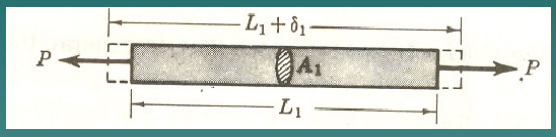
ESO204: Mechanics of Solids

Stress and Strain

Motivation

- Engineers need to design components which can resist applied loads without failure.
- Experimentally it is found that structural failure occurs when *internal* stresses in part of a structure get too large.
- To design against failure, we need to calculate internal stresses in different parts of any structure.

What is Axial stress?



- Axial Stress = Load/ Area
- Axial Strain = Change in length per unit length
- Modulus of elasticity = Stress/Strain
- We will generalize the definition of stress and define stress equal to force/area

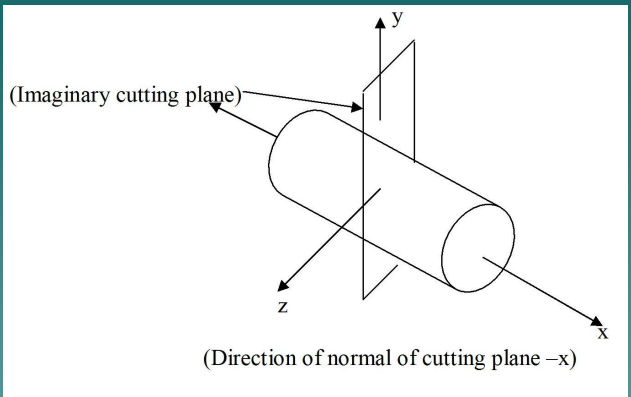
Stresses in slender members

- We had studied the general nature of internal forces in slender members by following the same reasoning which we used in finding reaction forces namely:
- Equilibrium
- Geometric Fit
- Force deformation

Slender members

- In general slender beams are subjected to bending moments, twisting moment, shearing forces and axial forces.
- The internal forces and moments in slender members were determined by imagining a cutting plane which cut the slender member in two pieces.

Internal forces in Slender members



- Any body can be thought of as consisting of two pieces, one of either side of one imaginary plane.

Internal forces in Slender members

If the axis of the slender member is taken to be the x-axis, the resultant forces and moments on the cutting plane (whose normal is along x-axis) are:

- Axial force (points along x-axis)
- Shear forces along directions y and z
- Torsional Moment along x-axis
- Bending moments along y and z

Internal forces in Slender members

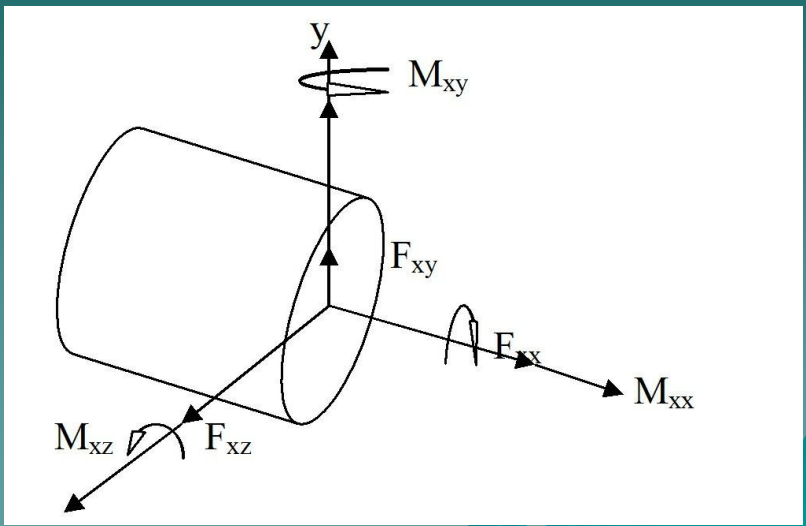
The resultant forces and moments on the two sides of the cutting plane (the normals on the two opposite faces are along +x and –x direction) are equal and opposite. The following conventions are adopted:

- Forces & moments are considered positive when they act on a positive face in a positive co-ordinate direction.
- Forces & moments are also considered positive when they act on negative face in a negative co-ordinate direction.

