0 Introduction

Continuum Mechanics is the science which deals with the mechanical behavior of solids and fluids on the macroscopic scale. Ignores discrete nature of matter (atoms etc) and considers the material as uniformly distributed.
0.1 Solid mechanics

The science which deals with the mechanical behavior of solids on the macroscopic scale.

- *Fracture Mechanics*: Analysis of cracked bodies, fatigue etc.

![Fig. 0.1. The modes of loading: Mode I – opening mode; Mode II – shear mode; Mode III – tearing mode. (Broek, D., 1988, *The Practical Use of Fracture Mechanics*, Kluwer, pg. 16.)*](image)

- *Mechanics of Composite Materials*: Composites are materials having two or more distinct constituents (matrix and reinforcement). Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs), Polymer Matrix Composites (PMCs) etc.

![Fig. 0.2. Examples of composites: (a) particulate, random; (b) discontinuous fibers, unidirectional; (c) discontinuous fibers, random; (d) continuous fibers, unidirectional. (Matthews, F. L. and Rawlings, R. D., 1994, *Composite Materials: Engineering and Science*, Chapman and Hall, pg. 8.)*](image)
• **Computational Solid Mechanics:** Finite Element Methods (FEM) and Boundary Integral Equation Methods (BIEM). Involves discretization of medium.

![Diagram of short cantilever beam and adaptive meshes of linear triangular elements.](image)

Fig. 0.3. Short cantilever beam and adaptive meshes of linear triangular elements. (Zienkiewicz, O. C. and Taylor, R. L., 2000, *The Finite Element Method, Vol. 1: The Basis*, Butterworth and Heinemann, pg. 408.)

• **Contact Mechanics:** Problems associated with different bodies in contact.
• **Elastic Wave Propagation**: How disturbances travel in an elastic medium. Different types of elastic waves. Scattering problems etc.

![Image of elastic waves]

<table>
<thead>
<tr>
<th>Wave type</th>
<th>Percentage of total energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rayleigh</td>
<td>67</td>
</tr>
<tr>
<td>Shear</td>
<td>26</td>
</tr>
<tr>
<td>Compression</td>
<td>7</td>
</tr>
</tbody>
</table>

Fig. 0.4. Distribution of displacement and energy in dilatational, shear and surface waves from a harmonic normal load on a half-space for \( \nu = \frac{1}{4} \). (Graff, K. F., 1975, *Wave Motion in Elastic Solids*, Ohio State University Press, pg. 356.)

• **Constitutive Modeling**: Modeling of different materials, Plasticity, Viscoelasticity, Shape Memory Alloys etc.

• **Damage Mechanics**: Effects of cracks are included in constitutive equations rather than in boundary conditions. Continuum mechanics and thermodynamic principles are used.

• **Geomechanics**: Mechanics of earthquakes, hydraulic fracturing, flow through porous media etc.

![Image of earthquake model]

Fig. 0.5. Configuration used to model 1971 San Fernando earthquake. The rupture starts at the bottom of the fault and propagates upward with a velocity of 2.5 km/sec on the lower segment and 2 km/sec on the upper segment. The medium has compressional and shear velocities of 5.6 km/sec and 3.2 km/sec. (Bouchon, M., 1978, 'A dynamic source model for the San Fernando earthquake', *Bulletin of the Seismological Society of America*, Vol. 68, No. 6, 1555-1576.)
• **Quantitative Nondestructive Evaluation (QNDE):** Methods to assess the deterioration of a material or structure and to detect and characterize discrete flaws.

• **Biomechanics:** Analysis of biological problems using principles of mechanics.

**Fig. 0.6.** Contact ultrasonic measurement setup.

**Fig. 0.7.** Some implants that are embedded in the human body, (a) hip prosthesis; (b) cardiovascular stents.

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**Review Articles on Solid Mechanics:**