ME 185/287: Introduction to Continuum Mechanics

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Course objectives: This course is a general introduction to the fundamental concepts of the mechanics of continuous media. We discuss the kinematics of deformation, the concept of stress, and the conservation laws for mass, momentum and energy. This is followed by an introduction to constitutive theory with applications to well-established models for viscous fluids and elastic solids. The concepts are illustrated through the solution of tractable boundary- and initial-value problems.

Prerequisites: Physics 7A, Math 50A-B, some prior exposure to the elementary mechanics of solids and fluids.

Suggested text: P. Chadwick, Continuum Mechanics: Concise Theory and Problems. Dover, N.Y. 1976.

Course reader: P.M. Naghdi's Notes on Continuum Mechanics (will be posted on bCourses).

Grading: Two in-class midterms (25% each), final exam (50%). Homework will be assigned approximately every two weeks. A consistent record of turning in complete assignments on time will be considered favorably in the case of borderline grades.

Topics:

I. Mathematical preliminaries:

1. Linear spaces.
2. Vectors and tensors in Euclidean spaces.
3. Tensor algebra and calculus.

II. Kinematics of deformation:

1. Bodies, configurations, motions.
2. Mass and density.
3. Deformation gradient and its polar decompositions; rotation and stretch; strain measures.
4. Velocity gradient, stretching and vorticity tensors.
5. Rigid-body motions.
6. Reynolds' transport theorems.

III. Physical principles:

1. Mass conservation.
2. Definition of forces.
3. Balance of linear momentum and moment of momentum.
4. Traction vector and stress tensor. Local (differential) equations of motion.
5. Alternative stress measures.
6. Change of frame and transformations under superposed rigid-body motions.
7. Balance of energy.

IV. Constitutive theory:

1. Invariance requirements and other restrictions on constitutive equations.

2. Viscid and inviscid fluids.
3. Elastic solids. Linearization of elasticity theory and associated kinematics.

Suggested reading:

1. C. Truesdell and R.A. Toupin. The classical field theories. In: S. Flügge, ed., *Handbuch der Physik III/1,* pp. 226-793. Springer-Verlag, Berlin, 1960. [QC22.H26 v.3.1]

2. C. Truesdell and W. Noll. The non-linear field theories of mechanics. In: S. Flügge, ed., *Handbuch der Physik III/3,* Springer-Verlag, Berlin, 1965. [QC22.H26 v.3.3]

3. L.E. Malvern. *Introduction to the Mechanics of a Continuous Medium.* Prentice-Hall, Englewood Cliffs, N.J., 1969. [QA808.2.M3]

4. G.E. Mase. *Schaum's Outline on Theory and Problems of Continuum Mechanics.* McGraw-Hill, N.Y., 1970 [QA808.2.M36]

5. A.J.M. Spencer. *Continuum Mechanics.* Longman,London, 1980 [QA808.2.S63]

6. M.E. Gurtin. *An Introduction to Continuum Mechanics.* Academic Press, N.Y., 1981. [QA3.M286]

7. C.A. Truesdell. *A First Course in Rational Continuum Mechanics.* Academic Press, Boston, 2nd edn., 1991. [QA3.P8 v.71]