution hardening, deformation of two phase aggregates, strengthening from fine particles, strengthening due to point defects. Martensite strengthening, cold worked structure, strain hardening, annealing of cold worked metal, Bauschinger effect, preferred orientation

Mechanical Behaviour of Polymeric Materials- Introduction, time dependent mechanical behaviour of polymeric materials, structure of polymers, deformation of polymers, yielding criteria for polymers, Rheology, viscoelastic behaviour, rubber elasticity, fracture and toughness

Fundamental of Metalworking- Mechanics of Metalworking, Flow stress determination, strain rate effects, deformation zone geometry, workability, residual stresses

Books Recommended

1. Fundamentals of Material Science and Engineering- William F Smith
2. Mechanical Metallurgy- Dieter
3. Physical Metallurgy- Reedhill
4. Physical Metallurgy- Van Vlack
5. Physical Metallurgy and Heat Treatment – Lakhtin
6. Physical Metallurgy Avner
7. Theory of Dislocations Hull

MEM 503 ADVANCED MECHANICS OF SOLIDS

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, to be set. The candidates will be required to attempt any five questions.

1. Analysis of stresses and strains in Cartesian and Polar coordinates. Stress transformations, Strain transformations, Generalized Stress- Strain Relations and Compatibility Conditions.

2. Fundamental laws of Elasticity and Plasticity, Generalised plane stress and plane strain relations, The Airy's Stress Function, Prandtl's Stress function for torsion, St. Venant's principle.

3. Elastic strain energy and external Work, Virtual work Methods, Elastic energy methods, Castigliano's Theorems and Statically Indeterminate Systems.

4. Stress Concentration: Stress concentration Factors, Theory of elasticity, Combined loads , Experimental techniques and Effective Stress concentration Factors. Contact Stresses: Method of Computing Contact stresses, Computation of Contact Stresses of two bodies in line contacts.

5. Solution to Boundary Value Problems for prismatic sections, Torsion of Prismatic sections, Membrane analogy for thin walled and multiple connected sections.

6. Beams on elastic foundations: General Theory, Infinite Beam Subjected to a concentrated; Boundary Conditions. Infinite Beam Subjected to a distributed load segment. Semi infinite beams subjected to loads at its ends. Short Beams.

7. Introduction to strain gauges; General, configurations, Instrumentation and Characteristics of Strain Gauge Measurements. Theory of Photoelasticity and techniques used in Photoelastic Applications.

Books Recommended:

1. *Advanced Mechanics of Materials*, A.P.Boresi, R.J. Schmidt, O.M. Sidebottom ,
   John Wiley & Sons, 1993.
2. *Advanced Strength and Applied Stress Analysis*, Budynas, R .,1988.
   McGraw-Hill.
3. *Contact Mechanics*, K.L.Johnson, Cambridge University Press.
4. *Theory of Elasticity*, S.P.Timoshenko and J. N. Goodier, McGraw-Hill.

MEM 504 VIBRATION ANALYSIS

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

Fundamentals of Vibrations- Introduction of Vibrations, Classification, Mathematical Modeling of Physical Systems & Dimensional analysis, Elements of vibrating systems, equivalent springs, Static equilibrium position, Inertia effects, viscous dampers, Equivalent systems.

Free Vibrations-Classification of free vibrations, Free vibrations of single degree of freedom systems & multi degree of freedom systems, application of Newton's Laws and energy methods to normal mode solution, natural frequencies & mode shapes, natural frequencies using flexible matrix, determination of natural frequencies by Matrix Iteration, Rayleigh Quotient, Duhamel's integral.

Transient Vibrations-Non-periodic excitation, derivation of Convolution Integral, Excitations whose form change with time, transient motion due to base excitation, Laplace transform solutions, shock spectrum, numerical methods for excitation.

Forced & Damped Vibrations-Harmonic excitation, Bending critical speeds of simple shafts, Method of Laplace transform, parametric excitation, Damping Models-viscous damping, structural damping, coulomb damping, single degree of freedom system with viscous damping, over damped system, critically damped system, under damped system, Logrithmic Decrement, Duhamel's integral, Negative damping-self excited vibrations.

Vibrations of Continuous Systems- Torsional oscillations of a circular shaft, vibrations of finite beam, Vibrations of beams of variable cross section, vibrations of plates & rings, Forced vibrations of beams.

Non-Linear Vibrations- Sources of non-linearity, free undamped vibrations with nonlinear restoring force, forced undamped vibrations with nonlinear restoring force, self excited vibrations & stability.

vibration Control- Basic concepts of vibration isolation, vibration isolation theory, vibration control by balancing, damping and damping treatment, practical aspects of vibration isolation, Dynamic vibration absorbers, damped vibration absorbers.

