CHAPTER 1

Introduction – Concept of Stress

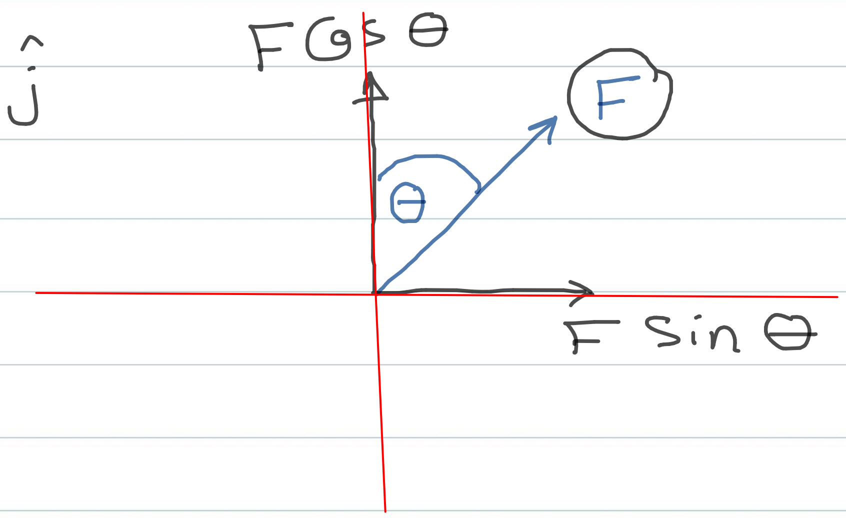
σ_{av}

τ_{av}

Rectangular/Cartesian Components Method

$\vec{F} = (F_x)\hat{i} + (F_y)\hat{j}$

$F = \sqrt{F_x^2 + F_y^2}$



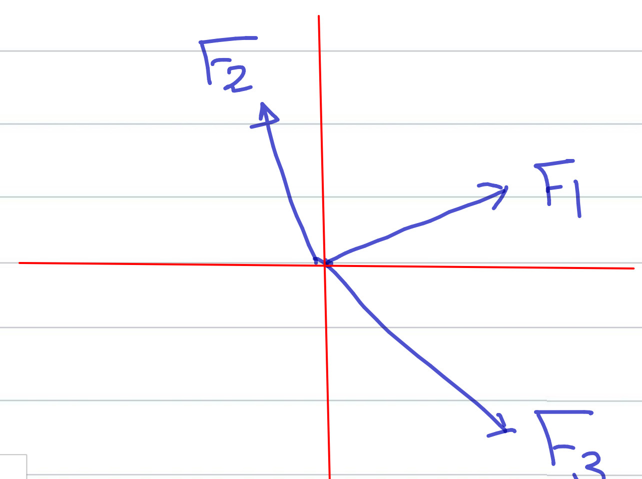
Equilibrium of a Particle

@ rest

① Resolve

② $\sum F_x = 0$ $\xrightarrow{+}$

$\sum F_y = 0$ $\uparrow +$



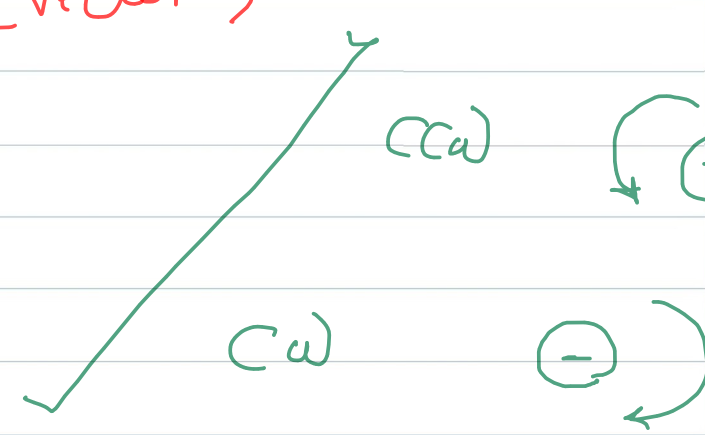
moment of the force

(Vector)

