VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR
M.TECH. Machine Design

I SEMESTER **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14 MDE11	Applied Mathematics	4	2	3	50	100	150	4
14 MDE12	Finite Element Method	4	2	3	50	100	150	4
14CAE13	Continuum Mechanics	4	2	3	50	100	150	4
14CAE14	Experimental Mechanics	4	2	3	50	100	150	4
	Elective – I	4	2	3	50	100	150	4
14MDE16	Design Engineering Lab I	--	3	--	25	50	75	2
14MMD17	SEMINAR	--	3	--	25	--	25	1
Total		**20**	**13**	**15**	**300**	**550**	**850**	**23**

ELECTIVE-I

14MDE 151	Computer Graphics	14 MDE 153	Mechatronics System Design
14MDE 152	Computer Applications in Design	14MDE 154	Design for Manufacture
14MEA155	Advanced Fluid Dynamics		

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. Machine Design

II SEMESTER **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
14MST 21	Composite Materials Technology	4	2	3	50	100	150	4
14MDE 22	Advanced Machine Design	4	2	3	50	100	150	4
14MDE 23	Dynamics & Mechanism Design	4	2	3	50	100	150	4
14MDE 24	Advanced Theory of Vibrations	4	2	3	50	100	150	4
	Elective – II	4	2	3	50	100	150	4
14MDE26	Design Engineering Lab II		3	3	25	50	75	2
14MMD27	SEMINAR	--	3	--	25	--	25	1
	**PROJECT WORK PHASE-I COMMENCEMENT (6 WEEKS DURATION)	--	--	--	--	--	--	--
Total		**20**	**13**	**15**	**300**	**550**	**850**	**23**

ELECTIVE-II

14CAE 251	Design Optimization	14CAE 253	Advanced Manufacturing Process Simulation
14MDE252	Theory of Plasticity	14MDE 254	Rotor Dynamics
14MEA255	Automobile System Design		

**** Between the II Semester and III Semester, after availing a vacation of 2 weeks.**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. Machine Design

III SEMESTER : INTERNSHIP **CREDIT BASED**

Course Code	Subject	No. of Hrs./Week		Duration of the Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work		I.A.	Exam		
14MMD31	SEMINAR / PRESENTATION ON INTERNSHIP (AFTER 8 WEEKS FROM THE DATE OF COMMENCEMENT)	-	-	-	25	-	25	
14MMD 32	REPORT ON INTERNSHIP	-	-	-		75	75	20
14MMD 33	INTERNSHIP EVALUATION AND VIVA-VOCE	-	-	-	–	50	50	
	Total	**-**	**-**	**-**	**25**	**125**	**150**	**20**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. Machine Design

IV SEMESTER **CREDIT BASED**

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Field Work / Assignment / Tutorials		I.A.	Exam		
14MDE41	Tribology and Bearing Design	4	--	3	50	100	150	4
	ELECTIVE-III	4	-	3	50	100	150	4
14MMD43	EVALUATION OF PROJECT WORK PHASE-II	-	-	-	25	-	25	1
14MMD44	EVALUATION OF PROJECT WORK PHASE-III	-	-	-	25	-	25	1
14MMD45	EVALUATION OF PROJECT WORK AND VIVA-VOCE	–	-	3	-	100+100	200	18
	Total	**12**	**07**	**09**	**150**	**400**	**550**	**28**
	Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits							

ELECTIVE-III

14CAE 421	Fracture Mechanics	14MDE 423	Robust Design
14MST422	Smart Materials & Structures	14CAE 424	Finite Element Methods for Heat Transfer and Fluid Flow Analysis.
14MEA425	Computational Fluid Dynamics		

NOTE:	Project Phase – II:16 weeks duration. 3 days for project work in a week during III Semester. Evaluation shall be taken during the first two weeks of the IV Semester. Total Marks shall be 25.
1)	Project Phase – III :24 weeks duration in IV Semester. Evaluation shall be taken up during the middle of IV Semester. At the end of the Semester Project Work Evaluation and Viva-Voce Examinations shall be conducted. Total Marks shall be 250 (Phase I Evaluation:25 Marks, Phase –II Evaluation: 25 Marks, Project Evaluation marks by Internal Examiner(guide): 50, Project Evaluation marks by External Examiner: 50, marks for external and 100 for viva-voce). Marks of Evaluation of Project: I.A. Marks of Project Phase – II & III shall be sent to the University along with Project Work report at the end of the Semester. During the final viva, students have to submit all the reports.
2)	The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following: a) Head of the Department (Chairman)(b) Guide (c) Two Examiners appointed by the university. (out of two external examiners at least one should be present).

Design Engineering ;
Common to Design Engineering (MDE), Engineering Analysis & Design (MEA),Machine Design (MMD),Computer Aided Engineering(CAE)

APPLIED MATHEMATICS

(Common to MDE,MMD,MEA,CAE,MCM,MAR,IAE,MTP,MTH,MTE,MST,MTR)

Sub Code : 14MDE11	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objectives:

The main objectives of the course are to enhance the knowledge of various methods in finding the roots of an algebraic, transcendental or simultaneous system of equations and also to evaluate integrals numerically and differentiation of complex functions with a greater accuracy. These concepts occur frequently in their subjects like finite element method and other design application oriented subjects.

Course Content:

1. Approximations and round off errors: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling and Engineering problem solving: Simple mathematical model, Conservation Laws ofEngineering.**06 Hours**

2. Roots of Equations: Bracketing methods-Graphical method, Bisection method, False position method, Newton- Raphson method, Secant Method. Multiple roots, Simple fixed point iteration.
   Roots of polynomial-Polynomials in Engineering and Science, Muller's method, Bairstow's Method Graeffe's Roots Squaring Method.**12 Hours**

3. Numerical Differentiation and Numerical Integration: Newton –Cotes and Guass Quadrature Integration formulae, Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae**06 Hours**

4. System of Linear Algebraic Equations And Eigen Value Problems: Introduction, Direct methods, Cramer's Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, Iteration Methods.

Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Householder’s method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method .**14 Hours**

5. Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering
   Orthogonality and Least Squares: Inner product, length and orthogonality, orthogonal sets, Orthogonal projections, The Gram-schmidt process, Least Square problems, Inner product spaces**. 12 Hours**

Text Books:

1. S.S.Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
2. Steven C. Chapra, Raymond P.Canale, Numerical Methods for Engineers, Tata Mcgraw Hill, 4th Ed, 2002.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engg computation, New Age International, 2003.

Reference Books:

1. Pervez Moin, Fundamentals of Engineering Numerical Analysis, Cambridge, 2010.

2. David. C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002.

Course Outcomes:

The Student will be able to

1. Model some simple mathematical models of physical Applications.
2. Find the roots of polynomials in Science and Engineering problems.
3. Differentiate and integrate a function for a given set of tabulated data, forEngineering Applications

FINITE ELEMENT METHOD

(Common to MDE,MEA,MMD,CAE,MTR)

Sub Code : 14MDE12	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objectives

1. To present the Finite element method (FEM) as a numerical method for engineering analysis of continua and structures
2. To present Finite element formulation using variational and weighted residual approaches
3. To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress & plane strain problems and 3-D solids, for thermal and dynamics problems.

Course Content:

1. **Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non Conforming elements, C_o C_1 and C_n Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions.

10 Hours.

2. **Solid Mechanics : One-Dimensional Finite Element Formulations and Analysis –** Bars- uniform, varying and stepped cross section- Basic(Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic(Linear) Elements Formulations for different boundary condition -Axial, Bending, Torsional, and Temperature Loads with problems.

10 Hours.

3. **Two Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems.

Triangular and Quadrilateral Axi-symmetric basic and higher order Elements formulation for axi-symmetric loading only with sample problems

Three Dimensional Finite Element Formulations for Solid Mechanics Problems: Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements

10 Hours.

4. **Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements
5. **Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilatateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.

10 Hours.

Text Books:

1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.

2. Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.

Reference Books:

1. Rao S. S. , Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
2. P.Seshu, Textbook of Finite Element Analysis, PHI, 2004.
3. J.N.Reddy, Introduction to Finite Element Method, McGraw -Hill, 2006.
4. Bathe K. J., Finite Element Procedures, Prentice-Hall, 2006..
5. Cook R. D., Finite Element Modeling for Stress Analysis, Wiley,1995.

