KERALA TECHNOLOGICAL UNIVERSITY

Master of Technology

Curriculum, Syllabus and Course Plan

Cluster	:	***Trivandrum***
Branch	:	***Mechanical Engineering***
Stream	:	***Machine Design***
Year	:	***2015***
No. of Credits	:	***67***

SEMESTER 1

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A	01MA6011	Special Functions, Partial Differential Equations and Tensors	3-0-0	40	60	3	3
B	01ME6101	Advanced Theory of Vibration	3-1-0	40	60	3	4
C	01ME6103	Finite Element Method	3-1-0	40	60	3	4
D	01ME6105	Continuum Mechanics	3-0-0	40	60	3	3
E	01ME6107	Industrial Tribology	3-0-0	40	60	3	3
S	01ME6999	Research Methodology	0-2-0	100			2
T	01ME6191	Seminar-I	0-0-2	100			2
U	01ME6193	Machine Dynamics Lab	0-0-2	100			1
		TOTAL	**15-4-4**	**500**	**300**	**-**	**22**

TOTAL CONTACT HOURS : 23
TOTAL CREDITS : 22

SEMESTER 2

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A	01ME6102	Advanced Theory of Mechanisms	3-1-0	40	60	3	4
B	01ME6104	Design of Pressure Vessels and Piping	3-0-0	40	60	3	3
C	01ME6106	Experimental Stress Analysis	3-0-0	40	60	3	3
D		Elective –I	3-0-0	40	60	3	3
E		Elective-II	3-0-0	40	60	3	3
V	01ME6192	Mini Project	0-0-4	100			2
U	01ME6194	Modelling & Analysis Lab	0-0-2	100			1
		TOTAL	**15-1-6**	**400**	**300**	**-**	**19**

TOTAL CONTACT HOURS : 22
TOTAL CREDITS : 19

Elective I

01ME6112 Design of Power Transmission Elements
01ME6114 Design & Analysis of Composite Structures
01ME6116 Advanced Computer Graphics
01ME6118 Condition Monitoring & Maintenance Engineering
01ME6110 Fracture Mechanics

Elective II

01ME6122 Optimization Techniques for Engineering
01ME6124 Acoustics and Noise Control
01ME6126 Advanced Finite Element Methods
01ME6128 Robotics

SEMESTER 3

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credits
					Marks	Duration (hours)	
A		Elective III	3-0-0	40	60	3	3
B		Elective IV	3-0-0	40	60	3	3
T	01ME7191	Seminar II	0-0-2	100			2
W	01ME7193	Project (Phase 1)	0-0-12	50			6
		TOTAL	**6-0-14**	**230**	**120**	**-**	**14**

TOTAL CONTACT HOURS : 20
TOTAL CREDITS : 14

Elective III

01ME7111 Advanced Numerical Methods
01ME7113 Advanced Non Destructive Evaluation
01ME7115 Advanced Design Synthesis
01ME7117 Mechatronics System Design
01ME7119 Computational Plasticity

Elective IV

01ME7121 Theory of plates and shells
01ME7123 Mechanical Behaviour of Materials
01ME7125 Computational Methods in Design & Manufacturing
01ME7127 Advanced Vehicle Dynamics
01ME7129 Control System
01ME6110 Fracture Mechanics

SEMESTER 4

Examination Slot	Course Number	Name	L-T-P	Internal Marks	End Semester Examination		Credit
					Marks	Duration (hours)	
W	01ME7194	Project (Phase 2)	0-0-23	70	30		12
		TOTAL	**0-0-23**	**70**	**30**	**-**	**12**

TOTAL CONTACT HOURS : 23
TOTAL CREDITS : 12

TOTAL NUMBER OF CREDITS: 67

SEMESTER - I

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01MA6011	**Special Functions, Partial Differential Equations and Tensors**	**3-0-0**	**3**	**2015**

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 differentia l equations

To familiarize with integral equations, its formation and application.

Syllabus

Vector calculus-Green's theorem-Stoke's Theorem and divergence Theorem-tensor calculus—eigen vectors of tensors-integral equations-transform method-partial differential equations-D-Alembert's method-canonical form-pde in polar coordinates-special functions-Bessel and Legendre functions-Numerical solution of partial differential equations.

Expected Outcome

At the end of the course the students will:
The student will be able to(1) Apply the concepts of tensors to solve engineering problems(2) develop numerical procedures to solve Design problems in terms of methods of Partial Differential Equations. (3)know and use advanced developments in special functions, tensor calculus, methods of solution of Partial differential equations in applications

References

1. Advanced Engineering Mathematics – Erwin Kreyzig

2. Vector, Tensors and Basic Equations of Fluid Mechanics – Rutherford Aris (Dover Publications)

3. Schaum's outline of Tensor Calculus – David Kay (Schaum's outline series)

4. Applications of Tensor Analysis – A. J. McConnell (Dover Books on Mathematics, 2011)

5. Introduction to Tensor Calculus and Continuum Mechanics – John Henry Heinbockel, Trafford Publishing 20016.Integral equations-Santhiswaroop-Krishna Prakash media

7. Higher Engineering Mathematics - Dr. B. S. Grewal – Khanna Publishers

8. Introduction to Partial Differential Equations – K. SankaraRao – Prentice Hall of India.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Vector calculus: An introduction to vector calculus -gradient, divergence, curl - green's theorem, Divergence theorem, Stokes theorem	7	15
II	Tensor calculus: Transformation of coordinates-Kronecker delta-contravariant tensor-tensor of high order-symmetric and skew symmetric tensors Metric tensor-contraction of a tensor-Christoffel symbols-transformation of Christoffel symbols	6	15
FIRST INTERNAL EXAM			
III	Integral Equations: Formation of Volterra and Fredhlom integral equations, solution of integral of equation of 2nd kind by transform methods, convolution type, method of successive approximation and iterative method.	6	15
IV	Partial differential equations:-Classification of PDE-Parabolic, elliptic and hyperbolic equations. -reduction to Canonical form, Characteristics, Green functions, Solution of partial differential equations using Laplace Transform Method.	7	15
SECOND INTERNAL EXAM			
V	Special functions: Beta, Gamma functions, Bessel functions-recurrence relation, generating functions, Legendre's equations and Legendre's Polynomials – recurrence relation and orthogonality property	8	20
VI	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.	8	20
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6101	Advanced Theory of Vibration	3-1-0	4	2015

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.

Syllabus

Analysis of un-damped, damped, free and forced SDOF systems, Transients – non periodic excitation of Single DOF systems. Two degree of freedom systems -dynamic vibration absorbers and damped vibration absorbers. Multi-degree freedom system- Matrix formulation. Lagrange's equation –Matrix Iteration. Vibration of continuous system. Approximate numerical methods- Holzer procedure for lumped masses.

Expected Outcome

At the end of the course the students will:
At the end of the course the students will:

- 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.

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

5. B. Balachandran , Edward B. Magrab, Vibrations , Thomson Brooks/Cole-www.brookscoole.com

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Oscillatory motion – Periodic motion- Analysis of un-damped, damped , free vibration- Logarithmic decrement –Introduction to harmonically excited vibrations.-Numerical problems	4	15
	Forced Vibration-magnification factor – Rotating and revolving unbalance – Base excitation – transmissibility – Vibration isolation-Structural damping- Numerical problems	4	
II	Transients – non periodic excitation of Single DOF systems – Impulseexcitation- Convolution Integral – Laplace Transform- Shock response spectrum	5	15
	Two degree of freedom systems – normal modes and natural frequencies – Principal co-ordinates –co-ordinate coupling - dynamic vibration absorbers – Vibration Damper- Numerical problems	3	
FIRST INTERNAL EXAM			
III	Introduction to multi-degree freedom system- Matrix formulation- Influence coefficients- Flexibility and stiffness-Orthogonality of Eigen vectors	4	15
	Lagrange‘s equation – Generalized co-ordinates- Virtual work – Derivation of Lagrange‘s equation- Mode summation	5	
IV	Eigen Value problem— Eigen value and Eigen vectors. frequency mode shape -Modal analysis.	4	15
	Matrix Iteration – Stodola – and Sweeping methods- Cholesky Decomposition. – Jacobi diagonalisation- Numerical problems	3	
SECOND INTERNAL EXAM			

V	Vibration of continuous system-Transverse vibration of strings- Longitudinal vibration of Rods- Numerical problems	6	20
	Torsional vibration of Rods- Euler Equation for beams- Numerical problems	6	
VI	Approximate numerical methods- Dunkerley's method - Rayleigh method – Rayleigh –Ritz method	8	20
	Holzer procedure for lumped masses-. Introduction to Transfer matrices.- MATLAB program for torsional systems	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6103	Finite Element Method	3-1-0	4	2015

Course Objectives

- Basic understanding of FEA. Preprocessing, solution and post processing
- Discretization of solution domain into a finite element mesh
- Assembly of element equations and boundary condition
- Solution for nodal unknowns and derived quantities over each element
- Finite element mesh refinement and convergence.
- Implementation and application of FEM in 1-D, 2-D and 3D static and dynamic structural analysis and heat conduction

Syllabus

Matrix algebra in FEM, Methods of solution of simultaneous equations, Basic concepts of FEM, Virtual work and variational methods, Introduction to the Stiffness (Displacement) Method, Spring, Bar elements and torsion element, Development of truss equations (Stiffness matrix, load vectors). Development of Euler beam equations, Frame and grid equations, Transformation of coordinates.Interpolation functions for general element formulation. Patch test, different type of refinements (h, p and r). Development of the Plane Stress and Plane Strain Stiffness Equations, Practical Considerations in Modeling, Interpreting Results and Examples of Plane Stress/Strain Analysis, Numerical integration, Full and reduced integration. Development of the CST, Linear-Strain Triangle Equations, Method of weighted residuals (Galerkin), Boundary conditions (Neumann, Dirichlet and Robin), Plate Bending Element. Axisymmetric Elements, Natural coordinates systems, Isoparametric Formulation, Three-Dimensional Stress Analysis, Lagrange and Serendipity Elements. Heat Transfer, Thermal Stress, Structural Dynamics, Evaluation of eigen values and eigen vectors, Transient analysis: Euler's method, Central difference technique, Rigid body modes.

Expected Outcome

At the end of the course the students will:

- Understand the fundamental ideas of the FEM like meshing, solution and post processing
- Know the behavior and usage of each type of elements covered in this course
- Be able to prepare a suitable FE model for structural mechanical analysis problems
- Be able interpret and evaluate the quality of the results
- Be aware of the limitations of the FEM to avoid GIGO (Garbage In Garbage Out)
- Gain an insight into programming FE

Efficient and effective use of commercial FE software like ANSYS, NASTRAN, ABAQUS

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, T. R.Chandrupatla and Ashok D. Belegundu , PHI

4. Elementary Finite Elements Method, Desai C. S.
5. The Finite Element Method, Zienkiewicz O. C.
6. Applied finite element analysis, Larry J.Segerlind
7. Finite Element Method, R. D. Cook
8. Finite Element Method, C.S. Krishnamurthy
9. Basics of F E M- Solid Mechanics, Heat transfer and Fluid mechanics, Dubuque I A and W C Brown.

