Advanced Solid Mechanics - Web course

COURSE OUTLINE

Mechanics of materials, the first course in mechanics, introduces the fundamental concepts and principles in the analysis of solids to the undergraduate students of civil engineering. Also, most of the problems that are solved are essentially one dimensional in nature. In this course “Advanced Solid Mechanics” a general theory available to study the response of solids to applied forces will be developed and will be used to study simple boundary value problems. In all the treatment would be three dimensional. The aim of the course material would be to inculcate in the reader some of the available tools to analyze a structure and to elucidate the simplifying assumptions made to make the structure analyzable. The course material would be self contained in that all the required mathematical tools will also be covered in adequate detail. Where possible, comparison of the 3D elasticity solutions to boundary value problems and simplified solutions would be presented. A number of problems will be solved to illustrate how the learnt concepts help solve problems of interest. Also exercise problems with different levels of difficulty would be included. The course material on advanced solid mechanics will be useful to final year undergraduate students, post-graduate students and teachers.

Contents:

Introduction to mechanics of solids – need and basic concepts, Introduction to tensor algebra and calculus, Kinematics, strain displacement relationship, Compatibility conditions, Concept of traction and stress, Equilibrium equations, Constitutive relations, Formulation of boundary value problems in linearized elasticity, Solution of 2D problems using Airy’s stress functions, Solution to boundary value problems corresponding to end torsion of prismatic beams, bending of prismatic straight and curved beams,

NP-TEL

NPTEL

http://nptel.iitm.ac.in

Civil Engineering

Pre-requisites:

1. Mechanics of Materials.

Additional Reading:

1. R.J. Atkin, and N. Fox, "An introduction to the theory of elasticity", Longman, New York, 1980.
2. G.A. Holzapfel, "Nonlinear Solid Mechanics", Wiley, New York, 2001.

Hyperlinks:

1. www.solidmechanics.org/contents.htm - Free web book on Applied Mechanics of Solids by A.F. Bower.

Coordinators:

Dr. U. Saravanan
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Beams on elastic foundation

COURSE DETAIL

Sl.No.	Topic	No. of Hours
1	**Introduction:** Review of basic concepts and equations in mechanics, Classification of materials, Outline of general techniques to solve boundary value problems	01
2	**Mathematical Preliminaries**: Indicial notation, Introduction to tensors, Representation of tensors, Gradient and related operators, Divergence theorem	04
3	**Kinematics**: Motion field, Displacement field, Deformation gradient, Transformation of curves, surfaces and volumes, strain measures, linearized strain measures, Principal strains and principal directions, Transformation of strain components with changes in coordinate basis, Compatibility conditions for linearized strain	06
4	**Traction and stresses**: Concept of traction, Cauchy's stress theorem, Postulate of Cauchy stress tensor, Traction on arbitrary planes, Extreme normal and shear	05

	traction, Octahedral shear stress, Other stress measure - Engineering stress	
5	**Equilibrium equations**: Derive equilibrium equations in Cartesian and cylindrical polar coordinates	01
6	**Constitutive relations**: Restrictions on constitutive relations, General relationship between Cauchy stress and Cauchy Green strain for isotropic materials, General Hooke's law and its reduction for isotropic and orthotropic materials	04
7	**Boundary value problems: Formulation** : Displacement method, Stress method, Airy's stress functions for plane stress and strain problems, Uniaxial Tension, Thick-walled annular cylinder subjected to uniform boundary pressure, Infinite medium with a stress-free hole under far field tension loading	04
8	**Bending of prismatic straight beams:** Pure bending, bending due to uniform transverse loading and bending due to transverse sinusoidal loading of a beam, Asymmetrical bending of straight beams, Shear center, Shear stresses in thin walled open sections	05
9	**End torsion of prismatic beams**:	06

	Formulation of the BVP for torsion of beams with solid cross section - warping function and Prandtl stress function approach, Torsion of circular, elliptic, rectangular and triangular cross sections, Membrane analogy, Torsion of thin walled tubes, thin rectangular sections, rolled sections and multiply connected sections	
10	**Bending of curved beams**: Winkler-Bach Formula, Elasticity solution for : pure bending of curved beams, curved cantilever under end loading	02
11	**Beam on elastic foundation**: Derivation of the basic governing equation, Solution to beam on an elastic foundation subjected to a point load at the center, moment at the center, uniformly distributed load over some length 'a' symmetrically about the center	03

References:

1. L.S. Srinath, "Advanced Mechanics of Solids" Tata McGraw Hill, 2007.
2. A.R. Ragab, and S.E. Bayoumi, "Engineering Solid Mechanics: Fundamentals and Applications", CRC Press, 1999.
3. M.H. Sadd, "Elasticity: Theory, Applications and Numerics", Academic Press, 2006.