Mechanics of Materials I:

Fundamentals of Stress & Strain and Axial Loading

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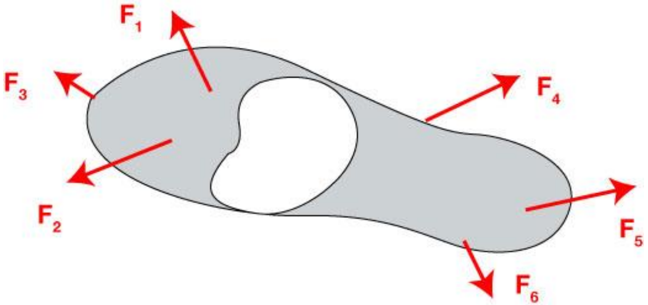
Mechanics of Materials I:
Fundamentals of Stress & Strain and Axial Loading

- ✓ Internal Forces due to External Loads
- ✓ Axial Centric Loads
- ✓ Normal Stress and Shear Stress
- ✓ General State of Stress at a Point (3D)
- ✓ Plane Stress (2D)
- ✓ Normal Strain and Shear Strain
- ✓ Stress-Strain Diagrams
- ✓ Mechanical Properties of Materials
- ✓ Linear Elastic Behavior, Hooke's Law, and Poisson's Ratio
- ❑ Stresses on Inclined Planes
- ❑ Principal Stresses and Max Shear Stress
- ❑ Mohr's Circle for Plane Stress
- ❑ Stress Concentrations
- ❑ Mohr's Circle for Plane Strain
- ❑ Strain Transformation and Measuring Strains
- ❑ Factor of Safety and Allowable Stresses/Loads
- ❑ Nonlinear Behavior and Plasticity
- ❑ Statically Indeterminate Structures
- ❑ Thermal and Pre-strain Effects

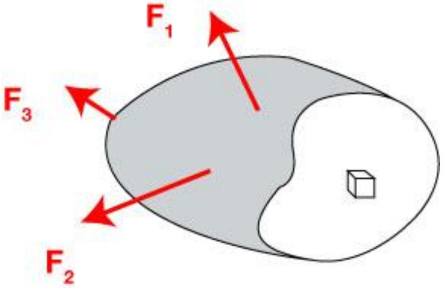
Module 16 Learning Outcomes

- Define stresses on inclined planes for the case of plane stress in general
- Define the sign convention for stresses on inclined planes in general

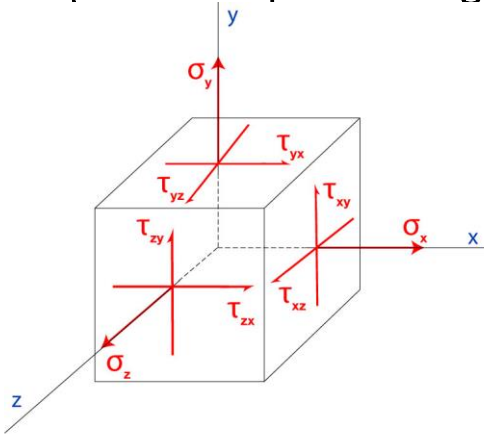
General 3D State of Stress at a Point
(Arbitrarily Loaded Member)



- For more complicated structural members , the stress distributions may not be uniform on arbitrary planes
- For an infinitesimally small point, the stress distribution approaches uniformity
- An infinite number or planes can be passed through each point.
- But, it can be shown that three mutually perpendicular planes is sufficient to completely describe the state of stress at any point for any orientation. (Hence we will use a cube to represent the state of stress at a point.)



3D State of Stress at a Point
(shown in positive sign convention)



