Stress Analysis

Mechanics: Stress and strain

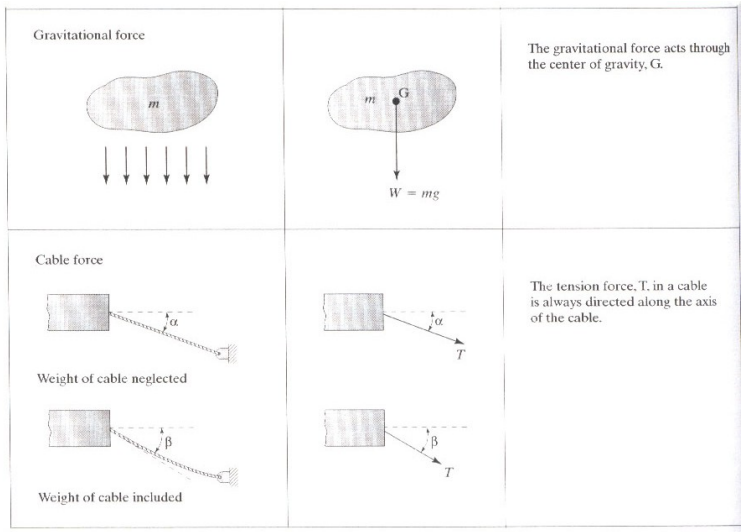
Topics

- Free Body Diagrams (Review)
- Stress
- Strain
- Deformation
- Hooke's Law
- Stress-Strain Diagrams
- Design: The Safety Factor

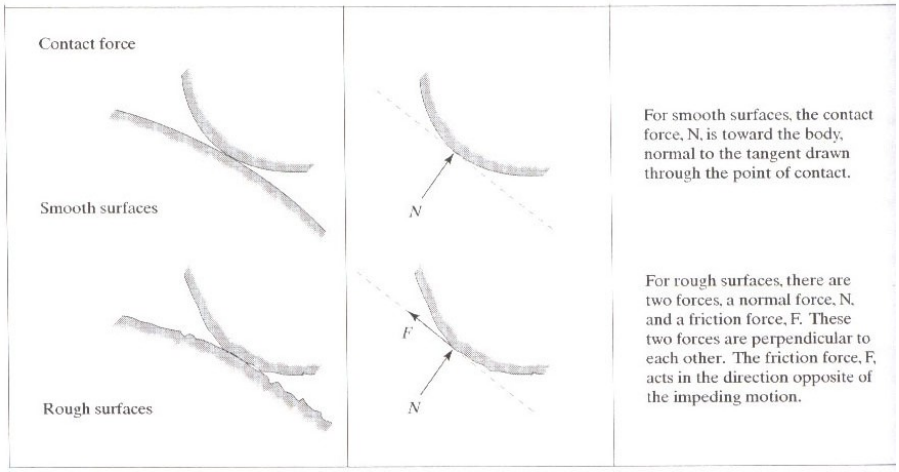
Free Body Diagrams

- Shows all external forces acting on the body
- Procedure
  1. Identify the isolated body and draw it
  2. At all force locations draw the vectors
     a. Supports
     b. Connections
     c. Contacts
  3. Add the Weight force
  4. Label forces with their value or a letter for unknowns
  5. Add a coordinate system
  6. Add geometric data (Lengths, angles, …)

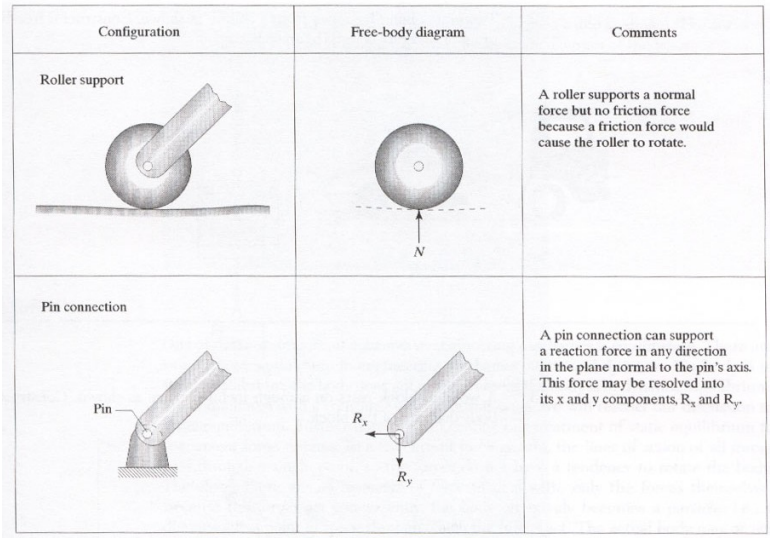
Examples 1



Examples 2



Examples 3



Stress

- Internal Forces
  - Reaction to external forces
  - Distributed throughout volume of material
- Stress
  - Normal stress
    - Acts at right angles to a selected plane
    - The axial direction in a rod or cable
  - Shear stress: stays in the selected plane (advanced topic: Strength of materials course)
  - **Can a structure withstand the forces applied to it?**

