Review Sheet
Saturday, October 19, 2019 6:47 PM

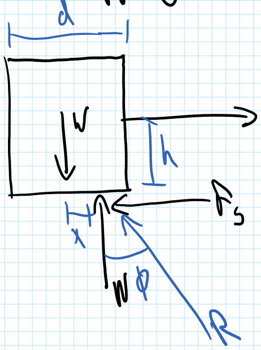
Friction

- force, acts tangential to surface
- resists movement
- Coulombic Friction

$$F_s \le \mu_s F_N \qquad F_K = \mu_K F_N$$

- due to inherit roughness of surfaces

- Block tipping?



Tip if $P \cdot h > W \cdot x$

or

$$\frac{2h}{d} > \frac{1}{\mu_s}$$

$$\phi = \arctan\left(\frac{F_s}{N}\right)$$
$$= \arctan(\mu_s)$$

Belts and Pulleys

- F_N, friction, T are not uniform throughout system

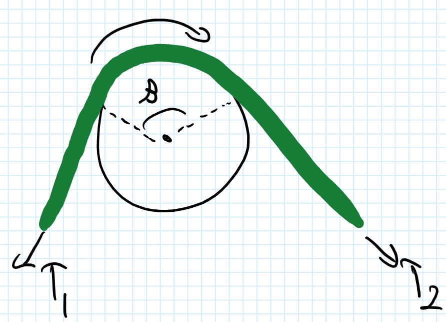
$$T_2 = T_1 e^{\mu \beta}$$

β ← angle of engagement

μ ← static coefficient of friction

T_2 ↑ direction of rotation

T_1 ↑ smaller tension



Trusses

- structure made up of multiple slender members connected at ends via pins

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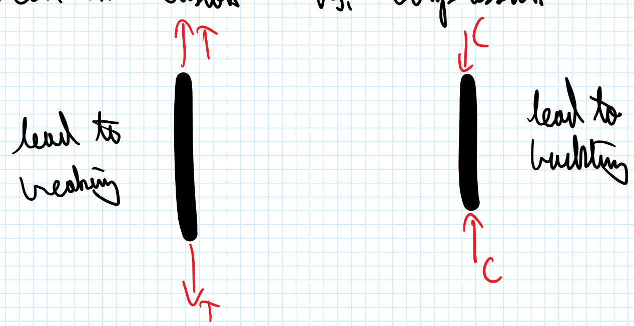
- all forces act on joints
  - ∴ all beams are 2 force members
- single base unit is a Δ

Beam in Tension vs. Compression



- How to solve truss problems
  1. Solve for reaction forces
  2. Use Method of Joints / Sections

Method of Joints

Look at a joint and all the forces acting on it. Solve ≃ equations to get unknowns

Method of Sections

Make a cut through members to reveal internal forces, solve for unknowns

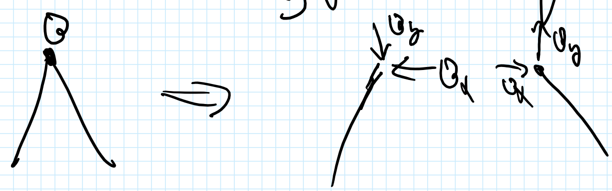
* Draw unknown forces in tension, if they turn out to be −, then they are in compression

- Zero force members
  - in a joint with 3 members, if 2 are colinear the third is a 0 force member

Frames / Machines

- not all 2 force members

- frames support loads
- machines contain moving parts and transmit/manipulate force
- disassemble frames at their joints
  - for two members, forces are equal and opposite



- Draw FBD for different components/groups of components to solve for desired unknown forces