Text Books:

1. Fundamentals of FEM by David V Hutton, Mc Graw Hill

2. A First Course in the Finite Element Method Fifth Edition - Daryl L. Logan - Thomson

3. An introduction to the Finite Element Method, 3rdEdn. Reddy J. N.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Matrix algebra in FEM, Methods of solution of simultaneous equations, Basic concepts of FEM, Virtual work and variational methods,	4	15
	Introduction to the Stiffness (Displacement) Method, Spring, Bar elements and torsion element, Development of truss equations (Stiffness matrix, load vectors)	4	
II	Development of Euler beam equations, Frame and grid equations, Transformation of coordinates.	4	15
	Interpolation functions for general element formulation. Patch test, different type of refinements (h, p and r)	4	
FIRST INTERNAL EXAM			
III	Development of the Plane Stress and Plane Strain Stiffness Equations	4	15
	Practical Considerations in Modelling, Interpreting Results and Examples of Plane Stress/Strain Analysis	4	
IV	Development of the CST, Linear-Strain Triangle Equations,	4	15
	Method of weighted residuals (Galerkin), Boundary conditions (Neumann, Dirichlet and Robin), Plate Bending Element	4	
SECOND INTERNAL EXAM			
V	Axisymmetric Elements, Natural coordinates systems, Isoparametric Formulation	4	20
	Numerical integration, Full and reduced integration	4	
	Three-Dimensional Stress Analysis, Lagrange and Serendipity Elements	4	
VI	Structural Dynamics, Mass matrix computation, Evaluation of eigen values and eigen vectors, Modal space,	4	20
	Transient analysis: Euler's method, Central difference technique, Critical time step, Rigid body modes.	4	
	Newton Raphson method for solving nonlinear differential equations…	4	

END SEMESTER EXAM

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6105	**Continuum Mechanics**	**3-0-0**	**3**	**2015**

Course Objectives

Develop a systematic and in-depth understanding of the principles of continuum mechanics.

Syllabus

Introduction to continuum theory, mathematical preliminaries and concept of tensor, Traction and stress. Kinematics and strain, Balance laws, Constitutive relations, Linearized plane elasticity problems, Applications in Fluid Mechanics and Viscoelasticity.

Expected Outcome

At the end of the course the students will:

- Have a comprehensive, systematic and integrated knowledge of the principles of continuum mechanics
- Be conversant with physical laws and analytical tools such as tensor calculus required to formulate and solve continuum problems
- Have an in-depth understanding of the common principles which underlie the disciplines of solid mechanics and fluid mechanics – hitherto considered mostly separate.

Be equipped to pursue further specialized areas of study such as aeroelasticity, nonlinear mechanics, biomechanics etc which are essentially based on continuum mechanics

References

1. G. Thomas Mase, George E. Mase.. Ronald E. Smelser. Continuum mechanics for engineers 3rd ed CRC Press
2. Lawrence E. Malvern. Introduction to the Mechanics of a Continuous Medium – Prentice Hall
3. J.H. Heinbockel, Introduction to Tensor Calculus and Continuum Mechanics – Open Source
4. W. Michael Lai, David Ribin, Erhard Kaempl, Introduction to Continuum Mechanics 4th Ed., Butterworth- Heinemann
5. J. N. Reddy, An Introduction to Continuum Mechanics with applications - Cambridge University Press
6. Y. C. Fung, A First Course in Continuum Mechanics for Physical and Biological Engineers and scientists - Prentice Hall
7. Han-Chin W, Continuum mechanics and plasticity - CRC Press
8. Sudhakar Nair, Introduction to Continuum Mechanics – Cambridge University press
9. Morton E. Gurtin, An introduction to continuum mechanics, Academic Press
10. S.P. Timoshenko, J.N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction to continuum mechanics – concept of continua in solid- and fluid mechanics – evolution, relevance and scope of the subject. Mathematical preliminaries - Index notation, Einstein's summation convention, Kronecker delta and Levi-Civita symbols, Matrix algebra, Cayley Hamilton theorem	3	15
	Concept of tensor - Vector space- Inner product space- Cartesian basis- Tensor as a linear transformation- Vector as a first order tensor- Second order tensor expressed as a dyad- Dyadic product- Components of a tensor- Coordinate transformation of vectors and tensors- Principal values, trace and invariants- Orthogonal and isotropic tensors- Symmetric and anti symmetric tensors- Spherical and deviatoric tensors Algebra and calculus of tensors - Dot and cross products, scalar triple product, tensor product, inverse, contraction - Gradient, divergence and curl of vector and tensor fields - Gauss' divergence and Stokes' theorems	3	
II	Traction and stress - Surface tractions in reference and current configurations; Cauchy and first Piola-Kirchoff stress tensors; Cauchy stress components along orthonormal basis vectors; Components of Cauchy stress vector on any plane;.	3	15
	Principal stress components; Principal planes; Principal coordinate system; Normal and shear stresses; Spherical and deviatoric stresses; Octahedral stress; Stress transformation; Mohr's circle for 3D and 2D stresses	4	
FIRST INTERNAL EXAM			

III	Kinematics and strain - Continuum body; Reference and current configurations; Lagrangian and Eulerian descriptions of motion; Material and spatial derivatives; Displacement, velocity and acceleration fields Extension of a line element; Deformation gradient tensor; Displacement gradient tensor; Nanson's formula	3	15
	Polar decomposition theorem; Right and left Cauchy Green tensors; Infinitesimal deformation theory; Linearized strain; Infinitesimal rotation; Rate of deformation gradient, velocity gradient and spin tensors; Determinant of deformation gradient Geometric interpretation of small deformation theory; Strain transformation; Principal strains; Saint Venant strain compatibility equations	4	
IV	Balance Laws - Reynold's transportation theorem; Localization theorem; Deformation of a volume element; Lagrangian and Eulerian forms of equation for mass balance	3	15
	Continuity equation; Balance of linear momentum equation; Equilibrium equations; Balance of angular momentum; Symmetry of stress tensor; Law of conservation of energy; Principle of virtual work	3	
SECOND INTERNAL EXAM			
V	Constitutive relations - Invariance of constitutive equations; Material frame indifference; Linear elasticity; Material symmetry; Independent constants in the 4^{th} order elasticity tensor for anisotropic, monoclinic, orthotropic and transversely isotropic materials;	4	20
	Generalized Hooke's law for isotropic materials in indicial and matrix forms; Lame's constants, Young's modulus , Poisson's ratio and Bulk modulus, Beltrami-Michell compatibility equations; Navier's equations. 2D formulation of field equations; Airy's stress function; Biharmonic equation	4	
VI	Uni axial tension and pure bending of a beam; End loaded cantilever; Polar coordinates; Axisymmetric formulation; Lame's thick cylinder problem; Quarter circle cantilevered beam with radial load; Uni axially loaded large plate with a small circular hole.	4	20
	Torsion formulation; Torsion of a solid elliptical shaft; Torsion of a cylinder with equilateral triangular section; Overview about the application of continuum mechanics for viscoelastic materials and fluids .	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6107	Industrial Tribology	3-0-0	3	2015

Course Objectives

Develop the essential knowledge both practical and theoretical in the field of tribology.

Syllabus

Introduction to Tribology , Friction, Wear, Fundamentals of viscous flow and Reynolds equation, Theory of hydrodynamic bearings, Theory of Hydrostatic and Rolling element bearings

Expected Outcome

At the end of the course the students will:

- 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.

References

Text Books :

1. Radzimovsky: Theory of lubrication of bearings, The Donald Press Company, London.
2. Fuller D.D: Theory and practice of lubrication for Engineers – John Willey& Sons, Inc.
3. I.M.Hutchings: Tribology-University of Cambridge
4. Gwidon.W.Stachowiak and Andrew.W.Batchelor-Engineering Tribology-Butterworth Heinemann Publishers
5. Bharat Bhusan: Introduction to Tribology- John Wiley & Sons, Inc.
6. Khonsari and Booser: Applied Tribology: Bearing Design and Lubrication, Wiley.
7. SushilkumarSrivastva: Tribology in Industries, S Chand Publishing.
8. BC Majumdar: Introduction to Tribology of Bearing, S Chand Publishing.
9. A. D. Sarkar: Friction and Wear, Pergamon.
10. Principles of Lubrication – A Cameron, Longman's Green Co. Ltd.

Reference books :

1. O'Conner and Boyd : Standard Hand Book of Lubrication Engineering McGraw Hill
2. Mahadevan, Design Data Hand Book
3. Duncan Dowson, History of Tribology, Second Edition, Professional Engineering Publishing, 1997.

COURSE PLAN			
Module	Contents	**Hours Allotted**	**% of Marks in End-Semester Examination**
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.	4	15
	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.	3	
II	Friction: Types of friction-dry-boundary and fluid-laws of friction and friction theories-Tomlinson hypothesis, Bowden and Tabor theory-	3	15
	Friction of metals, ceramic materials and polymers-Variables in friction – Surface cleanliness – effect of pressure, velocity, temperature, vibration etc.	3	
FIRST INTERNAL EXAM			
III	Wear – Classification – Running in wear-theories of wear- stages of wear- Types of wear mechanisms- adhesive and abrasive wear- factors affecting wear. Types of particles present in wear debris.	3	15
	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.	3	
IV	Lubrication: Role of lubrication- Lubricants-selection of lubricants- Importance of viscosity and methods for measuring viscosity- fundamentals of viscous flow- flow through capillary tube – flow between parallel pates -radial flow between parallel circular plates	4	15

	Flow between parallel pates -radial flow between parallel circular plates, Squeeze film lubrication –Reynolds's equation.	3	
SECOND INTERNAL EXAM			
V	Bearings- classification and applications- Selection of bearings. .	2	20
	Hydrodynamic bearings: Journal bearings eccentricity-pressure distribution – attitude angle, load carrying capacity, Petroff's equation – friction and power loss-ideal and real bearings – leakage factors-sommerfield number and design charts	3	
	Oil flow and heat dissipation in bearings- Analysis of hydro thrust bearings – Fixed and pivoted shoe bearings.	3	
VI	Hydrostatic bearings: Analysis of oil pads-hydrostatic step bearings-hydrostatic thrust bearing with shoes-	2	20
	Role of restrictors- bearing materials and lubricants.	2	
	Rolling element bearings: Types - static and dynamic capacities-bearing life – Stribeck's equation- cyclic loading	2	
	Selection of bearings– lubrication,mounting of bearings.	2	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6999	Research Methodology	0-2-0	2	2015

Course Objectives

1. To prepare the student to do the M. Tech project work with a research bias.
2. To formulate a viable research question.
3. To develop skill in the critical analysis of research articles and reports.
4. To analyze the benefits and drawbacks of different methodologies.
5. To understand how to write a technical paper based on research findings.