Internal forces in Slender members

- To indicate the direction of the cutting plane and the direction of the force (or moment), the forces and moments are indicated by a double subscript notation where the first subscript denotes the direction of the cutting plane.
- The second subscript denotes the direction of the force or moment.

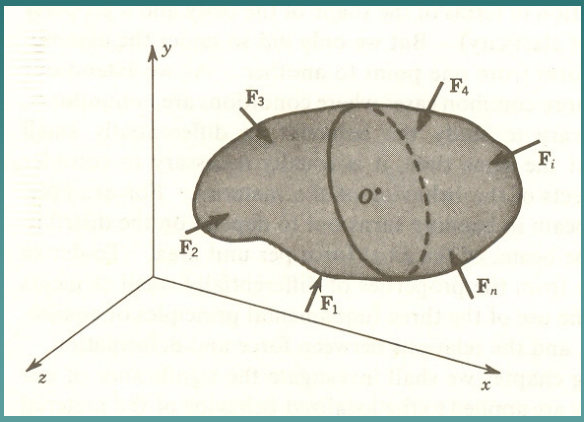
Internal forces in Slender members



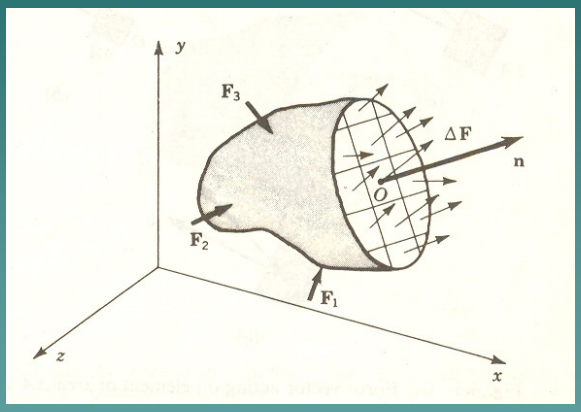
Internal forces and stresses in Slender members

- **Axial Force**: Denoted by F_{xx}, F_x
- **Shear Force:**
  Denoted by F_{xy} ,F_{xy} ,F_{xz} ,V , V_y or V_z
- We define:
- Axial Stress= Axial Force/Area
- Shear Stress= Shear force/Area
- Symbols: σ (Axial Stress)
- τ (Shear Stress)

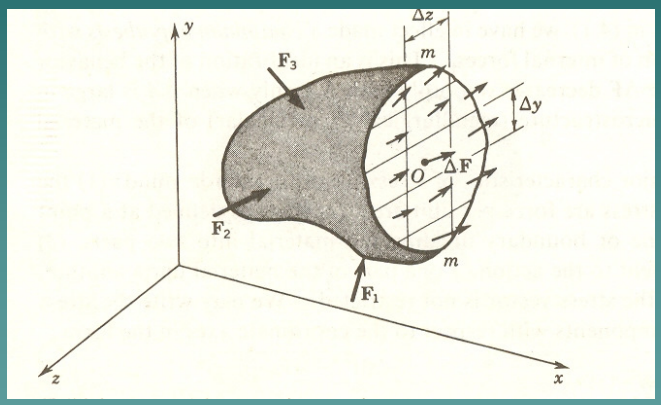
Internal forces in bodies of general shape



Internal forces in bodies of general shape



Internal forces in bodies of general shape



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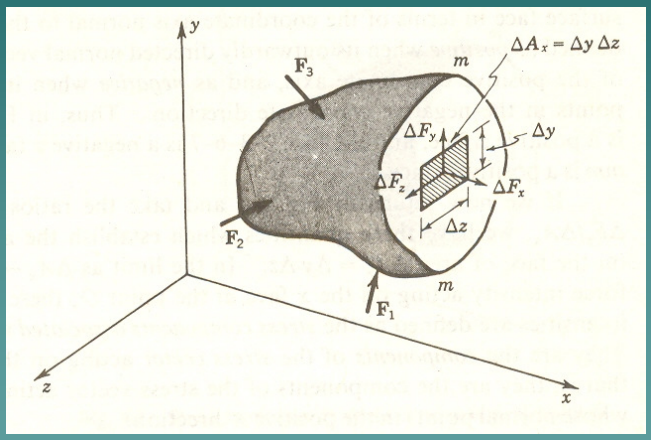

