Free Body Diagrams

System

- any isolated part or portion of a machine or structure

- Used to identify and isolate both internal and external loads on a design element (system)
- Defines coordinate system(s)
- Defines all Known and unKnown loads

$$\sum \bar{F} = \frac{d(\bar{p})}{dt}$$ ($\bar{p}$: linear momentum)

Newton's Second Law

$$\sum \bar{M} = \frac{d(\bar{H})}{dt}$$ ($\bar{H}$: angular momentum)

Euler's Equation of Motion

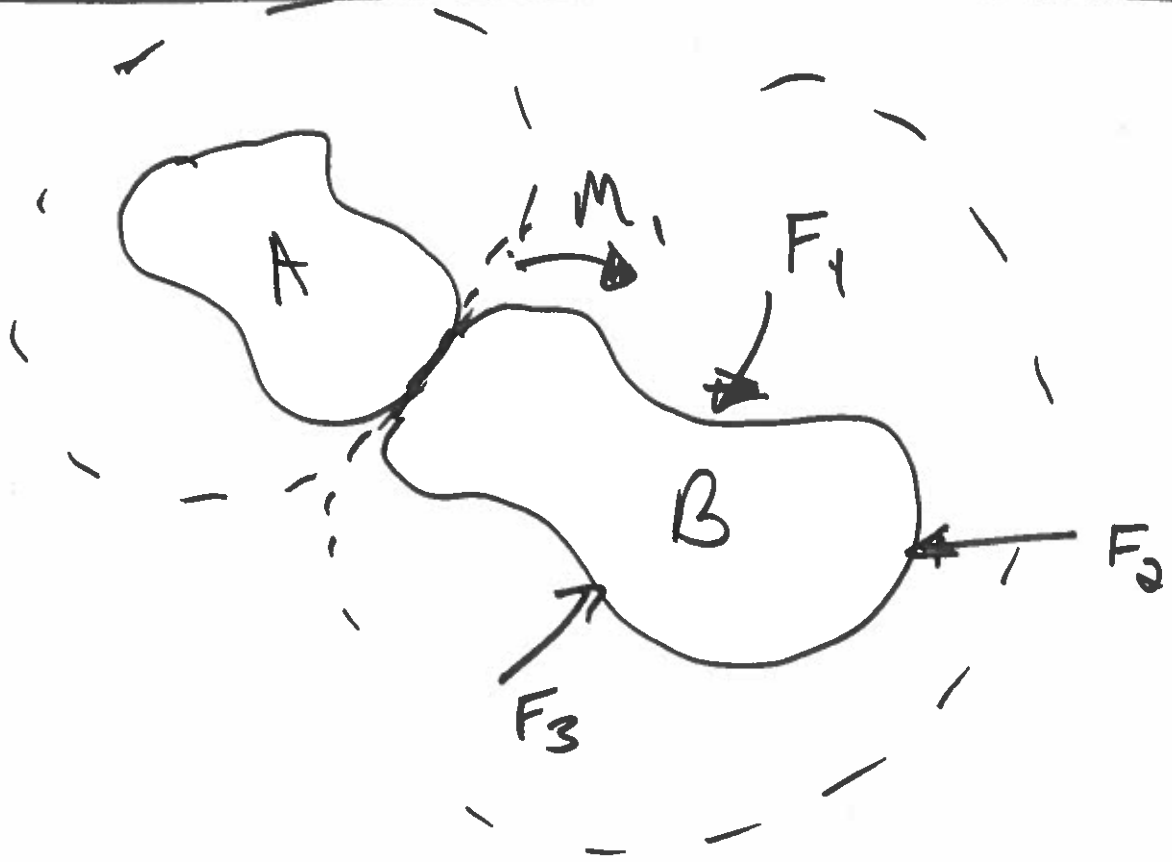
Equilibrium

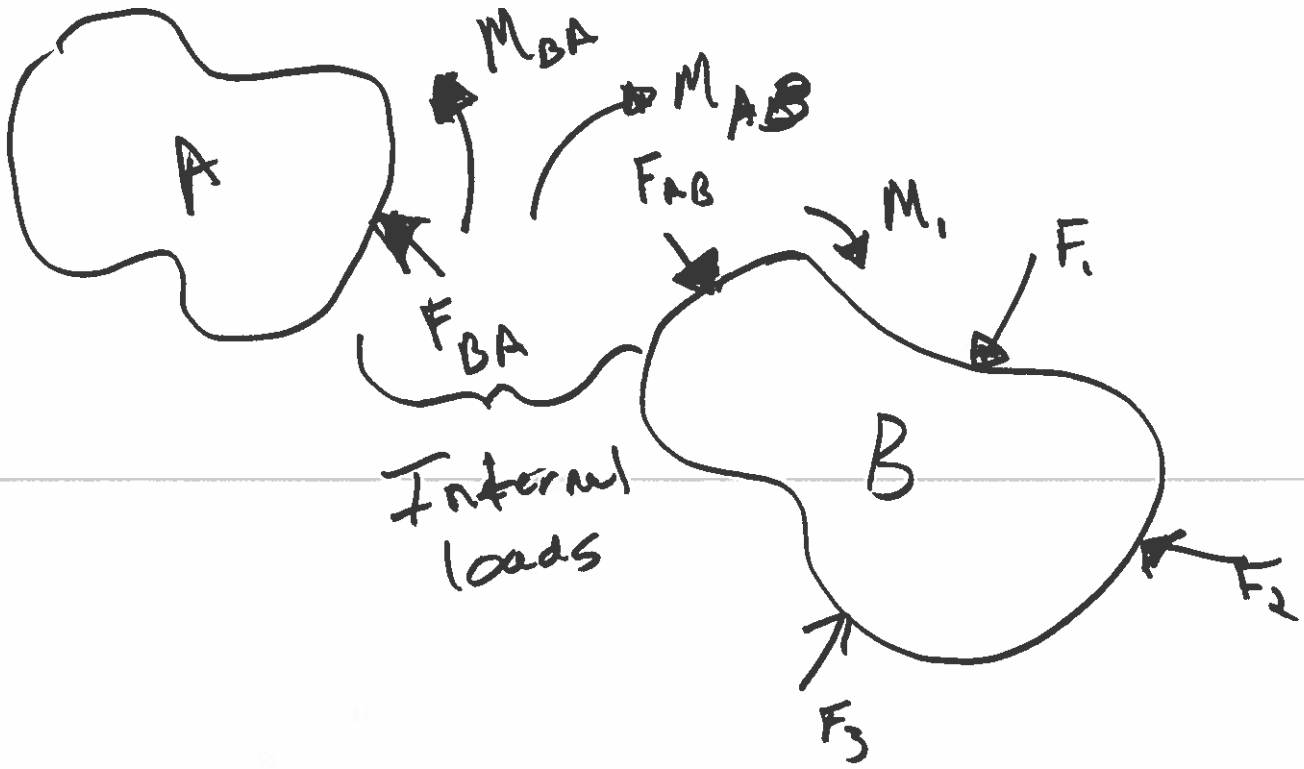
$$\frac{d\bar{P}}{dt} = 0 \qquad \frac{d\bar{H}}{dt} = 0$$