$M = \sum F * d_\perp$

x y

y x

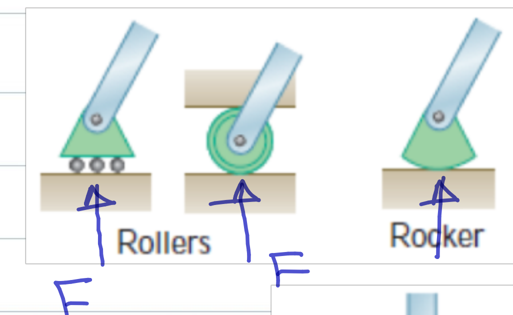


Equilibrium of Rigid Bodies

$\sum F_x = 0$ $\xrightarrow{+}$ $\sum F_y = 0$ $\uparrow +$ $\sum M = 0$ $\circlearrowleft +$

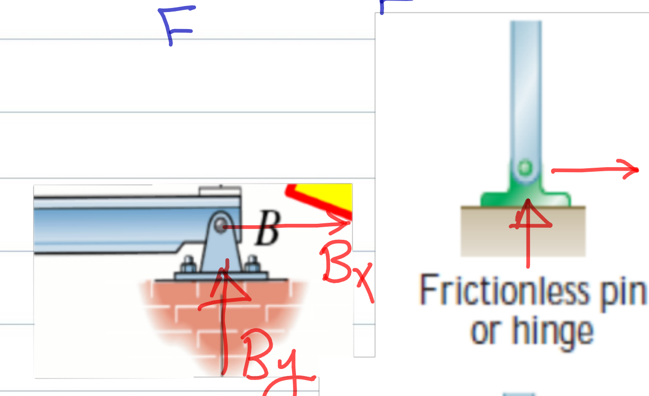
Support Reactions :–

① Roller



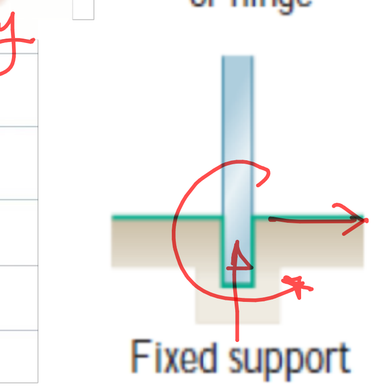
1- Reaction

② Pin or hinge



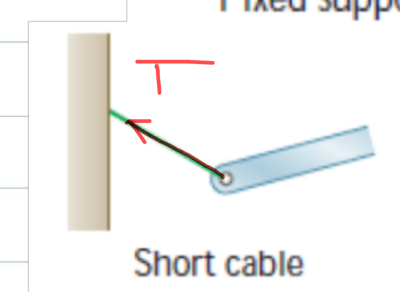
2- Reaction

③ Fixed



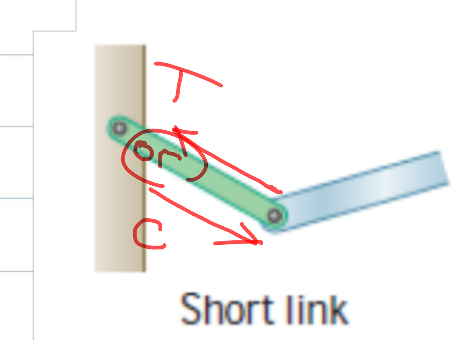
3-Reaction

④ Cable



only tension outside

⑤ Link



tension or compression

Example:

Consider the structure which was designed to support a 30-kN load. It consists of a boom AB with a 30 × 50-mm rectangular cross section and a rod BC with a 20-mm-diameter circular cross section. These are connected by a pin at B and are supported by pins and brackets at A and C, respectively. Find Force on Pins A, B and C.

