UNIVERSITY OF KERALA

REGULATIONS, SCHEME AND SYLLABUS

For

M.Tech. Degree Programme

In

MECHANICAL ENGINEERING

(2013 Scheme)

Stream: MACHINE DESIGN

M.Tech. Programme

Mechanical Engineering – Machine Design
Curriculum and scheme of Examinations

SEMESTER I

Code No.	Name of Subject	Credits	Hrs / week	End Sem Exam hours	Marks			Remarks
					Internal /Continuous Assesment	End semester Exam	Total	
MDM 1001	Engineering. Mathematics	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End sem exam is conducted by the university.
MDC 1001	Advanced Theory of Vibration	3	3	3	40	60	100	do
MDC 1002	Advanced Theory of Mechanisms	3	3	3	40	60	100	do
MDC 1003	Continuum Mechanics	3	3	3	40	60	100	do
MDC 1004	Industrial Tribology	3	3	3	40	60	100	do
MDC 1005	Finite Element Method	3	3	3	40	60	100	do
MDC 1101	Design Lab I	1	2	-	100	-	100	No end sem Examinations
MDC 1102	Seminar	2	2	-	100	-	100	do
	TOTAL	21	22	-	440	360	800	Seven hours departmental assistance

SEMESTER II

Code No.	Name of Subject	Credits	Hrs / week	End sem Exam hours	Marks			Remarks
					Internal Continuous Assessment	End Semester Exam	Total	
MDC 2001	Fracture Mechanics	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End sem exam is conducted by the university
MDC 2002	Design of power transmission Elements	3	3	3	40	60	100	do
*	Stream Elective I	3	3	3	40	60	100	do
*	Stream Elective II	3	3	3	40	60	100	do
*	Departmental Elective	3	3	3	40	60	100	do
MCC 2000	Research Methodology	2	2	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End sem exam is conducted by the individual institutions
MDC 2101	Design Lab II	1	2	-	100	-	100	No end sem Examinations
MDC 2102	Thesis Preliminary (Part 1)	2	2	-	100	-	100	do
MDC 2103	Seminar	2	2	-	100	-	100	do
	TOTAL	22	23		540	360	900	6 hours departmental assistance

* Students can select a subject from the subjects listed under stream/department electives for the second semester as advised by the course coordinator.

STREAM ELECTIVES I & II OFFERED IN MACHINE DESIGN FOR SEMESTER II

Stream Elective I	Stream Elective II
MDE 2001 Advanced Design Synthesis	MDE 2007 Experimental Stress Analysis
MDE 2002 Random Vibration Analysis	MDE 2008 Optimization Techniques for Engineering
MDE 2003 Design of Pressure Vessels and Piping	MDE 2009 Robotics
MDE 2004 Advanced Machine Tool Design	MDE 2010 Mechatronics System Design
MDE 2005 Advanced Finite Element Methods	MDE 2011 Computer Integrated Manufacturing
MDE 2006 Mechanics of Composite Materials	MDE 2012 Condition Monitoring & Maintenance Engineering

SEMESTER III

Code No.	Name of Subject	Credits	Hrs / week	End Sem Exam	Marks			Remarks
					Internal/ Continuous Assessment	End Semester Exam	Total	
*	Stream Elective III	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End sem exam is conducted by the Individual Institutions.
*	Stream Elective IV	3	3	3	40	60	100	do
**	Non Dept. (Interdisciplinary) Elective	3	3	3	40	60	100	do
MDC 3101	Thesis-Preliminary (Part 2)	5	14	---	200	---	200	No End sem Examinations
	TOTAL	14	23		320	180	500	6 hours departmental assistance

***** Students can select a subject from the subjects listed under stream electives for the third semester as advised by the course coordinator.

** Student can select a subject from the subjects listed under Interdisciplinary electives for the third semester as advised by the course coordinator

STREAM ELECTIVES OFFERED IN MACHINE DESIGN FOR SEMESTER III

Stream Electives III	Stream Electives IV
MDE 3001 Experimental Methods for Engineering	MDE 3004 Advanced Numerical Methods
MDE 3002 Computational Methods in Design and Manufacture	MDE 3005 Design and Analysis of Composite Structures
MDE 3003 Advanced Computer Graphics	

SEMESTER IV

Code No	Subject Name	Credits	Hrs/week	Marks					Remark
				Continuous Assessment		University Exam		Total	
				Guide	Evaluation Committee	Thesis Eva.	Viva Voce		
MDC 4101	Thesis Final	12	21	150	150	200	100	600	*5 % of the evaluation mark is earmarked for publication in journal/conference
	Total	12	21	150	150	200	100	600	8 hours departmental assistance

DEPARTMENTAL ELECTIVES IN MECHANICAL ENGINEERING FOR SEMESTER II

1. MID 2001 Reliability Engineering
2. MID 2002 Modern Information System
3. MDD 2001 Computational Plasticity
4. MDD 2002 Bio Mechanics
5. MDD 2003 Introduction to Signal Processing
6. MPD 2001 Finite volume method for fluid flow and heat transfer
7. MPD 2002 Transport Phenomena
8. MTD 2001 Finite Element Analysis for Heat Transfer.
9. MTD 2002 Cryogenics Engineering

M.TECH – MACHINE DESIGN
SYLLABUS

FIRST SEMESTER

MDM 1001: ENGINEERING MATHEMATICS **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- To introduce basic concepts of tensors and its applications to Continuum Mechanics
- To familiarize with methods of solution of special functions and its application to Engineering problems.
- To equip with the different methods of numerical solution of partial differential equations.
- To familiarize with integral equations, its formation and application.

Learning Outcomes:

By the end of the course, the student will be able to:

- Apply the concepts of tensors to solve engineering problems.
- Acquire skill to associate and develop numerical procedures to solve Design problems in terms of methods of Partial Differential Equations.
- Get an exposure to advanced developments in applications of special functions, tensor calculus, methods of solution of Partial differential equations.
- Acquire an ability to solve interdisciplinary level problems in Engineering.

Relevance of the course:

The topics in the course are active research areas connecting different branches of Engineering. It equips the students to relate Mathematical ideas to different fields of Engineering and make them efficient to solve problems of higher social necessary so as to attain a Developed Nation

Module I

Tensors:- An introduction to vector calculus (gradient, divergence, curl and green's theorem, Divergence theorem, Stokes theorem) Dyads- Polyads, Nonions, forms of a Dyadic, dual vectors and tensors, Tensor Calculus, Egen values and Eigen vectors of Tensors.

Module II

Integral equations: – solution of integral equations by (i) transform method (ii) method of successive approximations, Integro - differential equations.
Partial differential equations: – The Pfaffian differential equations, parabolic, elliptic and hyperbolic equations. D'Alembert's method. Canonical form, Characteristics, Green functions, Laplace equation in polar co-ordinates - solution and application

Module III

Special functions: - Beta, Gamma functions, Bessel functions-recurrence relation, generating functions, Legendre's equations and Legendre's Polynomials – recurrence relation and orthogonality property.

Numerical solutions of PDE: – Elliptic PDE – derivations of finite difference approximations – iterative method – solution of Poisson equation. Numerical solutions of parabolic PDE – Schmidt method, Durfort – Fankel method, implicit method, Crank- Nicolson method.Numerical solution of Hyperbolic PDE – finite difference method.

References:

1. Integral equations – SanthiSwarrop, Krishna Prakasan Media.
2. Higher Engineering Mathematics - Dr. B. S. Grewal – Khanna Publishers.
3. Higher Engineering Mathematics – N. V. Bali – Lekshmi Publications – New Delhi.
4. Higher Engineering Mathematics – M. K. Venkataraman – National Publishers Co.
5. Vector, Tensors and Basic Equations of Fluid Mechanics – Rutherford Aris (Dover Publications)
6. Intro. to Tensor Calculus and Continuum Mechanics – John Henry Heinbockel, Trafford Publishing 2001
7. Advanced Engineering Mathematics – Erwin Kreyzig
8. Partial Differential Equations – Ian Sneddon
9. Introduction to Partial Differential Equations – K. Sankara Rao – Prentice Hall of India.
10. Introductory Methods of Numerical Analysis – S. S. Sastry- Prentice Hall of India.
11. Introduction to PDE – K. Sankara Rao Prentice Hall of India.
12. Schaum's outline of Tensor Calculus – David Kay (Schaum's outline series)
13. Applications of Tensor Analysis – A. J. McConnell (Dover Books on Mathematics, 2011)

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDC-1001: ADVANCED THEORY OF VIBRATION 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

After completion of the course, the student should understand the Concepts of dynamic systems and the importance of vibration in engineering system design. The course aim to teach students the basic principles underlying the vibration of mechanical and structural systems. The students shall be prepared to demonstrate an understanding of linear vibration theory and the basic formulations for n degree-of-freedom and continuous systems and they can determine and apply the appropriate solution method to calculate the response of the system. The course provides the basis for the vibration analysis of structural components in mechanical, aerospace, and civil engineering.

Learning Outcomes:

By the end of this course, students will be able to:

- Write and solve the differential equations of motion of a mechanical system to determine the natural frequencies and response to free vibrations and to external periodic forces.
- Understand the various damping models and their effects on system behavior.
- Understand the matrix methods and other numerical approaches to solve for the vibration characteristics.

Module I

Analysis of un-damped, damped , free and forced SDOF systems – Logarithmic decrement –– magnification factor – Rotating and revolving unbalance – Base excitation – transmissibility – Seismic instruments –Transients – non periodic excitation of Single DOF systems – Impulsive response and Convolution Integral – Laplace Transform -
Two degree of freedom systems – normal modes and natural frequencies – Principal co-ordinates – co-ordinate coupling - dynamic vibration absorbers and damped vibration absorbers.

Module II

Introduction to multi-degree freedom system- Matrix formulation- Influence coefficients- Flexibility and stiffness- Eigen Value problem- frequency mode shape – Eigen value and Eigen vectors. Modal analysis - Mode summation- De-coupling of equations –, Lagrange’s equation – Generalized co-ordinates- Matrix Iteration – Stodola – and Sweeping methods

Module III

Vibration of continuous system- string – Bar – Torsional and flexural vibration – Solution – Boundary conditions- Approximate numerical methods- Rayleigh method – Rayleigh –Ritz method – Holzer procedure for lumped masses. Introduction to Transfer matrices.

References:

1. Leonard Meirovitch – Elements of Vibration Analysis, McGraw Hill
2. Thomson W.T , Theory of Vibration with Applications., Prentice Hall India.
3. Rao V and J Srinivas, Mechanical Vibrations, PHI Learning Pvt. Ltd.
4. S.S Rao, Mechanical Vibrations, Pearson Education India

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDC 1002 : ADVANCED THEORY OF MECHANISMS 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

To provide a solid foundation of the theory and principles of operation of mechanisms thereby equipping them with the know-how of solving practical engineering problems in the area of machines and mechanisms.
To equip students with good scientific and engineering breadth to enable them to comprehend, analyze, design and create novel products and solutions from real life problems.

Learning Outcomes:

Graduates will have been trained in solving real-life engineering problems from the study of theory and problem-solving skills practiced in the class room.
The course will equip learners in their career to recognize problems faced by industry and society; and propose and translate viable solutions thereto.

Module I

Planar Kinematics of Rigid Bodies: Velocity and acceleration relationships for two points in a rigid link -Vector approach, two-coordinate system approach for velocity and acceleration. (Applied to planar mechanisms: slider-crank mechanism, four bar linkage)

Instantaneous centre or Pole, centrode or polode, polode curvatutre collineation axis, radius of curvature, Four-bar coupler-point curves; Equation of coupler curves, circle of foci, multiple points, imaginary points, asymptote, Singular foci, double points and symmetry, cusp, crunode, symmetry.

The Roberts-Chebyshev Theorem, The Euler-Savary equation, the inflection circle, the cubic of stationary curvature, First Bobillier construction, Second Bobillier construction, Design based on the above.

