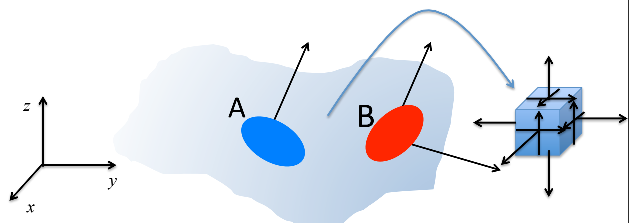
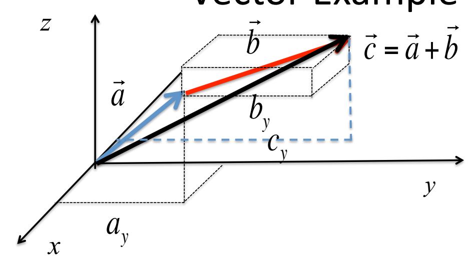
0.0 Background

- Scalar – Example: Temperature @ (x,y,z)
  - Temperatures at A, T_A, and at B, T_B.
- Vector – Forces & Moments
  - Statics & Dynamics - Force & Moment Equilibriums
- Tensor – Stress and Strain



Vector Example



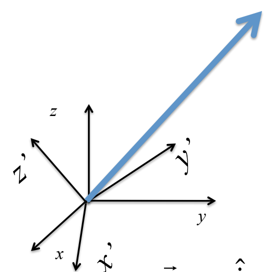
$$\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$$

$$\vec{b} = b_x\hat{i} + b_y\hat{j} + b_z\hat{k}$$

$$\vec{c} = \vec{a} + \vec{b} = (a_x + b_x)\hat{i} + (a_y + b_y)\hat{j} + (a_z + b_z)\hat{k}$$

$$\therefore c_x = a_x + b_x; \quad c_y = a_y + b_y; \quad c_z = a_z + b_z$$

Vector Transformation

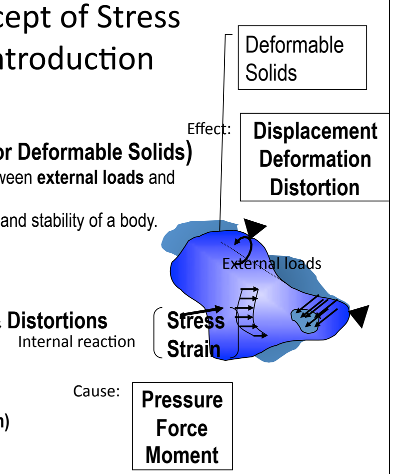


$$\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k} = a'_x\hat{i}' + a'_y\hat{j}' + a'_z\hat{k}'$$

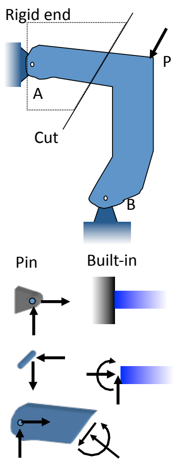
$$\therefore a_x \neq a'_x; \qquad a_y \neq a'_y; \qquad a_z \neq a'_z$$

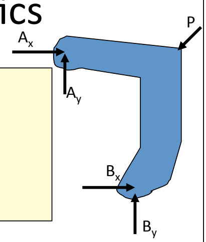
1. Concept of Stress
1.1 Introduction

- **Statics** (and Dynamics)
- **Mechanics of Materials (or Deformable Solids)**
  Understanding the relationships between **external loads** and **internal reactions** on a body.
  Deals with the integrity, deformation and stability of a body.
- **Pressure, Force & Moment**
  - Stresses
  - Not measureable quantity
- **Displacement, Deformation & Distortions**
  - Strains
  - Measurable quantity
- **Material Behavior**
  - Chalk **(Axial, Bending & Torsion)**
  - Rubber vs. Steel