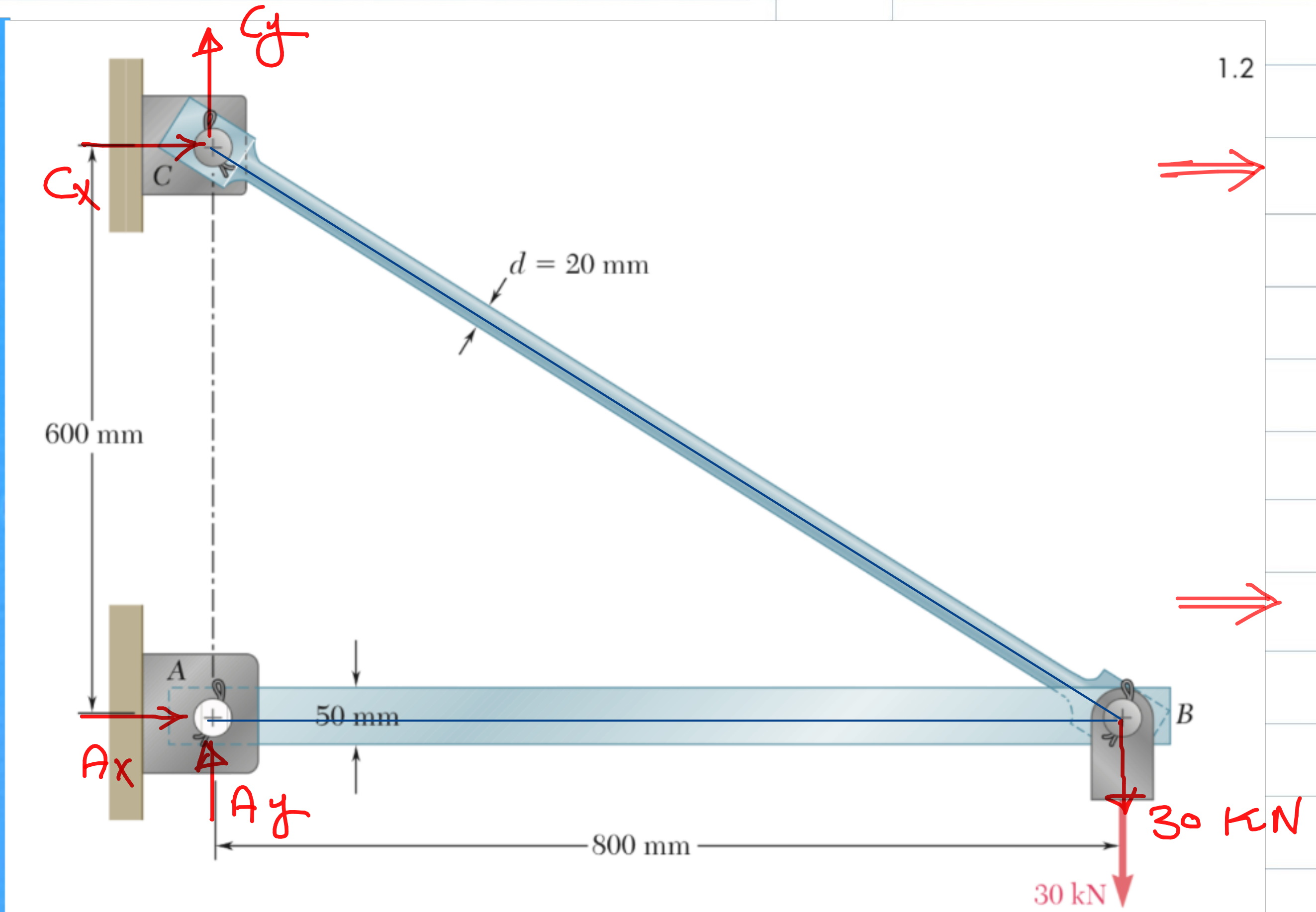