Module II

Synthesis of mechanisms: The four-bar linkage, Two-position design, design of crank-lever mechanisms for specified input crank motion and output crank motion, Transmission angle; Cams: Polydyne cams: Cam force analysis, Cam Dynamics: Analysis of eccentric cam effect of sliding friction, Analysis of disc cam with reciprocating roller follower Analysis of elastic cam systems, Follower response: Phase-plane method, Johnson's numerical analysis Position error, Jump and cross-over shock, unbalance, spring surge and wind-up Static force analysis; helical gears, straight bevel gears:

Module III

Dynamics: Plane motion of rigid bodies using the principle of impulse and momentum Kinetics of rigid bodies in three dimensions:- Angular momentum of a rigid body in three dimensions. Application of the principle of impulse and momentum to the three-dimensional motion of a rigid body Kinetic energy of a rigid body in three dimensions. Motion of a rigid body in three dimensions. Euler's equation of motion. Motion of a rigid body about a fixed axis. Motion of gyroscope: Eulerian angles Steady precession of a gyroscope. Motion of an axisymmetrical body under no force.

References:

1. Dynamics in Engineering Practice:
   Dara W Childs (CRC Press)
2. Theory of Machines and Mechanisms
   Joseph Edward Shigley (McGraw Hill)
3. Vector Mechanics for Engineers: Statics and Dynamics
   Beer and Johnston (McGraw Hill)
4. Engineering Mechanics
   Irving H Shames (Prentice Hall of India)

Assignment:

In order that students might be stimulated towards grasp of the subject assignments are mandatory. Assignments can be classified as minor assignment and major assignment. The minor assignment can compass problems, derivations, while the major assignment will be composed of a problem-solving task that is akin to a real-world engineering problem the solution of which requires application of principles drawn from a good portion of the syllabus.

As assignments have a significant role in assisting students in the learning process assignments should be viewed seriously and students are required to work on them by themselves avoiding plagiarism. Deadlines for assignments should be maintained. Both the assignments and the marks thereof should be deposited with the Department immediately after the deadline, leaving no room for handing in the assignments after the deadline. This need not be viewed as a penal measure, but as a means to encourage students to learn as they travel through the semester, rather than learning the subject once the semester ends as is the current practice.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDC 1003: CONTINUUM MECHANICS **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

This is an introductory but rigorous treatment of the subject of mechanics of solids and is a prerequisite course for several advanced level courses. The student is given a thorough exposure to the necessary mathematical background and the underlying physical and geometric concepts associated with the deformation of continuous medium subjected to three-dimensional force fields. The equations of linear elasticity and their application to bars are discussed. Measures of large deformation and concepts related to constitutive equations are included. Due to the high computational power of electronic computers, many programs of numerical computation, such as finite element programs, are written based on a rigorous treatment of solid mechanics. An understanding of the rigorous approach is necessary for an interpretation of the numerical results.

Learning Outcomes:

- Gain an understanding of matrix, vectors, and Cartesian Tensors
- Learn the concepts of stress vector and stress tensor and their characteristics
- Learn the concepts of material and spatial descriptions, deformation gradient, polar decomposition and strain measures
- Learn material rate of change, dual vectors and tensors, rate of deformation and spin tensor
- Learn bulk material rate of change, conservation of mass, momentum and energy, deformation of an area element, and Piola-Kirchhoff stresses
- Learn objective tensors, objective rates, Jaumann stress rate,and hyperelasticity
- Gain an understanding of Hooke's law, homogeneous deformations, boundary-value problems, compatibility equations, uniqueness of solution, extension of a long cylinder, torsion of a circular cylinder, and pure bending of a cylinder

Module I

Mathematical Preliminaries: Summation Convention, Transformation Law for Different Bases, vector space: Metric, Norm
Theory of Matrices: Matrix norms, Positive definite matrix
Vector Calculus: Gradient, Divergence, and Curl Theorems
Tensors: Dyads and Polyads, Nonion Form of a Dyadic, dual vectors and tensors, Tensor Calculus, Eigenvalues and Eigenvectors of Tensors.

Stress Principles The Stress Tensor, Principal Stresses, Mohr's Circles for Stress, Plane Stress, Deviator and Spherical Stress States, Octahedral Shear Stress, Cauchy's Formula.
Other Stress Measures - First Piola–Kirchhoff Stress Tensor, Second Piola–Kirchhoff Stress Tensor

Module II

Kinematics of Deformation and Motion

Particles, Configurations, Deformations and Motion, The Material Derivative, Deformation Gradients, , Finite Strain Tensors, Infinitesimal Deformation Theory, Compatibility Equations, Velocity Gradient, Rate of Deformation, Vorticity, Strain Measures, Cauchy–Green Deformation Tensors, Green Strain Tensor, Physical Interpretation of the Strain Components, Principal Strains, Polar Decomposition Theorem. objective tensors, objective rates, Jaumann stress rate and hyper elasticity

Fundamental Laws and Equations

Conservation of Mass, Continuity Equation, Equations of Motion, Lagrangian Equations of Motion, Moment of Momentum ,Principle, Law of Conservation of Energy, Generalized Hooke's Law, Orthotropic Materials, Isotropic Materials, Transformation of Stress and Strain Components.

Module III

Linearized Elasticity Problems

Elasticity, Hooke's Law, Strain Energy, Hooke's Law for Isotropic Media, Elastic Constants Elastic Symmetry; Hooke's Law for Anisotropic Media, Isotropic Elastostatics and Elastodynamics, Superposition Principle, Saint-Venant Problem, Extension, Torsion, Pure Bending, Flexure, Plane Elasticity, Airy Stress Function, Three-Dimensional Elasticity.

References:

1. G. Thomas Mase, George E. Mase.. Ronald E. Smelser. Continuum mechanics for engineers - - - 3rd ed CRC Press
2. J. N. Reddy, An Introduction to Continuum Mechanics with applications - Cambridge University Press
3. Y. C. Fung, A First Course in Continuum Mechanics for Physical and Biological Engineers and scientists - Prentice Hall
4. Han-Chin W, Continuum mechanics and plasticity - CRC Press
5. Sudhakar Nair, Introduction to Continuum Mechanics – Cambridge University press
6. J.H. Heinbockel, Introduction to Tensor Calculus and Continuum Mechanics – Open Source
7. W. Michael Lai, David Ribin, Erhard Kaempl, Introduction to continuum Mechanics fourth edn, Butterworth- Heinemann
8. Morton E. Gurtin, An introduction to continuum mechanics, Academic Press.
9. K. J. Bathe, Finite element procedures, 1996 Prentice Hall
10. S.P. Timoshenko, J.N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing Co. 1970
11. L.S. Srinath, Advanced Mechanics of Solids, 2nd Ed., TMH Publishing Co. Ltd., New Delhi, 2003.
12. D. S. Chandrasekharaiah, Lokenath Debnath, Continuum Mechanics, Academic Press, 1994.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDC 1004: INDUSTRIAL TRIBOLOGY **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- Describe surface topography, physico-chemical aspects of solid surfaces and surface interactions.
- Analysis of surface roughness- Measurement of surface roughness- Measurement of real area of contact.
- Origins and significance of Micro/Nanotribology.
- Recognize the laws of friction, mechanisms of friction, stick slip and surface temperature.
- Appreciate the various modes of wear: adhesive, delamination, fretting, abrasive, erosive, corrosive, oxidational (mild and severe), melt, and the wear-mechanism maps.
- Identify types of lubrication: boundary, solid-film, hydrodynamic, and hydrostatic lubrication.
- Analysis of hydrodynamic and hydrostatic lubrication with problems.
- Examine applications/case studies: sliding contacts, rolling contacts, bearing design, bearing selection, lubrication and mountings.
- Micro/Nanotribology/Atomic scale friction - Microscale friction - Nanoscale wear - Microscale scratching - Microscale wear.
- Tests and Instrumentation in Tribology

Learning Outcomes:

- Have a comprehensive, systematic and integrated knowledge of the principles of friction, wear and lubrication.
- Have a critical and coherent understanding of the methods used to combat friction and wear-related problems.
- Have the ability to identify, analyze and address industrial friction and wear-related problems.
- Understand the selection and design procedures of hydrodynamic, hydrostatic and antifriction bearings.

Module I

Introduction to tribology- Origins and significance of Micro/Nanotribology – tribological parameters like friction, wear and lubrication. Nature of surfaces-Physico-chemical characteristics of surface layers- Analysis of surface roughness- Measurement of surface roughness- Measurement of real area of contact.
Friction: Types of friction-dry-boundary and fluid-laws of friction and friction theories- Friction of metals, ceramic materials and polymers-Variables in friction – Surface cleanliness – effect of pressure, velocity, temperature, vibration etc.

Wear – Classification – theories of wear- stages of wear- Types of wear mechanisms- adhesive and abrasive wear- factors affecting wear. Types of particles present in wear debris. Wear of materials. Tests and Instrumentation in Tribology: Sliding friction and wear abrasion test, rolling contact and fatigue test, solid particle and erosion test, Corrosion test.

Module II

Lubrication: Role of lubrication- Lubricants-selection of lubricants- Importance of viscosity and methods for measuring viscosity- fundamentals of viscous flow- flow through capillary tubes between parallel pates- radial flow between parallel circular places – continuity equation and Reynold's equation.
Bearings- classification and applications- Selection of bearings.
Hydrodynamic bearings: Journal bearings eccentricity-pressure distribution – attitude load carrying capacity –friction and power loss-ideal and real bearings – leakage factors- sommerfield number and design charts. Oil flow and heat dissipation in bearings- Analysis of hydro thrust bearings – Fixed and pivoted shoe bearings.

Module III

Hydrostatic bearings: Analysis of oil pads-hydrostatic step bearings-hydrostatic thrust bearing with shoes- role of restrictors- bearing materials and lubricants.
Rolling element bearings: Types-bearings theory-static and dynamic capacities-bearing life – selection of bearings-lubrication and mounting of bearings.
Micro/Nanotribology: Surface force apparatus (SFA) studies- Description of an SFA- Static, Dynamic and Shear properties of molecularly thin liquid films- Description of Atomic force microscope (AFM) and Friction force Microscope (FFM)-Friction and adhesion-Atomic scale friction-Microscale friction-Nanoscale wear-Microscale scratching-Microscale wear.

References:

1. Radzimovsky: Theory of lubrication of bearings
2. O'Conner and Boyd : Standard Hand Book of Lubrication Engineering McGraw Hill
3. Fuller D.D: Theory and practice of lubrication for Engineers – John Willey& Sons, Inc.
4. I.M.Hutchings: Tribology-University of Cambridge
5. Gwidon.W.Stachowiak and Andrew.W.Batchelor-Butterworth Heinemann Publishers
6. Bharat Bhusan: Introduction to Tribology- John Wiley & Sons, Inc.
7. Khonsari and Booser: Applied Tribology: Bearing Design and Lubrication.
8. Sushil kumar Srivastva: Tribology in Industries.
9. BC Majumdar: Introduction to Tribology of Bearing

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDC 1005: FINITE ELEMENT METHOD **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- Development of element equations
- Discretization of solution domain into a finite element mesh
- Assembly of element equations
- Introduction of boundary conditions
- Solution for nodal unknowns
- Computation of solution and related quantities over each element

Learning Outcomes:

Student may be able to model a real life structural problem in FEM and to get the response and stress and strains at the critical locations by program as well as by commercial software such as ANSYS, NASTRAN etc.

Module I

Matrix algebra, Methods of solution of simultaneous equations, Basic concepts of FEM, Introduction to the Stiffness (Displacement) Method, Spring, Bar elements and torsion element, Development of truss equations, Development of beam equations, Frame and grid equations, Transformation of coordinates.

Module II

Development of the Plane Stress and Plane Strain Stiffness Equations, Practical Considerations in Modeling, Interpreting Results and Examples of Plane Stress/Strain Analysis, Development of the Linear-Strain Triangle Equations, Method of weighted residuals (Galerkin), Interpolation functions for general element formulation. Patch test, different type of refinements (h, p and r)

Module III

Axisymmetric Elements, Natural coordinates systems, Isoparametric Formulation, Three-Dimensional Stress Analysis, Plate Bending Element, Heat Transfer and Mass Transport, Thermal Stress, Structural Dynamics, Evaluation of eigen values and eigen vectors, Determination of critical speed of shafts, Rigid body modes.

(Assignments to write programs in Matlab/Fortran and to practice in FEM packages)
Finite element program packages - Pre-processing and post-processing, mesh generation.