Course Outcome:

On completion of the course the student will be

1. Knowledgeable about the FEM as a numerical method for the solution of solid mechanics, structural mechanics and thermal problems
2. Developing skills required to use a commercial FEA software

CONTINUUM MECHANICS

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14CAE13	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

This course aims at a comprehensive study of mechanics of solids. The topics covered are

1. Analysis of stress, strain and stress-strain relations.
2. Solution of plane elasticity problems in rectangular and polar coordinates using analytical methods including thermal loads, body forces and surface tractions
3. Formulation of 3-D boundary value problems
4. Torsion of prismatic bars

Course Content:

1. **Analysis of Stress:** Continuum concept, homogeneity, isotropy, mass density, body force, surface force Cauchy's stress principle-stress vector, State of stress at a point- stress tensor, stress tensor –stress vector relationship, Force and moment, equilibrium, stress tensor symmetry. Stress transformation laws, stress quadric of Cauchy. Principal stresses, Stress invariants, stress ellipsoid, maximum and minimum shear stress, Mohr's circle for stress, plane stress, deviator and spherical stress tensors.

   Deformation and Strain: Particles and points, continuum configuration-deformation and flow concepts. Position vector, displacement vector-Lagrangian and Eulerian description, deformation gradient, displacement gradient.Deformation tensors, finite strain tensors, small deformation theory, infinitesimal strain tensors.Relative displacement- linear, rotation tensors.Transformation properties of strain tensors. Principal strains, strain invariants, cubical dilatation, spherical and deviator strain tensors, plane strain, Mohr's circle, and compatibility equations.

   10 Hours

2. **Linear Elasticity:** Generalized Hooke's law, Strain energy function, isotropy, anisotropy, elastic symmetry. Isotropic media-elastic constants. Elastostatic and Elastodynamic problems. Theorem of superposition, uniqueness of solutions, St. Venant's principle.

   10 Hours

3. **Two dimensional elasticity**- plane stress, plane strain, Airy's stress function. Two dimensional elastostatic problems in polar coordinates. Hyperelasticity, Hypoelasticity, linear thermo elasticity.

10 Hours

4. **Plasticity:** Basic concept and definitions, idealized plastic behavior. Yield condition- Tresca and Von-Mises criteria. Stress space-□-plane, yield surface. Post yield behavior-isotropic and kinematic hardening. Plastic stress-strain equations, plastic potential theory. Equivalent stress, equivalent plastic strain increment. Plastic work, strain hardening hypothesis. Total deformation theory-elastoplastic problems. Elementary slip line theory for plane plastic strain

   Viscoelasticity: Linear viscoelastic behavior. Simple viscoelastic models-generalized models, linear differential operator equation. Creep and Relaxation- creep function, relaxation function, hereditary integrals. Complex moduli and compliances. Three dimensional theory-viscoelastic stress analysis, correspondence principles
5. **Fluids:** Fluid pressure, viscous stress tensor, barotropic flow. Constitutive equations-Stokesian, Newtonian fluids. Basic equation for Newtonian fluid, Nevier-Strokes-Duhum equations. Steady flow, hydrostatic, irrotational flow. Perfect fluids- Bernoulli's equation, circulation, potential flow, plane potential flow. **Fundamental Laws of Continuum Mechanics:** Conservation of mass, continuity equation. Linear momentum principle, equation of motion, equilibrium equations. Moment of momentum principle. Conservation of energy- first law of thermodynamics energy equation. Equation of state, entropy, second law of thermodynamics. Clausius-Duhem inequality, dissipation function. Constitutive equations-thermo mechanical and mechanical continua.

10 Hours

Text Books:

1. George. E. Mase, Continuum Mechanics, CRC Press, 2000.
2. J. N. Reddy, Introduction to Continuum Mechanics with Applications, Cambridge University Press, New York, 2008.
3. W. Michael Lai, David Rubin, Erhard Krempl, Introduction to Continuum Mechanics, Butterworth-Heinemann , 4th Ed, 2010.

References:

1. Batra, R. C., Elements of Continuum Mechanics, Reston, 2006.
2. George E. Mase, Schaum's Outline of Continuum Mechanics, McGraw-Hill, 1970.
3. Dill, Ellis Harold, Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity, CRC Press , 2006.
4. Fung Y. C., A First Course in Continuum Mechanics, Prentice-Hall, 2e, 1977.
5. Gurtin M. E., An Introduction to Continuum Mechanics, Academic Press, 1981.

Course Outcome: The student, upon completion of this course, will have Continuum mechanics background essential to solve engineering analysis problems by the FEM.

EXPERIMENTAL MECHANICS

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14CAE14	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

This course aims at a comprehensive study of mechanics of solids. The topics covered are

The objective of this course is to familiarize the student with state of the art experimental techniques namely strain gauges, photo elasticity, moiré interoferometry, brittle coating, moiré fringes and holography.

Course Content:

1. **Introduction**: Definition of terms, calibration, standards, dimension and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.

   Analysis of Experimental Data: Cause and types of experimental errors, error analysis. Statistical analysis of experimental data- Probability distribution, gaussian, normal distribution. Chi-square test, Method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis.

   10 Hours

2. **Data Acquisition and Processing:** General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to- Analog conversion, Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic.

   Force, Torque and Strain Measurement: Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage.

   10 **Hours**

3. **Stress Analysis:** Two Dimensional Photo elasticity **-** Nature of light, - wave theory of light,- optical interference - Polariscopes stress optic law - effect of stressed model in plane and circular Polariscopes, IsoclinicsIso chromatics fringe order determination - Fringe multiplication techniques - Calibration Photoelastic model materials. Separation methods shear difference method, Analytical separation methods, Model to prototype scaling**.**

10 Hours

4. **Three Dimensional Photo elasticity:** Stress freezing method, General slice, Effective stresses, Stresses separation, Shear deference method, Oblique incidence method Secondary principals stresses, Scattered light photo elasticity, Principals, Polari scope and stress data analyses**.**

10 Hours

5. **Coating Methods:** a) Photoelastic Coating Method-Birefringence coating techniques Sensitivity Reinforcing and thickness effects - data reduction - Stress separation techniques Photoelastic strain gauges. b) Brittle Coatings Method:Brittle coating technique Principles data analysis - coating materials, Coating techniques. c) Moire Technique - Geometrical approach, Displacement approach- sensitivity of Moire data data reduction, In plane and out plane Moire methods, Moire photography, Moire grid production.

   Holography: Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffeld curves, Reconstruction process, Holograpicinterferomerty, Realtime. and double exposure methods, Displacement measurement, Isopachics.

10 Hours

Text Books:

1. **Holman,**“Experimental Methods for Engineers” 7^{th} Edition, Tata McGraw-Hill Companies, Inc, New York, 2007.
2. **R. S. Sirohi, H. C. Radha Krishna,** “Mechanical measurements” New Age International Pvt. Ltd., New Delhi, 2004
3. **Experimental Stress Analysis** - Srinath, Lingaiah, Raghavan, Gargesa, Ramachandra and Pant, Tata McGraw Hill, 1984.
4. **Instrumentation, Measurement And Analysis -**Nakra&Chaudhry, B C Nakra K KChaudhry, Tata McGraw-Hill Companies, Inc, New York, Seventh Edition, 2006.

Reference Books:

1. **Measurement Systems Application and Design -** Doeblin E. A., 4th (S.I.) Edition, McGraw Hill, New York. 1989
2. **Design and Analysis of Experiments -** Montgomery D.C., John Wiley & Sons, 1997.
3. **Experimental Stress Analysis** - Dally and Riley, McGraw Hill, 1991.
4. **Experimental Stress Analysis -** Sadhu Singh, Khanna publisher, 1990.
5. **PhotoelasticityVol I and Vol II -** M.M.Frocht,. John Wiley and sons, 1969.
6. **Strain Gauge Primer -** Perry and Lissner, McGraw Hill, 1962.

Course Outcome: It helps the students to

1. Undertake experimental investigations to verify predictions by other methods.
2. To acquire skills for experimental investigations an accompanying laboratory course is desirable.

Elective-I

COMPUTER GRAPHICS

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE151	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:
This course will help the student to be knowledgeable of concepts, principles, processes and techniques essential to all areas of computer graphics

Course Content:
1. Transformations : Representation of points, Transformations: Rotation, Reflection, Scaling, Shearing, Combined Transformations, Translations and Homogeneous Coordinates, A geometric interpretation of homogeneous coordinates, Over all scaling, Points at infinity, Rotation about an arbitrary point, Reflection through an arbitrary line, Rotation about an axis parallel to coordinate axis, Rotation about an arbitrary axis in space, Reflection through an arbitrary plane.