$$\boxed{\sum \bar{F} = 0 \qquad \sum \bar{M} = 0}$$

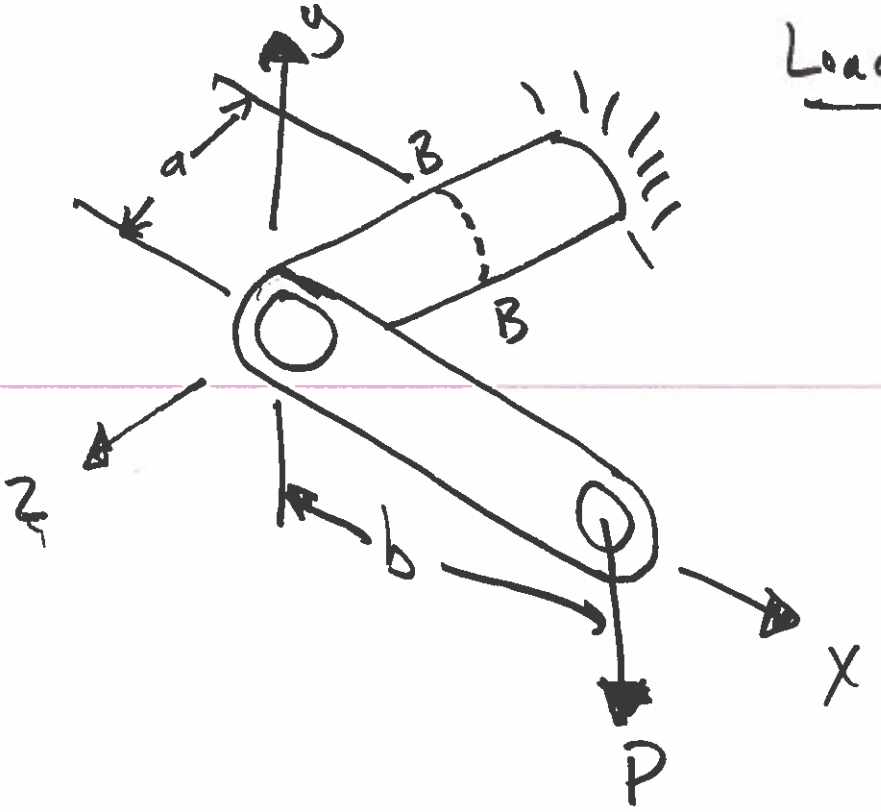
Static Equilibrium

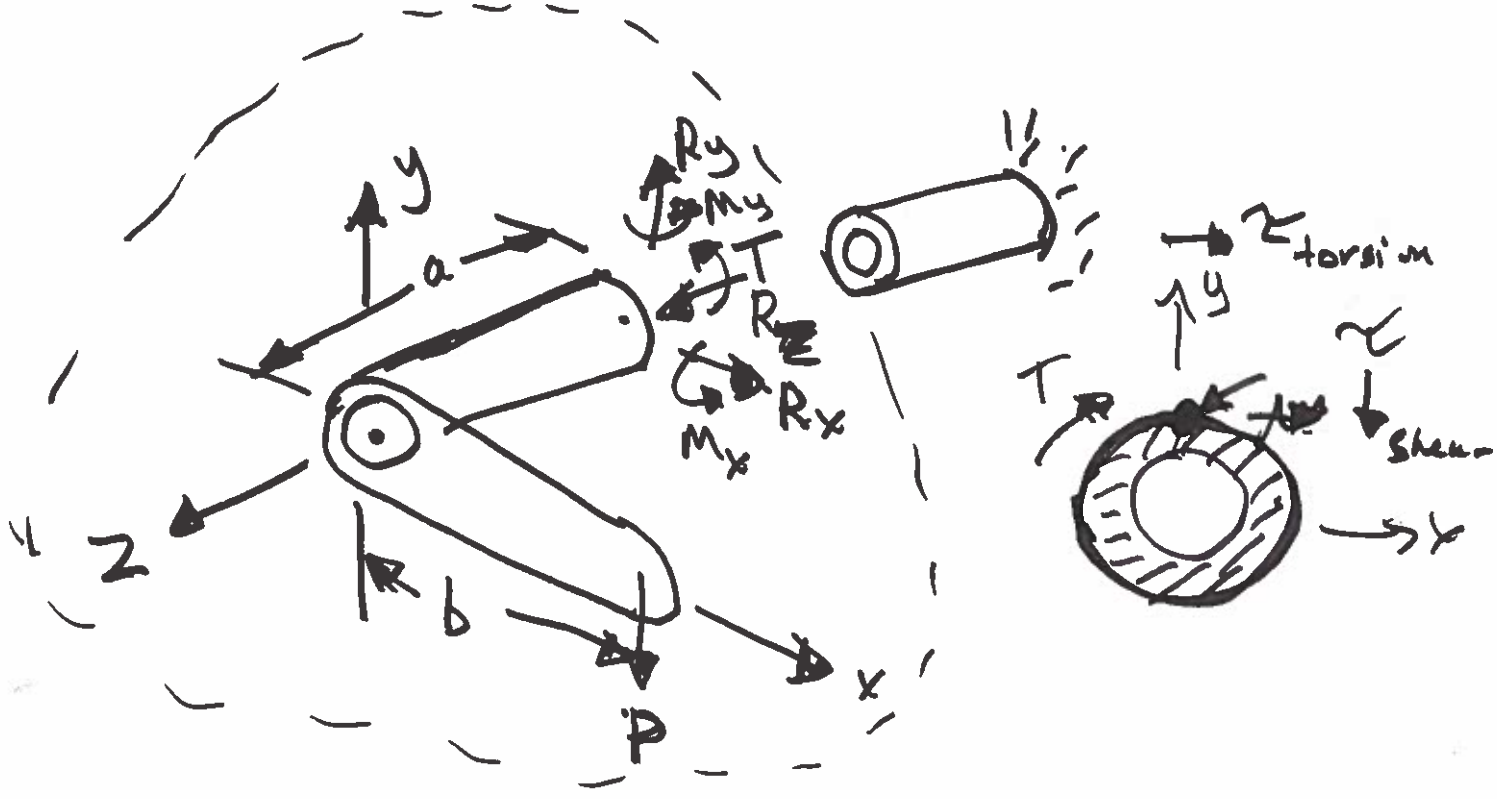
↳ object is at rest




A
M_{BA}
M_{AB}
F_{AB}
M_1
F_1
F_{BA}
Internal loads
B
F_2
F_3

Find the internal Loads at B-B





$\Sigma F = 0$

$\Sigma F_x = R_x = 0$

$\Sigma F_y = R_y - P = 0$

$R_y = P$ shear load

$\Sigma F_z = R_z = 0$

$\Sigma M = 0$

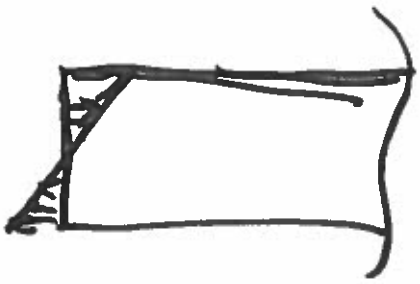
$\Sigma M_x^B = M_x + Pa = 0$

$M_x = -Pa$ bending

$\Sigma M_y^B = M_y = 0$

$\Sigma M_z^B = T - Pb = 0$

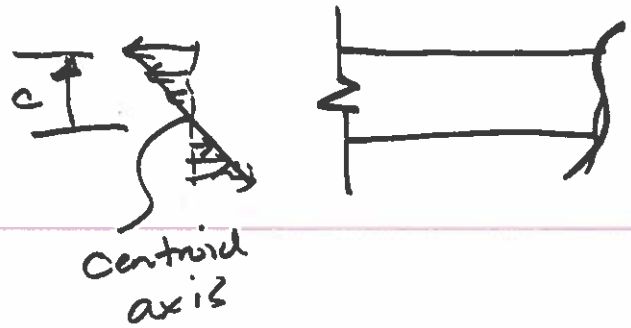
$T = Pb$ torsion / twist



Bending Stresses