References:

1. Finite element procedures K. J. Bathe, PHI
2. The Finite element methods in engineering, S S Rao
3. Introduction to finite elements in engineering, Thirupathi R.Chandrupatla and Ashok D. Belegundu , PHI
4. Elementary Finite Elements Method, Desai C. S.
5. The Finite Element Method, Zienkiewicz O. C.
6. An introduction to the Finite Element Method, Reddy J. N.
7. Applied finite element analysis, Larry J.Segerlind
8. Finite Element Method, R. D. Cook
9. Finite Element Method, C.S. Krishnamurthy
10. Basics of F E M- Solid Mechanics, Heat transfer and Fluid mechanics, Dubuque I A and W C Brown.
11. Fundamentals of FEM by David V Hutton, Mc Graw Hill
12. A First Course in the Finite Element Method Fifth Edition - Daryl L. Logan - Thomson

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDC 1101: DESIGN LAB 1 **0-0-2-1**

Sl. No	Name of experiment	Main Equipments needed
1	Study of vibrations of a box stationed on flexible springs.	Motor , Box, Springs, Variator, Tachometer , etc
2	Study of absorber system and its tuning for a fixed fixed beam.	Motor , Tuned damper , Variator, Auxiliary mass ,Tachometer , etc.
3	Study of free and forced vibration using universal vibration machine	Speed controller, motor, disc, tachometer, spring, damper, drum. Etc.
4	Estimation of damping of beam specimen for different damping treatments	Beam specimen of Steel, Viscoelastic material for attachments, Accelerometer, Charge amplifier, Oscilloscope
5	To find the natural frequencies and mode shapes of a free-free beam experimentally and verify the same analytically	Vibration exciter, Arbitrary function generator, free-free beam, Oscilloscope, Amplifier, laser displacement meter
6	Noise mapping of a machine using sound intensity probe	Sound Intensity probe and FFT analyzer
7	To verify the inverse square law for sound	Frequency generator, speaker and sound level meter
8	Study of various function of Sound Level Meter and use it for field measurements	Integrating Sound level Meter, Calibrator etc.
9	To get the transmission loss of any panel eg. door	Sound Level meter, Signal generator, amplifier, speaker.
10	To study the sound of musical instruments	Musical Instruments (Tabla, guitar), microphone, amplifier, FFT Analyzer
11	Determination of natural frequencies and mode shapes of a free-free plate.	laser displacement meter/Accelerometer, Oscilloscope, Exciter, plate, Labview sound and vibration tool kit
12	Use of Laser Doppler Vibrometer for measurement of complex structures	scanning laser Doppler vibrometer

Note: Any 8 experiments out of 12 is to be done.

MDC 1102 **SEMINAR** **0-0-2-2**

The student has to present a seminar in one of the current topics in the stream of specialization. The students have to undertake a detailed study based on current published papers, journals, books on the chosen subject, present the seminar and submit seminar report at the end of the semester in consultation with their respective guides.

Marks: Seminar Report Evaluation: 50
Seminar Presentation: 50

SECOND SEMESTER

MDC 2001: FRACTURE MECHANICS 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Learning objectives:

- To gain knowledge of fracture mechanics
- To gain knowledge of using fracture mechanics in the actual design
- To gain knowledge of using materials with existing cracks and know the behavior of existing cracks

Course outcome:

Students will understand how the theory is used in actual design
At the end of the course students will know about how to restrict the propagation of crack

Industrial relevance:

This course is having direct application to industry.
The knowledge of fracture mechanics will prevent industries to prevent catastrophic failures of pressure vessels, aero planes etc.

Module I

Introduction: Significance of fracture mechanics – Linear elastic fracture mechanics (LEFM)-Griffith energy balance approach - Irwin's modification to the Griffith theory - instability and R curve-Stress analysis of cracks- fracture toughness - modes I, II & III - mixed mode problems-expressions for stresses and strains in the crack tip region - finite specimen width - superposition of stress intensity factors (SIF) – SIF of centre cracked plate, single edge notched plate, and embedded elliptical cracks R-curve concept-thickness effect- Crack tip plasticity: Irwin plastic zone size - Dugdale approach - shape of plastic zone - state of stress in the crack tip region - influence of stress state on fracture behavior- LEFM testing: Plane strain and plane stress fracture toughness testing - determination of R-curves.

Module II

Elastic plastic fracture mechanics (EPFM): Development of EPFM - J-integral – Definition-Path independence-Application to engineering problems-crack opening displacement (COD) approach - COD design curve - relation between J and COD - tearing modulus concept - standard JIc test and COD test

Module III

Fatigue crack growth: Mechanisms of fracture and crack growth- Description of fatigue crack growth using stress intensity factor - effects of stress ratio - crack closure - prediction of fatigue crack growth under constant amplitude and variable amplitude loading - Fatigue Crack Initiation-Time-to-failure (TTF) tests - crack growth rate testing - practical significance of sustained load fracture testing- Basic Aspects of Dynamic Crack Growth-Basic Principles of Crack Arrest -Fracture Mechanics Analysis of fast fracture and Crack Arrest.

References:

M. Janssen, J. Zuidema and R. J. H. Wanhill., *Fracture Mechanics,* Taylor & Francis.
Broek D., *Elementary Engineering Fracture Mechanics,* Sijthoff & Noordhoff International Publishers.
T.L. Anderson , *Fracture Mechanics Fundamentals and Applications* , CRC PRESS.
Prashant Kumar, *Elements of Fracture Mechanics,* Wheeler Publishing.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDC 2002: DESIGN OF POWER TRANSMISSION ELEMENTS **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- To give an overview of Transmission elements.
- To gain knowledge of industrial design and analysis of power transmission elements.
- Study the thermal aspects in design of transmission elements.
- To gain knowledge of the dynamic analysis of the brakes, clutches etc.

Course outcome:

Students will understand the theory and applications of power transmission elements.
At the end of the course students will be able to select a suitable transmission drive mechanism, able to do dynamic, thermal and efficiency analysis of different power transmission elements.

Module I

Analysis, design and selection of chain drives and belt drives, design of couplings, selection of rolling element bearings.

Module II

Classification, theory and operation of friction drives, design considerations.
Gears Transmission – Types of Gears – Speed ratio – Design of Gears. Synthesis of multi speed gear boxes.

Module III

Brakes, disk brakes-self actuating brakes fixed, link and sliding anchor drum brakes. Dynamics and thermal aspects of vehicle braking.
Clutches – analysis and dynamics, design of automobile clutch, overrunning clutch.

References:

1. Braking of road vehicles-Newcom and Spurr
2. Design of Machine elements-Vol II-Nieman
3. Design of Machine elements-Reshtov
4. Design of Machine elements-Dobrovolkshy
5. Ground Vehicles- Wong

MCC 2000 RESEARCH METHODOLOGY 2-0-0-2

Structure of the Course

Lecture : 2 hrs/ Week Credits : 2
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objective:

To formulate a viable research question
To distinguish probabilistic from deterministic explanations
To analyze the benefits and drawbacks of different methodologies
To understand how to prepare and execute a feasible research project

Outcome

Students are exposed to the research concepts in terms of identifying the research problem, collecting relevant data pertaining to the problem, to carry out the research and writing research papers/thesis/dissertation.

Module 1

Introduction to Research Methodology - Objectives and types of research: Motivation towards research - Research methods *vs.*Methodology. Type of research: Descriptive *vs.*Analytical, Applied *vs.* Fundamental, Quantitative *vs.* Qualitative, and Conceptual*vs.* Empirical.
Research Formulation - Defining and formulating the research problem -Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem. Literature review: Primary and secondary sources - reviews, treatise, monographs, patents.Web as a source: searching the web. Critical literature review - Identifying gap areas from literature review - Development of working hypothesis.

Module 2

Research design and methods: Research design - Basic Principles- Need forresearch design — Features of a good design. Important concepts relating to research design: Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction. Development of Models and research plans: Exploration, Description, Diagnosis, Experimentation and sample designs.Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection - Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-Testing -Generalization and Interpretation.

Module 3

Reporting and thesis writing - Structure and components of scientific reports -Types of report - Technical reports and thesis - Significance - Different steps in the preparation, Layout, structure and Language of typical reports, Illustrations and tables, Bibliography, referencing and footnotes.Presentation; Oral presentation - Planning - Preparation -Practice - Making presentation - Use of audio-visual aids - Importance of effective communication.

Application of results of research outcome: Environmental impacts –Professional ethics - Ethical issues -ethical committees.Commercialization of the work - Copy right - royalty - Intellectual property rights and patent law - Trade Related aspects of Intellectual Property Rights - Reproduction of published material - Plagiarism - Citation and acknowledgement - Reproducibility and accountability.

References:

1. C.R Kothari, Research Methodology, Sultan Chand & Sons, New Delhi,1990
2. Panneerselvam, "Research Methodology", Prentice Hall of India, New Delhi, 2012.
3. J.W Bames," Statistical Analysis for Engineers and Scientists", McGraw Hill, New York.
4. Donald Cooper, "Business Research Methods", Tata McGraw Hill, New Delhi.
5. Leedy P D, "Practical Research: Planning and Design", MacMillan Publishing Co.
6. Day R A, *"How to Write and Publish a Scientific Paper"*, Cambridge University Press, 1989.
7. Manna, Chakraborti, "Values and Ethics in Business Profession", Prentice Hall of India, New Delhi, 2012.
8. Sople," Managing Intellectual Property: The Strategic Imperative, Prentice Hall of India, New Delhi, 2012.

MDC 2101: DESIGN LAB 2 **0-0-2-1**

Sl. No	Name of experiment	Main Equipments needed
1	To get the spatial distribution of SPL of a Noise Generator	Signal generator, amplifier, speaker, sound level meter
2	To study the frequency distribution of a signal generated and check the frequency content of human voice and compare it for two persons	Signal generator, oscilloscope, speaker and microphone
3	To determine natural frequencies corresponding mode shapes of the disc and mode shapes	Accelerometers, oscilloscope, charge amplifier, electrodynamics exciter, disk etc.
4	Modal analysis of a beam – by using impact hammer, and by using shaker	Accelerometers, oscilloscope, charge amplifier, impact hammer, electrodynamic exciter, beam and its fixer etc.
5	Modal analysis of plate – by using impact hammer, and by using shaker	Accelerometers, oscilloscope, charge amplifier, impact hammer, electrodynamic exciter, plate and its fixer etc.
6	Modal analysis of beam by modeling in CAD software and exporting the same to finite element analysis software.	Any FEM Software package, (ANSYS/NASTRAN/ABACUS/ADINA/COMSOL) Any 3D modeling CAD package (Pro-E, Inventor, Solidworks, Catia)
7	Modal analysis of plate using to finite element analysis software.	Any FEM Software package, (ANSYS/NASTRAN/ABACUS/ADINA/COMSOL) Any 3D modeling CAD package (Pro-E, Inventor, Solidworks, Catia)
8	Modal analysis of beam using computer program code	Software – MATLAB/FORTRAN/C++
9	Modal analysis of plate using computer program code	Software – MATLAB/FORTRAN/C++
10	For a single degree of freedom spring mass damper system subject to forced harmonic vibration, measure the FRF and identify the mass, stiffness and damping using the peak picking method	Spring mass system, accelerometer, FFT analyzer, exciter,
11	Material characterization of viscoelastic, hyper elastic and biological membrane material	Bi-axial testing machine
12	Fatigue fracture study of composites	Fatigue fracture testing machine

MDC 2102 THESIS – PRELIMINARY (PART 1) 0-0-2-2

The main objective of thesis is to provide an opportunity to each student to do original and independent study and research on the area of specialization. The student is required to explore indepth and develop a topic of his/her own choice, which adds significantly to the body of knowledge existing in the relevant field.The thesis has three parts (Part I in semester-2 and Part-2 in semester -3 & Part-3 in semester -4). The thesis can be conveniently divided into three parts as advised by the guide and the first part is to be completed in this semester The student has to present a seminar before the evaluation committee at the end of the semester that would highlight the topic, objectives , methodology and expected results and submit a report of the work completed in soft bounded form .

