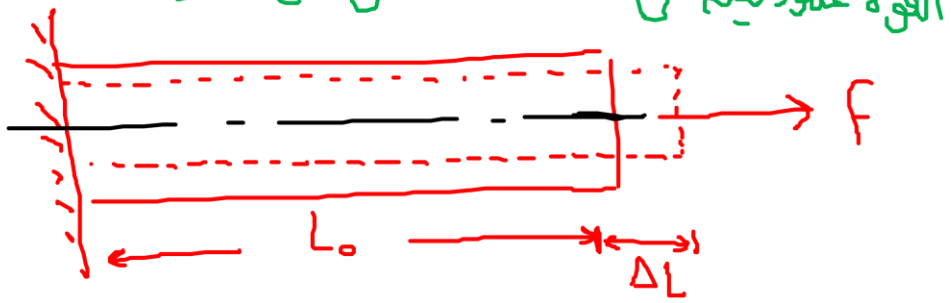
Solid Mechanics CE-211
Topic: Introduction and Stresses

* Normal Stress (σ)

القوة عمودية على المساحة - موازية لمحور العمود



الإجهاد Stress

$$\sigma = \frac{Force}{Area}$$

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

$$\varepsilon = \frac{\Delta L}{L_o}$$

Strain الانفعال

وحدة قياس الإجهاد $\frac{N}{m^2} \Rightarrow Pascal$

$KPa \rightarrow 10^3 Pa$

$MPa \rightarrow 10^6 Pa \Rightarrow \frac{N}{mm^2}\ (MPa)$

$GPa \rightarrow 10^9 Pa$

Modulus of Elasticity

$$E = \frac{\sigma}{\varepsilon}$$

Young's Modulus

معادلات الاتزان