Books Recommended

1. Vibration Problems in Engg. By John Wiley & Sons.
2. Fundamentals of Mechanical Vibrations by W. Weaver and D.H. Young.
3. Mechanical Vibration Analysis By P. Srinivasan.
4. Non-Linear Mechanical Vibrations By P. Srinivasan.
5. Fundamentals of Mechanical Vibrations By S. Graham Kelly.
6. Theory and Problems of Mechanical Vibrations By William W. Seto.

MEM 505 OPTIMIZATION TECHNIQUES

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

1. **Linear Programming**: Two phase method, Revised simplex method and dual simplex method. Sensitivity analysis. The dual problem and its role for post optimality analysis.

2. **Dynamic Optimization Models**: Formulation of dynamic optimization models for common industrial problems. Optimization of non-linear objective function by dynamic programming.

3. **Nonlinear optimization models**: Nonlinear objective queuing function of unconstrained variables, quadratic programming.

4. **Queueing Models**: Queuing with single and parallel channels with limited and unlimited service. Bulk input, bulk service, priority queue discipline.

5. **Heuristic Models** Need for heuristic programming, examples of heuristic models for traveling salesman problems, facilities design and assembly line balancing.

6. **Optimization Techniques**: Introduction, Theory and algorithms, classical method, non-linear optimization- Unconstrained optimization, constrained optimization: Langrangian multiplier method

Books Recommended

1. Fundamental of Operations Research Ackoff and Saseini: Wiley Eastern
2. Principles of OR with applications to managerial decisions by Wagner: Prentice Hall
3. Introduction to OR by Hillier & Lieberman: Holden day
4. Operations Research by D. S. Hira

MEM--506 Lab-I

Max. Marks: 100
Time Allowed: 2hrs

One lab /field/industrial oriented project /problem will be allocated to each student related to the subjects related to the subjects taught in 1st semester.

ME 507 FINITE ELEMENT METHODS IN DESIGN

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

1. **Introduction**- Field Conditions, Boundary conditions, Approximate solutions

2. **Basic Principles of structural Mechanics**- Equilibrium conditions, Strain-displacement relations, Linear constitutive relations, Principle of virtual work, Energy principles, Application to finite element method

3. **Element Properties**- displacement models, Relation between the nodal degrees of freedom and generalized coordinates, convergence requirements, Natural coordinate systems, Shape functions (interpolation functions), element strains and stresses, Element stiffness matrix, Static condensation

4. **Isoparametric Elements**- Two- dimensional Isoparametric elements, computation of stiffness matrix for isoparametric elements, convergence criteria for isoparametric element

5. **Direct Stiffness Method of Analysis** and Solution Technique- Assemblage of elements- direct stiffness method, Gauss elimination and matrix decomposition.

6. **Analysis of Framed Structures**- Two dimensional truss element, Three dimensional truss-element, Tree dimensional beam element

7. **Plane Stress and Plane Strain analysis**- Triangular elements, Rectangular elements, Isoparametric elements, Incompatible displacement models.

8. **Application of FEM to Heat conduction problems**.

Books Recommended

1. Finite Element Analysis- C S Krishnamoorthy
2. Finite Element Method- Desai and Abel
3. Finite element Method-Zienkiewics
4. Concepts and Applications of Finite Element analysis- Cook
5. Basic Programs in Finite Element Method- David K Brown

MEM 508 COMPUTER AIDED MACHINE DESIGN

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

1. Fundamentals of CAD: Introduction: Design Process: Application of computers in design: Creating manufacturing database: benefits of CAD. Computer Hardware; Graphic input devices; display devices; Graphics output devices; Central processing unit (CPU)
2. CAD software and Database: Software configuration of a graphics system: functions of a graphics package: geometric modeling: Database structure and control;
3. Geometric Transformations: Mathematics preliminaries, matrix representation of 2 and 3 dimensional transformation: Concatenation of transformation matrices. Application of geometric transformations.
4. Computer aided design of Transmission Belts (Flat & V) using C++/VC.
5. Computer aided design of Journal Bearing.
6. Application programs for selection of Ball and roller bearings using C++/VC
7. Computer aided design of Knuckle joint and flanged coupling using C++/VC.
8. Computer aided design & drafting of spur gears and flywheel using C++/VC.
9. Introduction to Design and Engineering Applications- geometry and mass property formulations, design projects with CAE focus

Books Recommended

1. CAD/CAM Ibrahim Zeid
2. Principles of computer aided design- J Rooney and P Steadman
3. Computer Aided Graphical Design – Daniel L Rayan
4. Computer Graphics and Design- P Radhakrishnan and Kothandaraman

MEM 509 INDUSTRIAL TRIBOLOGY

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

Introduction: friction, wear and lubrication, types of engineering contacts: conforming and non conforming, Types of motion: rubbing, sliding, oscillating, rolling, surface of interaction, elastic and plastic deformations, properties of materials, surface energy and flash temperature theory.