MDC 2103 SEMINAR 0-0-2-2

The student is expected to present a seminar in one of the current topics in the stream of specialization. The student will undertake a detailed study based on current published papers, journals, books on the chosen subject and submit seminar report at the end of the semester.

Marks: Seminar Report Evaluation: 50
Seminar Presentation: 50

SECOND SEMESTER STREAM ELECTIVES

MDE 2001: ADVANCED DESIGN SYNTHESIS **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- To give an overview of the techniques used in mechanical engineering for the analysis and synthesis of mechanisms.
- To familiarize the graphical and analytical techniques commonly used in the synthesis of mechanisms
- To provide sufficient theoretical background to understand contemporary mechanism design techniques.
- To develop skills for applying these theories in practice.
- Identify mechanisms by type of motion (planar, spatial, etc.)
- Select the best type of mechanism for a specific application and apply the fundamental synthesis technique to properly dimension the mechanism.

Learning Outcomes:

By the end of the course, the students will be able to

- Create and analyse a great number of types of mechanisms.
- Do kinematic analysis of common mechanisms used in machinery.
- Apply the analysis and synthesis methods to design a mechanism.

Module I

Floating Link, Special methods of Velocity and Acceleration Analysis using auxiliary points, Overlay method for conditioned crank mechanisms, coupler curves. Roberts – chebyshev theorem, Inflection circle, Euler Savery equation, Hartman construction, Bobillier construction, synthesis using Optimum transmission angle

Module II

Synthesis- Two point synthesis, Geometric methods of synthesis with three accuracy points:- poles of four bar linkages, Relative poles of four bar linkages, Function generators, poles of slider crank mechanisms, Relative poles of slider crank mechanisms, Rectilinear recorder mechanisms.
Geometric methods of synthesis with four accuracy points:- pole triangles, center point curves, Circle point curves, Construction of circle points, Cardinal points, opposite poles, Pole quadrilaterals, Function Generators, Rectilinear mechanisms.

Module III

Algebraic methods of synthesis using displacement equations: - Displacement equation of four bar linkage, Crank and follower synthesis- three accuracy points, Crank and follower synthesis:- angular velocities and accelerations, Syntheses of slider crank mechanism with three accuracy points. Synthesis of slider crank mechanism with four accuracy points. Algebraic methods of synthesis using complex numbers. Spatial motion and spatial linkages, Types of spatial mechanisms, Single loop linkage and multiple loop linkages. Mechanisms in Robots.

References:

1. Kinematic synthesis of Linkages by Richard.S.Hartenberg, Jacques Denavit, McGraw Hill Book Company
2. Kinematics and linkage design by Allen.S. Hall, Pentice Hall of India, Ltd.
3. Theory of Mechanisms and Machines by Shigley, McGraw Hill International Edition.
4. Dynamics of Machinery by A.R.Holowenko

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE-2002 : RANDOM VIBRATION ANALYSIS **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

Students taking this course will learn to apply tools from probabilistic modeling to analyze dynamic systems while accounting for variability and uncertainties that are inevitably present in real engineered systems. By the end of this class, you will be able to:

- Classify random excitations as stationary or non-stationary
- Discuss important properties of random processes
- Define and compute power spectral density functions
- Compute auto-and cross-correlation functions, and relate them to power spectral density functions
- Describe the dynamic response of a multi-degree-of-freedom system to a stochastic excitation
- Quantify the distributions of peak loads and peak responses from a system subject to stochastic excitation

Learning Outcomes:

- Understand the various probability related functions and solve problem involving probability.
- Able to solve problems involving various stochastic process
- Understand the response of various excitation like stationary, delta oriented and Gaussian excitations.

Module I

Probability Theory & Random variables- Introduction to Random vibration & probabilistic modeling. Axioms of probability theory: probability space & random variables. Probability distributions and density functions of random variables, joint and marginal distribuition and density functions, functions of random variables. Expectations and moments of random variables, Baye's theorem, conditional random variables, conditional expectations. uences of random variables, stochastic convergence, limit theorems

Module II

Stochastic Processes- Concepts of stochastic processes, probability distributions, moments, correlation and covariance functions. The power spectral density function., Stationarity and non-stationarity of stochastic processes, ergodicity of a stochastic process. Limits of a stochastic process, Continuity & differentiability, stochastic derivatives and integrals.

Module III

Linear Vibration Analysis- Review of deterministic dynamics and impulse response functions of systems, system response to random excitations.- Response to stationary & weakly stationary excitations and to delta-correlated excitations, Response to Gaussian excitations. Non-stationary excitations. Generalization to multi degree-of-freedom systems.

References:

1. Leonard Meirovitch – Elements of Vibration Analysis, McGraw Hill
2. Lin Y.K., "Probability Theory In Structural Dynamics ", McGraw Hill
3. Bendat & Piersol, "Random Data Analysis And Measurement Procedure ",Wiley Inter Science, John Wiley
4. Thomson W.T , Theory of Vibration with Applications., Prentice Hall India.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2003: DESIGN OF PRESSURE VESSELS AND PIPING 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- To gain knowledge of pressure vessel design
- To gain knowledge of designing of pipe
- To gain knowledge of using codes in design

Learning Outcomes:

- Students will understand how the theory is used in actual design
- At the end of the course students will know the usage of codes

Module I

Pressure vessel – Terminology - Types of loads-Types of pressure-Stresses in pressure vessels– Membrane stress Analysis of Vessel Shell components – Cylindrical shells, spherical shells, conical head, elliptical head – Thermal stresses- Discontinuity stresses in pressure vessels- -Use of code

Module II

Design of vessels ; Design of tall cylindrical self supporting process columns – supports for short vessels –Support for horizontal vessels-Design for wind load- Design for seismic load- Theory of reinforcement - Design of cone cylinder intersections -Use of codes

Module III

Buckling - Elastic buckling of cylinders under external pressure –Stiffeners – Stresses in thick walled cylinders- Lame’s equation-Use of codes
Piping- Pipe specification-Pipe classification- piping elements- piping layout and piping stress Analysis- Flexibility analysis- Use of codes

References:

1. John .F.Harvey, 'Theory and Design of Pressure Vessels' CBS Publisher and Distributors
2. Henry H bender, " Pressure vessels Design hand Book"
3. ASME Pressure Vessel Codes Section VIII, 2006
4. Dennis Moss Pressure vessel design manual Gulf publishing, 2003.
5. Brownell, L. E., and Young, E. H., Process Equipment Design, John Wiley and Sons,
6. Somnath Chathopadhyay, Pressure vessels Design and practice, C.R.C Press

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2004: ADVANCED MACHINE TOOL DESIGN 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- The major objective of this subject is to study in detail about the Machine Tool kinematics, drives and tool dynamics and application of Finite Element Analysis in thermal aspects of machine tool components.

Learning Outcomes:

- After completing the module I the students must able to design the drives and machine tool elements.
- FEM analysis of the machine tool structures.
- The students should be able to aware about the new developments in machine tool design.

Module I

General kinematics – design of drives and machine tool elements – design of tool changes and turrets – machine tool dynamics

Module II

FEM analysis of machine tool structures. Thermal aspect in machine tool design, machine tool noise and concepts of noise control. Design of slide ways – application of new materials – treatment of slide ways.

Module III

CNC machine tool structures. Static and dynamic testing of machine tools. Recent trends in machine tool design.

References:

1. M. Weck, Handbook of Machine Tools, Vol. 1-4, John Wiley, USA.
2. J. Tlusty And F. Koenigsbeger, Machine Tool Strucure, Vol. I, Pergamon Press, UK.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2005: ADVANCED FINITE ELEMENT METHODS 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

The objective in this course is to summarize modern and effective finite element procedures for the nonlinear analysis of static and dynamic problems. The modeling of geometric and material nonlinear problems is discussed. The basic finite element formulations employed are presented, efficient numerical procedures are discussed, and recommendations on the actual use of the methods in engineering practice are given.

Learning Outcomes:

The student may be able to model nonlinear problems

- Geometric nonlinear problems
- Material nonlinear problems
- Large deformation problems
- Dynamic problems of above types

Module I

Introduction to Nonlinear Analysis, Basic Considerations in Nonlinear Analysis Lagrangian Continuum Mechanics Variables for General Nonlinear Analysis, Total Lagrangian and updated Lagrangian formulation for Incremental General Nonlinear Analysis from the principles of continuum mechanics

Module II

Formulation of Finite Element Matrices from the principles of continuum mechanics: Two and Three-Dimensional Solid Elements; Plane Stress, Plane Strain, and Axisymmetric Conditions, Two-Noded Truss Element using Updated and Total Lagrangian Formulation.

Module III

Solution of the Nonlinear Finite Element Equations in Static Analysis, Solution of Nonlinear Dynamic Response, Use of Elastic Constitutive Relations in Total Lagrangian Formulation, Formulation of Finite Element Matrices for Beam, Plate and shell Elements.

Extra reading -
(Assignments to write programs in Matlab/Fortran and to practice in FEM packages)

Modeling of Elasto-Plastic and Creep Response

Reference:

1. Finite element procedures K. J. Bathe, PHI.
2. An Introduction to Nonlinear Finite Element Analysis, J.N Reddy, Oxford University Press, 2005.
3. Nonlinear Finite elements for continua and structures, Ted Belytschko, Wiley 2001.
4. Continuum Mechanics and plasticity, Han Chin Wu, CRC,2001.
5. An introduction to continuum mechanics with applications, J.N Reddy, Cambridge university Press, 2008.
6. Nonlinear Finite Element Analysis of Solids and Structures VOLUME 1 ESSENTIALS - M.A. Crisfield, Wiley.
7. Nonlinear Finite Element Analysis of Solids and Structures Volume 2 Advanced Topics - M.A. Crisfield, Wiley.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2006: MECHANICS OF COMPOSITE MATERIALS 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- To gain knowledge of Different types of engineering materials, anisotropy, orthotropic and composite materials.
- To gain knowledge of composites, types, applications, manufacturing and mechanics of composite structures.
- To gain knowledge of stress analysis and failure analysis of composites.
- To gain knowledge of basic design principles of composite structures.

Learning Outcomes:

- Students will understand how to select a composite material a suitable manufacturing method for the required application.
- At the end of the course students will know how to design a composite product and will be able to understand the failure mechanisms and testing methods of composite structures.

Module I

Basic Definitions and classification of composites - Basic definitions, Various types of composites.- Basic constituent materials in composites , composite Manufacturing Processes-PMC's, MMC's, CMC's and carbon-carbon composites. Micromechanical behavior of a lamina- volume and mass fractions, density and void content , evaluation of elastic moduli, ultimate strengths of a unidirectional lamina, thermal expansion coefficients, moisture expansion coefficients

Module II

Macro mechanical behavior of a lamina- Hooke's law for different types of materials, Hooke's law for a two dimensional unidirectional lamina, Hooke's law for a two dimensional angle lamina, engineering constants for an angle lamina, invariant form of stiffness and compliance matrices for an angle lamina, strength failure theories of an angle lamina - determination of laminate mechanical properties.
Macro mechanical analysis of a laminate- laminates code, stress-strain relations for a laminate, in-plane and flexural modulus of a laminate, hydrothermal effects in laminate.
Failure, analysis and design of laminates - first and last ply failure approaches Design of laminated based on strength and stiffness.

Module III

Stress analysis of laminated beams. Long-term environmental effects, interlinear stresses, impact resistance, fracture resistance and fatigue resistance. Machining of composite structures. Mechanical Testing of composites.

References:

1. R. M. Jones,- Mechanics of Composite Material, McGraw Hill Publishing.
2. S.S. W. Tsai, Composites Design, Think Composites, 1986.
3. B. D. Agrawal and L.J. Brountman, Analysis and Performance of Fiber Composite, Willey New York, 1980.
4. Geoff Eckold, Design and Manufacture of Composite Structures, Wood –heed, Publishing Limited, Combridge, England, 1994.
5. Stephen W.Tsai and H. Thomas Hahn, 'Introduction to Composite Material'', Technomic Publishing Company, Inc. Lancaster, 1980.
6. J. N. Reddy and A.V. Krishna Moorty, "Composite Structures, Testing, Analysis and Design Narosa Publishing House, New Delhi., 1992.