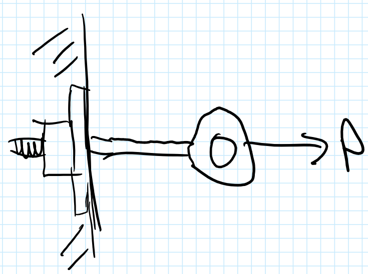
Internal Loads / Normal Stress

- Normal stress

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

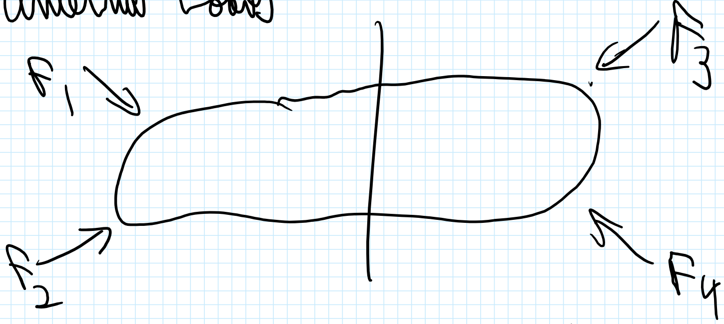
- Bearing stress

$$\sigma_b = \frac{P}{A_{projected}}$$



Bearing surface = surface of contact

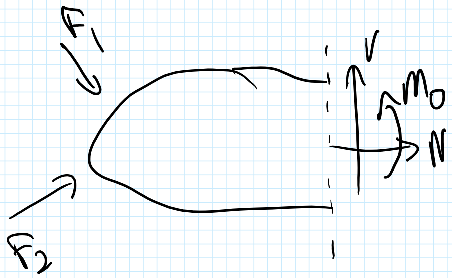
Internal Loads



- cut plane, expose internal forces

F_2 F_4

– cut plane, expose internal forces



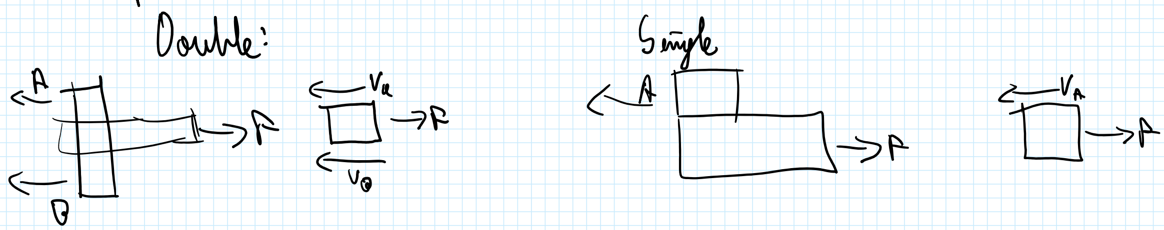
N: normal force
V: shear force
M_0: bending moment

Positive conventions

Shear Stress

$$\tau = \frac{V}{A}$$ ← A is ∥ to force

– on a pin



– yield strength: strength at which a material ceases to be elastic

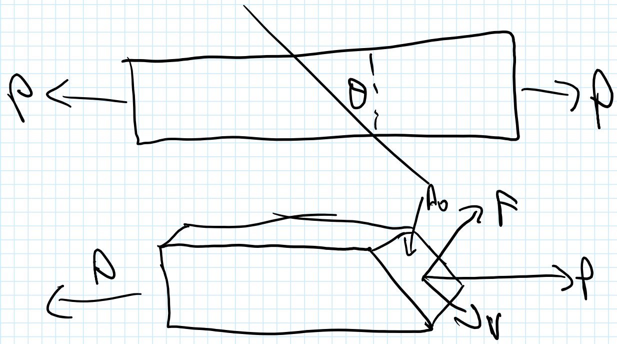
– Ultimate strength: max strength of a material

– factor of safety

$$FoS = \frac{\sigma_{fail}}{\sigma_{design}}$$

– stress on an inclined plane

- stress on an inclined plane



$F = P\cos\theta$

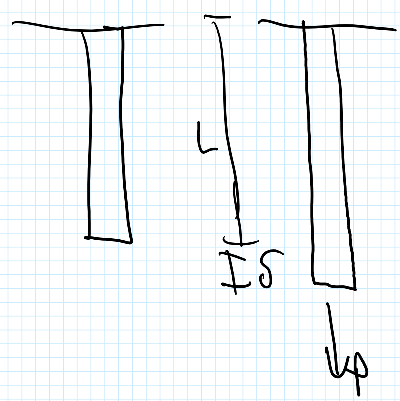
$V = P\sin\theta$

$A_\theta = \dfrac{A}{\cos\theta}$

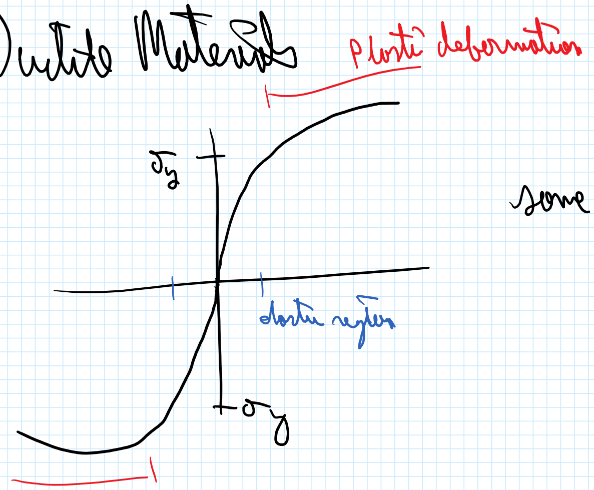
Strain

- deformation, change in length

$\epsilon = \dfrac{\delta}{L}$ ← stretch, ← original length



Ductile Materials



same yield strength in tension and compression

Brittle Materials

- much larger yield strength in compression

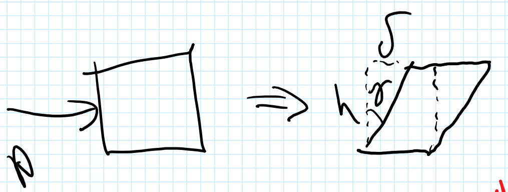
Young's Modulus

- material property which connects stress / strain

$$\sigma = E \cdot \epsilon$$

(σ: stress; E: young's modulus; ϵ: strain)

Shear strain



$$\tan \gamma = \frac{\delta}{h}$$

small angle aprox.

$$\gamma = \frac{\delta}{h}$$

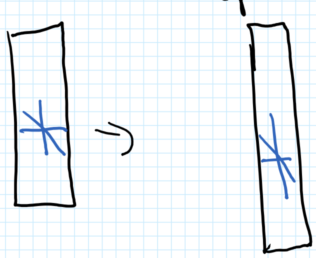
Shear Modulus

$$\tau = G \, \gamma$$

(τ: shear; G: shear modulus; γ: shear strain)

Contraction During Strain

- strain also develop ⊥ to applied load



Poisson's Ratio $\nu = \left| \frac{\text{Lateral strain}}{\text{Axial strain}} \right| = -\frac{\varepsilon_y}{\varepsilon_x} = -\frac{\varepsilon_z}{\varepsilon_x}$

- cannot be greater than 0.5