$$\Sigma f_x = 0$$

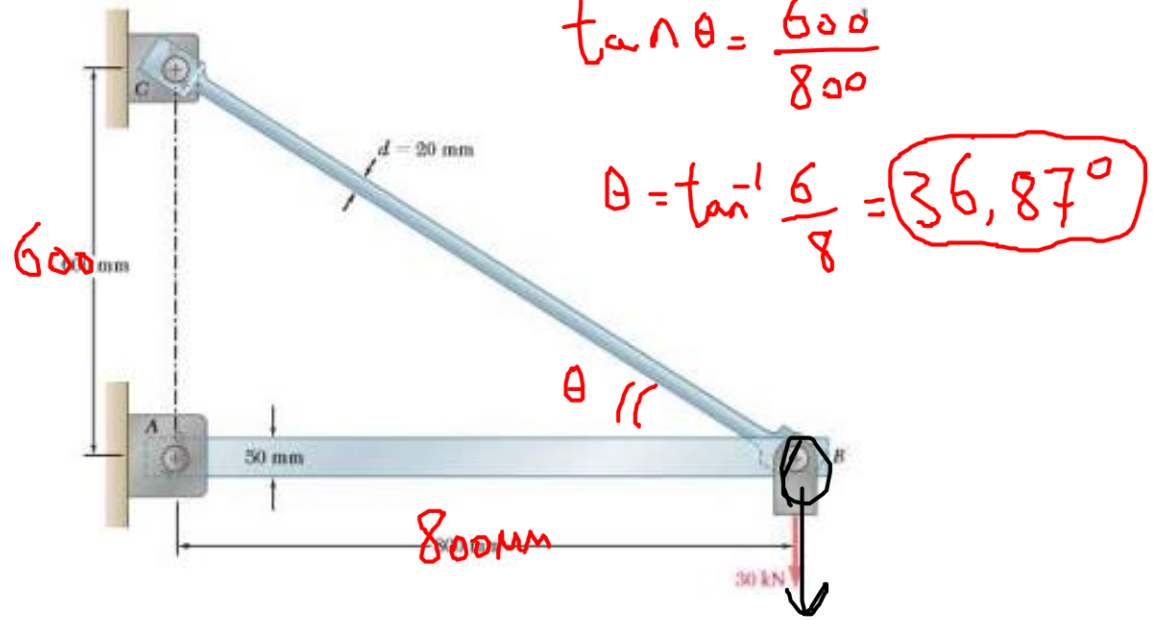
$$\Sigma f_y = 0$$

$$\Sigma M = 0$$

ردود الأفعال

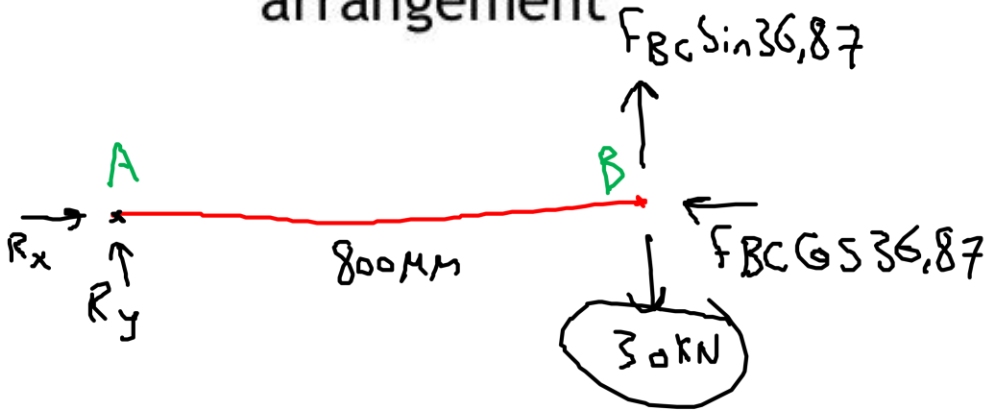
a) Find stresses in bar AB and BC.

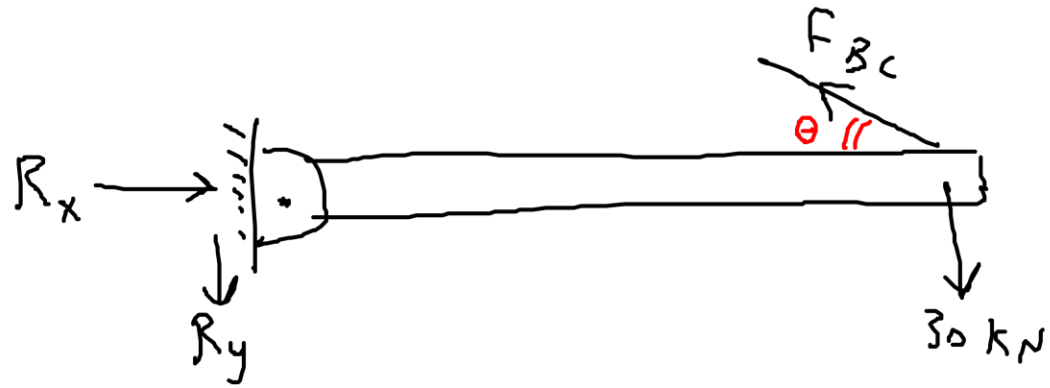
b) If maximum permissible stress (strength) for AB and BC is ***8000 MPa***, comment about the safety of the arrangement



$\tan\theta = \frac{600}{800}$

$\theta = \tan^{-1}\frac{6}{8} = 36,87°$





$\Sigma M_A = zero$

$30 * 800 - F_{BC}\sin 36,87 * 800 = zero$

$F_{BC} = 50\ kN$

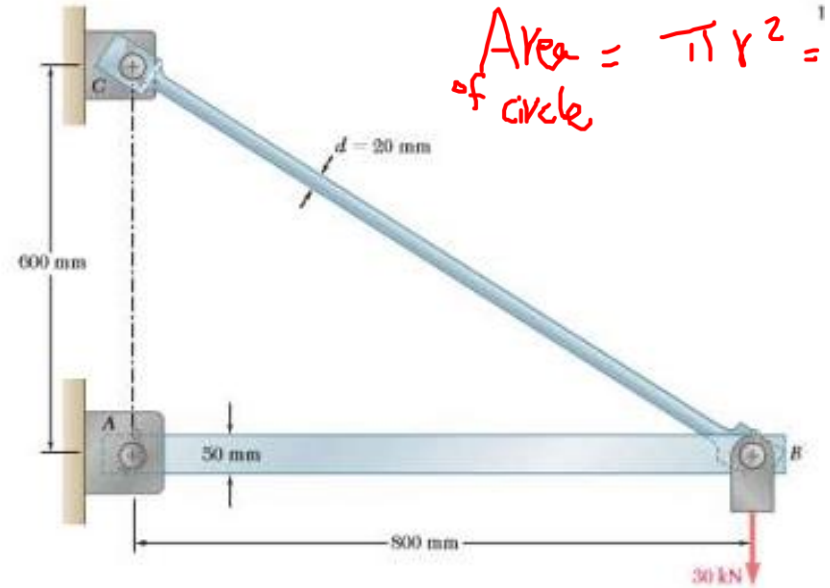
$\Sigma F_x = zero \qquad R_x - 50\cos 36,87 = zero$