Syllabus

Introduction to Research Methodology-Types of research- Ethical issues- Copy right-Royalty-Intellectual property rights and patent law-Copy left- Open access-

Analysis of sample research papers to understand various aspects of research methodology:

Defining and formulating the research Problem-Literature Review-Development of working Hypothesis-Research design and methods- Data Collection and analysis- Technical writing- Project work on a simple research problem

Approach

Course focuses on students' application of the course content to their unique research interests. The various topics will be addressed through hands on sessions.

Expected Outcome

Upon successful completion of this course, students will be able to

1. Understand research concepts in terms of identifying the research problem
2. Propose possible solutions based on research
3. Write a technical paper based on the findings.
4. Get a good exposure to a domain of interest.
5. Get a good domain and experience to pursue future research activities.

References

1. C. R. Kothari, Research Methodology, New Age International, 2004
2. Panneerselvam, Research Methodology, Prentice Hall of India, New Delhi, 2012.
3. J. W. Bames, Statistical Analysis for Engineers and Scientists, Tata McGraw-Hill, New York.
4. Donald Cooper, Business Research Methods, Tata McGraw-Hill, New Delhi.
5. Leedy P. D., Practical Research: Planning and Design, McMillan 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 ofIndia, New Delhi, 2012.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction to Research Methodology: Motivation towards research - Types of research: Find examples from literature. Professional ethics in research - Ethical issues-ethical committees. Copy right - royalty - Intellectual property rights and patent law - Copyleft-Openacess-Reproduction of published material - Plagiarism - Citation and acknowledgement. Impact factor. Identifying major conferences and important journals in the concerned area. Collection of at least 4 papers in the area.	5	
II	Defining and formulating the research problem -Literature Survey-Analyze the chosen papers and understand how the authors have undertaken literature review, identified the research gaps, arrived at their objectives, formulated their problem and developed a hypothesis.	4	
FIRST ASSESSMENT			
III	Research design and methods: Analyze the chosen papers to understand formulation of research methods and analytical and experimental methods used. Study of how different it is from previous works.	4	No end semester written examination
IV	Data Collection and analysis. Analyze the chosen papers and study the methods of data collection used. - Data Processing and Analysis strategies used– Study the tools used for analyzing the data.	5	
SECOND ASSESSMENT			
V	Technical writing - Structure and components, contents of a typical technical paper, difference between abstract and conclusion, layout,	5	

	illustrations and tables, bibliography, referencing and footnotes-use of tools like Latex.		
VI	Identification of a simple research problem – Literature survey- Research design- Methodology –paper writing based on a hypothetical result.	5	
END SEMESTER ASSESSMENT			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6191	SEMINAR I	**0-0-2**	**2**	**2015**

Course Objectives

To make students

1. Identify the current topics in the specific stream.
2. Collect the recent publications related to the identified topics.
3. Do a detailed study of a selected topic based on current journals, published papers and books.
4. Present a seminar on the selected topic on which a detailed study has been done.
5. Improve the writing and presentation skills.

Approach

Students shall make a presentation for 20-25 minutes based on the detailed study of the topic and submit a report based on the study.

Expected Outcome

Upon successful completion of the seminar, the student should be able to

1. Get good exposure in the current topics in the specific stream.
2. Improve the writing and presentation skills.
3. Explore domains of interest so as to pursue the course project.

SL. NO	01ME6193 **Machine Dynamics Lab** **Experiment**	**L-T-P : 0-0-2** **Credits : 1** **Main equipments required**
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 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
13	Determination of Young's modulus and shear modulus of the given specimens using ultrasonic longitudinal and shear velocities.	UntrasonicPulser-receiver, Transducers, Computer, DAC.

14	Micro structural examination of the given specimens using optical metallography and the determination of grain size	Polishing Machine, Optical Microscope
15	Determination of mechanical properties of material (Yield Strength, Tensile Strength, Elastic modulus) of the given specimen	Computerized Universal Testing machine
16	Determination of the hardness of the given specimen.	Micro Hardness Tester, Polishing Machine

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SEMESTER - II

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6102	**Advanced Theory of Mechanisms**	**3-1-0**	**4**	**2015**

Course Objectives

To impart adequate knowledge in the field of kinematic analysis, synthesis and design of mechanisms and Dynamic analysis.

Syllabus

Planar Kinematics of Rigid Bodies
Curvature Theory
Four-bar coupler-point curves
Cams
Synthesis of mechanisms
Dynamics

Expected Outcome

At the end of the course the students will:

- Have a comprehensive knowledge for the analysis of velocity and acceleration in mechanisms.
- Have the ability to synthesize and design mechanisms for specific motions and other applications.
- Have the ability to design cams and analyze its dynamic effects.
- Have the ability to analyze the dynamics of moving members in the machinery and design appropriately.

References

Text Books:

1. Dynamics in Engineering Practice- Dara W Childs (CRC Press)
2. Theory of Machines and Mechanisms- Joseph Edward Shigley (Mc Graw Hill)
3. Vector Mechanics for Engineers: Statics and Dynamics- Beer and Johnston (McGraw Hill)
4. Engineering Mechanics- Irving H Shames (Prentice Hall of India)
5. Kinematic Synthesis of linkages-Richard S Hartenberg and Jacques Denavit(Mc Graw Hill)
6. Kinematics and Linkage Design-Allen S Hall Jr,Prentice Hall
7. Cam Design Handbook-Harold A Rothbart. (McGraw Hill)

Reference books :

1. Kinematics and Dynamics of plane motion-Hirchorn J(Mc Graw Hill)
2. Kinematic Analysis and Synthesis of Mechanisms-MallikA.K, Amithabha Ghosh and Gunter Dittrich(CRC Press)
3. Advanced Mechanism Design: Analysis and Synthesis,George N Sandor and Arthur G Erdman. Prentice Hall.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
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:	4	15
	Slider-crank mechanisms, four bar linkages. Graphical approach to velocity and acceleration in mechanisms. Brief introduction to complex mechanisms.	4	
II	**Curvature Theory**: Instantaneous centre or Pole, centrode or polode, polode curvature, collineation axis, radius of curvature.	5	15
	The Euler-Savary equation, the inflection circle, Hartmans construction, Bobillier constructions, the cubic of stationary curvature. Design based on the above	3	
FIRST INTERNAL EXAM			
III	**Four-bar coupler-point curves**; Equation of coupler curves, circle of foci, multiple points, imaginary points, asymptote.	4	15
	Singular foci, double points and symmetry, cusp, crunode, symmetry. The Roberts-Chebychev Theorem and cognate linkages.	4	
IV	**Cams:**Polydyne cams: Cam Dynamics: Acceleration and Jerk. Analysis of eccentric cam, effect of sliding friction, Analysis of disc cam with reciprocating roller follower.	5	15
	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. Cam force analysis.	3	
SECOND INTERNAL EXAM			
V	**Synthesis of mechanisms**: The four-bar linkage, Two and Three position design.	6	20
	Design of slider crank and double lever mechanisms for specified input crank motion and output crank motion, Determination of minimum Transmission angle.	6	
VI	**Dynamics**: Plane motion of rigid bodies using the principle of impulse and momentum. Kinetics of rigid bodies in three dimensions:- Angular	8	20

	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 axi-symmetrical body under no force.	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6104	**Design of pressure vessels and piping**	**3-0-0**	**3**	**2015**

Course Objectives

To gain knowledge of pressure vessel design, designing of piping and piping systems, and using of design codes in design.

Syllabus

Terminology of Pressure Vessels- Stresses in pressure vessels
Stresses in Thick walled cylinders & Built up cylinders
Design of Tall Cylindrical Self Supporting process column
Reinforcement theory
Buckling of Pressure Vessels
Design of Piping

Expected Outcome

At the end of the course the students will:

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

References

Design Data Book is to be permitted in the University examination.
(P S G Data book by Faculty of Mechanical Engineering, P S G,
Design Data Handbook for Mechanical Engineering in SI and Metric UnitsbyK. Mahadevan, K. Balaveera Reddy
Standard Pressure Vessel Design Data Handbook ref. ASME ISI IBR)

Text Books :

1. John F. Harvey, 'Theory and Design of Pressure Vessels' CBS Publisher and Distributors
2. Brownell, L. E., and Young, E. H., Process Equipment Design, John Wiley and Sons
3. SomnathChathopadhyay, Pressure Vessels Design and practice, C. R. C Press

Reference books :

1. Henry H. Bender, 'Pressure Vessels Design hand book'
2. ASME Pressure Vessel Codes Section VIII, 2006
3. Dennis Moss Pressure Vessel Design Manual Gulf publishing, 2003

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Pressure vessel – Terminology – Types of loads – Types of pressure- Stresses in pressure vessels – Dilation of pressure vessels – Membrane stress analysis of vessel shell components	3	15
	Cylindrical shells, spherical shells, conical head, elliptical head – Discontinuity stresses in pressure vessels - Thermal stresses	3	
II	Stresses in thick walled cylinders – Lame's equation - Shrinkfit stresses in Built up cylinders, autofrettage of thick cylinders –	4	15
	Thermal stresses and its significance	3	
FIRST INTERNAL EXAM			
III	Design of vessels ; Design of tall cylindrical vessels	3	15
	supports for short vessels –Support for horizontal vessels	3	
IV	Design for wind load – design for seismic load and vibration–	4	15
	Theory of reinforcement , Familiarization of relevant ASME codes and standard practices	3	
SECOND INTERNAL EXAM			
V	Buckling – buckling phenomenon – Elastic buckling of cylinders under external pressure	4	20
	Stiffeners - buckling under combined compressive pressure and external load	4	
VI	Piping – Pipe specification – Pipe classification – Piping elements –	3	20
	Piping layout and piping stress Analysis – Flexibility Analysis (Practice of software such as CAESAR,CAEPIE, PVELITE etc. Not included in examination)	5	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6106	Experimental Stress Analysis	3-0-0	3	2015

Course Objectives

The course imparts to the studenrs, the basic aspects of theory of elasticity and stress-strain relationship as well as experimental stress analysis that includes the most versatile techniques like photoelasticity, strain gauges and non destructive test (NDT) methods.