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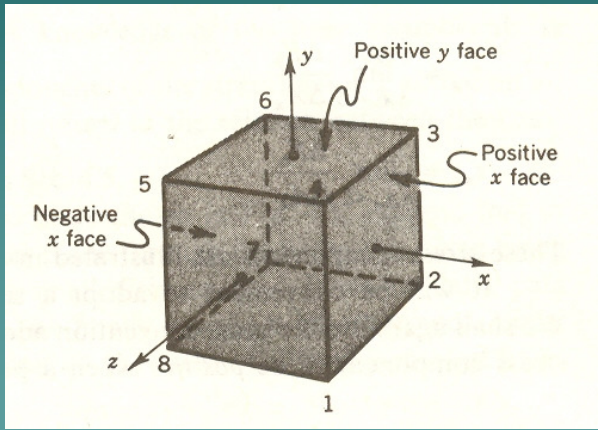

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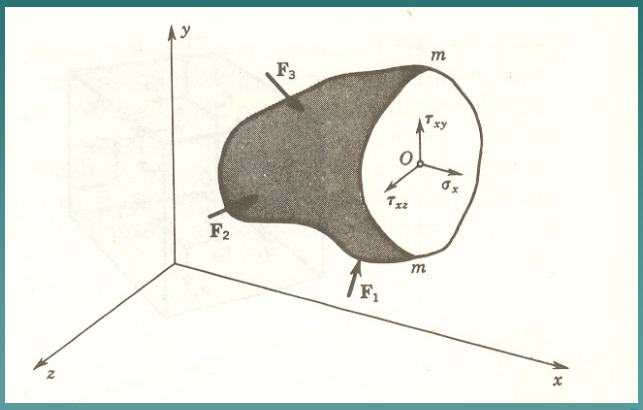

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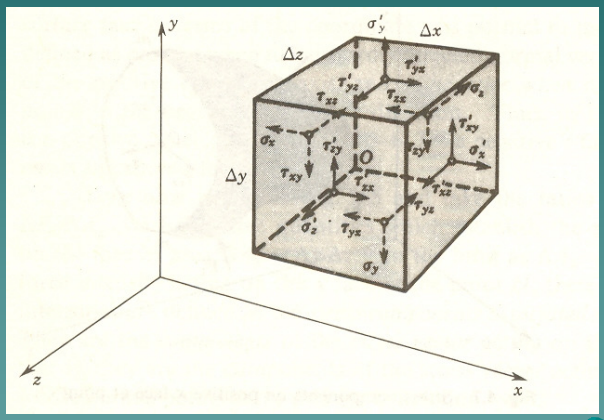
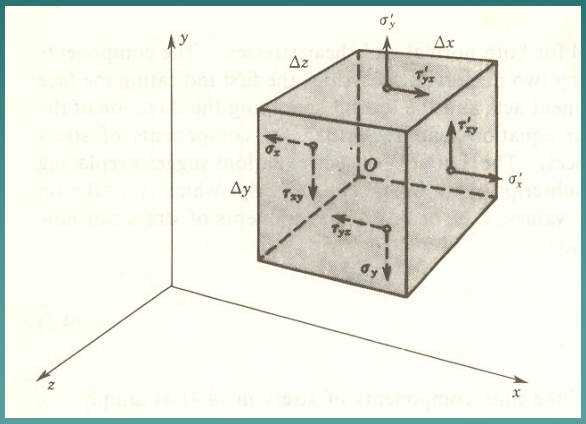


Internal forces in bodies of general shape (Plane stress)



Equilibrium of a differential element in plane stress