Structure of the Question paper

For the end semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2007: EXPERIMENTAL STRESS ANALYSIS 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To familiarize the basics of commonly used experimental stress analysis techniques.
- To familiarize different strain gages.
- To establish the fundamental concepts and new experimental techniques.
- To be able to use the experimental techniques on the practical problems.
- To equip the students with basic theory of elasticity and stress-strain relationships.
- To familiarize various strain measurement techniques.
- To familiarize various instrumentation for strain measurements.
- To introduce the concept of photo elastic stress analysis methods.
- To familiarize various nondestructive test methods.

Learning Outcomes:

- Apply the principles and techniques of photo elastic measurement.
- Apply the principles and techniques of strain gage measurement.
- Apply the principles and techniques of moiré analysis.
- Apply the principles and techniques of brittle coating analysis.

Module I

Stress analysis by strain measurement: Principal stresses and strains. Mohr's circle-measurement of strains and stresses. Strain gauges and Stress gauges. Mechanical, Optical and Electrical gauges-construction and applications. Variable resistance strain gauges, Gauge characteristics, Gauge sensitivity, circulatory for resistance strain gauges, Recording equipments static and dynamic strains- reduction of strain gauge data-compensation-strain measurement over long period at high and low temperature.

Module II

Photo elasticity: The Polariscope, stress optic law, Photo elastic model materials, Polariscope arrangements – Dark Field and Light field, Partial fringe value and compensation techniques, Use of photo elastic coatings. Movie fringe, Brittle coating Techniques.

Module III

Strain rosettes- Rectangular rosette, Delta rosette. Residual stresses: Beneficial and harmful effects – Principle of residual stress measurement:-methods only.
Non-destructive testing – Types –dye penetrate methods radiography-X-ray and Gamma ray-X-ray fluoroscopy-Penetrameter-Magnetic particle method.
Introduction to lasers in NDT – Ultrasonic flow detection

References:

1. Daily and Litty-Experimental stress Analysis-McGraw Hill
2. Dove and Adams-Experimental stress Analysis and Motion measurement-Prentice hall
3. Hetenyi-Handbook and Experimental stress Analysis-John wiley
4. Perry and Lissener-Strain gauge Primer-McGraw Hill
5. W.J. McGonnagle-Non-destructive Testing-Mc Graw Hill
6. American Society for Metals-Metals Hand Book – Vol.7.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2008: OPTIMIZATION TECHNIQUES FOR ENGINEERING 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- Formulate the given problem in a mathematical format which is acceptable to an optimization algorithm.
- Understand the techniques and applications of engineering optimization.
- Choose the appropriate optimization method that is more efficient to the problem at hand.

Learning Outcomes:

- Appreciate the application of optimization problems in varied disciplines.
- Model a real-world decision problem as an optimization problem.
- Perform a critical evaluation and interpretation of analysis and optimization results.

Pre-requisite: Review of vectors and matrices, set theory.

Module I

Introduction to Optimization: Historical sketch; Engineering applications of optimization; Statement of an optimization problem; Classification of optimization problems. Classical Optimization Techniques: Single variable optimization; Multivariable optimization with no constraints, with equality constraints and with inequality constraints. Review of Linear Programming Problems (LPP). (to be completed in 3 hours)

Module II

Linear Programming (LP): Decomposition principle; Sensitivity analysis; Quadratic programming and LCP. Non-Linear Programming (NLP): One-Dimensional Unconstrained Optimization – Single variable optimization; Fibonacci method; Golden-section method; Polynomial based methods (Brent's algorithm, Cubic polynomial fit); Unconstrained Optimization – Necessary and sufficient conditions for optimality; The steepest descent method; The Conjugate gradient method; Newton's method; Quasi-Newton method; Secant method.

Module III

Non-Linear Programming (NLP): Constrained Optimization – Problem formulation; Necessary and sufficient conditions for optimality; Rosen's Gradient Projection Method; Zoutendijk's method; Generalized Reduced gradient method; Sequential QP; Penalty function based methods.
Geometric programming; Dynamic programming; Integer programming; Goal programming. Stochastic programming (Overview only)

References:

1. H.A. Taha, Operations Research: An Introduction, Pearson Education
2. S.S. Rao, Engineering Optimization: Theory and Practice, New Age International Publishers.
3. A.D. Belegundu, T.R. Chandrupatla, Optimization Concepts and Applications in Engineering, Pearson Education.
4. H. M. Wagner, Principles of Operations Research, Prentice- Hall of India Pvt. Ltd.
5. Gross and Harris, Fundamentals of Queuing Theory, John Wiley & Sons
6. M.S. Bazaraa, J.J. Jarvis, H.D. Sherali, Linear Programming and Network Flows, John Wiley & Sons.
7. Kalyanmoy Deb, Optimization for Engineering Design: Algorithms and Examples, Prentice-Hall of India Pvt. Ltd.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2009: ROBOTICS **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- Objectives of the course are to give detailed study of Robotics, its mechanism, kinematics dynamics, various controllers and servo mechanisms.

Learning Outcomes:

- Students must be able to use robots and to control the robotic mechanisms in industries
- Students should able to write and understand CNC programs.

Module I

Overview of robotic mechanisms and controller – kinematics – position and orientation of objects. Coordinate transformation. Joint variables and position of end effectors. Inverse pneumatic problem. Jacobian matrix.

Module II

Dynamics : Lagrangian and Newton-Euler formulations, derivation of dynamic equations. Manipulability – manipulability ellipsoid and manipulability measures. Best configuration of Robotic mechanisms. Dynamic manipulability.

Module III

Position control – generating the desired trajectory, linear feed back control. Two stage control by linearization and servo compensation. Design and evaluation of servo compensation. Adaptive control. Force control – impedance control – hybrid.

References:

1. Introduction to Robotics , Second Edition , John J. Craig , International Student Edition, AWL.
2. Design of an Interactive Manipulator Programming Environment , UMI Research Press. R. Goldman, 1985.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2010: MECHATRONICS SYSTEM DESIGN **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks
End Semester Examination	: 60 Marks

Course Objectives:

To equip students with state of the art techniques and skills in the fields of automation and robotics. There is a huge demand from industries for qualified professionals in the areas of automation . MEMS is an emerging area where future developments are focused. Till now in India there was no manpower shortage . But in future we will lack youth employees to take tedious physical jobs. The only answer is automation. So it is the need of the hour to make students aware of the latest trends in sensors, actuators, pneumatic and hydraulic systems , PLC etc.

Learning Outcomes:

On successful completion of this course a student will be able to design and develop complicated pneumatic and hydraulic circuits to automate various equipments. They will be capable to apply their skills to develop new automatic machines. They will get a thorough knowledge about latest cutting edge technologies like MEMS, Robotics etc. They will get knowledge about microprocessors and microcontrollers which are an essential part of modern automatic devices . They will be capable to interface various types of sensors and actuators with computers by using data acquisition cards.

Module I

INTRODUCTION TO MECHATRONICS SENSORS AND TRANSDUCERS: Characteristics.Displacement and position sensors. Resolvers and synchros. Velocity and motion sensors. Principle and types of force, temperature, vibration and acoustic emission sensors.
ACTUATORS:Pneumatic, hydraulic and mechanical actuation systems used for mechatronics devices.
AUTOMATION SYSTEM DESIGN: Design of fluid power circuits – cascade, KV-map and step counter method. PLC ladder logic diagram, programming of PLC, fringe condition modules, sizing of components in pneumatic and hydraulic systems. Analysis of hydraulic circuits.

Module II

MODELING AND SIMULATION: Definition, key elements, mechatronics approach for design process, modeling of engineering systems, modeling system with spring, damper and mass, modeling chamber filled with fluid, modeling pneumatic actuator. transfer functions, frequency response of systems, bode plot. software and hardware in loop simulation.
MICROPROCESSORS & MICROCONTROLLERS: Microprocessors - introduction, 8085 architecture, types of memory, machine cycles and timing diagram, addressing modes, instruction set, development of simple programs. 8051 microcontroller architecture, registers, addressing modes, interrupts, port structure, timer blocks and applications- stepper motor speed control.
MICRO ELECTRO MECHANICAL SYSTEMS (MEMS): Fabrication methods - Working and applications of MEMS based accelerometer, pressure sensor and gyroscope

Module III.

REAL TIME INTERFACING: Introduction to data acquisition and control systems, overview of I/O process, virtual instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, SCADA systems.

ROBOTIC VISION :Image acquisition: Vidicom and charge coupled device (CCD) cameras. Image processing techniques: histogram analysis, thresholding and connectivity method.
CASE STUDIES OF MECHATRONICS SYSTEMS: Pick and place robot, Automatic Bottle filling unit, Automobile engine management system.

References:

1. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi 2007.
2. HMT, Mechatronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi 2004.
3. K.P. Ramachandran, G.K. Vijayaraghavan, M.S. Balasundaram. Mechatronics: Integrated Mechanical Electronic Systems. Wiley India Pvt. Ltd., New Delhi 2008.
4. David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems, McGraw-Hill Inc., USA 2003.
5. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, John Wiley & Sons Ltd., England 2006.
6. Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi 2006.
7. Gordon M. Mair, Industrial Robotics, Prentice Hall International, UK 1998.
8. Devadas Shetty and Richard A Kolk, Mechatronics System Design, Cengage Learning India Pvt Ltd, Delhi, 2012.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2011: COMPUTER INTEGRATED MANUFACTURING 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- To study the role of computers in manufacturing.
- Detailed study of computer controlled machine tools andits applications.
- To understand the advanced manufacturing processes, tools and systems.

Learning Outcomes:

- After completing the course the student is able to explain the various developments in manufacturing system and the role of computers in the system.
- They should thoroughly know about the advanced CNC Machines , its Programming, new systems like FMS and avdvanced RP tools..

Module I

Introduction – role of computers in design and manufacture. Wire-frame modeling-representation and data structures. Drafting system – configuration, functions and facilities- parametric representation – examples of drafting systems.

Module II

Definition and broad characteristics of Flexible Manufacturing Cells, Systems, Islands and Flexible transfer lines, Place of flexible manufacturing systems in CIM,The FMS relational: Economic and technological justification for FMS

Module III

Introduction to Numerical control in computer aided manufacturing – Components of CNC system – Types of CNC systems – Open loop and closed loop control systems, Drives and controls – Interpolators for CNC machine tools – Principal types of CNC machine tools and their constructional features – Design considerations – Tooling for CNC, Adaptive control of CNC machine tools – SMART manufacturing.CNC part programming – Manual and Computer assisted part programming – Post processors – CNC part programming with CAD / CAM systems. PLC Ladder, Logic Diagrams , Rapid prototyping , Rapid Tooling.

References:

1. C.B.Besant and C.W.K. Lui: Computer Aided Design and Manufacture, Affiliated East West, INDIA, 1988.
2. J. Rooney and P. Steadman: Principles of computer aided design, Prentice-Hall, INDIA, 1998.
3. M.P. Groover and E.W. Zimmera: CAD/CAM-Computer Aided Design and Manufacture, prentice-Hall, India, 1984.
4. Principles of Computer Integrated manufacturing – S. Kant Vajpayee, PHI
5. Computer Aided Design and Manufacturing – Dr. Sadhu Singh, Khanna Publishers.

Structure of the Question paper

For the end semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 2012: CONDITION MONITORING AND MAINTENANCE ENGINEERING 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- Various predictive maintenance techniques
- Destructive and Nondestructive testing techniques
- Analysis and remedial of condition monitoring and maintenance of various machinery in plants.

Learning Outcomes:

- Students must be able to apply predictive maintenance techniques.
- Students must be able to handle the maintenance of industrial machinery in plants.

Module I

Predictive Maintenance and Signature Analysis- observational and estimation techniques, online techniques specially dealing with instrumentation system, offline technique like visual inspection.

Module II

Destructive and Non destructive testing for materials, fluids and general mechanical and electrical components.

Module III

Predictive analysis of potential failures and end of useful life. Diagnostic maintenance, applications to specific industrial machinery and plants.