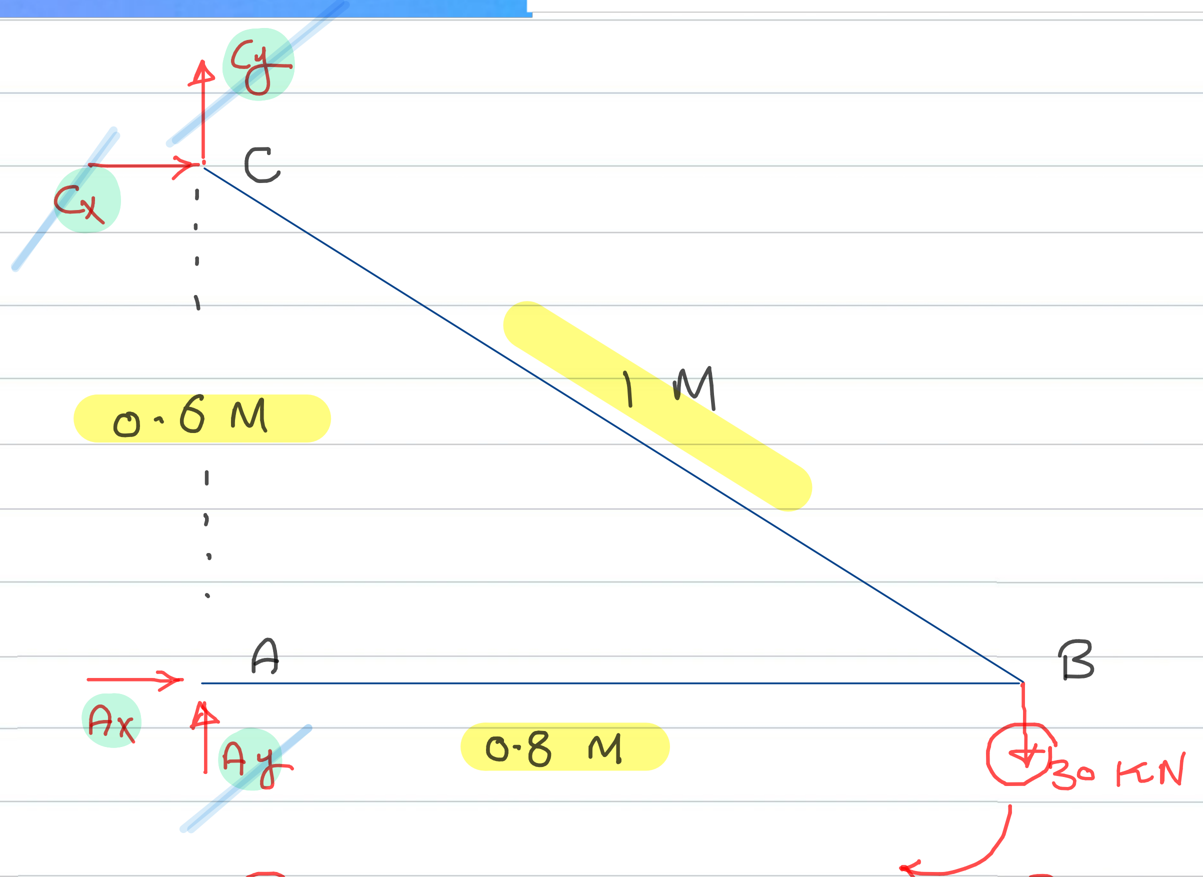