$$\sigma_{max} = \frac{Mc}{I}$$

→ Second moment of area



Normal Stress

$$\sigma = \frac{P}{A}$$ – cross section area

Torsional Stress

$$\tau_{max} = \frac{Tr}{J}$$ – radius of outer surface

– polar second moment of area

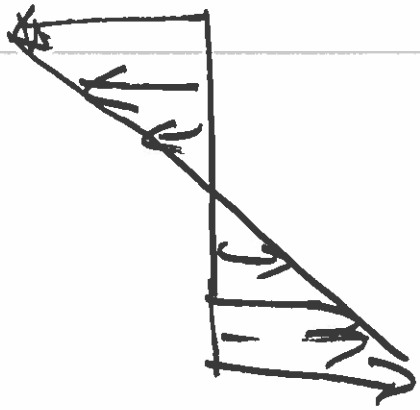
Axial

$$\sigma_{max} = \frac{P}{A} = \frac{\text{load}}{\text{areas}}$$

Bending

$$\sigma_{max} = \frac{Mc}{I}$$

M: moment
c: distance from centroidal axis
σ_{max}
I: second moment of area



Torsional

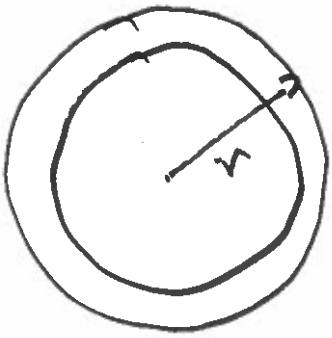
$$\tau_{max} = \frac{Tr}{J}$$

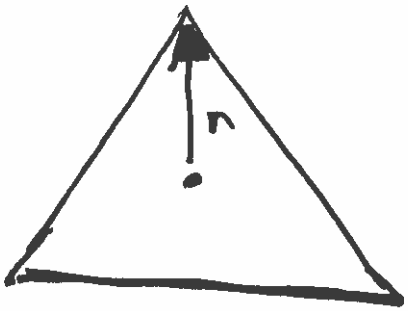
T: Torque outer radius
J: second polar moment of area