Syllabus

Overview of stress analysis
Strain measurement
Instrumentation
Photoelasticity
Brittle coatings
Non destructive testing (NDT) methods

Expected Outcome

On completion of the course, the students will be able to understand:

- the different types of strain gauges and related instrumentation
- photoelastic techniques of stress analysis
- the concepts of brittle coatings
- the different NDT methods

References

Text Books :

1. J. W. Dally and W. F. Riley, Experimental Stress Analysis - McGraw Hill, 1991
2. L.S. Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B. Pant, and K. Ramachandra, Experimental Stress Analysis, Tata Mc Graw Hill, 1984.
3. A. Mubin, Experimental Stress Analysis, Khanna Publishers, 2003.
4. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, 1996.
5. Jayamangal Prasad, C. G. Krishnadas Nair, Non-Destructive Test And Evaluation Of Materials, Tata McGraw-Hill, 2008
6. J. P. Holman, Experimental methods for engineers, McGraw-Hill Mechanical Engineering,

Reference books :

1. M. Hetenyi, Handbook of Experimental Stress Analysis, John Wiley & Sons Inc, New York, 1950

2. R.C.Dove and P.H.Adams, Experimental Stress Analysis and Motion Measurement, Macmillan Publishing Company, 1964
3. C.C. Perry and H.R. Lissener, Strain Gauge Primer, McGraw Hill, 2nd Ed., 1962.
4. W.J. McGonnagle-Non-destructive Testing-Mc Graw Hill, 1961.
5. Davis Joseph R. (ed.), .American Society for Metals Handbook- Volume 17, Non-destructive Evaluation and Quality Control, ASM International Materials Park, Ohio.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Overview of stress analysis : Theory of Elasticity, Plane stress and plane strain conditions, compatibility conditions, problem using plane stress and plane strain conditions, three-dimensional stress strain relations.	3	15
	Principal stresses and strains. Mohr's circle-measurement of strains and stresses. Stress analysis – Analytical, Numerical and Experimental approaches.	3	
II	Strain measurement : Strain gauges and Stress gauges. Mechanical, Optical and Electrical gauges- construction and applications.	2	15
	Variable resistance strain gauges, Gauge characteristics, Gauge sensitivity, static and dynamic strains- reduction of strain gauge data-compensation-strain measurement over long period at high and low temperature.	3	
	Strain rosettes- Rectangular rosette, Delta rosette. Residual stresses: Beneficial and harmful effects – Principle of residual stress measurement-methods only. Moire Method of Strain Analysis	2	
FIRST INTERNAL EXAM			
III	Instrumentation : Strain Circuits, Potentiometer Circuits ,Range and sensitivity, The Wheatstone Bridge , Sensitivity, Galvanometer, Transient response, Principles of Measurement: Errors, Accuracy and Precision, Uncertainity analysis, Curve fitting	3	15
	Oscillograph, Cathode Ray Oscilloscope, Transducers- Displacement, Force, Pressure, Velocity, Acceleration	3	
IV	Photoelasticity : The Polariscope, stress optic law, Photo elastic model materials, Polariscope arrangements – Plane polariscope and Circular polariscope,	4	15
	Dark Field and Light field, Isochromatics and Isoclinics, Jones Calculus, Partial fringe value and compensation techniques. Introduction to three dimensional photoelasticity, Use of photo elastic coatings.	3	
SECOND INTERNAL EXAM			

V	Brittle coatings : Coating stresses, Failure theories, Brittle coating crack patterns produced by direct loading, refrigeration, load release,	4	20
	Crack detection, Types of coatings, Steps in brittle coating tests, Coating selection, Surface preparation.	4	
VI	Non destructive testing (NDT) methods : Types –dye penetrate methods, Radiography-X-ray and Gamma ray-X-ray fluoroscopy-	5	20
	Penetrameter-Magnetic particle method. Introduction to lasers in NDT – Ultrasonic flaw detection	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6112	Design of power Transmission Elements	**3-0-0**	**3**	**2015**

Course Objectives

To gain knowledge of industrial design and analysis of power transmission elements. To understand the standard procedure available for design of power transmission elements and to learn to use standard data and catalogues.

Syllabus

Design of transmission systems for flexible elements, Design of clutches and brakes, **Design of shafts,** Spur gears and helical gears, Bevel and worm gears, Design of gear boxes

Expected Outcome

On completion of the course, the students will be able to understand:

- the different types of power transmission elements
- design power transmission systems

Design Data Book is to be permitted in the University examination.
(P S G Data book by Faculty of Mechjanical Engineering, P S G,
Design Data Handbook for Mechanical Engineering in SI and Metric UnitsbyK. Mahadevan, K. Balaveera Reddy
Machine Design Data Book by V. B. Bhandari)

Text Books :

1. ShigleyJ.E and Mischke C. R., "Mechanical Engineering Design", Sixth Edition, Tata McGraw-Hill , 2003.
2. V. B. Bhandari, "Design of Machine Elements", Tata Mc Graw Hill, 2002.
3. Sadhu Singh, Mechanical Machine Design, S. K. Kataria& Sons, 2013.

Reference books :

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

COURSE PLAN			
Module	Contents	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Selection of V belts and pulleys, selection of Flat belts and pulleys Selection of Wire ropes and pulleys,	3	15
	Selection of Transmission chains and Sprockets. Design of pulleys and sprockets.	4	
II	Design of plate clutches, axial clutches, cone clutches, internal expanding rim clutches.	3	15
	Brakes, internal and external shoe brakes disk brakes-self actuating brakes fixed, link and sliding anchor drum brakes.	3	
FIRST INTERNAL EXAM			
III	Shafts: Design of shafts subjected to twisting moment, bending moment, combined twisting and bending moments	3	15
	Design of shafts subjected to fluctuating loads, design of shafts based on rigidity.	3	
IV	Gear Terminology, Speed ratios and number of teeth, Force analysis, Tooth stresses, Dynamic effects, Fatigue strength, Factor of safety, Gear materials, Module and Face width-power rating calculations based on strength and wear considerations,	4	15
	Parallel axis Helical Gears, Pressure angle in the normal and transverse plane- Equivalent number of teeth-forces and stresses. Estimating the size of the helical gears.	3	
SECOND INTERNAL EXAM			
V	Straight bevel gear: Tooth terminology, tooth forces and stresses, equivalent number of teeth. Estimating the dimensions of pair of straight bevel gears.	4	20

	Worm Gear: Merits and demerits- terminology. Thermal capacity, materials-forces and stresses, efficiency, estimating the size of the worm gear pair.	4	
VI	Geometric progression, Standard step ratio, Ray diagram, Structural diagram, kinematics layout	4	20
	Design of sliding mesh gear box, Constant mesh gear box. Synthesis of multi speed gear boxes.	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6114	Design & Analysis of Composite Structures	3-0-0	3	2015

Course Objectives

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.

Syllabus

Design Classifications of Composites, Micro mechanics, Macro mechanics of laminates, Analysis based on classical laminate theory, Failure theory of laminated composites, Testing of composite materials

Expected Outcome

- 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.

References

Design Data Book is to be permitted in the University examination.
(P S G Data book by Faculty of Mechjanical Engineering, P S G,
Design Data Handbook for Mechanical Engineering in SI and Metric UnitsbyK. Mahadevan, K. Balaveera Reddy
Machine Design Data Book by V. B. Bhandari)

REFERENCES :
1. Stephen W.Tsai and H. Thomas Hahn, _Introduction to Composite Material‖, Technomic Publishing Company, Inc. Lancaster, 1980.
2. J. N. Reddy and A.V. Krishna Moorty, –Composite Structures, Testing, Analysis and Design Narosa Publishing House, New Delhi., 1992.

Text Books :

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, Cambridge, England, 1994.

COURSE PLAN			
Module	Contents	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Classical laminate theory - Hooke's law for anisotropic, monoclinic, orthotropic and transversely isotropic material.	4	15
	Macro mechanical behavior of a lamina. Determination of laminate mechanical properties for laminates.	4	
II	Strength failure criteria- maximum stress, maximum strain criteria, Tsai Hill and Tsai-Wu theories for an angle laminate.	3	15
	Micromechanical behavior of a lamina- volume and mass fractions, density and void content, evaluation of elastic moduli.	4	
FIRST INTERNAL EXAM			
III	Kirchhoff's assumption, Equilibrium equation s for laminated plates, buckling equations for laminated plates, vibration equations for laminated plates	4	15
	Solution techniques- symmetric, antisymmeric cross ply laminates. Impact and fatigue characteristics	4	
IV	Differences in fracture behviour of isotropic and composites. Type of fracture in composites- interlaminar and, intralaminar fracture.	4	15
	Modified crack closure approach - assess the failure strength. Evaluation of fracture toughness.	3	
SECOND INTERNAL EXAM			
V	Basic principles of sandwich structures, manufacturing process, sandwich local instabilities like, dimpling, wrinkling, shear crimpling, crushing.	4	20

	Stringer stiffened structures.Design of a sandwich plate. Design of stiffened plates.	4	
VI	Types of textile weaving, 3D composite and inflatable structures, stitched composites and nano-composites.	4	20
	Finite element analysis of composite beam, plate/ shell type composite structures.	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6116	Advanced Computer Graphics	3-0-0	3	2015

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

Syllabus

Introduction Computer Graphics, Input, output devices, Interactive model, Geometric transformation –I, Geometric transformation -II, Clipping, Hidden surface removal, Interactive Mesh displays- projection matrices, 3-D modeling – Space curves

Expected Outcome

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

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-RadraPrathap
5. –Computer Graphics – A Programming Approach-Steven Harrington , McGraw Hill Publication.
6. Edward Angel: Interactive Computer Graphics A Top-Down Approach with OpenGL, 5th Edition, Pearson Education, 2008.

