COURSE CONTENT

CONTINUUM MECHANICS								
I Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
BAED10	**Elective**	3	-	-	3	40	60	100
Contact Classes: 48	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 48**		
Prerequisite: Mechanics of Solids								

I. COURSE OVERVIEW:

The major emphasis of this course is to model the mechanical behavior of materials as a continuous mass rather than as discrete particles. Mathematical concepts in higher dimensions are introduced to understand further topics. Concept of continuum applied to solid mechanics, fluid mechanics to make a clear understanding of system behavior. Nonlinear systems are linearized to understand the stability behavior of systems.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Analyse the infinite dimensional problem in a finite dimensional space with an error control.
II. Apply the concept of Cauchy Stress Tensor and Cauchy's Formula, Transformation of Stress Components and Principal Stresses on solid domains.
III. Analyse the principles of Navier equations to a fluid domain.
IV. Apply the various mathematical methods to heat transfer related domain.

III. COURSE OUTCOMES:

After successful completion of the course, students will be able to:

CO 1 Apply the concept of vector calculus and linear algebra for solving engineering related problems in a finite dimensional space.
CO 2 Utilize the Cauchy Stress Tensor and Cauchy's Formula, Transformation of Stress Components and Principal Stresses for determining stresses and strains on solids.
CO 3 Apply the concept of Reynolds Transport Theorem, Conservation of Momenta, Principle of Conservation of Linear Momentum for determining the pressure and velocity vectors in fluid domains.
CO 4 Apply the concept of Hooks law, material symmetry to Monoclinic Materials, Orthotropic Materials, and Isotropic Materials, for determining the stresses and strains.
CO 5 Apply the Navier Equations, Beltrami-Michell Equations with various boundary conditions, for obtaining the velocity and pressure distribution on a given geometry.
CO 6 Apply the various mathematical methods like Laplace transforms to Spring Mass Damper system subjected to various inputs forcing functions, for determining the displacement and velocity.

IV. COURSE CONTENT:

MODULE-I: INTRODUCTION, VECTORS AND TENSORS (10)

Background and Overview, Vector Algebra - Definition of a Vector, Scalar and Vector Products, Plane Area as a Vector, Components of a Vector, Summation Convention, Transformation Law for Different Bases; Theory of Matrices - Definition, Matrix Addition and Multiplication of a Matrix by a Scalar, Matrix Transpose and Symmetric Matrix, Matrix Multiplication, Inverse and Determinant of a Matrix; Vector Calculus - Derivative of a Scalar Function of a Vector, The del Operator, Divergence and Curl of a

Vector, Cylindrical and Spherical Coordinate Systems, Gradient, Divergence and Curl Theorems; Tensors Dyads and Polyads, Nonion Form of a Dyadic, Transformation of Components of a Dyadic, Tensor Calculus, Eigenvalues and Eigenvectors of Tensors.

MODULE-II: KINEMATICS OF CONTINUA (10)

Introduction, Description of Motion- Configurations of a Continuous Medium, Material Description, Spatial Description, Displacement Field; Analysis of Deformation- Deformation gradient tensors, Isochoric, Homogeneous and Inhomogeneous Deformations, Change of volume and surface; Strain Measures Cauchy-Green deformation tensors, Green Strain tensor, Physical Interpretation of the Strain Components, Cauchy and Euler Strain Tensors, Principal Strains; Infinitesimal Strain Tensor and Rotation Tensor- Infinitesimal Strain Tensor, Physical Interpretation of Infinitesimal Strain Tensor Components, Infinitesimal Rotation Tensor, Infinitesimal Strains in Cylindrical and Spherical Coordinate Systems; Rate of Deformation and Vorticity Tensors- Definitions, Relationship between D and E, .Polar Decomposition Theorem, Compatibility Equations, Change of Observer- Material Frame Indifference.