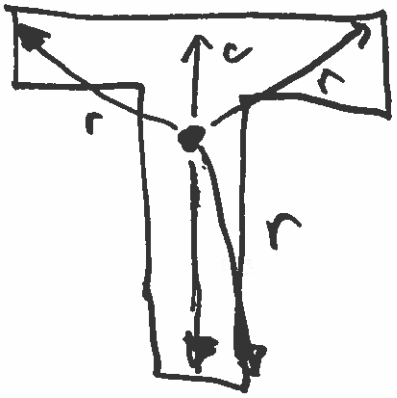
Table A-18 in the book provides area moments of inertia.

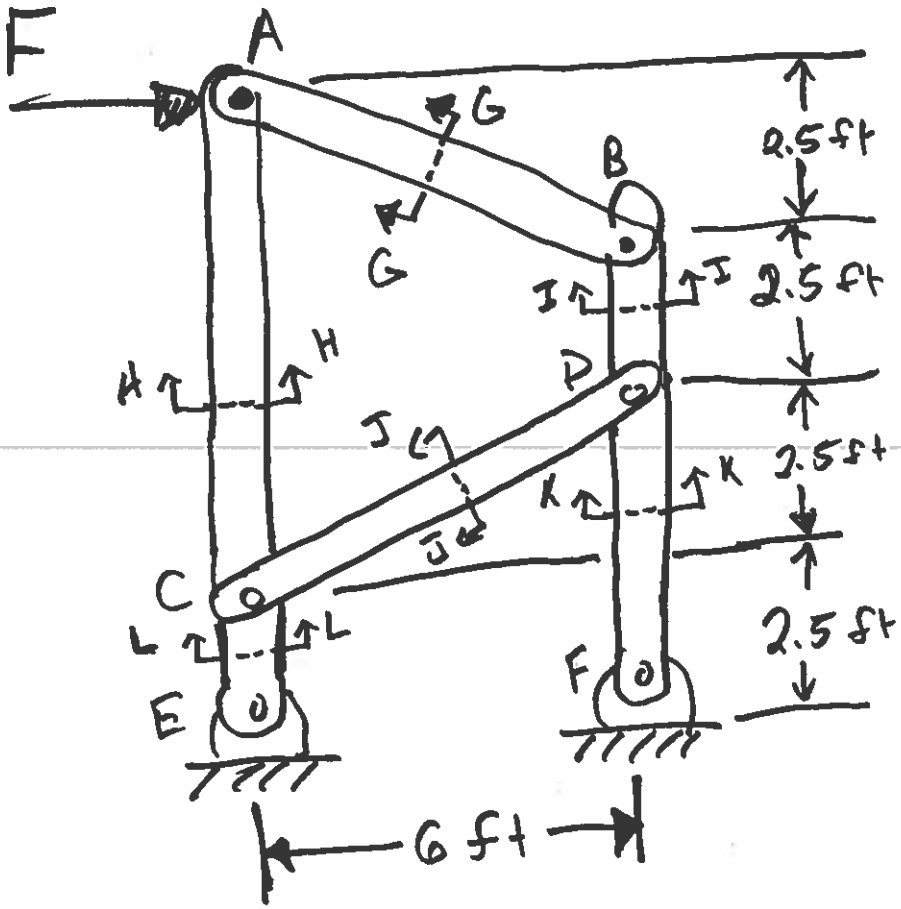
Wikipedia offers the same thing!