Fig. 1.1 Boom used to support a 30-kN load.



$$\Sigma M_C = 0 \quad \circlearrowleft +$$

$$A_x * 0.6 - 30 * 0.8 = 0$$

$$A_x = 40 \text{ kN}$$

$$\Sigma F_x = 0 \quad \xrightarrow{+}$$

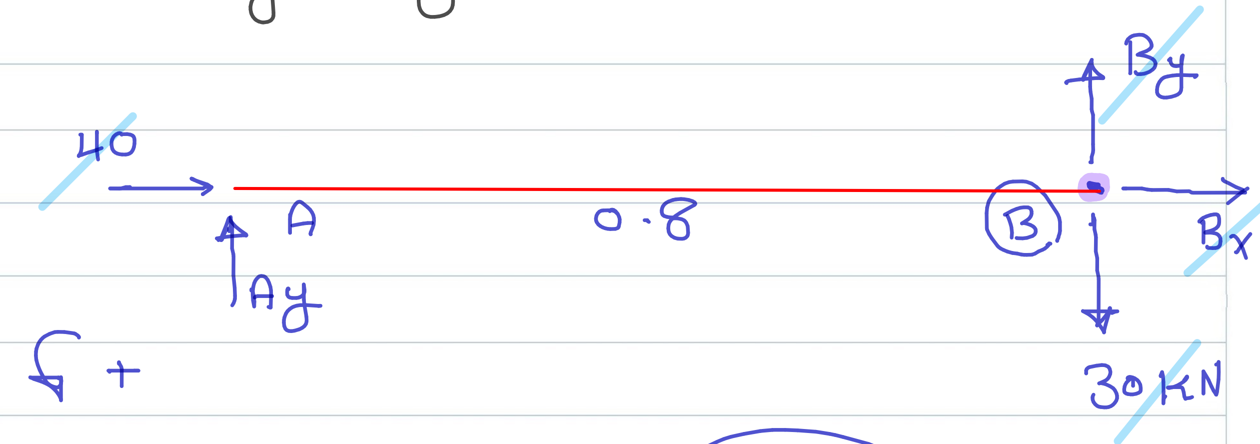
$$A_x + C_x = 0$$

$$C_x = -40 \text{ kN}$$

$$\Sigma F_y = 0 \quad \uparrow +$$

$$A_y + C_y - 30 = 0$$

$$A_y + C_y = 30 \Rightarrow \boxed{1}$$



$$\Sigma M_B = 0 \quad \circlearrowleft +$$

$$-A_y * 0.8 = 0 \Longrightarrow A_y = 0$$

in Eq[n] (1) $C_y = 30$ kN

$$\Sigma F_x = 0 \quad \xrightarrow{+}$$

$$B_x + 40 = 0$$

$$B_x = -40 \text{ kN}$$

$$\Sigma F_y = 0 \quad \uparrow +$$

$$0 + B_y - 30 = 0$$

$$B_y = 30 \text{ kN}$$

$$B = \sqrt{B_x^2 + B_y^2} = 50 \text{ kN}$$

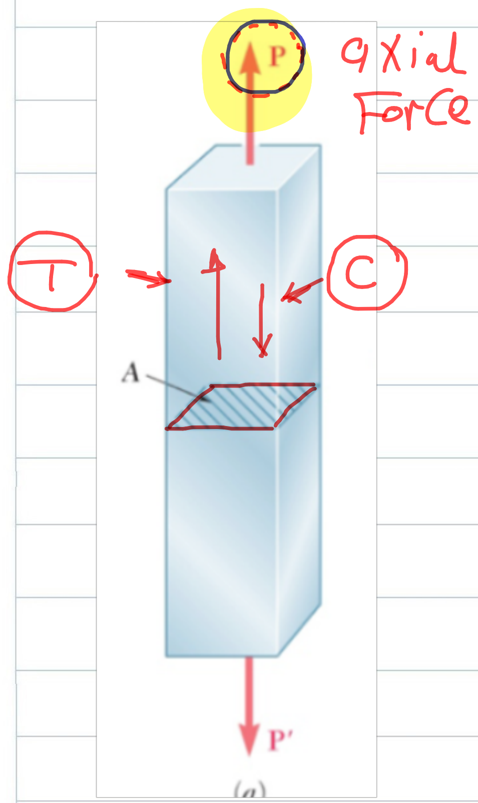
$$\theta = \tan^{-1}\frac{30}{-40} = \checkmark$$

Concept of Stress

$$\text{Stress} = \frac{\text{Force}}{\text{Area}} \qquad \left(N/m^2 = Pa \right)$$

Normal Stress

$P \perp A$



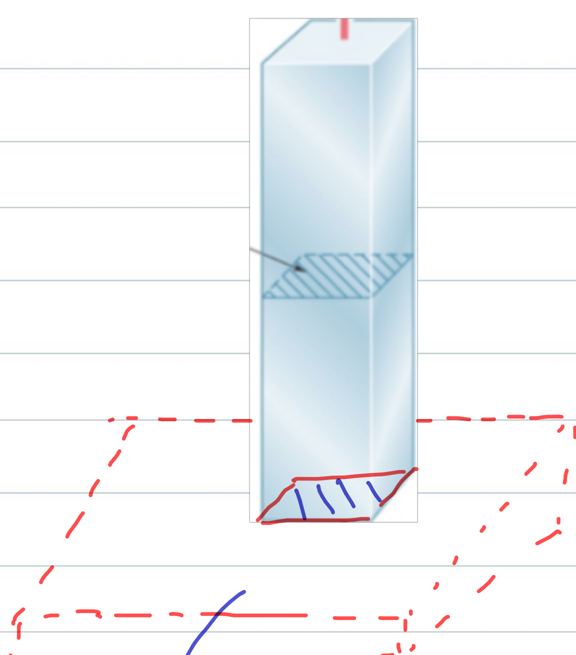
$$\sigma_{av} = \frac{P}{A}$$

$+$ Tensile Stress (outside)