Friction: Laws of sliding friction, concept of adhesion, Tabor's model of elastic thermo friction, rolling friction, measurement of friction

Wear: Laws of wear. types of wear such as adhesive, declamation, abrasive, corrosive, fretting, erosive and oxidative. Measurement of wear and friction in atmosphere and different environments, Prevention and control of wear and friction in machines, wear of cutting tools and dies, study of abrasion in grading, lapping/ honing

Lubrication: Mechanism of lubrication, Boundary, squeeze film hydrodynamic and elasto hydrodynamic and hydrostatic lubrication, plasto hydrodynamic lubrication, solution of Reynolds's equation in two and three dimensional flow, pressure distribution load carrying capacity friction forces in oil film and coefficient of friction in journal bearing, Solid, Liquid and Gas lubricants types and their applications

Bearing Design: Design of bearing clearance in journal bearing, minimum film thickness, sommar field number. oil grooves and flow of oil in axial and circumferential grooves cavitations and turbulence in oil bearings, Heat generation and cooling or bearing hydrostatic and dynamic and their applications in machine tools, Design of air bearings and other gas bearings

Rolling Friction: Reynold slip, Heathe cote concept selection of roller bearings and their methods of lubrication design aspects and modes of bearing failures and elasto hydrodynamic lubrication

Tests and Instrumentation in Tribology: Sliding friction and wear abrasion test, rolling contact and fatigue test, solid particle and erosion test, Corrosion test

Special instruments for lubricant analysis such as optical and infrared spectroscopy and infra red spectroscopy, atomic absorption and emission spectroscopy, mass spectroscopy, NMR spectroscopy, X ray diffraction and chromatographic techniques, Use of transducers and instruments in Tribology- film thickness measurement using modern techniques – Development of test rigs for Tribology research

Books Recommended

1. Friction, Wear, Lubrication: A text book in Tribology
2. Engineering Tribology by Gwidon W Stachowiah and Gwidon W
3. Principles and Application of Tribology by Bharat Bhusan
4. Applied Tribology: Bearing Design and Lubrication by Khonsari and Booser
5. Tribology in Industries by Sushil kumar Srivastva
6. Introduction to Tribology of Bearing by BC Majumdar

MEM 510 MECHATRONICS

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

INTRODUCTION
What is Mechatronics, Systems, Measurement Systems, Control Systems, Microprocessor- based controllers, The Mechatronics Approach.

SENSORS & TRANSDUCERS
Sensors and Transducers, Performance Terminology, (Displacement, Position & Proximity Sensors),(Velocity & Motion, Force, Fluid Pressure, Liquid Flow, Liquid Level, Temperature & Light Sensors), Selection of Sensors.

ELECTRONIC FUNDAMENTALS
Signal Conditioning Process, Operational Amplifier, Digital Logic, Logic Gates, Boolean Algebra, Data Acquisition Systems, Measurement Systems, Testing and Calibration.

ACTUATORS
Mechanical Actuation Systems, Hydraulic & Pneumatic Actuation Systems, Electrical Actuation Systems, A.C. Motor, D.C. Motor, Stepper Motor.

SYSTEM MODELLING & CONTROL
Mathematical Models, Engineering Systems, Electromechanical & Hydraulic-Mechanical Systems, Modeling Dynamic Systems, Transfer Functions, Introduction to METLAB & SIMULINK, Control Modes, PID Controller.

MICROPROCESSOR & COMPUTER
Computer and Interfacing, Microcomputer Structure, Microcontrollers, Application of Microcontrollers, PLC.

DESIGN & MECHATRONICS
Designing, Possible Design Solutions, Case Studies of Mechatronic Systems.

Books Recommended

1. Mechatronics, W. Bolton, Pearson Education Asia
2. Analytical Robotics and Mechatronics, Wolfram Stadler, McGraw Hill
3. Mechatronics, Dan Necsulescu, Pearson Education Asia
4. Mechatronics, HMT
5. Mechatronics, AMT
6. Introduction to Digital Computer Electronics, A.P. Mahind, TMH
7. Measurement Systems, E.O. Doeblin, McGraw Hill
8. Automatic Control Systems, B.C. Kuo, Ogata, PHI
9. Understanding Electromechanical Engineering; An Introduction to Mechatronics-Lawrence J K PHI

MEM 511 ADVANCED MACHINE TOOL DESIGN

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

1. Introduction, Classification of machine Tools, Elements of machine tools, selection of speed and feed, gear box design, various types of clutch systems, Sohopke and Report drive/s. double bound gears analysis, Lohr Criterion for optimizing double bond gear.