References:

1. A Guide to the condition monitoring of machines, Department of Industry, HMSO, 1979(Prepared by Micheal Neale & Associates).
2. Vibration monitoring and diagnosis – R.A.Collacott
3. Mechanical Fault diagnosis and condition monitoring-R.A.Collacott
4. First course on condition monitoring in the process industries, Nov 1979,Manchester, edited by M.J.Neale
5. Management of Industrial Maintenance-Newman-Butterworth, March 1978
6. Condition Monitoring Manual-National Productivity council,New Delhi
7. Terotechno logy –Institute of mechanical Engineers,1975

Structure of the Question paper

For the end semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

THIRD SEMESTER

MDC 3101 THESIS – PRELIMINARY (PART 2) 0-0-14-5

The student has to continue the thesis work done in the second semester in the same area. The student has to present two seminars.The first seminar shall be conducted in the first half of this semester mainly to highlight the progress of the work for the midterm evaluation and second seminar towards the end of the semester to access the quality and quantum of work done in this semester. The student has to submit a report of the work completed in soft bounded form. The seminars and the report shall be evaluated by the evaluation committee.

Evaluation of marks for the Thesis-Preliminary Part II

Evaluation of the Thesis-Preliminary work by the guide - 100 Marks
Evaluation of the Thesis–Preliminary by the Evaluation Committee-100 Marks

THIRD SEMESTER
STREAM ELECTIVES

MDE 3001: EXPERIMENTAL METHODS FOR ENGINEERING **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

To provide students theory and laboratory experience including computerized data acquisition and complex process type experiments. Strong emphasis is placed on problem solving, judgment, and the importance of accuracy, error, and uncertainty analysis and the usage of the experimental equipment such as strain gages, pressure sensors and dimensional metrology tools. After completing the course, students are expected to be aware of importance of experimental planning, different instrumentation and their selection and be able to apply knowledge from their science courses in order to design experiments and judge quality and precision of their measurements.

Learning Outcomes:

- An ability to use common measurement equipments.
- An ability to design and plan experiments.
- An ability to calculate the error/uncertainty propagation for calculations that include multiple terms with uncertainties.
- An ability to perform curve-fitting of multivariate data sets.
- An ability to perform statistical data analysis of univariate and bivariate data sets.

Module I

Basic concepts of measurement methods and planning and documenting experiments. Typical sensors, transducers, and measurements system behavior Data sampling and computerized data acquisition systems.
Statistical methods and uncertainty analysis applied to data reduction.

Module II

Procedures for hypothesis testing, means, proportions, variances, contingency, goodness of fit of data to a proposed model. Use of hypothesis tests to compare products or processes.
Simple and multiple regression analysis. Use of transformation, analysis of residuals, variable selection procedures

Module III

Principles of experimental design: randomization, replication, blocking. Analysis of variance: one-way and two-way analyses, with and without interaction. Cross-classified and nested forms. Fixed and random eff
ect models. Factorial experiments versus one factor-at-a time experiments.

References:

1. Experimental Methods for Engineers, J. P. Holman, McGraw-Hill Education (2000) ISBN 0071181652.
2. Experimental Methods: An Introduction to the Analysis and Presentation of Data, L. Kirkup, Wiley Text Books (1995) ISBN 0471335797.
3. Experimental Physics: Modern Methods, R. A. Dunlap, Oxford University Press (1988) ISBN 0195049497.
4. Experiments in Modern Physics, 2nd Edition, A. C. Melissinos, Academic Press (2003) ISBN 0124898513.
5. An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, 2nd Edition, J. R. Taylor, University Science Books (1997) ISBN 093570275X.
6. Design and Analysis of Experiments, Douglas C. Montgomery, John Wiley and Sons.

Structure of the Question paper

For the end semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 3002: COMPUTATIONAL METHODS IN DESIGN AND MANUFACTURE
3 Periods/Week

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

The purpose of this course is to prepare the students for the professional practice of analysis of mechanical engineering manufacturing and design through the application of engineering fundamentals. The following are specific goals:

- Appreciation of mechanical manufacturing as a continuous learning process involving tools such as nonlinear FEM and the related iterative analysis.
- Application of different stress and strain tensor for nonlinear analysis in the plastic deformation in metal forming and metal cutting processes.
- Use of total Lagrangian and updated Lagrangian methods to model the processes using FEM
- Preparation of computer programs for total Lagrangian and updated Lagrangian methods in Mat lab/ Fortran

Learning Outcomes:

- A basic understanding of the principles of machine component design is an essential requirement for mechanical engineers in an industrial environment. (Criterion 3(c))
- Potential employers and graduate programs expect the students to have an ability to:
- Apply knowledge of mathematics, science, and engineering. (Criterion 3(a))
- Design a system, component, or process to meet desired needs. (Criterion 3(c))
- Identify, formulate, and solve engineering problems. (Criterion 3(e))
- Communicate effectively and educate themselves. (Criterion 3(g), & (i))

Module I

Metal Forming and Machining Processes – Introduction to Metal Forming, Bulk Metal Forming, Sheet Metal Forming Processes, Machining, Turning, Milling etc. Index Notation and Summation Convention, Stress, Stress at a Point, Analysis of Stress at a Point, Equation of Motion, Deformation, Linear Strain Tensor, Analysis of Strain at a Point, Compatibility Conditions, Material Behavior, Elastic Stress-Strain Relations for Small Deformations, Elastoplasticity – yield criteria, incremental and deformation plasticity, flow rule, viscoplasticity. Finite element method-procedure, elements and shape function, stiffness, matrix, isoparametric simulations, assembly and solutions. Examples of applications in mechanical design.

Module II

Nonlinear analysis – total and updated Lagrangian formulations, geometric nonlinearity and material nonlinearity-formulations and procedures for static analysis.

Module III

Finite Element Modeling of Metal Forming Processes Using Eulerian Formulation - Applications of FEM to metal forming, metal cutting- forging, extrusion and sheet metal forming – mesh rezoning, heat transfer analysis – computational procedures for thermo plasticity

Following parts are only for assignment:

Finite Element Modeling of Metal Forming Processes Using Updated Lagrangian Formulation – application to Axisymmetric Open Die Forging and Deep Drawing of Cylindrical Cups.
Optimization of Metal Forming and Machining Processes

References:

1. O.C. Zienkiewicz and R.L. Taylor: Finite Element method, Vol.1, Basic formulation and linear problems, McGraw Hill Int.Edn., 1989.
2. J.N. Reddy: Energy and Variational Methods in Applied Mechanics, John Wiley and Sons, Inc., USA, 1984.
3. R.D. Cook:Concepts and Applications of Finite Element Analysis, John Wiley, USA, 1989.
4. Dr.J.J.Owen And E. Hinton: Finite Element in Plasticity – theory and practice, Pineridge press, USA, 1986.
5. S.Kobayashi, and T. Atlan:Metal forming and Finite Element method, Oxford University press, UK, 1989.

Structure of the Question paper

For the End Semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 3003: ADVANCED COMPUTER GRAPHICS **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

Objective of the programme is to make students to familiarize the mathematical concepts of advanced computer graphics techniques. It is also aimed to make students to write simple programs and simulations using C++ programming or any software tools like MATLAB

Learning Outcomes:

Each student will become expert in writing programs for simulating engineering concepts. They also will become expert in using MATLAB for their Thesis. This will further boost their aptitude in developing graphics for research and visualizing techniques useful for industry needs.

Module I

Overview of Graphic systems, output primitives Algorithm for line, circle, ellipse, simple C++ programming or Mat Lab coding to generate lines, circles, ellipse, polygon, etc. Introduction to 2D transformations.

Module II

Geometric transformations 3D. C++ programming or MATLAB coding for various matrix operations. C++ programmers or Matlab coding to demonstrate 2D and 3D transformation. Algorithms for windowing, clipping and corresponding programming in C++ or matlab coding to demonstrate the process. Programmes to demonstrate isometric and prespective projections of solids.

Module III

3D modeling techniques (Wire frame, solid modeling and surface modeling). C++ programming or Matlab coding to represent simple 3D geometric models. Mathematical formulation of space curves.(Cubic spline, and Bezier curves) C++ programming or Matlab coding to generate space curves. DBMS in computer Graphics.

References:

1. Mathematical elements of Computer Graphics-Rogers
2. Procedural element of computer Graphics-Rogers
3. Computer Graphics for Engineers- Vera B. Anand
4. Introduction to MATLAB-Radra Prathap
5. "Computer Graphics – A Programming Approach-Steven Harrington , McGraw Hill Publication.
6. CAD/CAM/CIM-Radhakrishnan

Structure of the Question paper

For the end semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 3004: ADVANCED NUMERICAL METHODS 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- To prepare and motivate students to pursue research programmes or to serve in industry or technical profession through rigourous education.
- To provide students with a solid foundation of the theory of Numerical Techniques thus equipping them to solve mathematical models of engineering systems.
- To equip students with good scientific and mathematical principles to model and solve engineering problems met with in engineering design so as to innovate or improve existing designs in view of the purpose of improvement of standard of life.
- To inculate in student's professional and ethical attitude, effective communication skills, multidisciplinary approach, and an ability to relate engineering issues to broader social context.
- To provide students with an academic environment that encourages them towards excellence, gain leadership qualities, to learn and live by ethical codes and guidelines and life0long learning needed for a successful professional career.
- With all of the above it is desired, as the objectives, that they become useful contributors to society and thus return to it what they received in their making of a successful individual.

Learning Outcomes:

- Graduates will have received training in solving real-life engineering problems from the study of theory and problem-solving skills practiced in the class-room.
- Graduates will have their minds developed to equip them in their career to recognize problems faced by industry and society, and forge out viable solutions there to.
- Graduates will demonstrate knowledge of professional and ethical responsibilities.
- Graduate will be able to communicate effectively in both verbal and writtern form.
- Graduates will show understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
- Graduates will develop confidence for self education and ability for life-long learning.
- Graduate be able to participate and succeed in competitive examinations

Module I

Solution of algebraic and transcendental equations- Review and comparison of various iterative methods, convergence – Generalised Newton-Raphson method for multiple roots – Higher order methods – Newton's method for non-linear systems.
Solution of simultaneous equatiuons-Direct & indirectmethods-Gauss elimination and Gauss Jordan methods – ill conditioning – pivoting – Jacobi, Gauss-Seidel and Relaxation methods-convergence-Eigen value problems-Vector iteration method.

Interpolation-Newton's Divided difference, Lagrange, Aitken, Hermite and Spline techniques – Inverse interpolation-Error estimates-Double interpolation-Trigonometric interpolation.

Module II

Numerical differential- Numerical integration-Newton-Cote's Integration formula-Gauss quadrature-Error estimates-Double integration.
Curve fitting – method of least squares – nn-linear relationships – Correlation and Regression – Linear Correlation – Measures of correlation – Standard error of estimate – Coefficient of correlation – Multiple linear regression.

Module III

Solution of ordinary differential equations-Single step & multi step methods-stability of solution – simultaneous first order differential equations- higher order different equations. Numerical solution of integral equations.
Partial eifferential equations – classification – Laplace equation, ID wave equation, ID heat equation – Finite differencemethods – Relaxation methods. Stability and convergence of solution.

<u>Optimization</u>
Finding the minimum of y=f(x) Minimizing a function of several variables - linear programming.

<u>Finite Element Analysis</u>
FEM for ordinary Differential equation and partial differential equations.

Note- Computer program assignments are essential as part of sessional requirements.

References:

1. Numerical methods for Scientific and Engineering Computation – Jain M.K.,
2. Elementary Numerical Analysis – Conte and Carl DeBoor
3. Introduction to Numerical Analysis – Gupta A and Bose S C
4. Introduction to Numerical Analysis – Hilderbrand FB
5. Introduction toNumerical Analysis – Fjorberg C E
6. An Introduction toNumerical Analysis – Kendall E Atkinson
7. Statistics – Murrey R Spiegel
8. Numerical Mathematical Analysis – James B. Scarborough
9. Applied Numerical Analysis – C F Gerald & P O Wheatley
10. Numerical algorithms – E V Krishnamurthy & S K Sen

Structure of the Question paper

For the end semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDE 3005: DESIGN AND ANALYSIS OF COMPOSITE STRUCTURES 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

- To gain knowledge of mechanics of composite structures, stress analysis of composite beams, plates and shells.
- To gain knowledge of buckling and vibration analysis of composite parts.
- To gain knowledge of fracture mechanics of composite structures.
- Study the stress analysis of bonded structures, sandwich structures and stiffened structures.
- Study the mechanics of Textile composites and inflatable structures.
- To gain knowledge of finite element analysis of composites.