10 Hours

2. Types and Mathematical Representation of Curves: Curve representation, Explicit, Implicit and parametric representation. Nonparametric and parametric representation of Lines, Circles, Ellipse, Parabola, Hyperbola, Conics. Parametric representation of synthetic curve, Hermite cubic splines, , Bezier curves: Blending function, Properties, generation, B-spline curves-Cox-deBoor recursive formula, Properties, Open uniform basis functions, Non-uniform basis functions, Periodic B-spline curve.
Types and Mathematical Representation of Surfaces Surface entities and parametric representation- Plane, Ruled, surface of revolution, Offset surface, Coons patch, Bezier surface, B-spline surface

10Hours

3. Types and Mathematical Representation of Solids
Solid entities: Block, Cylinder, Cone, Sphere, Wedge, Torus, Solid representation, Fundamentals of solid modeling, Set theory, Regularized set operations, Set membership classification, Half spaces, Basic elements, Building operations, Boundary representation and Constructive solid geometry, Basic elements, Building operations.
Scan Conversion and Clipping: Representation of points, lines, Drawing Algorithms: DDA algorithm, Bresenham's integer line algorithm, Bresenham's circle algorithm, Polygon filling algorithms: Scan conversion, Seed filling, Scan line algorithm. Viewing transformation, Clipping - Points, lines, Text, Polygon, Cohen-Sutherland line clipping, Sutherland-Hodgmen algorithm.

10Hours

4. Visual Realism: Introduction, Hidden line removal, Visibility of object views, Visibility techniques: Minimax test, Containment test, Surface test, Silhouttes, Homogeneity test, Sorting, Coherence, Hidden surface removal- Z-buffer algorithm, Warnock's algorithm, Hidden solid removal - ray tracing algorithm, Shading, Shading models, Diffuse reflection, Specular reflection, Ambient light, Shading of surfaces: Constant shading, Gourand shading, Phong shading, Shading enhancements, Shading Solids, Ray tracing for CSG, Z-buffer algorithm for B-rep and CSG

10 Hours

5.Applications: Colouring- RGB, CMY, HSV, HSL colour models, Data Exchange: Evolution of Data exchange, IGES, PDES, Animation: Conventional animation-key frame, Inbetweening, Line testing, Painting, Filming, Computer animation, Entertainment and Engineering Animation, Animation system hardware, Software architecture, Animation types, Frame buffer, Colour table, Zoom-pan-scroll, Cross bar, Real time play back, Animation techniques- key frame, Skelton. Path of motion and p-curves.

10 Hours

TextBooks:

1. IbrahamZeid, CAD/CAM-Theory and Practice-McGraw Hill, 2006.
2. David Rogers & Alan Adams, Mathematical Elements for Computer Graphics-Tata McGraw Hill, 2002.

ReferenceBooks:

1. Xiang Z, Plastock, R. A, Computer Graphics- Schaum's Outline, McGraw Hill, 2007.
2. Foley, van Dam, Feiner and Hughes, Computer Graphics- Principles and Practice-Addison Wesley, 1996.
3. Sinha A N., Udai A D., Computer Graphics- Tata McGraw Hill, 2008.

Course Outcome:

This course will enable students to:

1. Recognize how a visual image can be an effective means of communication
2. Acquire and develop the skills needed to creatively solve visual communication problems.
3. Understand, develop and employ visual hierarchy using images and text

COMPUTER APPLICATIONS IN DESIGN

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE152	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective

It helps the students to learn the principles of CAD/CAM/CAE Systems, Graphics Programming, Geometric Modeling Systems, CAD, CAM and CAE Integration, Standards for Communicating between Systems

Course Content:

1. **Introduction To CAD/CAM/CAE Systems**

   Overview, Definitions of CAD. CAM and CAE, Integrating the Design and Manufacturing Processes through a Common Database-A Scenario, Using CAD/CAM/CAE Systems for Product Development-A Practical Example.

   Components of CAD/CAM/CAE Systems: Hardware Components ,Vector-Refresh(Stroke-Refresh) Graphics Devices, Raster Graphics Devices, Hardware Configuration, Software Components, Windows-Based CAD Systems.**10 Hours**

2. **Basic Concepts of Graphics Programming**:

   Graphics Libraries, Coordinate Systems, Window and Viewport, Output Primitives - Line, Polygon, Marker Text, Graphics Input, Display List, Transformation Matrix, Translation, Rotation, Mapping, Other Transformation Matrices, Hidden-Line and Hidden-Surface Removal, Back-Face Removal Algorithm, Depth-Sorting, or Painters, Algorithm, Hidden-Line Removal Algorithm, z-Buffer Method, Rendering, Shading, Ray Tracing, Graphical User Interface, X Window System.

   Standards

   Standards for Communicating Between Systems: Exchange Methods of Product Definition Data, Initial Graphics Exchange Specification, Drawing Interchange Format, Standard for the Exchange of Product Data. Tutorials, Computational exercises involving Geometric Modeling of components and their assemblies

   10 Hours

3. **Geometric Modeling Systems**

   : Wireframe Modeling Systems, Surface Modeling Systems, Solid Modeling Systems, Modeling Functions, Data Structure, Euler Operators, Boolean Operations, Calculation of Volumetric Properties, Non manifold Modeling Systems, Assembly Modeling

Capabilities, Basic Functions of Assembly Modeling, Browsing an Assembly, Features of Concurrent Design, Use of Assembly models, Simplification of Assemblies, Web-Based Modeling.

Representation and Manipulation of Curves: Types of Curve Equations, Conic Sections, Circle or Circular Arc, Ellipse or Elliptic Arc, Hyperbola, Parabola, Hermite Curves, Bezier Curve, Differentiation of a Bezier Curve Equation, Evaluation of a Bezier Curve

10 Hours

4. B-Spline Curve, Evaluation of a B-Spline Curve, Composition of B-Spline Curves, Differentiation of a B-Spline Curve, Non uniform Rational B-Spline (NURBS) Curve, Evaluation of a NURBS Curve, Differentiation of a NURBS Curve, Interpolation Curves, Interpolation Using a Hermite Curve, Interpolation Using a B-Spline Curve, Intersection of Curves.

   Representation and Manipulation of Surfaces: Types of Surface Equations, Bilinear Surface, Coon's Patch, Bicubic Patch, Bezier Surface, Evaluation of a Bezier Surface, Differentiation of a Bezier Surface, B-Spline Surface, Evaluation of a-B-Spline Surface, Differentiation of a B-Spline Surface, NURBS Surface, Interpolation Surface, Intersection of Surfaces.

10 Hours

5. **CAD and CAM Integration**

   Overview of the Discrete Part Production Cycle, Process Planning, Manual Approach, Variant Approach, Generative Approach, Computer-Aided Process Planning Systems, CAM-I CAPP, MIPLAN and Multi CAPP, Met CAPP,ICEM-PART, Group Technology, Classification and Coding, Existing Coding Systems, Product Data Management (PDM) Systems.

10 Hours

Text Books:

1. Kunwoo Lee, “Principles of CAD/CAM/CAE systems”-Addison Wesley, 1999
2. RadhakrishnanP.,etal.,“CAD/CAM/CIM”-New Age International, 2008

Reference Books:

1. Ibrahim Zeid, “CAD/CAM – Theory & Practice”, McGraw Hill, 1998
2. Bedworth, Mark Henderson & Philip Wolfe, “Computer Integrated Design and Manufacturing” -McGraw hill inc., 1991.
3. Pro-Engineer, Part modeling Users Guide, 1998

Course Outcome:

Students develop expertise in generation of various curves, surfaces and volumes used in geometric modeling systems.

MECHATRONICS SYSTEM DESIGN

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE153	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective

1. To educate the student regarding integration of mechanical, electronics, electrical and computer systems in the design of CNC machine tools, Robots etc.
2. To provide students with an understanding of the Mechatronic Design Process, actuators, Sensors, transducers, Signal Conditioning, MEMS and Microsystems and also the Advanced Applications in Mechatronics.