$-$ Compression Force (inside)

Bearing Stress

$P \perp A$

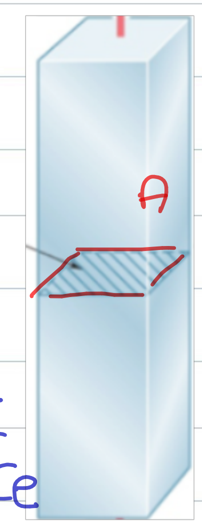


Contacting surface

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

Shear Stress

$P \parallel A$



$$\tau_{av} = \frac{P}{A}$$

Single Shear

Double Shear

Shearing Stress Examples

Single Shear

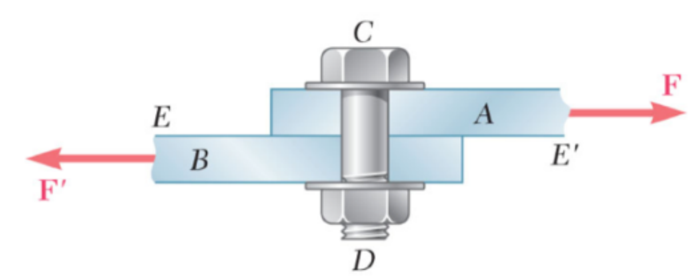
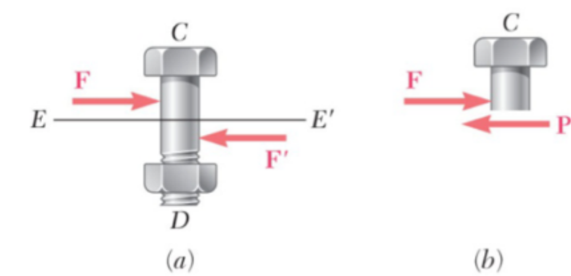
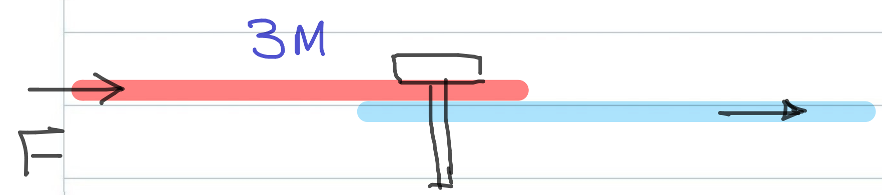


Fig. 1.16 Bolt subject to single shear.





2-Member

1-Cut

$$\tau_{av} = \frac{F}{A}$$

Double Shear

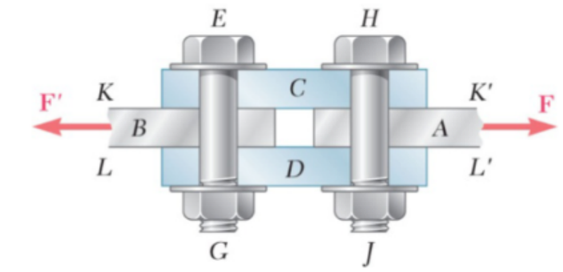
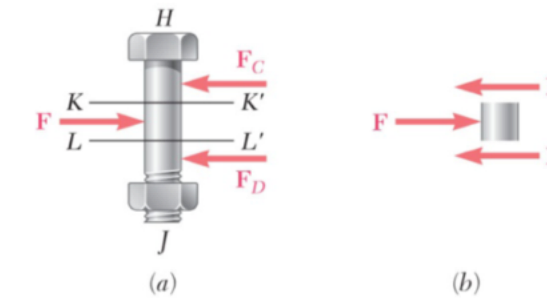
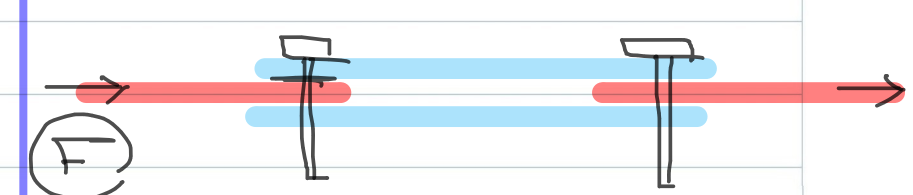


Fig. 1.18 Bolt subject to double shear.