Learning Outcomes:

- Students will understand how to design and predict the behavior of composite structures and bonded sandwich structures.
- At the end of the course students will be able to select, design, analyze structures made of composites.

Module I

Review of Classical Laminated Plate Theory, Review of Laminate Strength and Failure Criteria Energy method for composite analysis, Shear deformation theories. Analysis of composite beams, plates and shells. Buckling analysis. Free Vibrations – Natural Frequencies of composite structures. Impact and fatigue analysis

Module II

Fracture and damage mechanics of composites. Bonded joints and structures – mechanics and failure analysis Sandwich structures – mechanics - analysis of strength – failure - design problems Skin - stiffened structures -analysis of strength and failure

Module III

Textile composites and inflatable structures, stitched composites, 3D composite, nanocomposites, Finite element analysis of composites.

References:

1) Christos Kassapoglou, Design and analysis of composite structures with application to aerospace structures, Delft University of Technology, The Netherlands 2010
2) Calcote, L R. "The Analysis of laminated Composite Structures", Von – Noastrand Reinhold Company, New York 1998.
3) S.S. W. Tsai, Composites Design, Think Composites, 1986.
4) B. D. Agrawal and L.J. Brountman, Analysis and Performance of Fiber Composite, Willey New York, 1980.
5) Geoff Eckold, Design and Manufacture of Composite Structures, Wood –heed, Publishing Limited, Combridge, England, 1994.
6) Jack R. Vinson, The Behavior of Sandwich Structures of Isotropic and Composite Materials, CRC Press,1999
7) D Dillard, Advances in structural adhesive bonding, Woodhead publishing company,
8) Cambridge England, 2010
9) J N Reddy, Mechanics of Laminated Composite Plates and ShellsTheory and Analysis, Second Edition CRC Press, 2004
10) Serge Abrate, Impact on Composite Structures, Cambridge Univarsity press, 1998.
11) J. N. Reddy and A.V. Krishna Moorty, "Composite Structures, Testing, Analysis and Design Narosa Publishing House, New Delhi., 1992.
12) O.O. Ochoa, J.N. Reddy, Finite Element Analysis of Composite Laminates, Springer, 1992
13) Srinivasan Sridharan, "Delamination behaviour of composites" Woodhead publishing company, Cambridge England, 2008

Structure of the Question paper

For the end semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

FOURTH SEMESTER

MDC 4101 THESIS FINAL 0-0-21-12

The student has to continue the thesis work done in the second and third semester. There shall be two seminars (a midterm evaluation on the progress of the work and pre submission seminar to assess the quality and quantum of the work). At least one technical paper is to be prepared for possible publication in journals / conferences. The final evaluation of the thesis shall be an external evaluation. The marks for the Thesis-Final may be proportionally distributed between external and internal evaluation as follows.

Distribution of marks allotted for the Thesis

Internal Evaluation of the Thesis work by the guide - 150 Marks
Internal Evaluation of the Thesis by the Evaluation Committee - 150 Marks
Final Evaluation of the Thesis work by the Internal and External Examiners:
(Evaluation of Thesis: 200 marks + Viva Voce: 100 marks) - 300 Marks

DEPARTMENTAL ELECTIVES IN MECHANICAL ENGINEERING FOR SEMESTER II

MID 2001: RELIABILITY ENGINEERING **3-0-0-3**

Objective:

The objective of this course is to understand the theories and their practical uses with real-world examples and problems to solve. The course focuses on system reliability estimation for time independent and failure dependent models. It helps the students in assembling necessary components and configuring them to achieve desired reliability objectives, conducting reliability tests on components, and using field data from similar components. Also to provide more complex aspects regarding both the Maintainability, Availability and some fundamental techniques such as FMECA (Failure Mode, Effects, and Criticality Analysis) and FTA (Fault Tree Analysis) with examples.

Outcome

After the completion of the course one should be able to know:

- Reliability and Hazard Functions
- System Reliability Evaluation
- Time- and Failure-Dependent Reliability
- Estimation Methods of the Parameters of Failure-Time Distributions
- Parametric Reliability Models
- Models for Accelerated Life Testing
- Renewal Processes and Expected Number of Failures
- Preventive Maintenance and Inspection

Pre-requisite: Concepts of Probability and Statistics, Probability Distributions, Point Estimation, Interval Estimation, Goodness-of-fit Tests, Statistics of Extremes.

Module I

Introduction to reliability: definition, Reliability and Quality, failure and failure modes

Failure data analysis: Reliability and rates of failure, Reliability function, expected life, failure rate, hazard function, constant and time dependent hazard models, state dependent hazard models, Markov Analysis.

Module II

System Reliability models – Series, parallel, mixed configurations, k-out-of-m models
Redundancy techniques – component vs unit redundancy, mixed redundancy, Standby redundancy, weakest link technique
Reliability improvement, Reliability allocation

Module III

Fault tree analysis, use of Boolean algebra, Load strength analysis. Understanding of FMECA.
Maintainability- Definition, relationship between reliability and maintainability
Availability- Definition, relationship between reliability and availability, simple Markov models.

Case studies from industries demonstrating Reliability aspects. Computer softwares in reliability.

References

1) Charles E Eblings – An Introduction to Reliability and Maintainability Engineering, McGraw Hill
2) E. Balagrusamy - Reliability Engineering, Tata-McGraw Hill Publishing Company Limited, New Delhi, 1984.
3) L S Srinath – Reliability Engineering, East West Press
4) Lewis, E.E., Introduction to Reliability Engineering, John Wiley & Sons, New York, 1987.
5) O'Connor Patric D.T., Practical Reliability Engineering, 3/e revised, John Wiley & Sons, 1995.
6) Stamatis D.H., Failure Mode and Effect Analysis, Productivity Press India (P) Madras, 1997.

Structure of the Question paper

For the End semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MID 2002: MODERN INFORMATION SYSTEMS 3-0-0-3

Course Objectives

- To learn about different information systems.
- To effectively use and manage information technology in today's network enterprises.
- To study inter connected networks of information systems for end user collaboration.
- To learn systems for making timely decisions based on organized informations.

Learning Outcomes

After the completion of the course the student is expected to

- Widen his knowledge about information technology that will enable him to solve management problems.
- Explore full potential of computer as a problem solving tool.

Module I

Introduction to information systems , Types and examples of information systems, information technology infrastructure. System concepts, system design, development and analysis

Module II

Decision support systems: Overview, Data Mining and Warehousing, Modeling and. Analysis, Knowledge based DSS. Model management, modeling processes, modeling languages.

Module III

Neural computing, applications, advanced artificial intelligent systems and applications. Intelligent software agents, Impact of Management support systems.

References

1. Kenneth C. Laudon and Jane P. Laudon, Management Information Systems – Managing the digital firm, , Pearson education, 2002.
2. Burch John.G Jr and Others , Information Systems theory And Practice, John wiley &Sons
3. James A O'Briean, Management Information Systems, Tata Mc Graw Hill
4. Decision Support Systems and Intelligent Systems, , Prentice Hall International
5. Marakas , Decision Support System, Pearson Education
6. Robert Levine et al , "Comprehensive Guide to AI and Expert Systems",Mc Graw Hill Inc..Henry C. Mishkoff , "Understanding AI", BPB Publication, New Delhi, 1986

Structure of the Question paper

For the End semester Examination there will be three questions from each module out of which two questions are to be answered by the students.

MDD 2001: COMPUTATIONAL PLASTICITY **3-0-0-3**

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives:

At the end of this course, the students will
- gain insight into the behavior of metals under loading and heating conditions,
- be able to use elementary theory of plasticity to formulate bulk forming processes,
- be able to master the basic formulations and their applications to sheet forming Processes,
- be able to master and apply the basic theory of metal cutting,
- have the basic knowledge about the cutting tools, cutting fluids and the cutting
- parameters and how they affect the cutting performance,
- be able to optimize metal cutting operations for the selected criteria

Learning Outcomes:

At the completion of the course, students will be able to…
- Predict the changes in the mechanical behavior of materials due to thermo-mechanical processing based finite element modeling.
- Interpret and quantitatively determine elastoplastic behavior of metals.

Module I

Elements of continuum mechanics and thermodynamics – Kinematics of deformation - Infinitesimal deformations - Forces. Stress Measures - Fundamental laws of thermodynamics - Constitutive theory - Weak equilibrium. The principle of virtual work - The quasi-static initial boundary value problem The finite element method in quasi-static nonlinear solid mechanics - Displacement - based finite elements - Path-dependent materials. The incremental finite element procedure – Large strain formulation - Unstable equilibrium. The arc-length method

Module II

Overview of the program structure of FEM for plasticity
The mathematical theory of plasticity – Phenomenological aspects - One-dimensional constitutive model - General elastoplastic constitutive model - Classical yield criteria – Plastic flow rules - Hardening laws

Module III

Finite elements in small-strain plasticity problems – Preliminary implementation aspects - General numerical integration algorithm for elastoplastic constitutive equations - Application: integration algorithm for the isotropically hardening vonMises model - The consistent tangent modulus – Numerical examples with the vonMises model - Further application: the von Mises model with nonlinear mixed hardening

References:

1. Eduardo de Souza Neto, Djordje Peric, David Owens, Computational methods for plasticity : theory and applications - 2008 John Wiley & Sons Ltd
2. A. Anandarajah, Computational Methods in Elasticity and Plasticity – 2010 Springer
3. Han-Chin Wu, Continuum mechanics and plasticity - CRC Press
4. D R J Owen, E Hinton, Finite Elements in Plasticity Theory and Practice – 1980 Peneridge Press Ltd.
5. Jacob Lubliner, Plasticity theory – 2006
6. J. Chakrabarty, Theory of plasticity third edition – 2006 BH
7. D W A Rees, Basic engineering plasticity an introduction with engineering and manufacturing applications - BH

Structure of the Question paper

For the End Semester Examination There will be three questions from each module out of which two questions are to be answered by the students.

MDD 2002: BIO MECHANICS 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Objective:

- To gain knowledge of bio mechanics
- To gain knowledge of designing of artificial implants
- To gain knowledge of viscoelastic material modeling
- Understand various bio materials

Outcome:

- Students will understand how the theory is used in analyzing human body and motions
- At the end of the course students will know the different bio materials

Industrial relevance:

This course is having direct application to industry.
In medical field, implementation of theory of mechanics will help in implementing various designs

Module I

Human Anatomy & physiology: Anatomy & Physiology of major systems of the body Basic Terminology-Major Joints - Major Muscle Groups -Tissue Biomechanics -Hard and Soft -Bones - Bone Cells and Microstructure- Physical Properties of Bone- Bone Failure (Fracture and Osteoporosis)- Muscle Tissue-Cartilage-Ligaments- Scalp, Skull, and Brain -Skin Tissue

Module II

Kinetics of Human Body -Forces Exerted across Articulating Joints -Contact Forces across Joints - Ligament and Tendon Forces- Joint Articulation
Rheology of body material-Viscoelasticity-Definition of Viscoelasticity 1D Linear Viscoelasticity (Differential Form Based on Mechanical Circuit Models- Maxwell Fluid-Kelvin–Voigt Solid- 1-D Linear Viscoelasticity (Integral Formulation)- 3-D Linear Viscoelasticity -Dynamic Behavior of Viscoelastic Materials

Module III

Biomaterials:- Different types of biomaterials - metals, polymers, ceramics, glasses, glass ceramics, composites. Material properties. Reactions to biomaterials - inflammation, wound healing & foreign body response, immunology and compliment system, -, prostheses and orthotics. Artificial bio-implants – Dental implants, heart valves, kidneys, joints.

References:

1. Principles of Biomechanics by Ronald L Huston-CRC Press
2. Introduction to continuum biomechanics by Kyriacos A. Athanasiou and Roman M. Natoli-Morgan & Claypool
3. Duane Knudson Fundamentals of Biomechanics –Springer
4. Text book of Medical Physiology – C., M. D. Guyton..
5. Biomechanics: Motion,Flow stress and Growth, Y.C. Fung- Springer, New
6. York, 1990
7. Leslie Cromwell, Fred J.Weibell and Erich A.Pferffer. Biomedical instrumentation and Measurements -Prentice Hall of India, New Delhi.