2. Stepless drive, Mechanical stepless drive analysis, Hydraulic stepless drive circuit analysis, Design features, Throttle valves, Tracer controlled hydraulic circuit, Hydraulic servo controls, Electrical stepless drive circuits and characteristics.

3. Strength and Rigidity consideration, process capability and compliance, Design of Lathe Bed, use of stiffness in bed, design of radial drill column and milling machine column.

4. Analysis of spindle bearings, slides and guide, design of spindle/arbor, antifriction and journal bearing. Hydrodynamic action in slides, analysis of hydrostatic bearings, Roller guides, recirculating ball analysis, stick slip motion in guides-models, force analysis of Lathe guide ways.

5. Vibration of machine tools and dynamic rigidity: Effect of vibrations, source of vibrations, self excited vibration, single degree of freedom chatter, velocity principle and related models, regenerative principles, chatter in lathe, drilling, milling & grinding, Tlusty and palace model, Peters model, Elementation of machine tool structures matrix. Finite elements and lumped constant models.

6. Automation: Automation drives for machine tools, Degree of automation, Semi-automation, analysis of collect action, design of collect, bar feeding mechanism, tooling layout, single spindle mechanism, analysis, swiss type automatic machine. Loading and unloading. Transfer- devices, Modulator- design concept, in process gauging.

7. Control system of machine tools: control, mechanical, electrical, hydraulic, numeric and fluidic. Basic principle of control, hydraulic controls, fluid controls, numerical controls, feed back systems, Primary systems programming

Books Recommended

1. Machine tools design by Mehta: Tata McGraw Hill
2. Principles of machine tools by Sen et al Central Book Agency
3. Machine Tool Design by Bassu & Pal: Oxford & IBH
4. Machine tool Design vol. i to iv by Acherken: Mir Publishers
5. Design Principles of Metal cutting machine tools: Koenigsberger: Pergamon

MEM 512 AUTOMOTIVE DESIGN

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

Automotive Engineering Development: Innovations and Inventions, Engine Developments, (Transmission, Steering, Suspension, Brake) system development, Interior Refinement, Safety Design.
Modern Materials and Manufacturing Challenge: Structure, Properties and Manufacturing technology of automotive materials, Material selection, Design to manufacture as a single process and IPPD
Body Design: Styling process, Aerodynamics
Chassis Design & Analysis: Load case, Structural analysis by simple structural surfaces method, Computational methods.
Crashworthiness and its Influence on Vehicle Design: Accident and injurt analysis, Vehicle impact (General dynamics & crush characteristics), Structural collapse and its Influence upon Safety.
Noise, Vibration and Harshness: Vibration control, Fundamentals of acoustics, Sound measurement, General noise control Principles.
Occupant Accommodation: An Ergonomics Approach: Eight fundamental Fallacies, Ergonomics in the automotive industry, Strategies for improving occupant accommodation and comfort.
Suspension System and Components: Factors effecting design, Mobility of suspension mechanisms, Kinematic analysis, Roll center analysis, Force analysis, Vehicle ride analysis, Controllable suspensions.
The design of engine Characteristics for Vehicle Use
Transmissions and Driveline: Manual gearbox, Automatic transmission, Continuously variable transmission.
Braking Systems: Fundamentals of braking, Brake proportioning and adhesion utilization, Materials design.
Control Systems in Automobiles: Automotive application of sensors, EMS, Electronic Transmission control, Integration of EMS and TCS, Chassis control system, Multiplex wiring system, Vehicle safety and security system, On-board navigation system.
Failure Prevention: Important aspects of failures in real engineering world, Testing and Failure prediction, Automotive technology and the importance of avoiding failures.
Future Trends in Automobile Design: Mechanical possibilities, Electronic and Electrical Possibilities.

