Introduction to Continuum Mechanics

Course No SE 394

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Department Mechanical Engineering

Units (L-T-P-D-U) 3-0-0-0-4

Schedule LEC: MWF 12:00-13:00pm L6

Course website `http://home.iitk.ac.in/~bls/Homepage/SE394_2008.html`

Prerequisite Basic course in integral and differential calculus of functions of a real variable, basic course in linear algebra and differential geometry.

About the Course:

Rigorous introduction to continuum mechanics emphasizing solid mechanics and linear elasticity.

Course topics include vectors and tensors: tensor algebra, tensor analysis and tensor calculus with direct notation; kinematics: deformations, rotations, strains and strain rates; force and stress; balance principles; frame indifference; material symmetry; constitutive relations; three-dimensional elasticity; finite elasticity; small-strain theory; linear elasticity: anisotropic and isotropic, topics include linearization and stability; basic theorems of elastostatics and boundary-value problems.

Additional topics (for example: guest lectures) may also include rate-dependent materials, and materials with internal state variables, linear viscoelasticity, thermoelasticity, Newtonian fluids; constitutive inequalities; the entropy inequality; conservation laws; exact solution of special problems; singular solutions in linear elasticity; plane stress, plane strain, anti-plane shear, airy stress functions; cracks and dislocations; classical plasticity.

Contents

This course will introduce and develop the subject of elasticity, specially applicable to the circumstances when the material of a body experiences large (or finite) deformation including large displacement or large rotation.

- Introduction to the notion of a tensor and preparation of some background in tensor algebra, tensor analysis and tensor calculus.
- Definition of motion of a body, in particular a deformable body. Discussion of the concept of force. Definition of Cauchy stress. Definition of a reference configuration. Definition of several other notions of stress and some ways of quantifying 'strain' or 'strain rate'.
- Definition of objectivity (symmetry of physical space) and material symmetry (symmetry of material space). Discussion of certain crystalline symmetries that may be incorporated through an elastic model. Highlights on the role of a reference configuration in this subject.
- Definition of an elastic material. Discussion on the special case of an isotropic elastic material. Introduction to the three dimensional theory of hyperelasticity. Exposure to some useful results in the case of an isotropic hyperelastic material.
- Derivation of linear elasticity as a result of linearization of fully nonlinear theory discussed so far. Discussion on certain limitations of such linearization procedure.
- Conclusion of the course with a discussion of some open problems.

- *There may be a few guest research seminars in this course, given by various professors, in order to motivate this subject. A few lectures or reading assignments may be devoted to some interesting results in the theory of nonlinear elasticity which find application in diverse areas of engineering and sciences.

Grading policy

Thumbrule: 4 min of exam for each point out of 100

Quiz 1 (20 min): 5%,
MidSem I (1 hr): 15%,
Quiz 2 (20 min): 5%,
Quiz 3 (20 min): 5%,
MidSem II (1 hr): 15%,
Quiz 4 (20 min): 5%,
Quiz 5 (20 min): 5%,
EndSem (3 hr): 45%.

Topic of all quizzes will include: real analysis, calculus, tensors, linear algebra, tensor algebra, tensor analysis and tensor calculus.

Text Book

1. Gurtin, M. E.,1982. An Introduction to Continuum Mechanics, Academic Press (Textbook).
2. Gurtin, M. E.,1972. The Linear Theory of Elasticity, Handbuch der Physik, Vol. VIa/2, Springer.
3. Truesdell, C., 1977. A first course in Rational Continuum Mechanics, Academic Press.
4. Jog, C. S., 2007. Continuum Mechanics, Vol 1, Narosa.