Structure of the Question paper

For the End semester Examination There will be three questions from each module out of which two questions are to be answered by the students.

MDD 2003: INTRODUCTION TO SIGNAL PROCESSING 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- Understand Fundamentals of DSP and its use in Noise and Vibration Enhancement
- Understand how to correctly implement and use the results of an FFT
- Interpretation of common Frequency Domain Measurements
- Understand the fundamentals and applications of Digital Filters
- Application and interpretation of Order Tracking analysis

Learning Outcomes:

As an outcome of completing this course, students will be able to:

- Understand how the combination of A/D conversion, digital filtering, and D/A conversion may be used to filter analog signals such as speech and music (1-D), and images (2-D).
- Understand the time- and frequency-domain concepts related to A/D conversion.
- Understand the time- and frequency-domain concepts related to D/A conversion.
- Understand the role of oversampling in A/D and D/A conversion.
- Understand the roles of down sampling and up sampling in digital processing of analog signals.
- Understand the respective roles of the magnitude and phase response of a digital filter.
- Understand the concepts of phase delay and group delay of a digital filter.
- Understand the relations between the DTFT, the DFT, and the FFT.
- Understand the computational issues in the implementation of digital filters.
- Understand the notion of random signals as an aid to filter design.
- Design FIR filters using the Windowing Method.
- Write reports on filter design and DSP applications projects
- Assess the societal impact of DSP, and the engineer's responsibilities in this regard.

Module I

Introduction to Signal Processing: Descriptions of Physical Data (Signals), Classification of Data. **Deterministic Signals:** Periodic, Almost Periodic and Transient Signals. Periodic Signals and Fourier series, Delta Function, Complex Form of the Fourier Series, Spectra. Fourier Integral, Energy Spectra, Properties of Fourier Transforms, Importance of Phase, Echoes, Continuous-Time Linear Time-Invariant Systems and Convolution, Group Delay (Dispersion), Minimum and Non-Minimum Phase Systems, Hilbert Transform, Effect of Data Truncation (Windowing).

Module II

Fourier Transform of an Ideal Sampled Signal, Aliasing and Anti-Aliasing Filters, Analog-to-Digital Conversion and Dynamic Range, Shannon's Sampling Theorem. Sequences and Linear Filters, Frequency Domain Representation of Discrete Systems and Signals, Discrete Fourier Transform, Properties of DFT, Convolution of Periodic Sequences, Fast Fourier Transform. Basic Probability Theory, Random Variables and Probability Distributions, Expectations of Functions of a Random Variable.

Module III

Stochastic Processes: Probability Distribution Associated with a Stochastic Process, Moments of a Stochastic Process, Stationarity, and the Second Moments of a Stochastic Process, Ergodicity and Time Averages. Single-Input Single-Output Systems, Estimator Errors and Accuracy, Mean Value and Mean Square Value , Correlation and Covariance Functions, Power Spectral Density Function, Cross-spectral Density Function, Coherence Function, Frequency Response Function . Description of Multiple-Input Multiple-Output (MIMO) Systems, Residual Random Variables, Partial and Multiple Coherence Functions, Principal Component Analysis.

Reference:

1. Fundamentals of Signal Processing for Sound and Vibration Engineers, K. Shing and J.K. Hammond, Wiley, 2007
2. Digital Signal Processing for Measurement Systems: Theory and Applications, G. D'Antona and Alessandro Ferrero, Springer
3. Digital Signal Processing, Alan V. Oppenheim, Ronald W. Schafer, Prentice hall

Structure of the Question paper

For the End Semester Examination There will be three questions from each module out of which two questions are to be answered by the students.

MPD 2001: FINITE VOLUME METHOD FOR FLUID FLOW AND HEAT TRANSFER 3-0-0-3

Structure of the Course

Lecture : 3 hrs/ Week	Credits :3
Internal Continuous Assessment	: 40 Marks
End Semester Examination	: 60 Marks

Course Objectives:

- A number of physical problems related to Propulsion Engineering and Thermal Engineering can be modeled as partial differential equation and often non-linear. These equations cab not be solved by analytical methods and suitable numerical techniques are to be applied. The objective this stream elective is to give the students the necessary fundamentals ideas and their applications for real problems. An exposure to open source computational tools is also aimed. Reading and understanding at least two Journal Publications dealing with later developments in solution algorithms for flow and heat transfer.

Learning Outcomes:

- Mathematical formulation of physical problems and their solution.
- Capability to write computer programs based on the techniques learned.
- Development of a directory containing the basic and applied computer programs, tutorials and their document.

Module I

Governing equations of fluid flow and heat transfer-Programming in object oriented C++, Classes, Structures and Union (Portions up to this is for study by students themselves. Questions may be asked for the examinations). Governing equations in primitive variables – general scalar form for incompressible flow-conservative vector form for compressible flow-Linearisation -Jacobian-Mathematical nature of governing equations- Governing equations in terms of stream function and vorticity (2D and 3D).
Finite difference approximations for differential coefficients, order of accuracy, numerical examples-Stability, convergence and consistency of numerical schemes - Von-Neumann analysis for stability-Courant-Friedrich-Lewi criterion.

Module II

Rayleigh-Ritz, Weighted Residual, Galerkin and sub-domain methods, Interpolation and shape functions in FEM, FE discretisation of Laplace, Poissons and convection diffusion equations. Element equations for triangular, quadrilateral, tetrahedral and hexahedral elements. Numerical integration-Newton Cotes and Gauss quadrature. Application of boundary conditions, Solution of system of equations using TDMA and Conjugate gradient methods.

Module III

Finite volume discretisation of Laplace, Poissons and convection diffusion equations. Evaluation of gradients on regular and arbitrary cells, Upwind, Central and Power Law schemes. Structured and unstructured grids. Staggered and collocated grids, Pressure Poisson's equation, SIMPLE, PISO and PROJECTION algorithms for incompressible flow. Flux vector splitting method for compressible flow. Hybrid FE and FV, Semi Lagrangian and Spectral methods, Development of computer programs - Introduction to OpenFOAM. Computer assignments.

References:

1. Applied finite element analysis, Larry J. Segerlind
2. Numerical heat transfer and fluid flow, Suhas V. Patankar
3. Computational fluid dynamics: the basics with applications, John D. Anderson
4. Modern Compressible Flow: with Historical Perspective. John D. Anderson, JR
5. Introduction to Computational Fluid Dynamics, Anil W. Date

Structure of the Question paper

For the End Semester Examination There will be three questions from each module out of which two questions are to be answered by the students.

MPD 2002:TRANSPORT PHENOMENA 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

1.To develop and detailed understanding of the physics behind transport phenomena in engineering systems.
2. To learn solution techniques in advanced transport phenomana.

Learning Outcomes

1. Student will be capable of applying theoretical knowledge in various industrial and academic situations
2. They will be in a position to develop models for a particular problem involving heat and mass transfer.

Module I

Viscosity and the mechanism of momentum transport-pressure and temperature dependence of viscosity-Theory of viscosity of gases at low density- Theory of viscosity of liquids.

Thermal conductivity and the mechanism of energy transport-temperature and pressure dependence of thermal conductivity in gases and liquids-theory of thermal conductivity of gases at low density – theory of thermal conductivity of liquids- thermal conductivity of solids.

Diffusivity and the mechanism of mass transport- definitions of concentrations, velocities and mass fluxes-Fick's law of diffusion- temperature and pressure dependence of mass diffusivity- theory of ordinary diffusion in gases at low density- theories of ordinary diffusion in liquids.

Module II

Shell balance for momentum, energy and mass, boundary conditions, Adjacent flow of two immiscible fluids- heat conduction with a nuclear heat source-diffusion through a stagnant gas film-diffusion with heterogeneous chemical reaction- diffusion with homogeneous chemical reaction-diffusion into a falling liquid film: Forced convection mass transfer-diffusion and chemical reaction inside a porous catalyst; the "Effectiveness factor'.
The equations of change for isothermal, non isothermal and multi component systems- the equations of continuity of species A in curvilinear co-ordinates-dimensional analysis of the equations of change for a binary isothermal mixture.

Module III

Concentration distributions in turbulent flow- concentration fluctuations and the time smoothed concentration-time smoothing of the equations of continuity of A.

Inter phase transport in multi component systems-definition of binary mass transfer coefficients in one phase – correlations of binary mass transfer coefficients in one phase at low mass transfer rates-definition of binary mass transfer coefficients in two phases at low mass transfer rates- definition of the transfer coefficients for high mass transfer rates.

Macroscopic balances for multi component systems- the macroscopic mass, momentum, energy and mechanical energy balance-use of the macroscopic balances to solve steady state problem.

References:

Text book: Transport Phenomena Bird R B, Stewart W E and Lightfoot F N

Note: Use of approved charts & tables are permitted in the examinations.

Structure of the Question paper

There will be three questions from each module out of which two questions are to be answered by the students.

MTD2001: FINITE ELEMENT ANALYSIS FOR HEAT TRANSFER 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

To impart an awareness regarding various types of equations and their methods of solving
To analyse a given situation to find out the temperature profiles and rate of heat transfer

Learning Outcomes

The students will be capable of analyzing theoretically any heat transfer problems by using FEM

Module I

Review of the fundamentals of the three modes of heat transfer. Governing differential equations. Initial and boundary conditions.

Review of the numerical techniques for the solution of matrix equations.
Basic concepts of Finite Element method. Mesh generation-
Types of elements, Node numbering scheme. Interpolation polynomials. Finite element equations and element characteristic matrices. Variational approach, Galerkin approach. Assembly of element matrices. Solution of finite element system of equations.

Module II

Steps involved in a thermal analysis. Analysis of linear and nonlinear conduction problems in steady and transient hea t transfer. 1D, 2D and 3D analysis with simple examples. Axisymmetric heat transfer. Finite element solution in the time domain.

Effects of convection in heat transfer- advection-diffusion. Analysis of heat transfer problems with radiation.

Module III

Concepts of adaptive heat transfer analysis. Implementation of the adaptive procedure.

Computer programming and implementation of FEM. Introduction to general purpose FEM packages

References:

1. R W Lewis, K Morgan, H R Thomas and K Seetharamu: The Finite Element Method in Heat Transfer Analysis
2. H C Huang and A Usmani: Finite Element Analysis for Heat Transfer
3. L J Segerland: Applied Finite Element Analysis
4. C Zeinkewicz: The Finite Element Method

Structure of the Question paper

For the End semester Examination There will be three questions from each module out of which two questions are to be answered by the students.

MTD 2002: CRYOGENIC ENGINEERING 3-0-0-3

Structure of the Course

Lecture: 3 hrs/ Week Credits: 3
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Course Objectives

- To impart a basic concepts of low temperature production and utilization
- To study various systems for low temperature production

Learning Outcomes

- The students will be capable of designing a liquefaction system
- They will be able to produce liquefaction systems with minimum energy consumption

Module I

Introduction: Historical development-present areas involving cryogenic engineering. Low temperature properties of engineering materials-Mechanical properties-Thermal properties-Electric and magnetic properties-Properties of cryogenic fluids.

Module II

Gas liquefaction systems: Introduction-Production of low temperatures-General liquefaction systems-Liquefaction systems for Neon, Hydrogen and Helium-Critical components of liquefaction systems.
Cryogenic Refrigeration systems: Ideal Refrigeration systems-Refrigerators using liquids and gases as refrigerants-refrigerators using solids as working media.

Module III

Cryogenic fluid storage and transfer systems: Cryogenic fluid storage vessels-Insulation-Cryogenic fluid transfer systems.
Applications of Cryogenics: Super conducting devices-Cryogenics in Space Technology-Cryogenics in biology and medicine.

References:

1. Cryogenic Systems – Randall Barron
2. Cryogenic Engineering- R.B.Scott
3. Cryogenic Engineering – J.H.Bell Jr.

Structure of the Question paper

For the End semester Examination There will be three questions from each module out of which two questions are to be answered by the students.