Books Recommended

1. An Introduction to Modern Vehicle Design, Julian Happian-Smith, Butterworth
2. Advanced Vehicle Technology, Heisler, ISBN
3. Automobile Design: Twelve Great Designers and Their Work, R. and Harding, SAE
4. Road Vehicle Aerodynamic Design, Barnard, R. H., Longman
5. Manufacturing Processes for Engineering Materials, Kalpakjikan, S. Addison-Wesley
6. Automotive Ergonomics, Peacock, B. and Karwowski, Taylor & Francis
7. Automotive Sensory Systems, Nwagboso, C.O., Chapman and Hall,

MEM 513 SYSTEMS DESIGN

System Theory and Concepts. Engineering and engineering profession; Engineer, Science and Scientist. Engineering and society, new challenges of engineering. Social responsibility and engineering. Design, designer, qualities in a designer. System, its characteristics and system design

Design cycle and its logic. Divergence, transformation and convergence, Feasibility study, Engineering analysis. Information and information resources. Procedure to obtain information and information handling.

Inventiveness, features and steps of inventiveness, obstacles and aids to creativity. Estimation and bidding. Checking, methods of checking.

Optimization, optimal solution, methods of optimization. Decision making and its requirements. Methods for decision making, preliminary design, finding alternatives. Reliability analysis.

Modeling, advantages and limitations of modeling, types of models and their description. Detailed design and factors affecting detailed design. Steps in detailed Design. Production drawings. Revision. Report writing.

Case studies to be discussed involving Systems Design process

Note:

1. One compulsory question carrying about 40 percent marks on Case Study is to be asked
2. The students may be asked to attempt another three questions of 20 marks each.

Books Recommended

1. An introduction to System Design by Dixon
2. Systems Design by D. K. Aggarwal and S.L. Singla

MEM 514 DESIGN OF EXPERIMENTS

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

INTRODUCTION
Strategy of experimentation, Some typical applications of experimental design, Basic principles, Guidelines for designing experiments, A brief history of statistical design, Using statistical design in experimentation.

SIMPLE COMPARATIVE EXPERIMENTS
Introduction, Basic statistical concepts, Sampling and sampling Distribution, Inferences about the Differences in means, randomized designs, Inferences about the Differences in means, Paired comparison Designs, Inferences about the Variances of Normal Distributions.

RANDOMIZED BLOCK DESIGNS
Randomized complete block design, Latin square design, Balanced incomplete block design.

INTRODUCTION TO FACTORIAL DESIGN
Basic definition and principles, Advantages of factorials, The two factor factorial design, General factorial design, Fitting response curves and surfaces, Blocking in a factorial design.

FITTING REGRESSION MODELS
Introduction, Linear regression models, Estimate of parameters in linear regression models, Hypothesis testing in multiple regression, Confidence intervals in multiple regression, Prediction of new response observations, Regression model diagnostics, testing for lack of fit

TAGUCHI METHOD OF DESIGN OF EXPERIMENTS
Concept design, Parameter design, Tolerance design, Quality loss function, Signal-to-Noise ratio, Orthogonal array experiments, Analysis of Mean(ANOM), Quality characteristics, Selection and testing of noise factors, Selection of control factors, Parameter optimization experiment, Parameter design case study.

ANALYSIS OF VARIANCE (ANOVA)
Introduction, Example of ANOVA process, Degrees of freedom, Error variance and pooling, Error variance and application, Error variance and utilizing empty columns, the F-test.

Books Recommended

1. Design and Analysis of Experiments, Douglas C Montgomery, John Wiley
2. Statistical Design and Analysis of Experiments, John P.W.M., Macmillan,
3. Introduction to Linear Regression Analysis, Montgomery D.C., Runger G. C.,
4. Response Surface Methodology: Process Ang Product Optimisation Using Designed Experiments, Myres R.H., Montgomery D. C., Wiley, New York
5. Introduction to Quality Engineering, Taguchi, G., Asian Productivity Organisation, UNIPUB, White Plains, New York
6. System of Experimental Design: Engineering Methods to Optimize Quality and Minimize Cost, Taguchi, G. UNIPUB, White Plains, New York
7. Statistical Analysis for Engineers And Scientists, J. Wesley Barnes, McGraw Hill Inc.

MEM 515 ROBOTICS ENGINEERING

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

INTRODUCTION Definition of a Robot, Difference between hard automation and robotic automation, Characteristics of a robot, Need for robots and their benefits, Economic aspects in robotic application, Robot classification and their applications, Robot generations

ROBOT IN WORK PLACE

Nee for interfacing, Part feeding, Orienting devices, Special fixtures, Conveyor belts, Overhead transport, Work cell organization in robotic environment, Work cell design and control.

REPRESENTATION OF A ROBOT

Functional and graphical representation of a robot, Arm structures in use, Structure of end effectors, Degrees of freedom of a rigid body, Degrees of freedom of a robot, Degrees of freedom and mobility.

ROBOT TECHNOLOGY

Robot anatomy and functional units, Work volume, Elements and types of drive and control systems, Precision of movement, Actuators , Power transmission systems, Manipulator kinematics and path control, Configuration of a robot controller.