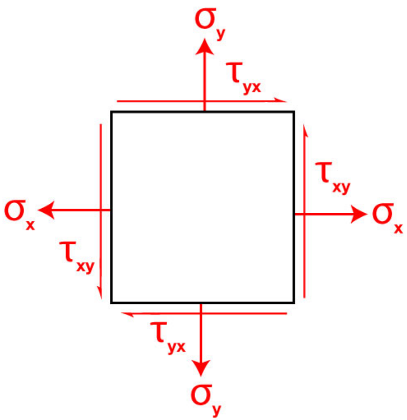
$$\tau_{xy} = \tau_{yx}$$

$$\tau_{yz} = \tau_{zy}$$

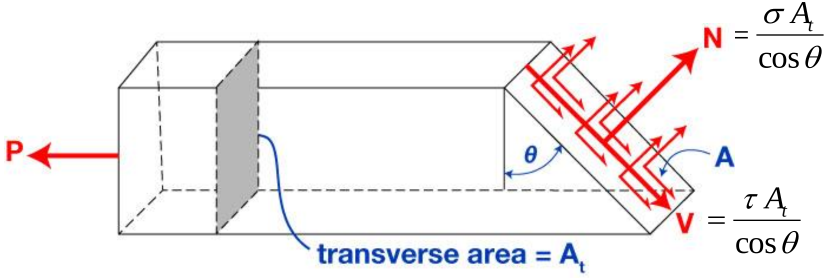
$$\tau_{xz} = \tau_{zx}$$

For Two-Dimensional (2D) or Plane Stress,
all out of plane stresses are zero

$$\sigma_z = \tau_{xz} = \tau_{zx} = \tau_{yz} = \tau_{zy} = 0$$



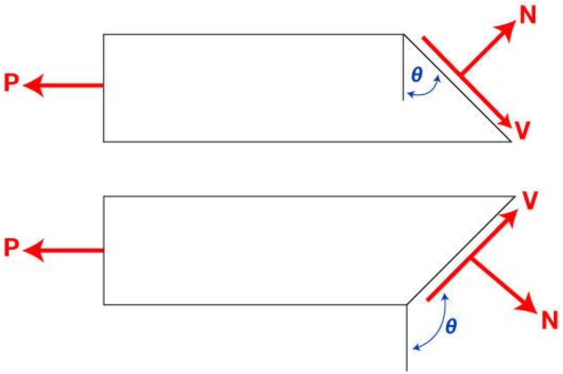
Normal and Shear Stresses on Inclined Planes for Uniaxial Loading



$$\sigma = \frac{P}{A_t}\cos^2\theta \qquad \tau = \frac{P}{2A_t}\sin 2\theta$$

$$\sigma_{MAX} \;\; occurs \;\; if \;\; \theta = 0°, 180°$$

$$\tau_{MAX} \;\; occurs \;\; if \;\; \theta = 45°, 135°$$



(Note: The sign of Shear Stress changes for θ > 90 degrees
and the Shear Force vector changes direction.)

NOTE: $$|\sigma_{MAX}| = 2|\tau_{MAX}|$$ for uniaxial loading

Stresses on Inclined Planes for Plane Stress in general

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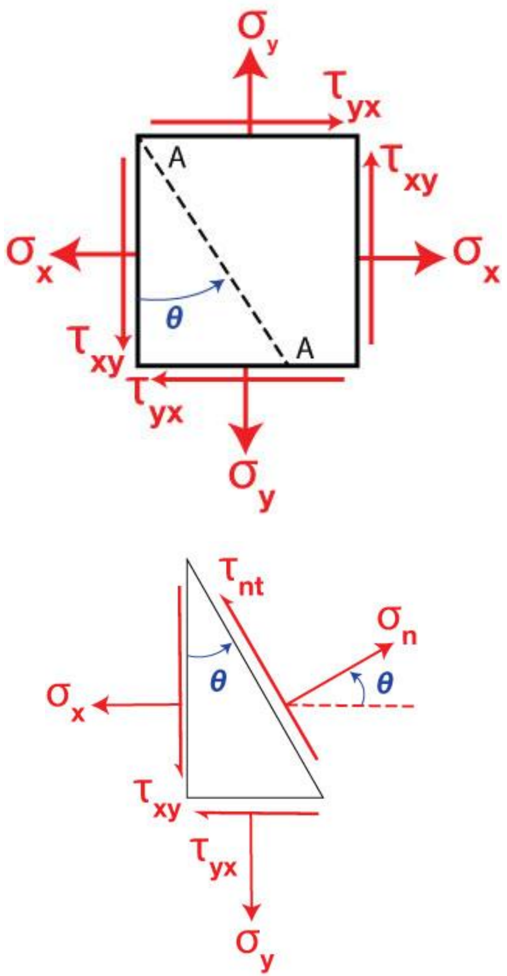