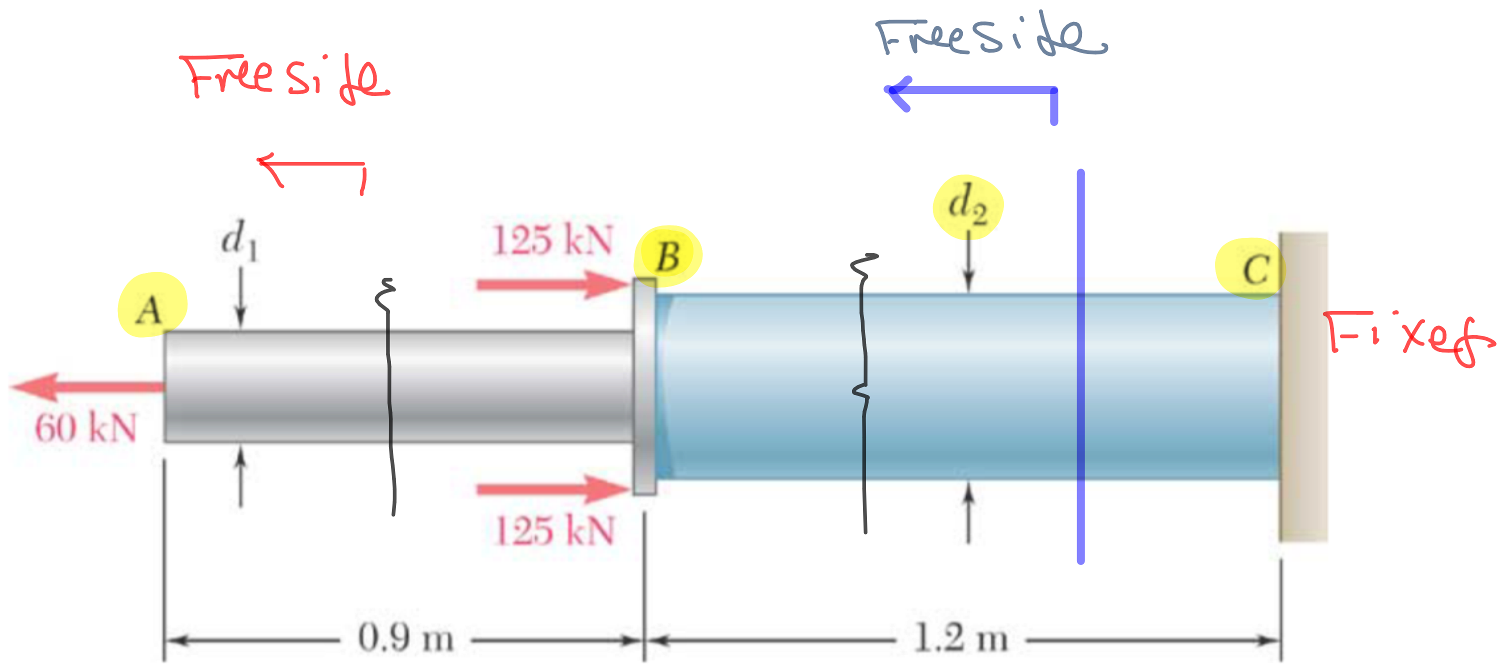
3-Member

2-Cut

$$\tau_{av} = \frac{F}{2A_{bolt}}$$

Problem # 1

Two solid cylindrical rods *AB* and *BC* are welded together at *B* and loaded as shown. Knowing that $d1 = 30$ mm and $d2 = 50$ mm, find the average normal stress at the midsection of (*a*) rod *AB*, (*b*) rod *BC*.