Course Content:

1. Introduction: Definition and Introduction to Mechatronic Systems. Modeling &Simulation of Physical systems Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers. Study of Sensors and Transducers: Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics. **10 Hours**

2. Electrical Actuation Systems: Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors.
   System Models: Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems. **11 Hours**

3. Signal Conditioning: Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals , Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation.
   MEMS and Microsystems: Introduction, Working Principle, Materials for MEMS and Microsystems, Micro System fabrication process, Overview of Micro Manufacturing, Micro system Design, and Micro system Packaging. **13 Hours**

4. Data Presentation Systems: Basic System Models, System Models, Dynamic Responses of System. **8 Hours**

5. Advanced Applications in Mechatronics: Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design. **8 Hours**

Text Books:

1. W. Bolton, "Mechatronics" - Addison Wesley Longman Publication, 1999
2. HSU "MEMS and Microsystems design and manufacture"- Tata McGraw-Hill Education, 2002

Reference Books:

1. Kamm, "Understanding Electro-Mechanical Engineering an Introduction to Mechatronics"- IEEE Press, 1 edition ,1996
2. Shetty and Kolk "Mechatronics System Design"- Cengage Learning, 2010
3. Mahalik "Mechatronics"- Tata McGraw-Hill Education, 2003
4. HMT "Mechatronics"- Tata McGraw-Hill Education, 1998
5. Michel .B. Histand& David. Alciatore, "Introduction to Mechatronics & Measurement Systems"–. Mc Grew Hill, 2002
6. "Fine Mechanics and Precision Instruments"- Pergamon Press, 1971.

Course Outcome:

This course makes the student to appreciate multi disciplinary nature of modern engineering systems. Specifically mechanical engineering students to collaborate with Electrical, Electronics, Instrumentation and Computer Engineering disciplines.

DESIGN FOR MANUFACTURE

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE154	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

To educate students a clear understanding of factors to be considered in designing parts and components with focus on manufacturability

Course Content:

1. Effect of Materials And Manufacturing Process On Design: Major phases of design. Effect of material properties on design Effect of manufacturing processes on design. Material selection process- cost per unit property, Weighted properties and limits on properties methods.

   Tolerence Analysis: Process capability, mean, varience, skewness, kurtosis, Process capability metrics, Cp, Cpk, Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance- Sure fit law and truncated normal law. **12 Hours**

2. Selective Assembly: Interchangeable part manufacture and selective assembly, Deciding the number of groups -Model-1 : Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, Laminated shims, examples.

   Datum Features : Functional datum, Datum for manufacturing, Changing the datum. Examples.**12 Hours**

3. Design Considerations: Design of components with casting consideration. Pattern,Mould, and Parting line. Cored holes and Machined holes. Identifying the possibleand probable parting line. Casting requiring special sand cores. Designing to obviatesand cores.

Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish- machining operations. **13 Hours**

4. True positional theory : Comparison between co-ordinate and convention method offeature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging. **7 Hours**

5. Design of Gauges: Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft. **6 Hours**

Text Books:

1. Harry Peck , “Designing for Manufacturing”, Pitman Publications, 1983.
2. Dieter , “Machine Design” - McGraw-Hill Higher Education, -2008
3. R.K. Jain, "Engineering Metrology", Khanna Publishers, 1986
4. Product design for manufacture and assembly - Geoffrey Boothroyd, Peter dewhurst, Winston Knight, Merceldekker. Inc. CRC Press, Third Edition
5. Material selection and Design, Vol. 20 - ASM Hand book.

Course Outcome:

Students will have added capability to include manufacturability in mechanical engineering design of parts and their assemblies.

ADVANCED FLUID DYNAMICS

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MEA155	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

The student will gain knowledge of dynamics of fluid flow under different conditions.

1. **Review of undergraduate Fluid Mechanics** : Differential Flow analysis- Continuity equation (3D Cartesian, Cylindrical and spherical coordinates) Navier Stokes equations (3D- Cartesian, coordinates) Elementary inviscid flows; superposition (2D). **8 Hours**

2. **Integral Flow Analysis**: Reynolds transport theorem, Continuity, momentum, moment of momentum, energy equations with applications such as turbo machines, jet propulsion &propellors;

   Exact solution of viscous flow equations: Steady flow: Hagen Poiseuille problem, plane Poiseuille problem, Unsteady flow: Impulsively started plate **12 Hours**

3. **Low Reynolds number flows**:Lubrication theory (Reynolds equation), flow past rigid sphere, flow past cylinder

   Boundary Layer Theory:Definitions, Blasius solution, Von-Karman integral, Separation, **10 Hours**

4. Thermal Boundary layer and heat transfer, (Laminar & turbulent flows);
   Experiments in fluids: Wind tunnel, Pressure Probes, Anemometers and flow meters

   10 Hours

5. **Special Topics**:Stability theory; Natural and forced convection; Rayleigh Benardproblem;Transition to turbulence; Introduction to turbulent flows

   10 Hours

Text Books:

1. **“Foundations of fluid mechanics” -** S. W. Yuan,SI Unit edition, 1988.

2. **“Advanced Engineering Fluid Mechanics**”- K. Muralidhar& G. Biswas, Narosa Publishers, 1999.

Reference Books:

1. **“Physical Fluid Dynamics”** 2nd edition **–** D.J. Tritton, Oxford Science Publications, 1988.

2. **“Boundary Layer Theory”**8th edition, H. Schlichting, McGraw Hill, New York., 1999.

Course Outcome:
The student will be able to apply concepts of fluid dynamics in solving real time problems.

Design Engineering Laboratory – Lab 1

(Common to MDE,MEA,MMD,CAE,MCS)

Sub Code : 14MDE16	IA Marks :25
Hrs/ Week : 6	Exam Hours : 03
Total Hrs:84	Exam Marks :50

Note:

1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:

Experiment #1
Numerically Calculation and MATLAB Simulation
Part A:Invariants, Principal stresses and strains with directions
Part A: Maximum shear stresses and strains and planes,Von-Mises stress
Part C: Calculate and Plot Stresses in Thick-Walled Cylinder

Experiment #2
Stress analysis in Curved beam in 2D
Part A : Experimental studies using Strain Gauge Instrumentation.
Part B : 2D Photo elastic Investigation.
Part C :Modelling and Numerical Analysis using FEM.

Experiment #3
Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. shear
Part A: Matlab simulation for Calculation and Plot of normalized hoop Stress at hole boundary in Infinite Plate

Part B: Modelling of plate geometry under chosen load conditions and study the effect of plate geometry.
Part C: Numerical Analysis using FEA package.

Experiment #4
Single edge notched beam in four point bending.
Part A: Modellingof single edge notched beam in four point bending.
Part B: Numerical Studies using FEA.
Part C: Correlation Studies.

Experimental #5
Torsion of Prismatic bar with Rectangular cross-section.
Part A: Elastic solutions, MATLAB Simulation
Part B: Finite Element Analysis of any chosen geometry.
Part C: Correlation studies.

Experiment #6
Contact Stress Analysis of Circular Disc under diametrical compression
Part A: 3-D Modelling of Circular Discs with valid literature background, supported with experimental results on contact stress.
Part B: Numerical Analysis using any FEA package.
Part C: 2D Photo Elastic Investigation.

Experiment #7

Vibration Characteristics of a Spring Mass Damper System.
Part A: Analytical Solutions.
Part B: MATLAB Simulation.
Part C: Correlation Studies.

Experiment #8
Modelling and Simulation of Control Systems using MATLAB.

II Semester

COMPOSITE MATERIALS TECHNOLOGY

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MST21	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

Mechanics of composite materials provides a methodology for stress analysis and progressive failure analysis of laminated composite structures for aerospace, automobile, marine and other engineering applications.

Course Content:

1. **Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.

   Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications

   Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems.Invariant properties.Stress-Strain relations for lamina of arbitrary orientation, Numerical problems. **10 Hours**

2. **Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems.

   Experimental Characterisation of Lamina- Elastic Moduli and Strengths
   Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations.

   10 Hours

3. **Macro Mechanical Analysis of Laminate**: Introduction, code, Kirchoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation) **10 Hours**

4. **Analysis of Composite Structures:** Optimization of Laminates, composite laminates of uniform strength, application of optimal composite structures, composite pressure vessels, spinning composite disks, composite lattice structures

10 Hours

5. **Manufacturing and Testing:** Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

   Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites. **10 Hours**

Text Books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Press, 2nd Ed, 2005.
2. MadhijitMukhopadhay, Mechanics of Composite Materials & Structures, Universities Press, 2004.