http://en.wikipedia.org/wiki/List_of_area_moment_of_inertia


r


r


r
r
r
r



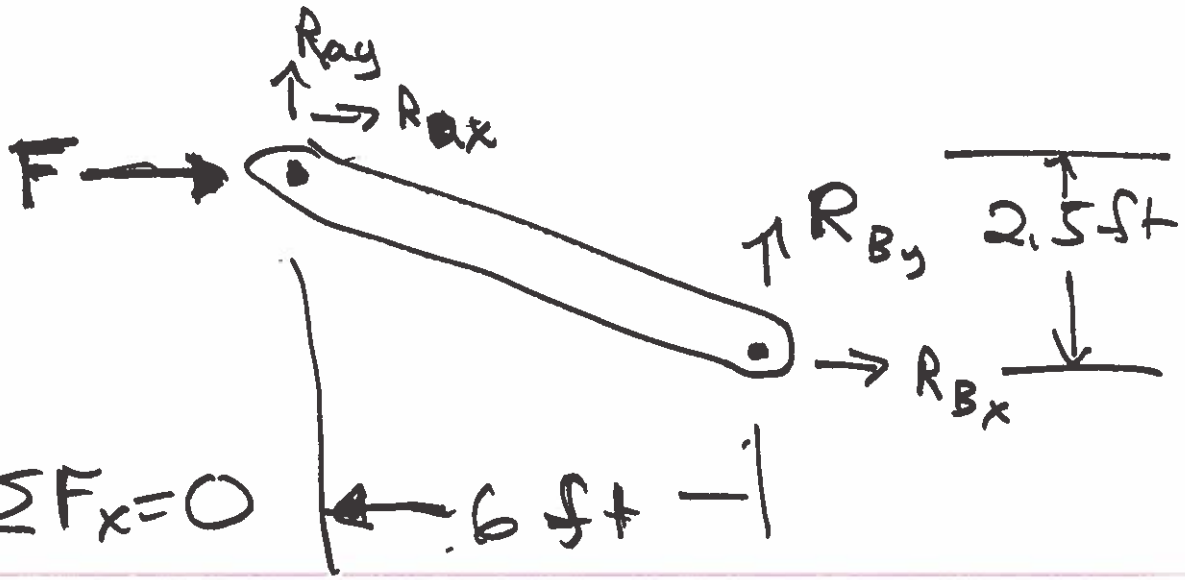
How many FBDs are needed to find the internal loads at all cross sections?

A. 4
B. 3
C. 5
D. 2

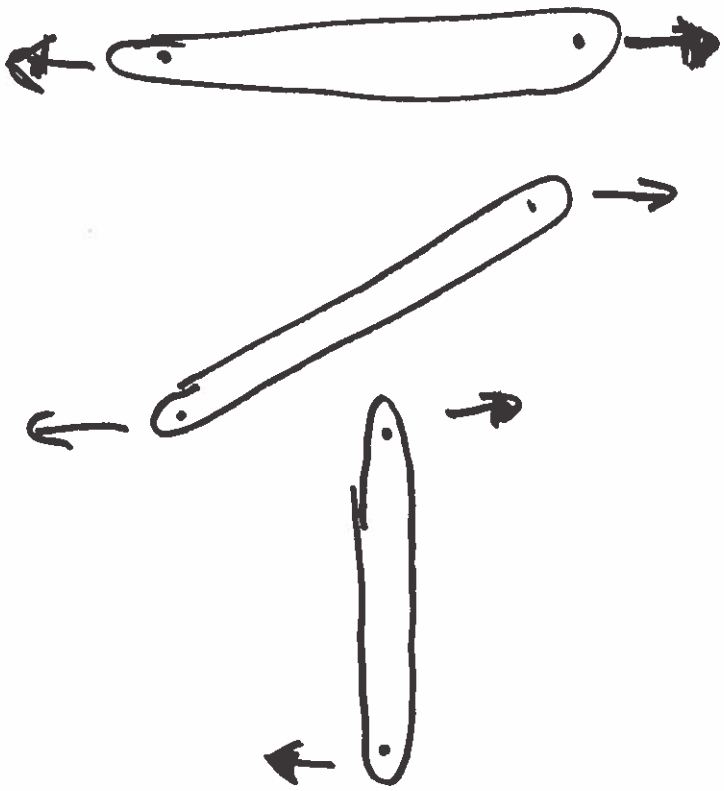
} Fix this => more change to at all the joints.

Is beam A-B in:

A. Tension
B. Compression
C. Compressin + bending
D. Tension + bending



compression / tension



If only pin joints and forces at pins, there is no way to put the member into bending (ignoring buckling loads).