(a) rod AB :-

$$F_{AB} = 60 \text{ kN (tension)}$$

$$A_{AB} = \frac{\pi d_1^2}{4} = \frac{\pi}{4}\left(\frac{30}{1000}\right)^2$$

$$= 706.9 * 10^{-6} \text{ m}^2$$

$$\sigma_{AB} = \frac{F}{A} = \frac{60 * 10^3}{706.9 * 10^{-6}} = 84.9 * 10^6 \text{ Pa}$$

$$= 84.9 \text{ MPa}$$

Rod BC :-

$$P_{BC} = -125 - 125 + 60 = -190 \text{ kN}$$

$$A = \frac{\pi d_2^2}{4} = \frac{\pi}{4}\left(\frac{50}{1000}\right)^2 = 1.96 * 10^{-3} \text{ m}^2$$

$$\sigma_{BC} = \frac{P_{BC}}{A} = \frac{-190 * 10^3}{1.96 * 10^{-3}}$$

$$= -96.8 * 10^6 \text{ Pa}$$

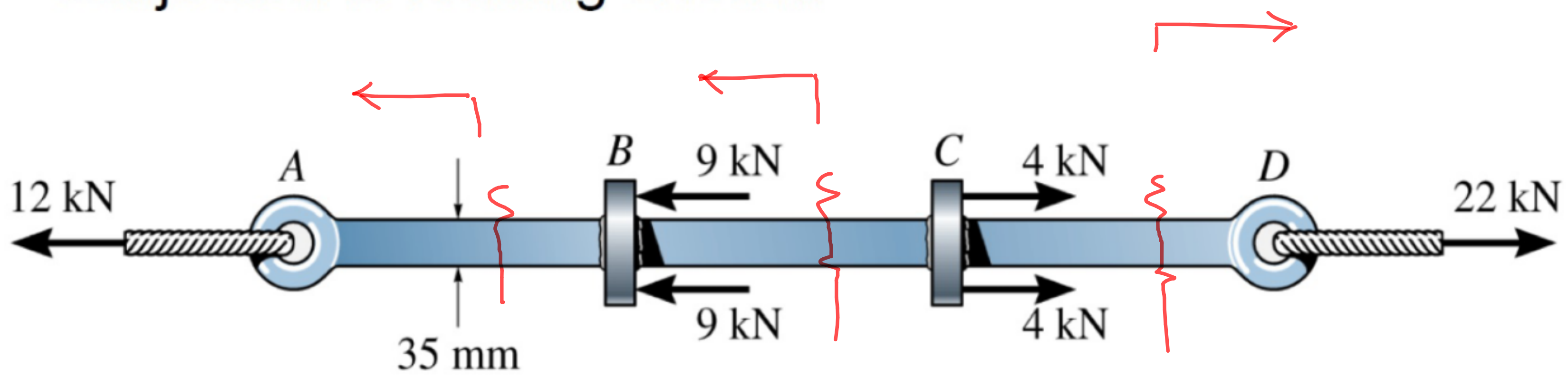
$$\sigma_{BC} = -96.8 \text{ MPa}$$

Quiz ①

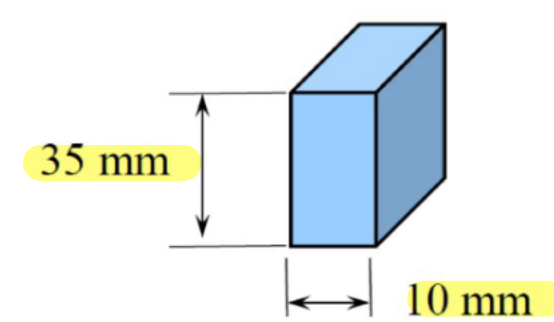
EXAMPLE 1.6

Bar width = 35 mm, thickness = 10 mm

Determine max. average normal stress in bar when subjected to loading shown.



SOL



Section → Change Area
→ Change Force

$P_{AB} = 12\ kN$ (tension)

$P_{BC} = 9 + 9 + 12 = 30\ kN$ (tension)

$P_{CD} = 22\ kN$ (tension)

$$\sigma_{Max} = \frac{P_{Max}}{A} = \frac{P_{BC}}{A}$$

$$= \frac{30 * 10^3}{35 * 10} \quad \frac{N}{MM^2}$$

$\sigma_{Max} = 85.7\ MPa$

tensile

stress

static

solid

Saturday