COURSE PLAN			
Module	Contents	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction to Computer Graphics; Input output devices; Clients and Servers; Display Lists; Display Lists and Modeling;	3	15
	Programming Event Driven Input; Menus; Picking; A simple CAD program; Building Interactive Models; Animating Interactive Programs;	3	
II	Geometric Transformations Scalars, Points, and Vectors; Three-dimensional Primitives; Coordinate Systems and Frames;	4	15
	Modeling a Colored Cube; Affine Transformations; Rotation, Translation and Scaling;	3	
FIRST INTERNAL EXAM			
III	Geometric Objects and Transformations; Transformation in Homogeneous Coordinates; Concatenation of Transformations;	4	15
	OpenGL Transformation Matrices; Interfaces to three dimensional applications;	3	
IV	Clipping; Line-segment clipping; Polygon clipping; Clipping of other primitives; Clipping in three dimensions;	3	15
	I Rasterization; Bresenham's algorithm; Polygon Rasterization; Hidden-surface removal; Antialiasing;	3	
SECOND INTERNAL EXAM			
V	Interactive Mesh Displays; Parallel-projection matrices;	4	20
	Perspective-projection matrices; Projections and Shadows.	4	

VI	3D modeling techniques (Wire frame, solid modeling and surface modeling). C++ programming or Matlab coding to represent simple 3D geometric models.	4	20
	Mathematical formulation of space curves.(Cubic spline, and Bezier curves) C++ programming or Matlab coding to generate space curves.	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6118	Condition Monitoring & Maintenance Engineering	3-0-0	3	2015

Course Objectives

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

Syllabus

Introduction to Machine Condition Monitoring and Condition Based Maintenance, Fundamentals of Machinery Vibration and Rotor dynamics, Vibration & Noise Monitoring, Digital Signal Processing & Instrumentation, Condition monitoring Techniques, Machine Tool Condition Monitoring

Expected Outcome

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

Text Books:

1. Machinery Condition Monitoring, Principles & Practices, Amiya R. Mohanty, CRC Press, 2015.
2. Vibration Based Condition Monitoring, Robert Bond Randall, John Wiley Publication-2010

References :

1. Mechanical Fault diagnosis and condition monitoring- R.A.Collacott
2. First Course on Condition monitoring in the process Industry, Manchester, Edited by M.J Neale.
3. Condition Monitoring Manual- National Productivity Council, New Delhi
4. Condition Monitoring Using Computational Intelligence Method, Tshilidzi Marwala, Springer Publications, ISBN-978-4471-2379-8, 2012

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction to condition monitoring and fault diagnosis –Machinery failure-	3	15
	Type and cause – Frequency of failure- Bath-tub curve- Basic Maintenance strategies	3	
II	Characteristics of Vibrating systems- Vibration of continuous systems- Mode shape and operational deflection shapes-	4	15
	Experimental modal analysis-Simple rotor disc systems and critical speed-Condition monitoring of large rotor systems	3	
FIRST INTERNAL EXAM			
III	Vibration monitoring- Misalignment and eccentricity detection- Bearing fault- Gear fault-Cavitations induced vibration in fluid machines -	4	15
	Noise measurement : Decibel scale – relationship between pressure, intensity and power – Noise source	3	
IV	Introduction- Classification of signals-Frequency domain- Signal Analysis-Fourier series-Discrete Fourier Transforms – Fundamentals of FFT,.	3	15
	Auto power spectrum – Frequency Response Spectrum – Basic Measuring Equipments for Vibration, Force, Rotational speed	3	
SECOND INTERNAL EXAM			

V	Introduction- Radiography- Ultrasound Testing- Thermography-	4	20
	Wear Debris Analysis- Eddy current Testing – Acoustic Emission-	4	
VI	Introduction- Case studies of condition monitoring in Process & Manufacturing industry.	4	20
	Bend Pulley Failure Analysis, Vibration measurement on a multi-stage gearbox drive set.	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6110	**Fracture Mechanics**	**3-0-0**	**3**	**2015**

Course Objectives

The course helps the students to gain knowledge of fracture mechanics, to use fracture mechanics in the actual design, know the behavior of existing cracks and ensure fail-safe design using materials with existing cracks

Syllabus

Basic stress analysis and mechanical properties

Linear Elastic Fracture Mechanics (LEFM)

LEFM approach to crack-tip plasticity

Elastic-Plastic Fracture Mechanics (EPFM)

Fatigue crack growth

Fracture toughness testing

Expected Outcome

By the end of the course,

Students will understand how the theory of fracture mechanics is used in actual design. At the end of the course students will know about how to ensure fail-safe design using materials with existing cracks for different load conditions.

Text Books :

1. M. Janssen, J. Zuidema and R. J. H. Wanhill., *Fracture Mechanics*, Taylor & Francis, 2nd ed., 2002.
2. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, Dordrecht, 1986.
3. T.L. Anderson , *Fracture Mechanics Fundamentals and Applications* , CRC PRESS, 3rd ed., 2005
4. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw Hill, New Delhi, India, 2009.
5. K. R.Y. Simha, Fracture Mechanics for Modern Engineering Design, Universities Press (India) Limited, 2001

Reference books :

1. E.E. Gdowan, Fracture Mechanism: An Introduction, Springer, 2005.
2. ASM Metal Hand Book, Vol 12, Fractography, ASMInt, 2004.
3. A.F. Liu, Mechanics and Mechanisms of Fracture: An Introduction, ASM, 2004.
4. G.Dieter, Mechanical Metallurgy,McGraw Hill, 3rd ed., 2013.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Basic stress analysis and mechanical properties: Elasticity, General 3-D relations, Plane stress and plane strain.	3	15
	Mohr's circle-principal stresses, Yield in materials, Tresca and Von Mises criteria, Ideal and actual strength of materials. Typical stress/strain curves for different classes of materials.	3	
II	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-	4	15
	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	3	
FIRST INTERNAL EXAM			
III	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-	4	
	Elastic plastic fracture mechanics (EPFM): Development of EPFM - J-integral – Definition-Path independence-	3	
IV	Application to engineering problems-crack opening displacement (COD) approach - COD design curve - relation between J and COD - tearing modulus concept -.	3	
	Fatigue crack growth: Mechanisms of fracture and crack growth-Description of fatigue crack growth using stress intensity factor	3	
SECOND INTERNAL EXAM			
V	Effects of stress ratio - crack closure - prediction of fatigue crack growth under constant amplitude and variable amplitude loading	4	20

	Fatigue Crack Initiation- - Basic Aspects of Dynamic Crack Growth-Basic Principles of Crack Arrest -Fracture Mechanics Analysis of fast fracture and Crack Arrest.	4	
VI	K_{IC} test technique, various test specimens, load-displacement test, J_{IC} testing, Test methods to determine G_{IC} and G_{IIC},	4	20
	Determination of CTOD/COD, Time-to-failure (TTF) tests - crack growth rate testing - practical significance of sustained load fracture testing	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6122	**Optimization Technique for Engineering**	**3-0-0**	**3**	**2015**

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.

Syllabus

Introduction to Optimization
Classical Optimization Techniques, Review of Linear Programming Problems
Linear Programming (LP), Non-Linear Programming (NLP)
Unconstrained Optimization
Non-Linear Programming (NLP): Constrained Optimization
Geometric programming; Dynamic programming; Integer programming; Goal programming. Stochastic programming

Expected Outcome

☐☐ 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.

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.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction:, Formulation of optimization problems, examples	3	15
	Classification of optimization problems, Properties of objective function	4	
II	Maxima, minima and points of inflection , Concavity and convexity of one and two variable functions, Taylor's theorem: single variable and multi variable function	4	15
	Hessian matrix, Unconstrained Optimization of multi variable functions, Lagrange multiplier method	3	
FIRST INTERNAL EXAM			
III	Single variable optimization: optimality criteria, Exhaustive search and dichotomous search	3	15
	Region elimination methods- Fibonacci search and Golden section search, Gradient based methods- Newton Raphson method, Secant method	4	
IV	Multivariable optimization: optimality criteria, Unidirectional search, Direct search method-Simplex search method, Powell's conjugate direction method	4	15
	Gradient based methods- Method of steepest ascent/ steepest descent, conjugate gradient method	3	
SECOND INTERNAL EXAM			
V	Constrained optimization: Kuhn Tucker conditions, Transformation method- Penalty function method	3	20
	Linearized search-Frank-Wolfe method	3	
VI	Geometric programming; Dynamic programming; Integer programming;	4	20
	Goal programming. Stochastic programming	4	

END SEMESTER EXAM				
Course No.	**Course Name**	**L-T-P**	**Credits**	**Year of Introduction**
01ME6124	**Acoustics And Noise Control**	**3-0-0**	**3**	**2015**

Course Objectives

- To gain knowledge of the principles of acoustics and noise control in various engineering applications.

Basic Acoustic Principles
Acoustic transmission through different media
Noise measurement
Environmental Noise Control
Acoustic materials – Theory of acoustic filters and mufflers
Principles of Noise Control in machinery – in an Auditorium

Expected Outcome

☐☐On completion of the course, the students will be able to understand:

- The basic principles of acoustics, noise control and the design of acoustical elements such as filters, mufflers, resonators etc and the noise control applications in the area of machinery, auditorium design etc

Text Books :

1. Kinsler and frey – Fundamentals of Acoustics
2. Berenek, L. L. – Noise and Vibration Control
3. Grad – Industrial noise and vibration

Reference books :

1. Harris, C. K. – Handbook of Noise Control
2. Petrusowicz and Longmore – Noise and Vibration control for industrialists
3. Thumann and Miller- Secrets of noise control
4. R. D. Ford – Introduction to Acoustics
5. Douglas P. Reynolds – Engineering Principles of Acoustics

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction – Basic acoustic principles- acoustic terminology and definitions – Plane wave- harmonic solution.	3	
	Velocity of sound in inviscid fluids – relationship between wavelength-particle velocity, acceleration – Energy density – acoustic intensity – reference standards	4	
II	Transmission through one, two and three media – Transmission through pipes – branched and unbranched – resonators – Transmission loss- reflection at plane surface	3	15
	spherical waves – radiation – simple source – hemispherical source- radiating piston – pressure intensity distribution – Beam width and directivity index – sound absorbing materials	3	
FIRST INTERNAL EXAM			
III	Noise measurement : Decibel scale – relationship between pressure, intensity and power – sound level meter, noise analyzer and graphic level recorder –	4	
	Measurement in anechoic and reverberation chambers - Standing waves-standing wave apparatus.	3	
IV	Environmental noise control : Human reaction to sound – definitions of speech interference level, perceived noise level, phon and soneetc, hearing loss	4	
	principles of noise control, control at source, during transmission and at receiver- protection of receiver	2	
SECOND INTERNAL EXAM			
V	Acoustic insulation – acoustic materials – acoustic filter and mufflers – plenum chamber – noise criteria and standards – noise and number index guide lines for designing quieter equipments-	4	20
	Methods of controlling noise using baffles, coverings, perforations etc. transmission through structures – control - vibration damping and other methods	5	
VI	Principles of noise control in machinery such as pumps, rotating machines, reciprocating machines etc	4	20
	Introduction sound design requirements of an auditorium	3	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6126	**Advanced Finite Element Method**	**3-0-0**	**3**	**2015**

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. Students will learn advanced topics and techniques in finite element methods and how to implement and apply these techniques to solve nonlinear systems of ordinary and partial differential equations.How particular continuum and structural (beam, plate and shell) elements can be formulated, integrated and used to solve elastic problems.

- Numerical difficulties, such as shear locking, inherent in some elements and how to overcome them.
- The fundamental concepts of using FEA to model buckling of structures.
- The fundamental concepts of the theory of plasticity.
- How different plasticity models can be used to approximate the behaviour of different materials.
- The fundamental concepts of geometric nonlinearity.