Reference Books:

1. J. N. Reddy, Mechanics of Laminated Composite Plates & Shells, CRD Press, 2nd Ed, 2004.
2. Mein Schwartz, Composite Materials handbook, McGraw Hill, 1984.
3. Rober M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1998.
4. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009.
5. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012.
6. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993.

Course Outcome:

This course provides the background for the analysis, design, optimization and test simulation of advanced composite structures and components.

ADVANCED MACHINE DESIGN

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE22	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

This course enables the student to identify failure modes and evolve design by analysis methodology. Design against fatigue failure is given explicit attention.

Course Content:

1. Introduction: Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples.

   Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods ,Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features. **12 Hours**

2. Stess-Life (S-N) Approach: S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach.

   Strain-Life(ε-N)approach: Monotonic stress-strain behavior ,Strain controlled test methods ,Cyclic stress-strain behavior ,Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach. **12 Hours**

3. LEFM Approach: LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean

stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber's rule, Glinka's rule, applications of fracture mechanics to crack growth at notches. **13 Hours**

4. Fatigue from Variable Amplitude Loading: Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach. **7 Hours**

5. Surface Failure: Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength. **6 Hours**

Text Books:

1. Ralph I. Stephens, Ali Fatemi, Robert, Henry o. Fuchs, "Metal Fatigue in engineering", John wileyNewyork, Second edition. 2001.
2. Failure of Materials in Mechanical Design, Jack. A. Collins, John Wiley, Newyork 1992.
3. Robert L. Norton , "Machine Design", Pearson Education India, 2000

Reference Books:

1. S.Suresh , "Fatigue of Materials", Cambridge University Press, -1998
2. Julie.A.Benantine , "Fundamentals of Metal Fatigue Analysis", Prentice Hall,1990
3. Fatigue and Fracture, ASM Hand Book, Vol 19,2002.

Course Outcome:

This course enriches the student with state of the art design methodology namely design by analysis and damage tolerant design.

DYNAMICS AND MECHANISM DESIGN
(Common to MDE,MEA,MMD,CAE,MAR)

Sub Code : 14MDE 23	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:
To include dynamics considerations in the design of mechanisms for engineering applications is the objective of this course.

Course Content:

1. Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoffs law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method. **6 Hours**

2. Generalized Principles of Dynamics: Fundamental laws of motion, Generalized coordinates, Configuration space, Constraints, Virtual work, principle of virtual work, Energy and momentum, Work and kinetic energy, Equilibrium and stability, Kinetic energy of a system, Angular momentum, Generalized momentum. Lagrange's Equation: Lagrange's equation from D'Alembert's principles, Examples, Hamiltons equations, Hamiltons principle, Lagrange's, equation from Hamiltons principle, Derivation of Hamiltons equations, Examples. **13 Hours**

3. System Dynamics: Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation: Poles and relative poles, Location of poles and relative poles, polode, Curvature, Inflection circle. **13 Hours**

4. Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Ana1ytical Methods of

Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra. **12 Hours**

5. Spatial Mechanisms: Introduction, Position analysis problem, Velocity and acceleration analysis, Eulerian angles. **6 Hours**

Text Books:

1. K.J.Waldron&G.L.Kinzel , “Kinematics, Dynamics and Design of Machinery”, Wiley India, 2007.
2. Greenwood , “Classical Dynamics”, Prentice Hall of India, 1988.

References Books:

1. J E Shigley, “Theory of Machines and Mechanism” -McGraw-Hill, 1995
2. A.G.Ambekar , “Mechanism and Machine Theory”, PHI, 2007.
3. Ghosh and Mallick , “Theory of Mechanism and Mechanism”, East West press 2007.
4. David H. Myszka , “Machines and Mechanisms”, Pearson Education, 2005.

Course Outcome:

The knowledge of dynamics considerations in mechanism design is essential to use commercial multi body dynamics software in mechanical engineering design

ADVANCED THEORY OF VIBRATIONS
(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE24	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

To teach students how to use the theoretical principles of vibration, and vibration analysis techniques, for the practical solution of vibration problems. The course thus builds on student's prior knowledge of vibration theory, and concentrates on the applications. Thus the student will fully understand the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions.

Course Content:

1. Review of Mechanical Vibrations: Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency.
   Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation. **12 hours**

2. Vibration Control: Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, Vibration dampers.
   Vibration Measurement and applications : Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis
   11 hours

3. Modal analysis & Condition Monitoring: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis. Non Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. **13 hours**

4. Random Vibrations : Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response. **8 hours**

5. Continuous Systems: Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams. **6 hours**

Text Books

1. Theory of Vibration with Application, - William T. Thomson, Marie Dillon Dahleh, ChandramouliPadmanabhan , 5th edition Pearson Education
2. S. Graham Kelly , "Fundamentals of Mechanical Vibration" - McGraw-Hill, 2000
3. S. S. Rao , "Mechanical Vibrations", Pearson Education, 4th edition.

Reference Books

1. S. Graham Kelly , "Mechanical Vibrations", Schaum's Outlines, Tata McGraw Hill, 2007.
2. C Sujatha , "Vibraitons and Acoustics – Measurements and signal analysis", Tata McGraw Hill, 2010.

Course Outcome:

A student who has met the objectives of the course will be able to solve major and realistic vibration problems in mechanical engineering design that involves application of most of the course syllabus

Elective-II

DESIGN OPTIMIZATION

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14CAE251	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

It aids the students to acquire the basics of optimum design, Classical Optimization Techniques, Non - linear Programming, Unconstrained Optimization Techniques, Integer Programming and Dynamic Programming.

Course Content:

1. **Engineering Design Practice:** Evolution of Design Technology, Introduction to Design and the Design Process, Design versus Analysis, Role of Computers in Design Cycle, Impact of CAE on Design, Numerical Modeling with FEA and Correlation with Physical Tests.

   Applications of Optimization in Engineering Design: Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO.

   10 Hours

2. **Optimum Design Problem Formulation**: Types of Optimization Problems, The Mathematics of Optimization, Design Variables and Design Constraints, Feasible and Infeasible Designs, Equality and Inequality Constraints, Discrete and Continuous Optimization, Linear and Non Linear Optimization.

   Optimization Theory – Fundamental Concepts, Global and Local Minimum, Gradient Vector and Hessian Matrix, Concept of Necessary and Sufficient Conditions, Constrained and Unconstrained Problems, Lagrange Multipliers and Kuhn Tucker Conditions

   10 Hours

3. Sensitivity Analysis, Linear and Non Linear Approximations. Gradient Based Optimization Methods – Dual and Direct.

Optimization Disciplines: Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. Internal and External Responses, Design Variables in Each Discipline.

10 Hours

4. **Manufacturability in Optimization Problems:** Design For Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems.

   Design Interpretation: Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum .

10 Hours

5. **Dynamic Programming:** Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples.

10 Hours

Text Books:

1. **S.S.Rao, Engineering** Optimization: Theory and Practice, John Wiley, 2009
2. **JasbirArora**, Introduction to Optimum Design, McGraw Hill, 2011.

Reference Books:

1. Optimisation and Probability in System Engg - Ram, Van Nostrand.
2. Optimization methods - K. V. Mital and C. Mohan, New age International Publishers, 1999.
3. Optimization methods for Engg. Design - R.L Fox, Addison – Wesley, 1971.

Course Outcome:

It provides the student with knowledge required to optimize an existing design with single or multiple objective functions. However the skills have to be acquired through commercial optimization programs

THEORY OF PLASTICITY

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE252	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:
This course focuses on stress-strain relations, yield criteria and associated flow rules for elastic-plastic analysis of components and structures

Course Content:

1.Definition and scope of the subject, Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatricstress, Invariance in terms of the deviatoricstresses, Idealisedstress-strain diagrams for different material models, Engineering and natural strains, Mathematical relationships between true stress and true strains, Cubical dilation, finite strains co- efficient Octahedral strain, Strain rate and the strain rate tensor.

10hours

2.Material Models, Stress-strain relations, Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic materials, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material, flow rule normality, Yield locus, Symmetry convexity, Deformation of isotropic and kinematic hardening, bilinear stress-strain relationship, power law hardening, deformation theory of plasticity, J_2 flow theory, J_2incremental theory,.

10hours

3. Plastic stress-strain relations, Prandtl- Rouss Saint Venant, Levy-Von Mises,Experimentalverification of the Prandtl- Rouss equation Upper and lower bound theorems and corollaries, Application to problems: Uniaxial tension and compression, Stages of plastic yielding,.

