Mechanics of Materials I:

Fundamentals of Stress & Strain and Axial Loading

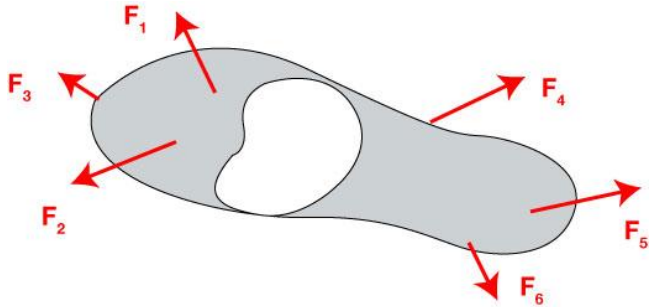
Dr. Wayne Whiteman
Senior Academic Professional and Director of the Office of Student Services
Woodruff School of Mechanical Engineering

Georgia Institute of Technology

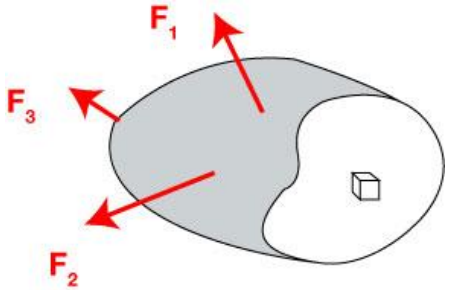
Module 5 Learning Outcomes

- Define the state of stress for at a point in three dimensions (3D)
- Define the sign convention for the state of stress at a point in 3D

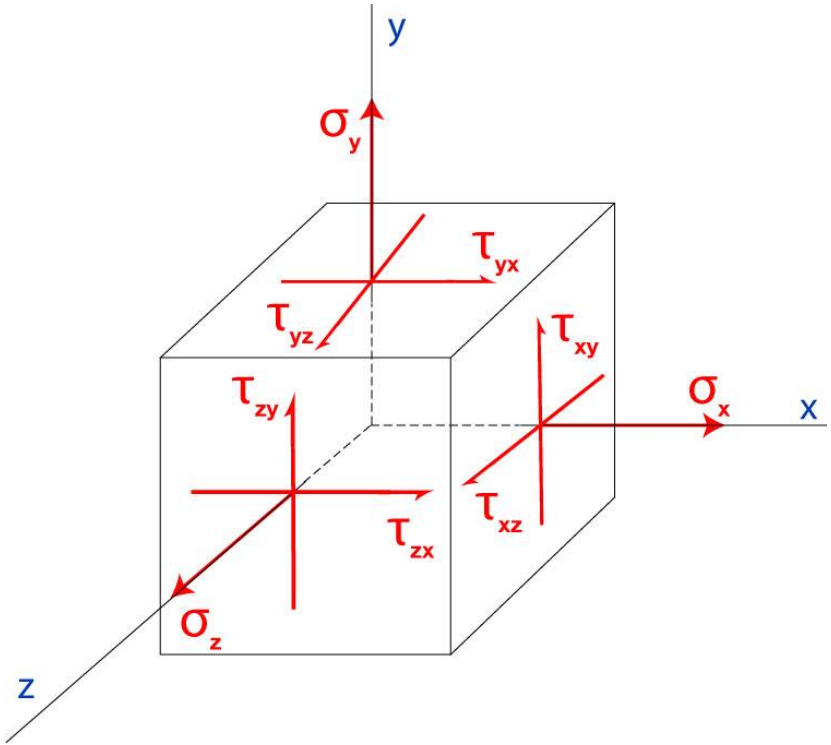
General 3D State of Stress at a Point
(Arbitrarily Loaded Member)



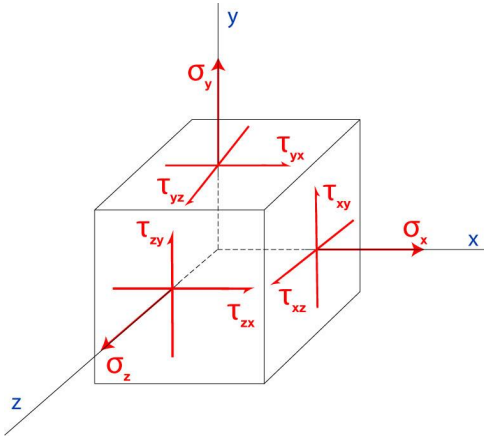
- For more complicated structural members , the stress distributions may not be uniform on arbitrary planes
- For an infinitesimally small point, the stress distribution approaches uniformity
- An infinite number or planes can be passed through each point.
- But, it can be shown that three mutually perpendicular 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)



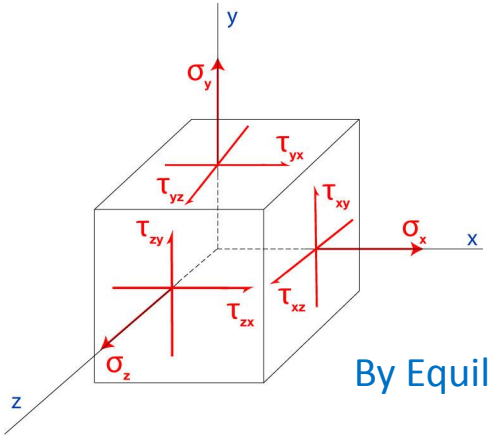
3D State of Stress at a Point



- Stress is a tensor
- A tensor represents a physical/geometric property/quantity by a mathematical idealization of an array of numbers

  (see Module 20 of my course “Advanced Engineering Systems in Motion: Dynamics of 3D Motion” for a more detailed discussion of tensors)

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

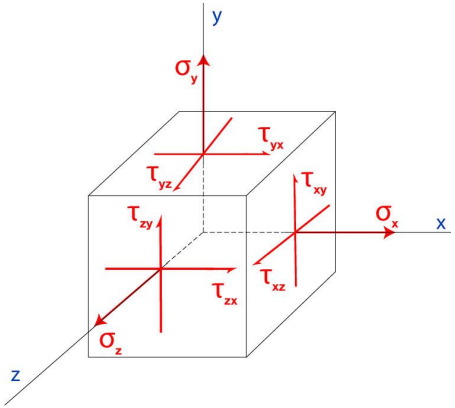


By Equilibrium:

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

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

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



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

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

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

Matrix Notation:

$$\begin{bmatrix} \sigma_x & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_y & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_z \end{bmatrix}$$