Syllabus

Introduction to Nonlinear Analysis, nonlinear differential equations.
Total Lagrangian and updated Lagrangian formulation for Incremental General Nonlinear Analysis from the principles of continuum mechanics.
Updated and Total Lagrangian Formulation.
Formulation of Finite Element Matrices for Beam and Plate elements.
Linearization and Directional derivatives. Solution of Nonlinear Dynamic Response,Solution of the Nonlinear Finite Element Equations in Static Analysis

Expected Outcome

☐☐☐The student may be able to model nonlinear problems with

- Static and dynamic problems with Geometric and material nonlinearities
- Be aware of the limitations of the nonlinear FEM to avoid GIGO (Garbage In Garbage Out)
- Gain an insight into programming nonlinear FE using MATLAB, C++ etc.
- Efficient and effective use of commercial FE software like ANSYS, NASTRAN, ABAQUS and to understand the solution control options like load step, substep, time step, restart, stability of solution at bifurcation etc.

Reference books :

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.
8. Introduction to Nonlinear Finite Element Analysis, , Nam-Ho Kim,Spinger
9. Advanced Topics in Finite Element Analysis of Structures: With Mathematica and MATLAB Computations, M. Asghar Bhatti, Wiley
10. Nonlinear Finite Element Methods, Peter Wriggers, Springer
11. Structural Analysis with the Finite Element Method. Linear Statics Volume 2: Beams, Plates and Shells, Eugenio Oñate, Springer.

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction to Nonlinear Analysis, nonlinear differential equations,	3	15
	Basic Considerations in Nonlinear Analysis Lagrangian Continuum Mechanics Variables for General Nonlinear Analysis, Virtual work principle and variational methods,	3	
II	Continuum Mechanics Variables for General Nonlinear Analysis– TotalLagrangian formulation for Incremental General Nonlinear Analysis from the principles of continuum mechanics.	4	15
	Formulation of Finite Element Matrices from the principles of continuum mechanics: Two-Noded Truss Element	3	
FIRST INTERNAL EXAM			
III	Updated Lagrangian formulation for Incremental General Nonlinear Analysis from the principles of continuum mechanics.	3	
	Formulation of Finite Element Matrices from the principles of continuum mechanics: Two-Noded Truss ElementFormulation of the Nonlinear Finite Element Equations.	3	
IV	Two and Three-Dimensional Solid Elements; Plane Stress, Plane Strain, and Axisymmetric Conditions, Constitutive relations	4	
	Formulation of Finite Element Matrices for Beam and Plate elements, Kirchhoff's and Mindlin's beam/plate theory, nodal coordinate system, surface normal, transformation matrices.	3	
SECOND INTERNAL EXAM			
V	Linearization and Directional derivatives, Directional derivatives of different strain measures.	4	20
	Linearization of weak form in terms of second PiolaKirchoff stresses and the Green Lagrange strains, Solution of Nonlinear Dynamic Response,	4	
VI	Solution of the Nonlinear Finite Element Equations in Static Analysis, Newton Raphson,	4	20
	Modified Newton Raphson, Secant method, Arc length method, Force and displacement control, residual calculation, convergence criterion.	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6128	**Robotics**	**3-0-0**	**3**	**2015**

Course Objectives

- To introduce the basic concepts, parts of robots and types of robots.
- To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming of robots.
- To discuss about the various applications of robots, justification and implementation of robot

Syllabus

Introduction and classification of robots
Robot kinematics and dynamics
Robot drives and power transmission systems
Robot end effectors
Path planning & programming
Robot Language- Software- Industrial application

Expected Outcome

- At the end of the course the students will:
- The Student must be able to design automatic manufacturing cells with robotic control using
- The student could understand the principle behind robotic drive system, end effectors, sensor, machine vision robot kinematics and programming.

References

1 Deb S. R. and Deb S., “Robotics Technology and Flexible Automation”, Tata McGraw Hill Education Pvt. Ltd, 2010.
2. John J.Craig , “Introduction to Robotics”, Pearson, 2009.
3. Mikell P. Groover et. al., "Industrial Robots - Technology, Programming and Applications", McGraw Hill, New York, 2008.
4. Richard D Klafter, Thomas A Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Eastern Economy Edition, Prentice Hall of India Pvt. Ltd., 2006.
5. Fu K S, Gonzalez R C, Lee C.S.G, "Robotics : Control, Sensing, Vision and Intelligence", McGraw Hill, 1987

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Specifications of Robots- Classifications of robots – Work envelope	4	15
	Flexible automation versus Robotic technology – Applications of Robots	3	
II	ROBOT KINEMATICS AND DYNAMICS :Positions, Orientations and frames, Mappings: Changing descriptions from frame to frame, Operators: Translations, Rotations and Transformations -	4	15
	Transformation Arithmetic - D-H Representation - Forward and inverse Kinematics Of Six Degree of Freedom Robot Arm – Robot Arm dynamics	2	
FIRST INTERNAL EXAM			
III	ROBOT DRIVES AND POWER TRANSMISSION SYSTEMS: Robot drive mechanisms, hydraulic – electric – servomotor- stepper motor	3	15
	Pneumatic drives, Mechanical transmission method - Gear transmission, Belt drives, cables, Roller chains, Link - Rod systems	2	
	Rotary-to-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearing screws	2	
IV	ROBOT END EFFECTORS : Classification of End effectors – Tools as end effectors.	3	15
	Drive system for grippers-Mechanicaladhesive-vacuum-magnetic-grippers. Hooks&scoops. Gripper force analysis and gripper design. Active and passive grippers.	3	
SECOND INTERNAL EXAM			
V	Drive system for grippers-Mechanical adhesive-vacuum-magnetic-grippers. Hooks &scoops.	4	20
	Gripper force analysis and gripper design. Active and passive grippers.	4	
VI	Robot languages -.computer control and Robot software	4	20
	Industrial Application of robots	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME6192	MINI PROJECT	**0-0-4**	**2**	**2015**

Course Objectives

To make students

Design and develop a system or application in the area of their specialization.

Approach

The student shall present two seminars and submit a report**.**The first seminar shall highlight the topic, objectives, methodology, design and expected results. The second seminar is the presentation of the work / hardwareimplementation.

Expected Outcome

Upon successful completion of the miniproject, the student should be able to

1. Identify and solve various problems associated with designing and implementing a system or application.
2. Test the designed system or application.

SL. NO	01ME6194 **Modelling & Analysis Lab** **Experiment**	**L-T-P : 0-0-2** **Credits : 1** **Main equipments/Software required**
1	3D Modelling of Universal Coupling	Any Three Modelling Package
2	3D modeling of Clutch Assembly	Any Three Modelling Package
3	3D Modelling of a 4 speed Gear box	Any Three Modelling Package
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 SDOF system 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
13	To get the spatial distribution of SPL of a Noise Generator	Signal generator, amplifier, speaker, sound level meter
14	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
15	To determine natural frequencies corresponding mode shapes of the disc and mode shapes	Accelerometers, oscilloscope, charge amplifier, electrodynamics exciter, disk etc.

SEMESTER - III

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7111	Advanced Numerical Methods	3-0-0	3	2015

Course Objectives

- 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.

Syllabus

Solution of algebraic and transcendental equations
Solution of simultaneous equations-Direct & indirect methods
Interpolation & Curve Fitting
Numerical Differentiation & Integration
Solution to ordinary Differential Equations
Solution to partial differential Equations- FEM

Expected Outcome

By the end of the course,

- 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.

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

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Solution of algebraic and transcendental equations- Review and comparison of various iterative methods, convergence	4	15
	Generalised Newton-Raphson method for multiple roots – Higher order methods – Newton's method for non-linear systems.	3	
II	Solution of simultaneous equations-Direct & indirect methods-Gauss elimination and Gauss Jordan methods – ill conditioning – pivoting –	3	15
	Jacobi, Gauss-Seidel and Relaxation methods-convergence-Eigen value problems-Vector iteration method	3	
FIRST INTERNAL EXAM			
III	Interpolation & Curve Fitting-Newton's Divided difference, Lagrange, Aitken, Hermite and Spline techniques – Inverse interpolation -Double interpolation-Trigonometric interpolation.	4	
	Curve fitting – method of least squares – non-linear relationships – Correlation and Regression – Linear Correlation – Measures of correlation – Standard error of estimate – Coefficient of correlation – Multiple linear regressions.	3	
IV	Numerical differentiation – Derivative using forward, backward and central difference scheme, Maxima and minima of tabulated functions.	4	
	Numerical integration-Newton-Cote's Integration formula-Gauss quadrature- Simson rule, Double integration. Error estimates-	2	
SECOND INTERNAL EXAM			
V	Solution of ordinary differential equations-Single step & multi step methods-stability of solution –	4	20
	Simultaneous first order differential equations- higher order different equations. Numerical solution of integral equations.	3	
VI	Partial differential equations – classification – Laplace equation, ID wave equation, ID heat equation – Finite difference methods – Relaxation methods.	4	20

	Stability and convergence of solution. FEM for ordinary Differential equation and partial differential equations.	5	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7113	**Advanced Non-Destructive Evaluation**	**3-0-0**	**3**	**2015**

Course Objectives

The aim of the course is to familiarize the various nondestructive evaluation techniques and the identification of technique suitable for particular requirement.

Introduction, surface NDT methods
Eddy current method
Thermography
Radiography
Ultrasonic NDT
Advance NDE methods

Expected Outcome

At the end of the course the students will:

- Understand various surface and volumetric non destructive evaluation techniques and its sensitivity towards various types of defects
- Gain knowledge about various advanced NDE techniques
- Understand the principle of ultrasonic NDE and mechanics of elastic wave propagation.

Text Books :

1. P.J. Shull,Nondestructive evaluation, theory techniques and application, Marcell Decker Inc, New York 2002
2. D.E. Bray and R.K.Stanley, Nondestructive evaluation, a tool in design manufacturing and service, CRC Press, 1996
3. Paul E. Mix,Introduction to nondestructive testing- a training guide, Wiley International, USA, 2005

Reference books :

1. NDT Handbooks Volume 1-17, ASNT Press, OH USA
2. Charles J. Hellier,Handbook of nondestructive evaluation, Mc Graw Hill
3. Nondestructive evaluation and quality control, ASM Handbook, ASM International

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Introduction to nondestructive evaluation, Visual inspection, Liquid Penetrant Testing – rinciples, types and properties of liquid penetrants, developers, advantages and limitations of various methods.	4	15
	Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.	3	
II	Electro-Magnetic Methods - Maxell's Equations, Magnetic Flux Leakage.	3	15
	Eddy Current, Low Frequency Eddy Current, Remote Field Eddy Current, Pulsed Eddy Current.	3	
FIRST INTERNAL EXAM			
III	Principles of Thermography, Contact and non contact inspection methods - Heat sensitive paints - Heat sensitive papers - thermally quenched phosphors liquid crystals - techniques forapplying liquid crystals - calibration and sensitivity -	4	
	Other temperature sensitive coatings -non contact thermographic inspection - Advantages and limitation -infrared radiation andinfrared detectors, Instrumentations and methods, applications.	3	
IV	Radiographic Methods - Principles of X-ray NDT, Equipment, Calibration, Image Collection, Quantification, and Interpretation. High power sources and high quality films.	4	
	Digital Radiography, Introduction to Tomography and Laminography.	3	
SECOND INTERNAL EXAM			
V	Nature of sound waves, wave propagation - modes of sound wave generation - longitudinal waves, transverse waves, surface waves, lamb waves - Velocity, frequency and wavelength of ultrasonic waves	3	20

	Ultrasonic pressure, intensity and impedance - Attenuation of ultrasonic waves - reflection, refraction and mode convection - Snell's law and critical angles - Fressnel and Faunhofer effects - ultrasonic beam split.	3	
	Various methods of ultrasonic wave generation - Piezoelectric effect, Piezo electric materials and their properties, contact testing , Pulse echo method and through transmission method, immersion testing, couplants - Data presentation A, B and C scan displays	3	
VI	Formulation of elastic wave equation, Elastic wave propagation in isotropic and anisotropic materials, Cristoffel equation.	4	20
	Overview of advance ultrasonic techniques-Phased array technique, Time of flight diffraction technique, Ultrasonic guided waves, EMAT, laser ultrasonics, nonlinear ultrasonics, acoustic emission technique.	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7115	**Advanced Design Synthesis**	**3-0-0**	**3**	**2015**

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

Syllabus

Floating Link, Overlay method, Coupler curves
Inflection circle, Transmission angle.
Two point synthesis and Three point synthesis of Mechanisms.
Synthesis with Four accuracy points.
Synthesis using Displacement Equations.
Synthesis using Complex numbers, Spatial mechanisms

Expected Outcome

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

- Create and analyses 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.