$R_x = 40\ kN$

a) Find stresses in bar AB and BC.

b) If maximum permissible stress (strength) for AB and BC is ***8000 MPa***, comment about the safety of the arrangement

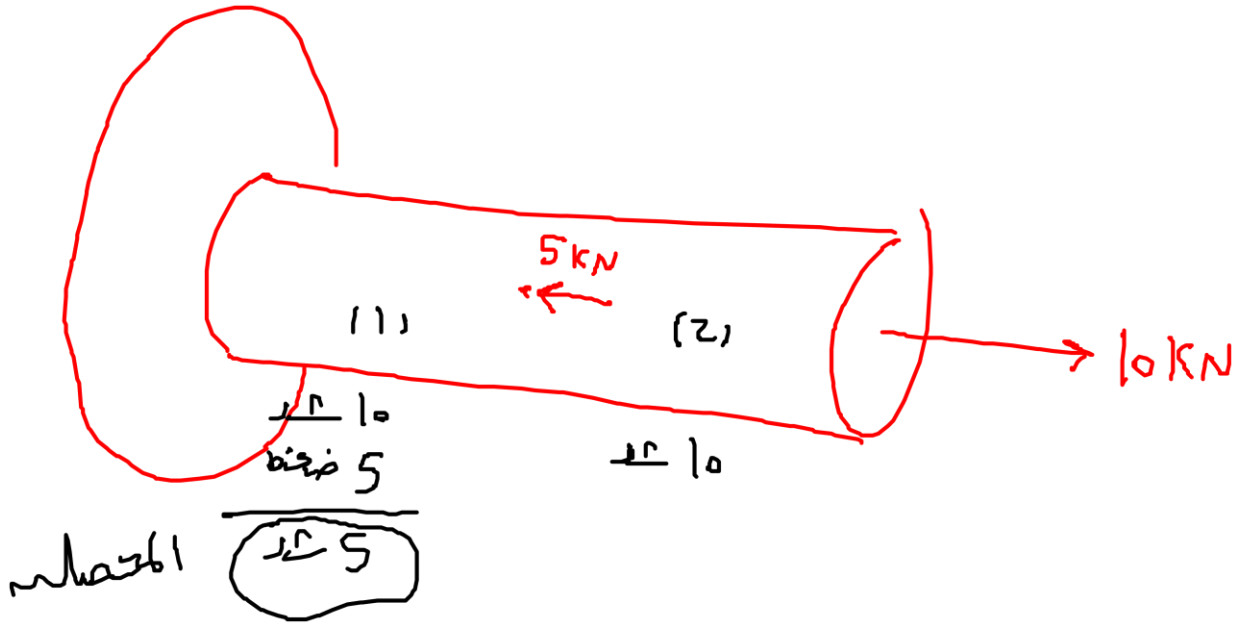
أقصى اجهاد يتحمله المادة



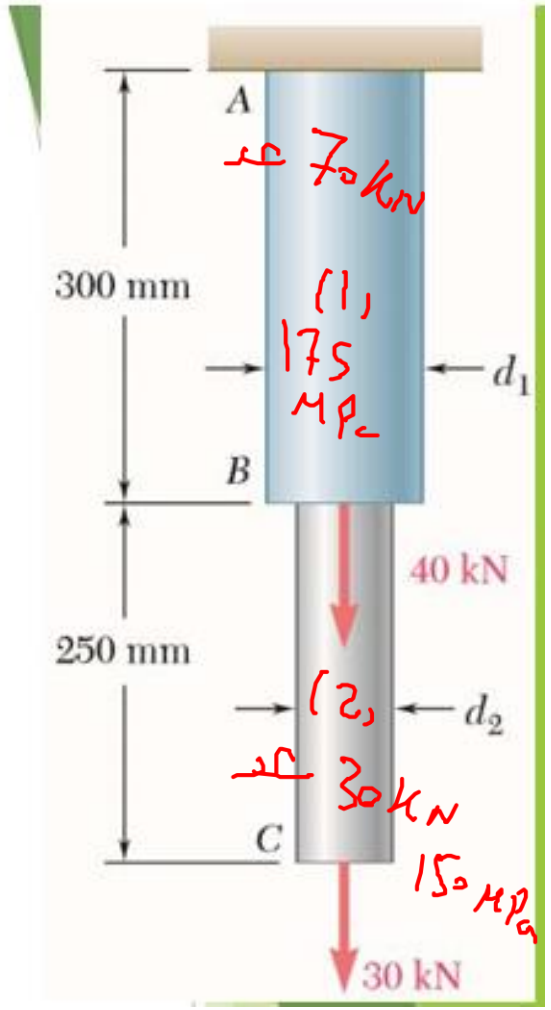
Area of circle $= \pi r^2 = \frac{\pi d^2}{4}$

