EN1750 – Advanced Mechanics of Solids 2019

1. Fundamental Postulates of Solid Mechanics
2. Introduction to FEA using ABAQUS
3. Math Review, introduction to tensors and index notation
4. Describing Deformations
5. Describing Forces
6. Equations of Motion
7. Overview of material models – relating stress to strain
8. Linear Elastic Stress-Strain Relations
9. Analytical Solutions for Linear Elastic Solids
10. Energy Methods for Linear Elastic Solids
11. Implementing the Finite Element Method for Elastic Solids
12. Solids with special shapes – beams and plates
13. Dynamic elasticity – waves and vibrations
14. Plastic stress-strain relations;
15. Solutions for elastic-plastic solids
16. Modeling failure

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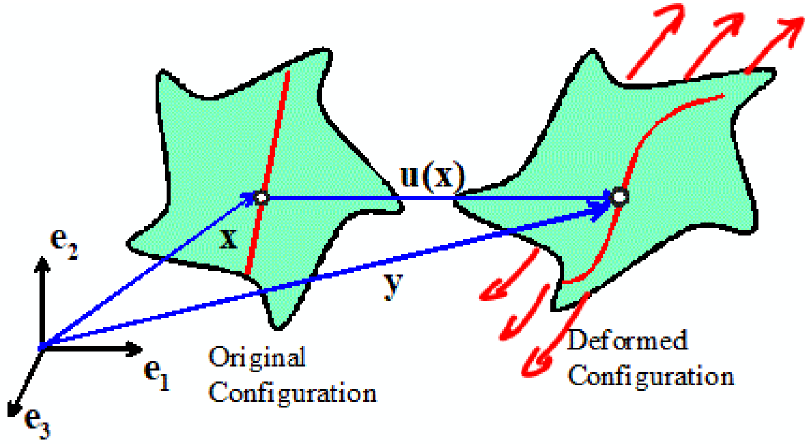
1.1 Goal of solid mechanics



Given: (1) Initial shape
(2) Material model, properties
(3) Loading, prescribed displacements
(4) Initial Conditions

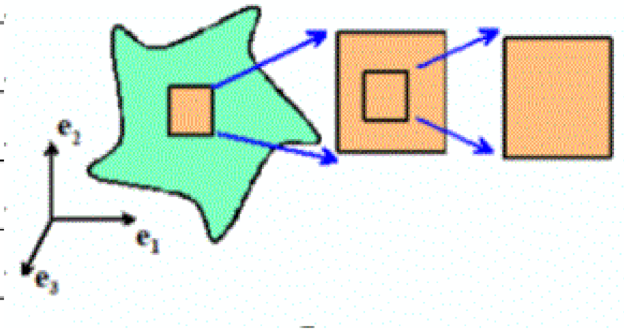
Predict: Displacement field

$$\underline{u}(\underline{x}, t) = \underline{y}(\underline{x}, t) - \underline{x}$$

Deduce internal forces, predict failure

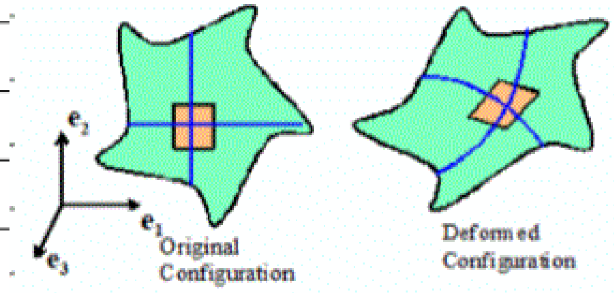
1.2 Usual postulates of solid mechanics

(1) Continuum description of matter
- Matter is infinitely divisible



(2) Local Homogeneity : sufficiently small vol elements from same region are identical

(3) Locally homogeneous deformation
- straight lines deform to smooth curves

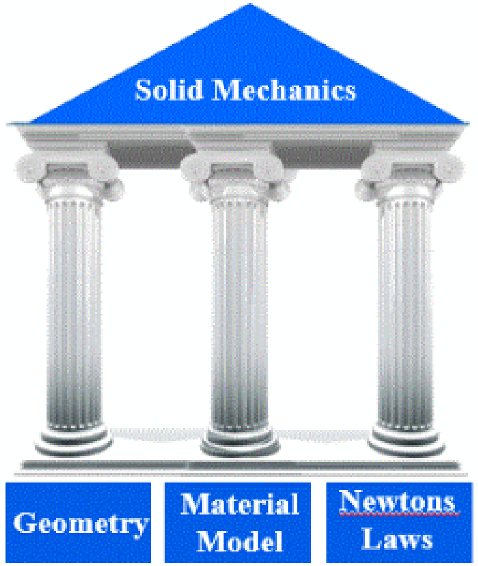


(4) Infinitesimal area elements exert forces on each other but not moment

(5) Linear momentum - force relation (Newton) holds for all sub-volumes in solid

(6) Principle of local action : Internal forces at a point depend only on deformation of immediate neighborhood

1.3 Pillars of solid mechanics



(1) Describing deformation : Geometry

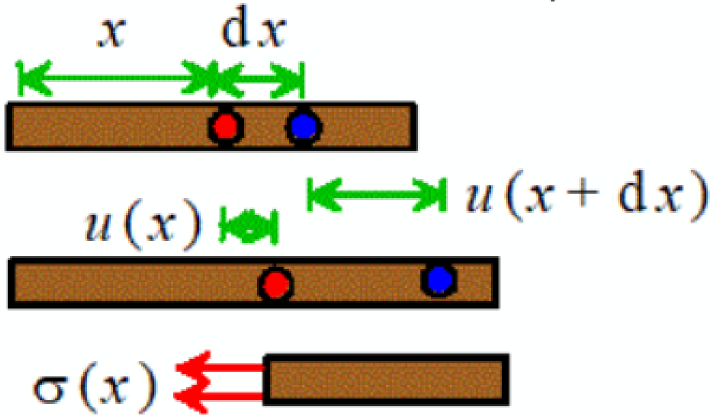
(2) Material model : generally based on experiment, guided by physics & thermodynamics

(3) Description of internal forces (Newton)

- Combine (1) - (3) System of PDEs

- Solve !

1.4 Example (for illustration, derive eqs later) 1D elastic bar



(1) Geometry

$$\varepsilon = \frac{\delta l}{l} = \frac{\partial u}{\partial x}$$

(2) Stress-strain law $\sigma = E\varepsilon$

σ - Stress E - Youngs modulus

(3) Linear momentum $\frac{\partial \sigma}{\partial x} = \rho \frac{\partial^2 u}{\partial t^2}$ ρ - mass density

Combine $\frac{\partial^2 u}{\partial x^2} = \frac{\rho}{E}\frac{\partial^2 u}{\partial t^2}$ - 1D wave equation