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. Prentice Hall of India, Ltd.

3. Theory of Mechanisms and Machines by Shigley, McGraw Hill International Edition.

4. Dynamics of Machinery by A.R.Holowenko.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Floating Link, Special methods of Velocity and Acceleration Analysis using auxiliary points.	4	15
	Overlay method for conditioned crank mechanisms, coupler curves. Roberts – chebyshev theorem	3	
II	Inflection circle,Euler Savery equation, Hartman construction, Bobillier construction,	3	15
	Synthesis using Optimum transmission angle	3	
FIRST INTERNAL EXAM			
III	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.	4	
	Synthesis of slider crank mechanism with three accuracy points.	3	
IV	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,	4	
	Function Generators, Synthesis of slider crank mechanism with four accuracy points.	2	
SECOND INTERNAL EXAM			
V	Algebraic methods of synthesis using displacement equations: - Crank and follower synthesis- three accuracy points,	4	20
	Crank and follower synthesis- angular velocities and accelerations.	3	
VI	Rectilinear mechanisms, Algebraic methods of synthesis using complex numbers.Spatial motion and spatial linkages	4	20
	Types of spatial mechanisms, Single loop linkage and multiple loop linkages. Simple mechanisms in Robots.	5	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7117	Mechatronics System Design	3-0-0	3	2015

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.

Syllabus

Introduction to mechatronics sensors and transducers
Automation system design
Modeling and simulation of mechatronics systems
Microprocessors & microcontrollers
Real time interfacing
Robotic vision and case studies

Expected Outcome

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.

Reference books :

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.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Characteristics. Displacement and position sensors. Resolvers and synchros. Velocity and motion sensors..	3	15
	Principle and types of force, temperature, vibration and acoustic emission sensors.	2	
	ACTUATORS: Pneumatic, hydraulic and mechanical actuation systems used for Mechatronics devices	2	
II	AUTOMATION SYSTEM DESIGN: Design of fluid power circuits – cascade, KV-map and step counter method. PLC ladder logic diagram,	3	15
	Programming of PLC, fringe condition modules, sizing of components in pneumatic and hydraulic systems. Analysis of hydraulic circuits.	3	
FIRST INTERNAL EXAM			
III	Modeling And Simulation: Definition, key elements, mechatronics approach for design process, modeling of engineering systems, modeling system with spring, damper and mass.	4	15
	Modeling chamber filled with fluid, modeling pneumatic actuator. Transfer functions, frequency response of systems, bode plot. software and hardware in loop simulation.	3	
IV	Microprocessors & Microcontrollers: Microprocessors - introduction, 8085 architecture, types of memory, machine cycles and timing diagram, addressing modes, instruction set, development of simple programs.	4	15
	8051 microcontroller architecture, registers, addressing modes, interrupts, port structure, timer blocks and applications- stepper motor speed control.	2	
SECOND INTERNAL EXAM			
V	Real Time Interfacing: Introduction to data acquisition and control systems, overview of I/O process.	4	20
	Virtual instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, SCADA systems.	4	
VI	ROBOTIC VISION :Image acquisition: Vidicom and charge coupled device (CCD) cameras. Image processing techniques: histogram analysis, thresholding and connectivity method.	4	20

	Case Studies Of Mechatronics Systems: Pick and place robot, Automatic Bottle filling unit, Automobile engine management system.	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7119	**Computational Plasticity**	**3-0-0**	**3**	**2015**

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

Syllabus

Elements of continuum mechanics and thermodynamics
The principle of virtual work. Displacement - based finite elements. Large strain formulation. The mathematical theory of plasticity.Finite elements in small-strain plasticity problems. Application: integration algorithm for the isotropically hardening vonMises model. Numerical examples with the vonMises model - Further application: the von Mises model with nonlinear mixed hardening

Expected Outcome

☐ 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.

References:

1. Eduardo de Souza Neto,DjordjePeric, 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

8. Modeling of Metal Forming and machining processes by fem - Prakash M. Dixit, Uday S. Dixit
9. Introduction to Nonlinear Finite Element Analysis, , Nam-Ho Kim, Spinger

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Elements of continuum mechanics and thermodynamics – Kinematics of deformation - Infinitesimal deformations - Forces. Stress Measures -	4	15
	Fundamental laws of thermodynamics - Constitutive theory - Weak equilibrium.	3	
II	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.	3	15
	The incremental finite element procedure – Large strain formulation - Unstable equilibrium. The arc-length method	3	
FIRST INTERNAL EXAM			
III	The mathematical theory of plasticity.	3	15
	Overview of the program structure of FEM for plasticity	3	
IV	Phenomenological aspects - One-dimensional constitutive model	3	15
	General elastoplastic constitutive model - Classical yield criteria – Plastic flow rules - Hardening laws	4	
SECOND INTERNAL EXAM			
V	Finite elements in small-strain plasticity problems – Preliminary implementation aspects	4	20
	General numerical integration algorithm for elastoplastic constitutive equations	4	
VI	Application: integration algorithm for the isotropically hardening vonMises model - The consistent tangent modulus	4	20

	Numerical examples with the vonMises model - Further application: the von Mises model with nonlinear mixed hardening	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7123	**Mechanical Behavior Of Materials**	**3-0-0**	**3**	**2015**

Course Objectives

The aim of the course is to provide information about the structure of crystalline materials, imperfections in crystals and its implications in the strength of materials, elastic and plastic behavior of crystalline materials to applied forces. In conjuction with the microstructural aspects of the plasticity a clear idea about the dislocation theory, strengthening mechanisms and fracture mechanics is attained. Basic information related to recovery, recrystallisation and grain growth and its influence on mechanical properties is also obtained. An understanding about the mechanical behavior of polymers, ceramics and composites is also achieved.

Syllabus

Structure and imperfections in crystals
Mechanical behaviour of metals
Strengthening mechanisms, recovery, recrystallisation and grain growth, Alloying
Fracture
Fatigue and creep
Mechanical behaviour of composites, polymers and ceramics. Advanced materials

Expected Outcome

At the end of the course the students will:

- Have a thorough understanding about the structure of crystalline solids and the various imperfections in it.
- Attain an in-depth understanding about dislocation theory and the various strengthening mechanisms.
- Achieve basic concepts of fracture mechanics and failure mechanisms like fatigue and creep.
- Gives information about the mechanical behavior of polymers, ceramics and composites.

Text Books :

1. MechancialBehaviour Materials by Marc Andre Meyers, K.K. Chawla,PHI

2. MechancialBehaviour Materials by Thomas H. Courtney, Waveland PrInc; 2 edition

Reference books :

1. Mechanical Metallurgy by GE Dieter; McGraw-Hill Book Co. Kogakusha Co. Ltd.
2. Fatigue of Metals by PG Forrest; Pergammon Press.
3. Material Science by Abdul Mubeen; Khanna Publishers

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Elements of crystal structure, Imperfections in crystals, dislocation motion and dislocation theory.	3	15
	Slip in crystalline solids, Deformation twinning and kink bands, Grain boundaries and poly crystalline aggregates, Plasticity and the theoretical strength of materials.	3	
II	States of stress and strain, Elasticity: origins, isotropic materials, anisotropic material .	3	15
	Stress-strain curves; plasticity; empirical relations for stress and strain, criteria for necking, Yield Criteria, strength coefficient and strain hardening exponent, Effect of strain rate and temperature on tensile properties and torsion, Mechanical testing methods	4	
FIRST INTERNAL EXAM			
III	Strengthening mechanisms: solid solution, grain refinement, strain hardening, precipitation hardening, Recovery, recrystallisation and grain growth, Principles of Alloying - Solid solutions and intermediate phases - Gibbs phase rule and equilibrium diagram -	4	
	Types of binary phase diagrams ,Isomorphous - Eutectic -Peritectic and Peritectoid reactions, Iron-iron carbide equilibrium diagram, TTT diagram, martensitic transformation	3	
IV	Ceramics, polymers and composites. Advances and modern materials	2	
	Mechanical behavior of ceramics, Polymers and Composites.	3	
SECOND INTERNAL EXAM			
V	Types of fractures - Ductile and brittle fractures - features of fracture - surface for ductile, brittle and mixed modes.	3	20
	The history of failure of engineering structures and parts, high strain rate, stress concentration and low temperature effects, impact tests and results, transition temperature and factors affecting transition temperature.	4	
VI	Stress cycle, fatigue curve, fatigue fracture characteristics. Fatigue testing and testing machines, determination of fatigue strength. Factors affecting fatigue- size, surface, stress concentration, Creep, Creep curve, Creep mechanisms,	4	20
	Low temperature and high temperature creep theories, Fracture at elevated temperature. Stress rupture, Deformation mechanism maps, Material	5	

	aspects of creep design, Creep resistance as related to material properties and structure, Super plasticity		
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7125	**Computational Methods in Design and Manufacturing**	**3-0-0**	**3**	**2015**

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.

Syllabus

Metal Forming and Machining Processes
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 ,viscoplasticity. Finite element method – general procedure, elements and shape function, stiffness matrix, isoparametric simulations, assembly and solutions Basic Considerations in Nonlinear Analysis,Linearization and Directional derivatives. Solution of the Nonlinear Finite Element Equations in Static Analysis

Expected Outcome

A basic understanding of the principles of machine component design is an essential requirement for mechanical engineers in an industrial environment.