10 Hours

4. Bending of beams, Torsion of rods and tubes, Nonlinear bending and torsion equations, Simple forms of indentation problems using upper bounds, Application of **M**etal forming: Extrusion, Drawing, Rolling and Forging.

10hours

5.Sliplinetheory,Introduction, Basic equations for incompressible two dimensional flow, continuity equations, Stresses in conditions of plain strain conventionforslip-lines,Geometryofsliplines,Propertiesofsliplines, Computational Plasticity- Finite element method, Formulations, Plasticity models

10hours

Text Books

1. Engineering Plasticity - Theory and Application to Metal Forming Process -R.A.C..Slater, McMillan Press Ltd., 1977
2. Theory of Plasticity and Metal forming Process - Sadhu Singh, Khanna Publishers, Delhi, 1999.

Reference Books

1. Introduction to the Theory of Plasticity for Engineers- Haffman and Sachs, LLC, 2012.
2. Theory of plasticity - J Chakrabarty, Butterworth, 2006.
3. Plasticity for Mechanical Engineers - Johnson and Mellor, Van Nostrand, 1966.

Course Outcome:

The students learn the theory of plasticity as a background for nonlinear analysis (Material nonlinearity) by the Finite element method.

ADVANCED MANUFACTURING PROCESSES SIMULATION

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14CAE253	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:
The course aims at bringing in clear understanding of finite element modeling for simulation of various manufacturing processes.

Course Content:

1. **Finite Element Models of Sheet Metal Forming Processes:** Introduction, fundamentals of continuum mechanics- strain and stress measurement, Material Models , FE-Equations for Small Deformations, FE-Equations for Finite Deformations, Flow Approach- Eulerian FE-Formulations for Rigid-Plastic Sheet Metal Analysis, The Dynamic, Explicit Method, Historical Review of Sheet Forming Simulation

   Plastic Behaviour of Sheet Metal: Anisotropy of Sheet Metals- Uniaxial and biaxial Anisotropy Coefficients, Yield Criteria for Isotropic Materials, Classical Yield Criteria for Anisotropic Materials.

   (10 Hours)

2. **Advanced Anisotropic Yield Criteria:**Banabic-Balan-Comsa (BBC) 2005 Yield Criterion, Banabic-Balan-Comsa (BBC) 2008 Yield Criterion, Recommendations on the Choice of the Yield Criterion, Modeling of the Bauschinger Effect.

   Formability of Sheet Metals: Evaluation of the Sheet Metal Formability-method based on simulation test and limit dome height diagram, Forming Limit Diagram- definition, experimental determination, methods of determining the limit strain, factors influencing the forming limit, Theoretical Predictions of the Forming Limit Curves, Semi-empirical Model.

   (10 Hours)

3. **Numerical Simulation of the Sheet Metal Forming Processes:** Simulation of the Elementary Forming Processes. Simulation of the Industrial Parts Forming Processes, Robust Design of Sheet Metal Forming Processes, The Spring-back Analysis, Computer Aided Spring-back Compensation.

   Forging: Classification, various stages during forging, Forging equipment, brief description, deformation in compression, forging defects. Residual stresses in forging.

   (10 Hours)

4. **Rolling :**Classification, forces and geometrical relationships in rolling., Deformation in rolling, Defects in rolled products, Residual stresses in rolled products. Torque and Horsepower. **Drawing and Extrusion:**Principles of Rod and wire drawing, variables in wire drawing, Residual stresses in rod, wire and tube drawing, Defects in Rod and wire drawing. Extrusion equipment, Classification, variables in extrusion, Deformation in extrusion, Extrusion defects, Work done in extrusion.

(**10 Hours)**

5. **Composite Materials and Honeycomb Structures:** Manufacturing processes and environmental requirements for manufacturing of composite components, NDT methods and quality control, sandwich structures and adhesive bonding. Heat Treatment Processes: Purpose of heat treatment and theory of heat treatment processes, heat treatment of alloys of aluminum, magnesium, titanium, steel and case hardening.

(**10 Hours)**

Text Books

1. **Dorel Banabic,**Sheet Metal Forming Processes: Constitutive Modeling and Numerical Simulation, Springer, 2010.
2. **Dieter G.E.** Mechanical Metallurgy, McGraw Hill, 1986.
3. **ASM** Metals Handbook **–**Volume II.

Reference Books:

1. **Aircraft Materials and Manufacturing Process** - George F.Titterton, published by Himalayan books, New Delhi, 1968.
2. **Aircraft Production Technology and Management -** ChennaKeshu S and Ganapathy K K, Interline Publishing, Bangalore, 1993.
3. **SachG** "Fundamentals of working of metals" Pergamon Press.
4. **N Bhatnagar, T S Srivatsan, "**Processing and Fabrication of Advanced Materials", IK International
5. **Phillip F. Ostwald, Jairo Muñoz,** "Manufacturing processes and systems", John Wiley, 1997.
6. **Stephen F. Krar, Arthur Gill,** "Exploring advanced manufacturing technologies", Industrial Press, 2003.
7. **Kobayashi** "Metal forming and finite element methods", Oxford, 1989.
8. **PrakashMahadeo Dixit, Uday S. Dixit,** "Modeling of metal forming and machining processes", Springer, 2008.
9. **Dorel Banabic,**"Advanced Methods in Material Forming", Springer, 2007.
10. **Schuler GmbH.,** "Metal forming handbook", Springer, 1998.

Course Outcome:

Students will be able to analyse the behaviour of materials during forming.

ROTOR DYNAMICS
(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE254	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:
This course is of interest to turbo machinery designers. Specifically modeling of bearings, shafts and rotor stages (compressors, turbines including blades) to predict instability like whirling including gyroscopic and corialis effect.

Course Content:

1. Fluid Film Lubrication: Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.

   Stability of Flexible Shafts: Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field. **12 Hours**

2. Critical Speed: Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center **6 Hours**

3. Turborotor System Stability by Transfer Matrix Formulation: General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions. **10 Hours**

4. Turborotor System Stability by Finite Element Formulation: General turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearised model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis. **14 Hours**

5. Blade Vibration: Centrifugal effect, Transfer matrix and Finite element, approaches.

8 Hours

Reference Books:

1. Cameron, “Principles of Lubrication”, Longman Publishing Group, 1986
2. Bolotin , “Nonconservative problems of the Theory of elastic stability”, Macmillan, 1963
3. Peztel, Lockie , “Matrix Methods in Elasto Mechanics”, McGraw-Hill, 1963.
4. Timosenko , “Vibration Problems in Engineering”, Oxford City Press, 2011
5. Zienkiewicz, “The finite element method in engineering science”, McGraw-Hill, 1971

Course Outcome:

Provides the student understanding of modeling a rotating machine elements theoretically. However rotor dynamic analysis demands FE modeling using a commercial FEA software

AUTOMOBILE SYSTEM DESIGN
(Common to MDE, MMD, MEA and CAE)

Sub Code	:	14MEA255	IA Marks	:	50
Hrs/ Week	:	04	Exam Hours	:	03
Total Hrs.	:	52	Exam Marks	:	100

Course Objective:
This course would facilitate understanding of the stages involved in automobile system design. The student will be exposed to industrial practices in design of various systems of an automobile.

1. **Body Shapes**: Aerodynamic Shapes, drag forces for small family cars.

Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit.

12 Hours

2. **Design of I.C. Engine** I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines.

8 Hours

3. **Design of I.C. Engine II**: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3 cylinders).

10 Hours

4. **Transmission System**: Design of transmission systems – gearbox (max of 4-speeds), differential.

Suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension.

10 Hours

5. **Cooling System**: Heat exchangers, application to design of cooling system (water cooled).

Emission Control: Common emission control systems, measurement of missions, exhaust gas emission testing.

10 Hours

Text Books:

1. **Design of Automotive Engines**, - A .Kolchin& V. Demidov, MIR Publishers, Moscow
2. **The motor vehicle, Newton steeds &Garratte** - Iliffee& sons Ltd., London
3. **I.C. Engines** - Edward F Obert, International text book company.

Reference Books:

1. **Introduction to combustion** - Turns
2. **Automobile Mechanic -**, N.K.Giri, Khanna Publications, 1994
3. **I.C. Engines** - Maleev, McGraw Hill book company, 1976
4. **Diesel engine design** - HeldtP.M.,Chilton company New York.
5. **Problems on design of machine elements -** V.M. Faires&Wingreen, McMillan Company., 1965
6. **Design of I.C.Engines -** John Heywood, TMH

Course Outcome:

The student will be able to apply the knowledge in creating a preliminary design of automobile sub systems.