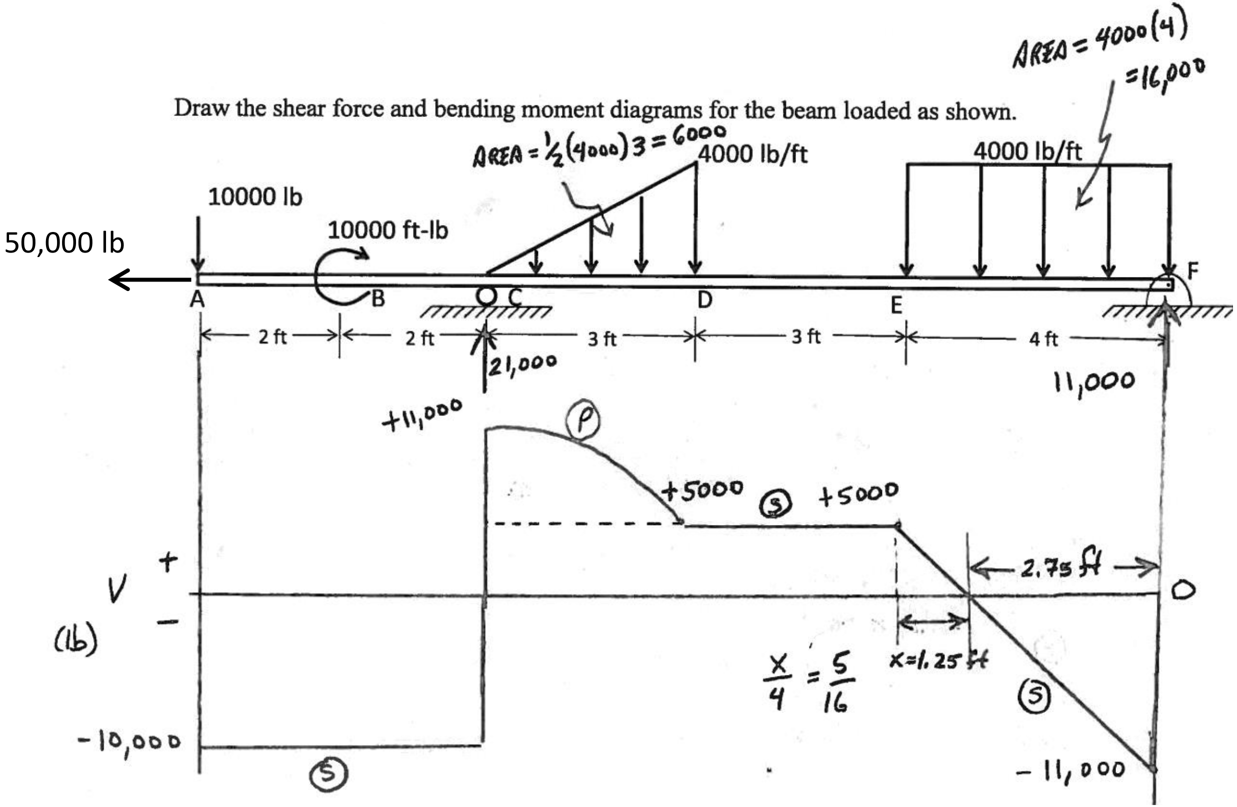

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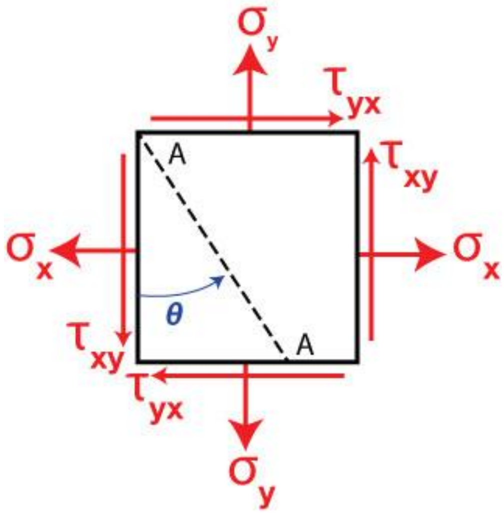

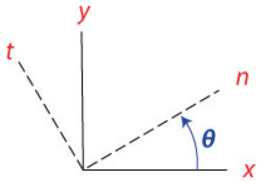

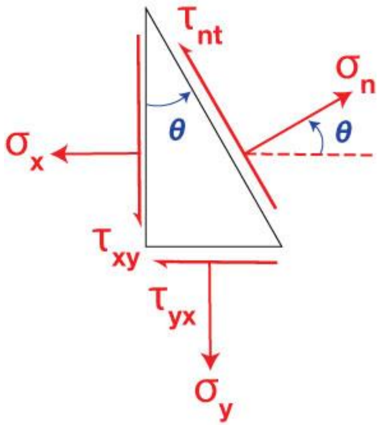

Sign Convention

Normal Stress
(+) Tension
(-) Compression

Shear Stress
Shear stress is **(+)** if it is in the **(+)** direction of the coordinate axis

Angle
Counterclockwise angle θ is **(+)** as measured from positive x axis as reference