MODULE-III: STRESS MEASURES, CONSERVATION OF MASS, MOMENTA AND ENERGY (10)

Introduction, Cauchy Stress Tensor and Cauchy's Formula, Transformation of Stress Components and Principal Stresses- Transformation of Stress Components, Principal Stresses and Principal Planes, Maximum Shear Stress. Other Stress Measures - Preliminary Comments, First Piola- Kirchhoff Stress Tensor, Second Piola- Kirchhoff Stress Tensor, Equations of Equilibrium.

Introduction, Conservation of Mass - Preliminary Discussion, Material Time Derivative, Continuity Equation in Spatial Description, Continuity Equation in Material Description, Reynolds Transport Theorem. Conservation of Momenta - Principle of Conservation of Linear Momentum, Equation of Motion in Cylindrical and Spherical Coordinates, Principle of Conservation of Angular Momentum, Thermodynamic Principles - Introduction, The First Law of Thermodynamics: Energy Equation, Special Cases of Energy Equation, Energy Equation for One-Dimensional Flows , The Second Law of Thermodynamics..

MODULE-IV: CONSTITUTIVE EQUATIONS AND LINEARIZED ELASTICITY (10)

Introduction, Elastic Solids - Generalized Hooke's Law, Material Symmetry, Monoclinic Materials, Orthotropic Materials, Isotropic Materials, Transformation of Stress and Strain Components, Nonlinear Elastic Constitutive Relations, Constitutive Equations for Fluids - Ideal Fluids, Viscous Incompressible Fluids, Non-Newtonian Fluids, Heat Transfer - General Introduction, Fourier's Heat Conduction Law, Newton's Law of Cooling, Stefan-Boltzmann Law, Electromagnetics - Maxwell's Equation, Constitutive Relations. Governing Equations, The Navier Equations, The Beltrami-Michell Equations, Types of Boundary Value Problems and Superposition Principle. Clapeyron's theorem and Reciprocity Relations - Clapeyron's theorem, Betti's Reciprocity Relations, Maxwell's Reciprocity Relation, Solution Methods, Types of Solution Methods, Example: Rotating Thick-Walled Cylinder; Two-Dimensional Problems, Airy Stress Function, End Effects: Saint-Venant's Principle, Torsion of Noncircular Cylinders. Principle of Minimum Total Potential Energy - Total Potential Energy Principle, Derivation of Navier's Equations, Castiglian's Theorem. Hamilton's Principle-Hamilton's Principle for a Rigid Body, Hamilton's Principle for a Continuum.

MODULE-V: FLUID MECHANICS AND HEAT TRANSFER, LINEAR VISCOELASTICITY (08)

Preliminary Comments- Initial Value Problem, the Unit Impulse, and the Unit Step Function, The Laplace Transform Method, Spring and Dashpot Models - Creep Compliance and Relaxation Modulus, Maxwell Element, Kelvin-Voigt Element, Three-Element Models, Four-Element Models, Integral Constitutive Equations, Hereditary Integrals, Hereditary Integrals for Deviatoric Components, The Correspondence Principle, Elastic and Viscoelastic Analogies.

V. TEXT BOOKS:

1. An Introduction to Continuum Mechanics, J.N. Reddy, Cambridge University Press, 2007
2. George. E. Mase, Schaum's, "Continuum Mechanics" Outline Series, McGraw-Hill Book Company, 1969.
3. Ellis H. Dill, "Continuum Mechanics", CRC Press, 2006.

VI. REFERENCE BOOKS:

1. Ahmed A. Shabana, "Computational Continuum Mechanics", Cambridge University Press, 2008.
2. W. Michael Lai, David Rabin and Erhard krempl, "Introduction to Computational Mechanics", Elsevier Inc, 4th Edition, 2010.
3. Lawrence E. Malvern, "Introduction to the Mechanics of a Continuous Medium", Prentice- Hall, 1969.

VII. ELECTRONICS RESOURCES:

1. https://en, wikipedia.org/wiki/Mechanism_(engineering)
2. https://en, wikipedia.org/wiki/Machine_(mechanical)

VIII. MATERIALS ONLINE

1. Course template
2. Assignments
3. Tutorial question bank
4. Model question paper – I
5. Model question paper – II
6. Lecture notes
7. Power point presentations