TYPES OF GRIPPERS

Mechanical grippers, Consideration in gripper selection and design.

ROBOT SENSORS

Tactile, Proximity and Range sensors in robots, Velocity sensors, Robot vision, Introduction to motion planning and image processing.

METHODS OF ROBOT PROGRAMMING

Robot programming languages, Introduction to intelligent robots.

ROBOT APPLICATIONS IN INDUSTRIES

Material handling and processing, Metal cutting processes, Welding, Spray coating, Inspection, Assembly and hazardous operating conditions, Safety in robotics, Social and labour issues in robotics, Metal handling using AGV's, Automated storage systems using mobile robots, Issues in implementation of robotics in industry.

LABORATORY WORK

Exercises in programming of robots, Exercises in design and layout of robot workplace, Exercises in programming of mobile robots using simple mobile robot kits, Exercise in robot sensors, Vision and image processing using simple robot kits.

Books Recommended

1. Industrial Robotics: Technology, Programming and Applications, Groover, Weiss, Nagal and Odrey, McGraw Hill, New York.
2. Robotics: Control, Sensing, Vision and Intelligence, Lee, Fu & Gangalase,
3. Robotic Engineering: An Integrated Approach, Klafter, Chmielewski & Negui
4. Robotics for Engineers, Y. Koren, McGraw Hill, New York.
5. Introduction to Robot Technology, Coiffet and Chirouze, McGraw Hill
6. Robotics And flexible Automation, S.R.Deb, Tata McGraw Hill, New Delhi.
7. Fundamentals of Robotics Analysis and Control, Robot J. Schilling, PHI
8. Introduction to Robotics, J.J.Craig, Pearson Education Asia.

MEM 517 DESIGN OF MACHINE FRAMES AND HOUSINGS

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

Purposes of housing, Design of housing observing various factors such as thickness of the casting, clearance inside of housing for all moving parts, suitable floor flanges, suitable stiffening ribs on the housing walls, provision for eye bolt, arrangements for oil drain out and oil level indicator, housings for reduction gears, chains and bearings, supports and Retainment of parts.

Classification of machine frames on the basis of purpose, form, presence of parting line. Choice of optimum form of cross section. Design of C clamp, frame of screw clamp, frame of punch press and shearing machine. Materials for beds, bases and columns, Typical construction of beds, ;bases and columns. Design of machine tool columns, roaming, tables, cross rails and carriages. Modern machine tool bed design. Design of frames for static and dynamic stiffness.

Criteria for requirements on stiffness, deformation of frames caused by weight forces, cutting forces and forced vibrations

Books Recommended

1. Machine structures vol. 1 J Tlusty F. Koenigsberger
2. Machine tool Design vol. 3 N. Acherkan et al

MEM--516 Lab-II

Max. Marks: 100
Time Allowed: 2hrs

One lab /field/industrial oriented project /problem will be allocated to each student related to the subjects related to the subjects taught in 2nd semester.

ME 518 PRODUCT DESIGN AND DEVELOPMENT

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

Introduction: to Product Design: Design by Evolution and Innovation, Essential factors of product design, Production consumption cycle, Flow and value addition in Production consumption cycle, The Morphology of Design, Primary design phases and flowcharting, Role of Allowances, process capability and tolerances in detailed design and assembly

Product Design and Industry: The Designer- his role, myth and reality, the industrial design organization, basic design considerations, Role of Aesthetics in product design, Functional design practice

Design for Production: Producibility Requirements in the design of machine components, Forging design, Pressed component design, Casting design for economical molding, eliminating defects and features to aid handling, Design for machining ease, the role of process Engineer, Ease of location and Clamping, Some additional aspects of production design, Design of powder metallurgical parts

Economic Factors Influencing Design: Product value, Design for safety, reliability and Environmental considerations, Manufacturing operations in relation to design, Economic analysis, profit and competitiveness, break even analysis, Economics of a new product design (Samuel Eilon Model)

Value Engineering and Product Design: Introduction, Historical perspective, Value, Nature and measurement of value, Maximum value, Normal degree of value, Importance of value, The value Analysis Job Plan, Creativity, Steps to problem solving and value analysis, Value Engg. Idea generation check list, Cost reduction , materials and process selection in value engineering

Modern Approaches to product Design: Concurrent Design, Quality Function Deployment, reverse engineering,

Rapid Prototyping: Stereo lithography, Solid ground cutting, Selective laser sintering, Laminated object manufacturing, data transfer to RPT, Constraints on the Model, RPT in manufacturing, tooling, RPT in Industrial Design, Medical applications verses conventional technologies

