COURSE CONTENT

THEORY OF ELASTICITY AND PLASTICITY								
I Semester: STE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
BSTE02	Core	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	40	60	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: NIL								

I. COURSE OVERVIEW:

This course introduces the principles of elasticity, components of stresses and strains, differential equations of equilibrium, boundary conditions, compatibility conditions and stress function. This course also covers the two-dimensional problems in rectangular coordinates and polar coordinates, Fourier series for two-dimensional problems stress distribution symmetrical about an axis, pure bending of curved bars, strain components in polar coordinates, displacements for symmetrical stress distributions, simple symmetric and asymmetric problems, analysis of stress strain in three dimensions, torsion of prismatic bars and plasticity.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Stress–strain relations and the governing equations of elasticity in two and three dimensions, including equilibrium, compatibility, and boundary conditions.
II. Mathematical formulations such as stress functions, Fourier series, and polynomial solutions to analyze two-dimensional problems in rectangular and polar coordinates.
III. The state of stress and strain in three dimensions, determine principal stresses and strains, and employ general theorems such as uniqueness, reciprocal theorem, and superposition for solving structural problems.
IV. Torsional and bending behavior of prismatic bars with different cross-sections and study plasticity models, yield criteria, and stress–strain relationships for materials beyond the elastic range.

III. COURSE OUTCOMES:

At the end of the course students should be able to:

CO 1 Explain the fundamental concepts of elasticity, including stress–strain components, strain–displacement relations, Hooke's law, and governing equations for plane stress and plane strain problems.
CO 2 Apply mathematical methods such as polynomial solutions and Fourier series to solve two-dimensional problems in rectangular and polar coordinates, including stress distributions, beam bending, and gravity loading.
CO 3 Analyze the state of stress and strain in three dimensions, determine principal stresses and strains, and evaluate compatibility and equilibrium conditions for structural elements.
CO 4 Explain and apply general theorems of elasticity such as superposition, uniqueness, reciprocal theorem, and equilibrium equations to solve boundary value problems.
CO 5 Evaluate torsional and bending behavior of prismatic bars with various cross-sections using stress function, energy methods, and analogies for structural design applications.
CO 6 Demonstrate an understanding of plasticity concepts, yield criteria, and stress–strain models to analyze structures beyond the elastic range for safe and efficient design.

IV. COURSE CONTENT:

MODULE - I: INTRODUCTION TO PLANE STRESS AND PLANE STRAIN ANALYSIS (09)
Elasticity – Notation for Forces and Stresses-Components of Stresses-Components of Strain, Hooke's Law. Plane Stress, Plane Strain, Differential Equations of Equilibrium, Boundary Conditions, Compatibility Equations, Stress Function, Boundary Conditions.

MODULE - II: TWO DIMENSIONAL PROBLEMS IN RECTANGULAR COORDINATES (10)
Two dimensional problems in rectangular coordinates, solution by polynomials, St. Venant's principle, determination of displacements, bending of simple beams, application of Fourier series for two dimensional problems, gravity loading. Two dimensional problems in polar coordinates, stress distribution symmetrical about an axis, pure bending of curved bars, strain components in polar coordinates, displacements for symmetrical stress distributions, simple symmetric and asymmetric problems, general solution of two-dimensional problems in polar coordinates, application of general solution in polar coordinates.

MODULE - III: ANALYSIS OF STRESS AND STRAIN IN THREE DIMENSIONS (09)
Analysis of stress and strain in three dimensions, principal stresses, stress ellipsoid, director surface, determination of principal stresses, max shear stresses, homogeneous deformation, and principal axes of strain rotation.

General theorems: Differential equations of equilibrium, conditions of compatibility, determination of displacement, equations of equilibrium in terms of displacements, principle of super position, uniqueness of solution, the reciprocal theorem.

MODULE - IV: TORSION OF PRISMATICAL BARS (9)
Torsion of prismatic bars, bars with elliptical cross sections, other elementary solution, membrane analogy, torsion of rectangular bars, solution of torsion problems by energy method, use of soap films in solving torsion problems, hydro dynamical analogies, torsion of shafts, tubes, bars etc. Bending of prismatic bars: Stress function, bending of cantilever, circular cross section, elliptical cross section, rectangular cross section, bending problems by soap film method, displacements.

MODULE - V: THEORY OF PLASTICITY (8)
Theory of Plasticity: Introduction, concepts and assumptions, idealized stress train behavior, Elastic perfectly plastic material, perfectly plastic material, linearly strain hardening material, power law stress train model, strain hardening, nominal and true stress strain, yield criterions.

V. TEXTBOOKS:

1. C.S. Reddy, "*Basic Structural Analysis*", Tata McGraw-Hill, 3rd Edition, 2010.
2. R. Vaidyanathan & P. Perumal, "*Comprehensive Structural Analysis – Vol. I & II*", Laxmi Publications, 2005.
3. A. Ghose, "*Matrix Methods of Structural Analysis*", Prentice Hall of India, 1996.
4. W. Weaver & J.M. Gere, "*Matrix Analysis of Framed Structures*", CBS Publishers, 3rd Edition, 1990.

VI. REFERENCE BOOKS:

1. R.C. Hibbeler, "*Structural Analysis*", Pearson, 10th Edition, 2017.
2. Aslam Kassimali, "*Matrix Analysis of Structures*", Cengage Learning, 2nd Edition, 2011.
3. Devdas Menon, "*Advanced Structural Analysis*", Narosa Publishing, 2009.
4. M.L. Gambhir, "*Fundamentals of Structural Mechanics and Analysis*", PHI Learning, 2011.

VII. ELECTRONICS RESOURCES:

1. https://nptel.ac.in/courses/105101085
2. https://nptel.ac.in/courses/105101086
3. https://nptel.ac.in/courses/105106050

VIII. MATERIAL ONLINE:

1. Course Outline Description
2. Tutorial Question Bank
3. Assignments
4. Model Question Paper – I
5. Model Question Paper - II
6. Lecture Notes
7. Early Lecture Readiness Videos
8. Power point presentation