Design Engineering Laboratory - Lab 2

(Common to MDE,MEA,MMD,CAE,MCS)

Sub Code : 14MDE26	IA Marks :25
Hrs/ Week : 6	Exam Hours : 03
Total Hrs:84	Exam Marks :50

Note:

1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Course Content:

Experiment #1

Structural Analysis

Part A: FE Modeling of a stiffened Panel using a commercial preprocessor.

Part B: Buckling, Bending and Modal analysis of stiffened Panels.

Part C: Parametric Studies.

Experiment #2

Design Optimization

Part A: Shape Optimization of a rotating annular disk.

Part B: Weight Minimization of a Rail Car Suspension Spring.

Part C: Topology Optimization of a Bracket.

Experiment #3

Thermal analysis

Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.

Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4

Thermal Stress Analysis

Part A: A Thick Walled Cylinder with specified Temperature at inner and outer Surfaces.

Part B: A Thick Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment#5

CFD Analysis

Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.

Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.

Part C: Experimental Investigations using a Journal Bearing Test Rig.

Part D: Correlation Studies.

Experiment #6

Welded Joints.

Part A : Fabrication and Testing.

Part B : FE Modeling and Failure Analysis .

Part C : Correlation Studies.

Experiment #7

Bolted Joints.

Part A : Fabrication and Testing.

Part B : FE Modeling and Failure Analysis .

Part C : Correlation Studies.

Experiment #8

Adhesive Bonded Joints.

Part A : Fabrication and Testing.

Part B : FE Modeling and Failure Analysis .

Part C : Correlation Studies.

IV Semester

TRIBOLOGY AND BEARING DESIGN

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE41	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

Gives in-depth knowledge regarding hydrodynamic, hydrostatic lubrication and various bearings, with their design and applications

Course Content:

1. Introduction to Tribology: Introduction, Friction, Wear, Wear Characterization, Regimes of lubrication, Classification of contacts, lubrication theories, Effect of pressure and temperature on viscosity. Newton's Law of viscous forces, Flow through stationary parallel plates. Hagen's poiseuille's theory, viscometers.Numerical problems, Concept of lightly loaded bearings, Petroff's equation, Numerical problems.**7 Hours**

2. Hydrodynamic Lubrications: Pressure development mechanism. Converging and diverging films and pressure induced flow. Reynolds's 2D equation with assumptions. Introduction to idealized slide bearing with fixed shoe and Pivoted shoes. Expression for load carrying capacity. Location of center of pressure, effect of end leakage on performance, Numerical problems
   Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems. **12 Hours**

3. Hydrostatic Bearings: Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restricters, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings.
   EHL Contacts: Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant.Grubin type solution.**13 Hours**

4. Antifriction bearings: Advantages, selection, nominal life, static and dynamic load bearing capacity, probability of survival, equivalent load, cubic mean load, bearing mountings.
   Porous Bearings: Introduction to porous and gas lubricated bearings. Governing differential equation for gas lubricated bearings, Equations for porous bearings and working principal, Fretting phenomenon and its stages.
   12 Hours

5. Magnetic Bearings: Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.
   6 hours

Text Books

1. Mujamdar.B.C "Introduction to Tribology of Bearing", Wheeler Publishing, New Delhi 2001
2. Radzimovsky, "Lubrication of Bearings - Theoretical principles and design" Oxford press Company, 2000

Reference Books

1. Dudley D.Fulier " Theory and practice of Lubrication for Engineers", New YorkCompany.1998
2. Moore "Principles and applications of Tribology" Pergamon press, 1975
3. Oscar Pinkus, BenoSternlicht, “Theory of hydrodynamic lubrication”, McGraw-Hill, 1961
4. G W Stachowiak, A W Batchelor , “Engineering Tribology”, Elsevier publication 1993.
5. Hydrostatic and hybrid bearings, Butterworth 1983.
6. F. M. Stansfield, Hydrostatic bearings for machine tools and similar applications, Machinery Publishing, 1970

Course Outcome:

Students develop skills to design and selection of bearings on Varioustribological factors to be considered in moving and rotating parts.

Elective-III

FRACTURE MECHANICS
(Common to MDE,MEA,MMD,CAE)

Sub Code : 14CAE421	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

Fracture mechanics provides a methodology for prediction, prevention and control of fracture in materials, components and structures. It provides a background for damage tolerant design. It quantifies toughness as materials resistance to crack propagation.

Course Content:

1. Fracture mechanics principles: Introduction and historical review, Sources of micro and macro cracks. Stress concentration due to elliptical hole, Strength ideal materials, Griffith's energy balance approach. Fracture mechanics approach to design. NDT and Various NDT methods used in fracture mechanics, Numerical problems. The Airy stress function. Complex stress function. Solution to crack problems. Effect of finite size. Special cases, Elliptical cracks, Numerical problems. **12 Hours**

2. Plasicity effects, Irwin plastic zone correction. Dugdale approach. The shape of the plastic zone for plane stress and plane strain cases, Plastic constraint factor. The Thickness effect, numerical problems.
   Determination of Stress intensity factors and plane strain fracture toughness: Introduction, analysis and numerical methods, experimental methods, estimation of stress intensity factors. Plane strain fracture toughness test, The Standard test.Size requirements.Non-linearity.Applicability.**12 Hours**

3. The energy release rate, Criteria for crack growth. The crack resistance(R curve). Compliance, J integral. Tearing modulus. Stability. Elastic plastic fracture mechanics : Fracture beyond general yield. The Crack-tip opening displacement. The Use of CTOD criteria. Experimental determination of CTOD. Parameters affecting the critical CTOD. Use of J integral. Limitation of J integral. **12 Hours**

4. Dynamics and crack arrest: Crack speed and kinetic energy. Dynamic stress intensity and elastic energy release rate. Crack branching. Principles of crack arrest. Crack arrest in practice. Dynamic fracture toughness. **6 Hours**

5. Fatigue crack propagation and applications of fracture mechanics: Crack growth and the stress intensity factor. Factors affecting crack propagation. variable amplitude service loading, Means to provide fail-safety, Required information for fracture mechanics approach, Mixed mode (combined) loading and design criteria. **8 Hours**

Text Books:

1. David Broek, "Elementary Engineering Fracture Mechanics", Springer Netherlands,2011
2. Anderson , "Fracture Mechanics-Fundamental and Application", T.L CRC press1998.

Reference Books:

1. Karen Hellan , "Introduction to fracture mechanics", McGraw Hill, 2^{nd} Edition
2. S.A. Meguid , "Engineering fracture mechanics" Elsevier Applied Science, 1989
3. Jayatilaka, "Fracture of Engineering Brittle Materials", Applied Science Publishers, 1979
4. Rolfe and Barsom , "Fracture and Fatigue Control in Structures" , Prentice Hall, 1977
5. Knott , "Fundamentals of fracture mechanisms", Butterworths, 1973

Course Outcome:

At the end of the course students will:

1. Develop basic fundamental understanding of the effects of cracklike defects on the performance of aerospace, civil, and mechanical engineering structures.
2. Learn to select appropriate materials for engineering structures to insure damage tolerance.
3. Learn to employ modern numerical methods to determine critical crack sizes and fatigue crack propagation rates in engineering structures.
4. Gain an appreciation of the status of academic research in field of fracture mechanics.

SMART MATERIALS AND STRUCTURES

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MST422	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

Knowledge of smart materials and structures is essential designing mechanical systems for advanced engineering applications ,the course aims at training students in smart materials and structures application and analysis

Course Content:

1. **Smart Structures**: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements Of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor.

   Beam Modeling: Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectrical Applications. 12 **Hours**

2. **Shape memory Alloy:** Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka's Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems.

   ER and MR Fluids: Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response.Post-Yield flow applications in Clatches, Dampers and Others.

   13 **Hours**

3. **Vibration Absorbers:** series and Parallel Damped Vibrations (OverView), Active Vibration Absorbers, Fiber Optics, Physical Phenomena,Characteristics, Sensors, Fiber Optics in Crack Detection, applications.

   Control of Structures: Modeling, Control Strategies and Limitations, Active Structures in Practice.

   13 **Hours**

4. **MEMS –** Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration. **6 Hours**

5. **Devices:** Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications.