Books Recommended

1. Product Design and Development by Kail T Ulrich and Steven D Eppinger
2. Product Design and Development by AK Chitale and Gupta
3. Design of Systems and Devices by Middendorf Marcel Dekker

MEM 519 COMPUTATIONAL NUMERICAL TECHNIQUES

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

Errors in Numerical Calculation:
Introduction, Numbers and their accuracy, errors, Absolute, Relative and percentage errors and their analysis. General error Formula

Interpolation:
Finite differences, forward differences, Backward difference, Central Difference, Symbolic Relations, Difference of a Polynomial, Newton's Formulae for interpolation, Central Difference, Stirling Formula, Bessel's Formula, Gauss Central Difference Formulae , Everett's Formula, Interpolation with unevenly spaced points: Lagrange's , Interpolation Formula , Hermite Interpolation , Newton's General Interpolation Formula

Numerical Differentiation, Numerical Integration, Trapezoidal rule, Simpson's Rule, Gaussian quadrature,

Numerical Solution of Ordinary differential equations: Initial value problems, Single-step methods. Runga-Kutta Methods, Multisteps Methods, Predictor Corrector Methods. Adams- Bashforth Method. Milne's methods, Simultaneous and Higher order equations, Two-point boundary value problems.

Numerical solution of partial differential equations, Finite-difference approximation to derivatives, Solution of Laplace equation by Jacobi's Methods.

Finite element method, Weighted Residual Method, Variational Methods. Finite elements, Application to boundary value problems

Books Recommended:

1. Elementary Numerical Analysis – S.D Conte. McGraw Hill
2. Introducation methods of Numerical analysis S.S Sastry, Prentice Hall of India
3. Numerical Mathematical Analysis, J.B. Scarborough, Oxford
4. Numerical Solution of differential Equations by M.K. Jain, Wiley Eastern
5. Introduction to Finite Element Method, By Desai & Abel, Van Nostrand
6. Introduction to Matrix & Numerical Methods By K.I. Majid, Wood Stock Publishing.
7. Numerical Methods By Dr. B.S. Grewal, Khanna Publisher

MEM 521 MODELLING AND SIMULATION

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

1. Introduction and overview, concept of system, system environment, elements of system, Monte Carlo method, system simulation, simulation, a management laboratory, advantages limitations or system simulation, continuous and discrete systems.
2. Technique of Simulation, Monte-Carlo method, System simulation, comparison of simulation with analytical methods, experimental nature of simulation ,advantages, limitations and application of system simulation.
3. Numerical computational techniques-for continuous and discrete models. Distributed lag models. Cobwals models, examples involving numerical methods of analysis.
4. Simulation of continuous systems: characteristics of a continuous system, comparison of numerical integration with continuous simulation system. Simulation of an integration formula. Simulation of trajectories, pure pursuit, serial pursuit, chemical reaction and auto pilot. Analog methods, digital-analog simulation time simulation, hybrid simulation.
5. Simulation of discrete system: Time flow mechanisms, Discrete and continuous probability density functions. Generation of random numbers, testing of random numbers for randomness and for auto correlation, generation of random variates for discrete distribution, generation of random variates for continuous probability distributions-binomial, normal, exponential and beta distributions; combination of discrete event and continuous models. The rejection method. Simulation of reliability, queuing and inventory problems.
6. Design of Simulation experiment: Length of run, elimination of initial bias. Variance reduction techniques, stratified sampling, antipathetic sampling, common random numbers, time series analysis, spectral analysis, model validation, optimisation procedures, search methods, single variable deterministic case search, single variable non-deterministic case search, regenerative technique.
7. Simulation Languages: Continuous and discrete simulation languages, block structured continuous languages, special purpose simulation languages, SIMSCRIPT, GESS SIMULA importance and limitations of special purpose languages.

PRACTICALS:
Students will be required to develop design and execute computer simulation experiments to analyse complex real life industrial situations.

Books Recommended

Simulation and Modelling	Loffick	Tara Mcgraw Hill
System Simulation with Digital Computer	Deo Narsingh	Prantice Hall
System Simulation	Hira, D.S.	S. Chand & Co.
Computer Simulation and Modelling	Meeiamkavil	John Willey
System Simulation	Gerden	Printice Hall

PTU/BOS/ME/201/27-07-2004

MEM 522 COMPOSITE MATERIALS

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions.