☐☐Potential employers and graduate programs expect the students to have an ability to:

☐☐Apply knowledge of mathematics, science, and engineering.

☐☐Design a system, component, or process to meet desired needs.

☐☐Identify, formulate, and solve engineering problems.

☐☐Communicate effectively and educate themselves.

References:

1. Finite element procedures K. J. Bathe, PHI.
2. Modeling of Metal Forming and machining processes by fem - Prakash M. Dixit,Uday S. Dixit
3. An Introduction to Nonlinear Finite Element Analysis, J.N Reddy, Oxford University Press, 2005.
4. Nonlinear Finite elements for continua and structures, Ted Belytschko, Wiley 2001.
5. Continuum Mechanics and plasticity, Han Chin Wu, CRC,2001.
6. Introduction to Nonlinear Finite Element Analysis, , Nam-Ho Kim,Spinger

7. Advanced Topics in Finite Element Analysis of Structures: With Mathematica and MATLAB

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Metal Forming and Machining Processes – Introduction to Metal Forming, Bulk Metal Forming, Sheet Metal Forming Processes, Machining, Turning, Milling etc.	3	15
	Index Notation and Summation Convention, Stress, Stress at a Point, Analysis of Stress at a Point, Equation of Motion,	3	
II	Deformation, Linear Strain Tensor, Analysis of Strain at a Point,	4	15
	Compatibility Conditions, Material Behavior, Elastic Stress-Strain Relations for Small Deformations,	3	
FIRST INTERNAL EXAM			
III	Elastoplasticity – yield criteria, incremental and deformation plasticity, flow rule, viscoplasticity.	3	15
	Finite element method – general procedure, elements and shape function, stiffness matrix, isoparametric simulations, assembly and solutions. Examples of applications in mechanical design.	3	
IV	Basic Considerations in Nonlinear Analysis, Lagrangian Continuum Mechanics Variables for General Nonlinear Analysis, Virtual work-	3	15
	Linearization and Directional derivatives, Directional derivatives of different strain measures,	2	
	Linearization of weak form in terms of second PiolaKirchoff stresses and the Green Lagrange strains principle and variational methods,	2	
SECOND INTERNAL EXAM			
V	Nonlinear analysis – Total and Updated Lagrangian formulations,	4	20%
	geometric nonlinearity and material nonlinearity-formulations and procedures for static analysis.	4	
VI	Solution of the Nonlinear Finite Element Equations in Static Analysis	4	20%
	Newton Raphson, Modified Newton Raphson, Secant method, Arc length method,	4	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7127	Advanced Vehicle Dynamics	3-0-0	3	2015

Course Objectives

Develop an essential knowledge aboutdynamic behavior and mathematical modeling and simulation of vehicles.

Introduction to dynamics
Stability of Vehicles
Vehicle kinematics
Dynamic stability of vehicles
Tire dynamics and modeling
Driveline dynamics
Steering dynamics
Vehicle vibrations

Expected Outcome

At the end of the course the students will:

- Get knowledge of different parameters affect the static and dynamic behavior of vehicles.

☐☐Get knowledge of braking performance and analysis of automobiles.

☐☐Get knowledge of tire mechanics and modeling of tire system.

- Understand how to control the vibrations of the vehicle.

☐☐At the end of the course, students will know the behavior of the vehicle under different input conditions and will be able to numerically model and analyze different subsystems of road vehicles.

Text Books :

1. Vehicle dynamics-Theory and applications - Reza.N.Jazar – Springer-2008
2. Fundamentals of Vehicle Dynamics - Gillespie T.D, SAE USA 1992.
3. Tire and Vehicle Dynamics - Ham B, Pacejka - SAE Publication - 2002

Reference books :

1. Vehicle Dynamics and Control,- Rajesh Rajamani Springer-2008
2. Mechanics of road vehicles, W. Steeds- Wildlife book Ltd, London, 1990
3. Steering, suspension and tyres-. J.G. Giles-, Wildlife books Ltd, London, 1968
4. Theory of ground vehicles TY. Wong-, Johnwiley and sons Inc, New York
5. Automobile mechanics N.K. Giri-, Khanna Publishers, Delhi, 1986
6. Wolf- Heinrich Hucho – Aerodynamics of road vehicles, SAE

COURSE PLAN			
Module	**Contents**	**Hours Allotted**	**% of Marks in End-Semester Examination**
I	Introduction to dynamics Stability of Vehicles- load distribution weight transfer during acceleration and braking, optimum braking, wheel locking and vehicle skidding, antilock braking system.	4	15
	Over steer, under steer, steady state cornering. Effect of braking, driving torques on steering. Effect of camber, transient effects in cornering. Directional stability of vehicles.	3	
II	Vehicle kinematics Coordinate transformations, Euler angles, time derivative and coordinate frames, rigid body dynamics.	3	15
	Dynamic stability of vehicles -Vehicle planar dynamics Longitudinal vehicle dynamics-Lateral vehicle dynamics -Vehicle roll dynamics	3	
FIRST INTERNAL EXAM			
III	Tire dynamics and modeling -Tire and rim fundamentals, Tire components, Tire coordinate frame and tire force systems, Tire Stiffness-linear and non linear tire stiffness, hysteresis effect, Static tire stresses Effective radius Rolling resistance.	3	
	Effect of speed on rolling resistance Effect of inflation pressure, load camber angle and side slip angle on rolling resistance, Forces on the tire-linear force, lateral force and camber force, Stresses and deformation of a rolling tire Mathematical model of rolling tire- damping structure and spring Structure.	4	
IV	Driveline dynamics- Basic engine dynamics - power, speed and torque Characteristics.	4	
	Driveline components -Gear box and clutch dynamics, gear box design	2	
SECOND INTERNAL EXAM			
V	Steering dynamics-Analysis of steering mechanisms, Steering of multi-axle vehicles, vehicles with trailer.	4	20
	Four wheel steering, optimization of steering mechanisms, Suspension mechanisms- Suspension optimization	3	
VI	Vehicle vibrations Fundamentals of vibrations- single degree freedom and multi degree freedom vibrations.	4	20
	Passenger comfort and vibrations Numerical modelling of vehicle vibrations-Quarter car model Half car model, full car model	5	

END SEMESTER EXAM

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7129	**Control System**	**3-0-0**	**3**	**2015**

Course Objectives

1 To introduce the elements of control system and their modeling using various Techniques.
2 To introduce methods for analyzing the time response, the frequency response and the stability of systems
3 To introduce the state variable analysis method

Basic Elements of Control System –- Transfer function, - characteristics equation
Time response analysis P, PI, PD and PID Compensation, Analysis using MATLAB
Frequency Response– Nichol's Chart -.
Compensators - Analysis using MATLAB.
Stability, Routh-Hurwitz Criterion, Root Locus Technique, Analysis using MATLAB
State space representation of Continuous Time systems – State equations – Transfer function from State Variable
State space representation for Discrete time systems. Sampled Data control systems – Sampling Theorem

Expected Outcome

1. Perform time domain and frequency domain analysis of control systems required for stability analysis.
2. Design the compensation technique that can be used to stabilize control systems.

COURSE PLAN

Module	Contents	Hours Allotted	% of Marks in End-Semester Examination
I	Basic Elements of Control System – Open loop and Closed loop systems - Differential equation - Transfer function,	5	15
	Translational and rotational mechanical systems - Block diagram reduction Techniques - Signal flow graphMason's gain formula - characteristics equation	4	
II	Time response analysis - First Order Systems - Impulse and Step Response analysis of second order systems - Steady state errors – P, PI, PD and PID Compensation, Analysis using MATLAB	6	15
FIRST INTERNAL EXAM			
III	Frequency Response - Bode Plot, Polar Plot, Nyquist Plot - Frequency Domain specifications from the plots - Constant M and N Circles –.	5	15
	Nichol's Chart - Use of Nichol's Chart in Control System Analysis. Series, Parallel, series-parallel Compensators - Lead, Lag, and Lead Lag Compensators, Analysis using MATLAB	4	
IV	Stability, Routh-Hurwitz Criterion, Root Locus Technique, Construction of Root Locus, Stability, Dominant Poles,	4	15
	Application of Root Locus Diagram - Nyquist Stability Criterion - Relative Stability, Analysis using MATLAB	4	
SECOND INTERNAL EXAM			
V	State space representation of Continuous Time systems – State equations	4	20
	Transfer function from State Variable Representation – Solutions of the state equations	3	
VI	Concepts of Controllability and Observability – State space representation for Discrete time systems.	4	20
	Sampled Data control systems – Sampling Theorem – Sampler & Hold – Open loop & Closed loop sampled data systems	2	
END SEMESTER EXAM			

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7191	SEMINAR II	**0-0-2**	**2**	**2015**

Course Objectives

To make students

1. Identify the current topics in the specific stream.
2. Collect the recent publications related to the identified topics.
3. Do a detailed study of a selected topic based on current journals, published papers and books.
4. Present a seminar on the selected topic on which a detailed study has been done.
5. Improve the writing and presentation skills.

Approach

Students shall make a presentation for 20-25 minutes based on the detailed study of the topic and submit a report based on the study.

Expected Outcome

Upon successful completion of the seminar, the student should be able to

1. Get good exposure in the current topics in the specific stream.
2. Improve the writing and presentation skills.
3. . Explore domains of interest so as to pursue the course project.
4. Able to assimilate the ideas presented in the latest journal papers

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7193	PROJECT (PHASE 1)	0-0-12	6	2015

Course Objectives

To make students

1. Do an original and independent study on the area of specialization.
2. Explore in depth a subject of his/her own choice.
3. Start the preliminary background studies towards the project by conducting literature survey in the relevant field.
4. Broadly identify the area of the project work, familiarize with the tools required for the design and analysis of the project.
5. Plan the experimental platform, if any, required for project work.

Approach

The student has to present two seminars and submit an interim Project report. The first seminar would highlight the topic, objectives, methodology and expected results. The first seminar shall be conducted in the first half of this semester. The second seminar is the presentation of the interim project report of the work completed and scope of the work which has to be accomplished in the fourth semester.

Expected Outcome

Upon successful completion of the project phase 1, the student should be able to

1. Identify the topic, objectives and methodology to carry out the project.
2. Finalize the project plan for their course project.

SEMESTER - IV

Syllabus and Course Plan

Course No.	Course Name	L-T-P	Credits	Year of Introduction
01ME7194	PROJECT (PHASE II)	**0-0-23**	**12**	**2015**

Course Objectives

To continue and complete the project work identified in project phase 1.

Approach

There shall be two seminars (a mid term 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 has to be prepared for possible publication in journals / conferences based on their project work.

Expected Outcome

Upon successful completion of the project phase II, the student should be able to

1. Get a good exposure to a domain of interest.
2. Get a good domain and experience to pursue future research activities.