1.2 Review on Statics

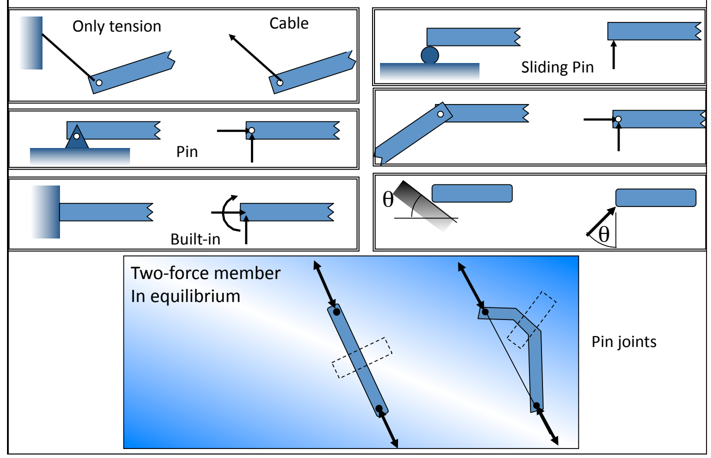




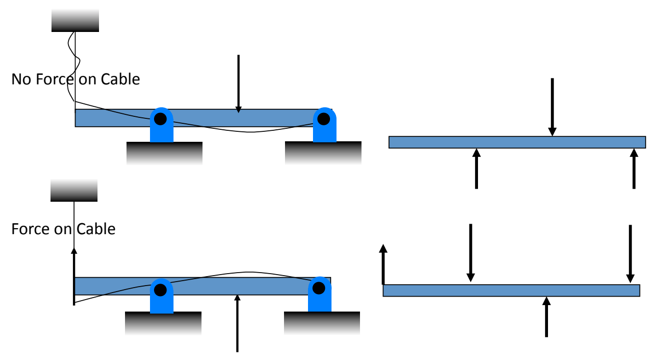
- **Free Body Diagram**
- **External Force**
  - *Surface Force & Traction*
  - *Body Force (weight)*
  - *Reactions*

- **Equation of Equilibrium**
  - *Balance of Force:* $\Sigma \mathbf{F} = 0$: $\Sigma F_x = 0$, $\Sigma F_y = 0$ (2-D), $\Sigma F_z = 0$
  - *Balance of Moment:* $\Sigma \mathbf{M}_p = 0$: $\Sigma M_x = 0$, $\Sigma M_y = 0$, $\Sigma M_z = 0$ (2-D)

Boundary Conditions



Tension in Cable



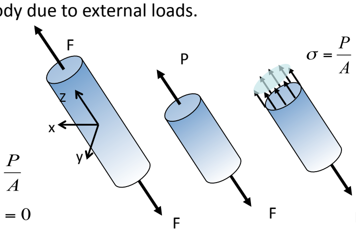
1.3 STRESSES

Stresses

The reaction of a deformable body due to external loads.

Why do we use Stresses rather than Loads and Moments?

$$\sum F_x = 0;\ \sum F_y = 0;$$
$$\sum F_z = 0;\ \int dF = \int_A \sigma dA;\quad \sigma = \frac{P}{A}$$
$$\sum M_x = 0;\ \sum M_y = 0;\ \sum M_z = 0$$



$\sigma = \frac{P}{A}$

English unit - psi (Pound per inch^2), ksi(10^3psi)

SI Unit - Pa (N/m2), kPa (10^3Pa), MPa(10^6Pa), GPa (10^9Pa)

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1.4 Analysis and Design

- Allowable Stress – Related to Material Properties (e.g. Strength)
- Allowable Load - Related to Material Properties and Geometry
- Analysis - Check for failure
  - Material Limitation - Allowable Stress (e.g. Yield Strength)

$$\sigma = \frac{P}{A} < \sigma_{allow}$$

- Design
  - Based on Material Limitation, the size of a structure can be designed.

$$\sigma_{allow} = \frac{P}{A}, \qquad \text{Slove for } Area \text{ or } Diameter$$

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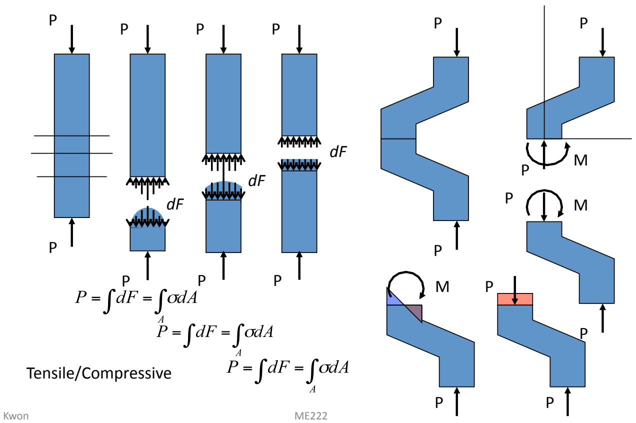
1.5 Axial Loading-Normal Stress



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