Stress 2

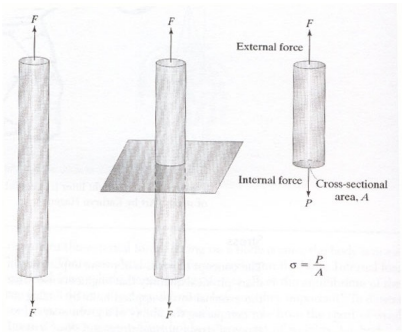
$\sigma = P/A$ (Pascals)

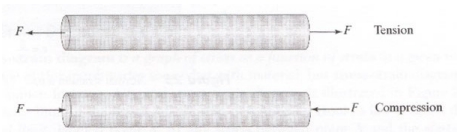
σ: Average stress

P: Applied force

A: Cross section area

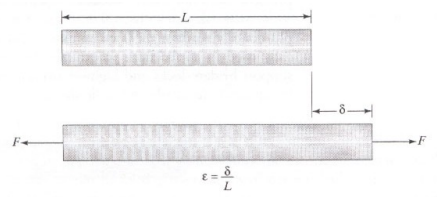
Tension / Compression





Strain

- Strain: deformation due to stress
  - $\varepsilon = \delta / L$
    - ε: Normal strain
    - δ: Change in length
    - L: Original (unstressed) length

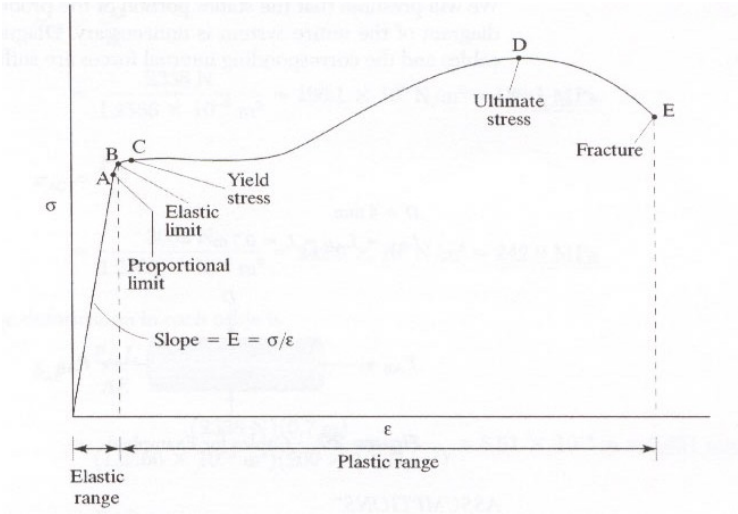


Hooke's Law

- Springs
  $F = kx$
  - F: Applied Force
  - k: Spring constant
  - x: displacement
- Stress-Strain
  $\sigma = E\varepsilon$
  - σ: Stress
  - E: Modulus of Elasticity
  - ε : Strain
- Using
  $\sigma = P / A$ and
  $\varepsilon = \delta / L$

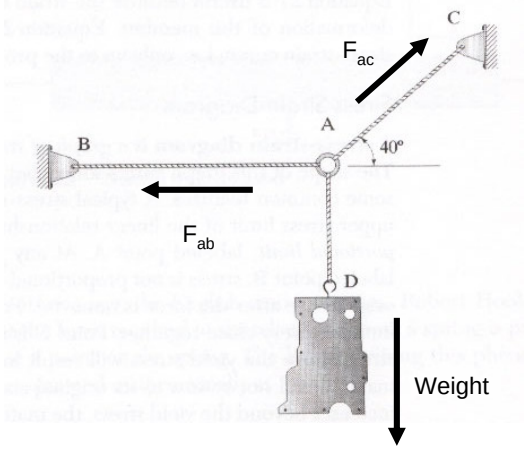
$$\delta = \frac{P * L}{A * E}$$

Stress-Strain Diagram



Example 6

- 200 kg engine block
- Cables
  - 0.7 m long
  - 4 mm diameter
  - E = 200 GPa
- Find
  - Normal Stress
  - Axial Deformation



F = 200 kg * 9.8 m/sec^2

F = 1960 newtons