1. Introductions to Composites; History and categorization of composite into particle- and- fiber- reinforced systems, Fibers, Matrix, Reinforcement/matrix interface, polymer matrix composites, Aramid Aluminium Laminates, Metal Matrix Composites, Ceramic Matrix Composites, Carbon-Carbon Composites, Cement Matrix Composites, Applications of fiber reinforced structural composites.

2. Nature of fiber reinforcement (glass, carbon, Kevlar and whiskers), Fabrics, Fillers, Matrix materials (thermosets, thermoplastics and metal alloys) and Fiber/Matrix Adhesion.

3. Comparison of mechanical properties with other engineering materials. Structures and processing for laminated structures, Press Moulding Processes, Filament Winding, the Pultrusion process for continuous Automated Manufacture of Engineered Composite Profiles and Processing thermoplastic matrix composites.

4. Micro mechanics of fiber and particle reinforced composites. Prediction of elastic components. Strength of Composites parallel and perpendicular to fibers, Krenchel Coefficients. Load transfer in composites, interfacial shear, critical fiber lengths, critical aspect ratio. Inter- laminar shear strength.

5. Fracture and Damage Mechanics in Laminated Composites; Damage classification and failure mechanisms, Free edge delamination, stiffness loss in laminae due to damage. Toughness of composites, Cook- Gordon effect, fracture energy of cross-laminated composites. Fatigue and creep of composites, S-N Curves, residual strength.

6. Environmental Effects and Non Destructive Testing (NDT) of composites, High Strength, High temperature composite materials. Design Methodology and Practices in Composite Materials Design.

Books Recommended :

1. *Modern Composite Materials*, L.J. Broutman and R.M.Krock, Addison-Wesley.
2. *Composite Materials- Science & Engineering*, K. K. Chawla, Springer-Verlag, New York.
3. *Mechanisms and Mechanics of Composite Fracture*, R. B. Bhagat, S.G. Fishman,R.J. Arsenault, ASM Intrenationals,1993.

MEM 523 ENGINEERING FRACTURE MECHANICS

Note: In all eight questions, covering the whole syllabus evenly, each of 20 marks, are to be set. The candidates will be required to attempt any five questions

Introduction Historical Review, The Significance of Fracture Mechanics, The Griffith Energy Balance Approach , Irwin's Modification to the Griffith Theory , The Stress Intensity Approach , Crack Tip Plasticity, Fracture Toughness, Elastic-Plastic Fracture Mechanics, Subcritical Crack Growth, Influence of Material Behaviour ***Part II Linear***

Elastic Fracture Mechanics **The Elastic Stress Field Approach** Introduction, Derivation of the Mode I Elastic Stress Field Equations, Useful Expressions, Finite Specimen Width, Two Additional Important Solutions for Practical Use, Superposition of Stress Intensity Factors, Some Remarks Concerning Stress Intensity Factor Determinations

Crack Tip Plasticity Introduction, The Plastic Zone Size According to Irwin, The Plastic Zone Size According to Dugdale: The Strip Yield Model, First Order Approximations of Plastic Zone Shapes, The State of Stress in the Crack Tip Region, Stress State Influences on Fracture Behaviour

The Energy Balance Approach Introduction, The Energy Balance Approach, Relations for Practical Use, Determination of Stress Intensity Factors from Compliance, The Energy Balance for More Ductile Materials, Slow Stable Crack Growth and the *R*-Curve Concept

Elastic-Plastic Fracture Mechanics, Basic Aspects of Elastic-Plastic Fracture Mechanics, Introduction, Development of Elastic-Plastic Fracture Mechanics. The *J* Integral, Remarks Concerning the *J* Integral Concept, *J* as a Stress Intensity Parameter, The Crack Opening Displacement (COD) Approach, Remarks on the COD Approach, Relation Between *J* and CTOD

Fracture Mechanics Concepts for Crack Growth, Fatigue Crack Growth, Introduction, Description of Fatigue Crack Growth Using the Stress Intensity Factor, The Effects of Stress Ratio and Crack Tip Plasticity: Crack Closure, Environmental Effects, Prediction of Fatigue Crack Growth Under Constant Amplitude Loading,

Sustained Load Fracture Introduction, Time-To-Failure (TTF) Tests, Crack Growth Rate Testing, Experimental Problems, Method of Predicting Failure of a Structural Component, Practical Significance of Sustained Load Fracture Testing

Books Recommended

1. Fracture Mechanics, M. Jansen, J Zuidema, K J H Wanhill, Delft Univ Press
2. Fatigue of Metals, Subra Suresh, Cambridge Univ Press
3. Fracture Mechanics, Fundamentals and Applications, Anderson, CRS Press
4. Analytical Fracture Mechanics, David J Unger, Dover Publications
5. Fatigue of Metals, Pope