6Hours

TEXT BOOKS :

1. Smart Materials and Structures - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B. Culshaw, Artech House, Boston, 1996 (ISBN :0890066817).
3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

REFERENCE BOOKS:

1. Electroceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin; New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magnetostrictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN: 052144487X).

Course Outcome:

At the completion of this course, students will be able to:

1. Understand the behavior and applicability of various smart materials
2. Design simple models for smart structures & materials
3. Perform simulations of smart structures & materials application
4. Conduct experiments to verify the predictions

ROBUST DESIGN
(Common to MDE,MEA,MMD,CAE)

Sub Code : 14MDE423	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:
Course aims at giving orientation to design of experiments and taguchi's orthogonal array techniques which are predominantly used in optimization of parameters.

Course Content:

1. Quality by Experimental Design : Quality, western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions.
   Robust Design : Steps in robust design : parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples.
   Experimental Design: Classical experiments: factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-levelexperimental design for two factors and three factors. 3-level experiment deigns for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples.**12 Hours**

2. Measures of Variability : Measures of variability, Concept of confidence level, Statistical distributions : normal, log normal and Weibull distributions. Hipothesis testing, Probability plots, choice of sample size illustration through numerical examples. Analysis and interpretation of experimental data: Measures of variability, Ranking method, column effect method and ploting method, Analysis of variance (ANOVA), in factorial experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data, illustration through numerical examples.**14 Hours**

3. Taguchi's Orthogonal Arrays : Types orthogonal arrays, Selection of standard orthogonal arrays, Linear graphs and interaction assignment, dummy level technique, Compound factor method, modification of linear graphs, Column merging method, Branching design, Strategies for constructing orthogonal arrays.

Signal to Noise ratio (S-N Ratios) : Evaluation of sensitivity to noise, Signal to noise ratios for static problems, Smaller – the – better types, Nominal – the –better – type, larger – the- better – type. Signal to noise ratios for dynamic problems, Illustrations through numerical examples.**14 Hours**

4. Parameter Design and Tolerance Design : Parameter and tolerance design concepts, Taguchi's inner and outer arrays, Parameter design strategy, Tolerance deign strategy, Illustrations through numerical examples**.6 Hours**

5. Reliability Improvement Through Robust Design : Role of S-N ratios inreliability improvement ; Case study; Illustrating the reliability improvement ofrouting process of a printed wiring boards using robust design concepts.**4 Hours**

Text Books:

1. Madhav S. Phadake , "Quality Engineering using Robust Design", Prentice Hall,1989.
2. Douglas Montgomery, "Design and analysis of experiments", Willey India Pvt.Ltd., 2007.
3. Phillip J. Ross, Taguchi , "Techniques for Quality Engineering",McGraw Hill Int. Ed., 1996.

Reference Books:

1. Thomas B. Barker , "Quality by Experimental Design", Marcel Dekker IncASQC Quality Press, 1985

2. C.F. Jeff Wu, Michael Hamada , "Experiments planning, analysis and parameter design optimization", John Willey Ed., 2002
3. W.L. Condra, Marcel Dekker , "Reliability improvement by Experiments", MarcelDekkerInc ASQC Quality Press, 1985

Course Outcome:

After taking this course, a student will:

1. Have knowledge, understanding and the ability to apply methods to analyze and identify opportunities to improve design processes for robustness
2. Be able to lead product development activities that include robust design techniques.

FINITE ELEMENT METHODS FOR HEAT TRANSFER AND FLUID FLOW ANALYSIS

(Common to MDE,MEA,MMD,CAE)

Sub Code : 14CAE424	IA Marks :50
Hrs/ Week : 04	Exam Hours : 03
Total Hrs: 50	Exam Marks :100

Course Objective:

The student will learn finite element formulation of various modes of heat transfer and fluid flow and to solve numerical examples.

Course Content:

1. **Introduction to Heat Transfer and Fluid Mechanics:** Mathematical Preliminaries, Governing equations of a continuum, Governing equation in terms of primitive variables, porous equations, low speed compressible flow equations, auxiliary transport equations, chemically reacting systems, boundary conditions, change of phase, enclosure radiation.

   Finite Element Methods: Introduction, model differential equation, finite element approximations, interpolation functions, library of finite elements, modeling considerations, assembly of elements, numerical integration, discussion of results with some practical examples, time dependent problems.

(10 Hours)

2. **Steady State Conduction Heat Transfer:** Introduction, one dimensional linear, quadratic element. Homogeneous, composite wall with uniform and varying cross sectional area. Radial heat flow in a cylinder. Conduction –convection systems. Numerical examples.

Conduction Heat Transfer: Interpolation functions for tetrahedral, hexahedral, pyramid and prism elements. Numerical integration, computation of surface flux, semi-discrete finite element model, solution of nonlinear equations for transient problems.Radiation solution algorithms.Variable properties.

(10 Hours)

3. **Advanced topic in Conduction:** specialty elements, computation of boundary conditions, bulk nodes, reactive materials, material motions. Example problems on conduction, radiation, temperature dependent conductivity, anisotropic conduction, brazing and welding, investment casting.

(10 Hours)

4. **Flows of Viscous Incompressible Fluids:** Governing equation, mixed finite element model, penalty finite element models. Finite element models of porous flow

   Computational consideration: Interpolation functions for triangular, quadrilateral, tetrahedral and hexahedral elements. Evaluation of element matrices in penalty model, pressure calculation and traction boundary conditions.Numerical examples.

(10 Hours)

5. **Coupled Fluid Flow and Heat Transfer:** Introduction to non-isothermal incompressible flows, governing equations and boundary condition. Mixed, penalty finite element model. Finite element model for porous flow. Non-isothermal low speed compressible flows: governing equation, boundary conditions, mixed finite element model and solution methods. Convection with change of phase, convection with enclosure radiation, turbulent heat transfer, chemically reacting systems. Numerical examples.

(10 Hours)

Text Books:

1. JNReddy, David K. Gartling,**"The finite element method in heat transfer and fluid dynamics" , CRC, 2004.**
2. Roland Wynne Lewis, PerumalNithiarasu, K. N. Seetharamu,**" Fundamentals of the finite element method for heat and fluid flow"** John Wiley, 2004

Reference Books:

1. Ching Jen Chen, R. A. Bernatz, **"Finite analytic method in flows and heat transfer" ,**Taylor & Francis.
2. Gianni Comini, Stefano Del Giudice, Carlo Nonino, **"Finite Element Analysis in Heat Transfer: Basic Formulation and Linear problems"** Taylorand Francis, 1994.

Course Outcome:

This course enables the student to use numerical methods for solving problems of fluid flow and heat transfer.

COMPUTATIONAL FLUID DYNAMICS

(Common to MDE,MEA,MMD,CAE)

Sub Code	:	14MEA425	IA Marks	:	50
Hrs/ Week	:	04	Exam Hours	:	03
Total Hrs.	:	52	Exam Marks	:	100

Course Objective:

This course would create awareness about the theory behind fluid dynamics computations as applied in analysis tools.

1. **Basic Concepts** - Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic & Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy).

8 Hours

2. **Finite Difference Methods** - Discretisation; Boundary conditions; error propagation; Introduction to spectral methods; examples.

10 Hours

3. **Finite volume method** - Surface & volume integrals; Interpolation & differentiation; Boundary conditions; Examples.

10 Hours

4. Gausian Elimination; LU decomposition; Tridiagonal Systems; Iterative methods; convergence; ADI & other splitting methods.

   Multi-grid method - Coupled equations; Simultaneous solutions, sequential solutions & under relaxation.Non linear systems

10 Hours

5. Initial value problem & Boundary value problems; Implicit & Explicit Schemes; 2D and 3D examples.

   Heat and Mass transfer Problems; Multi Phase Flows.

12 Hours

Text Books:

1. **Computational Methods for Fluid Dynamics**, 3rd edition - J.H. Ferziger& M. Peric, Springer, 2002.
2. **Numerical Solutions of Partial Differential Equations, Finite Difference methods,** 3rd ed., - G.D. Smith, Oxford University Press. 1986.

Reference Books:

1. **Computational Fluid Dynamics -** T. J. Chung, Cambridge Univ. Press, 2002.
2. **Partial Differential Equations for Scientists and Engineers** - Farlow, John Wiley, 1982.

Course Outcome:

The student will be able to analyse and obtain numerical solutions to fluid dynamics problems