$F_{BC} = 50\ kN$, $F_{AB} = 40\ kN$

$$\sigma_{BC} = \frac{50*10^3}{\frac{\pi}{4}(20)^2} = 159,154\ MPa \quad ; \quad \sigma_{AB} = \frac{40*10^3}{\frac{\pi}{4}(50)^2} = 20,37\ MPa$$


5kN
(1)
(2)
10kN
10 cm
5 cm
10 cm
5 cm
المحصلة

1.1 Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. Knowing that the average normal stress must not exceed 175 MPa in rod AB and 150 MPa in rod BC, determine the smallest allowable values of d_1 and d_2.



AB

(1)

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

$$175 = \frac{70 * 10^3}{\frac{\pi}{4}(d_1)^2}$$

$$d_1 = 22.56 \text{ mm}$$

BC

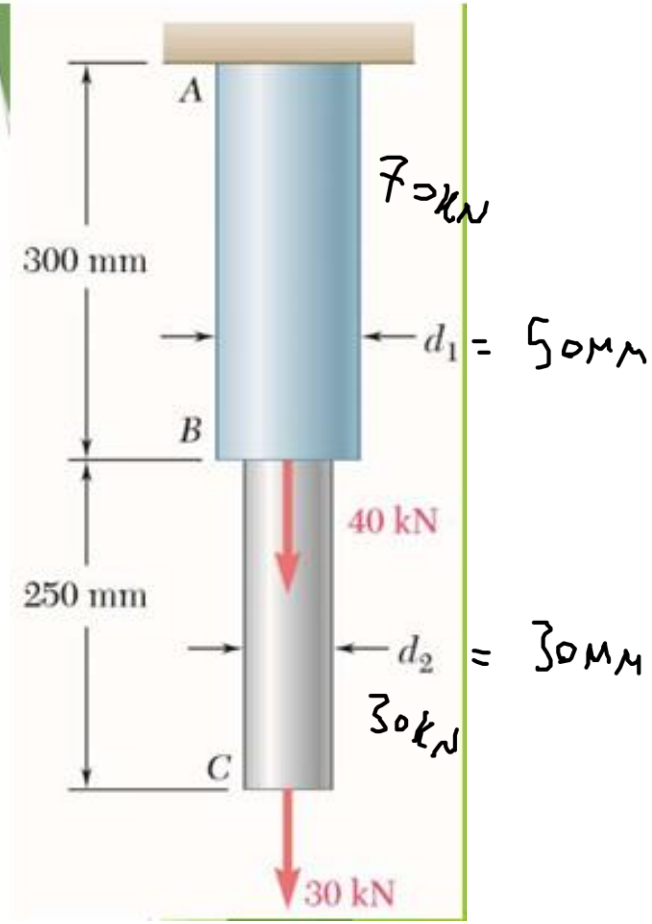
(2)

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

$$150 = \frac{30 * 10^3}{\frac{\pi}{4}(d_2)^2}$$

$$d_2 = 15.95 \text{ mm}$$

1.2 Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. Knowing that $d_1 = 50$ mm and $d_2 = 30$ mm, find the average normal stress at the midsection of (*a*) rod AB, (*b*) rod BC.



AB

(1)

$$\sigma = \frac{70 * 10^3}{\frac{\pi}{4}(50)^2} = 35,65 \text{ MPa}$$

BC

(2)

$$\sigma = \frac{30 * 10^3}{\frac{\pi}{4}(30)^2} = 42,44 \text{ MPa}$$

Example

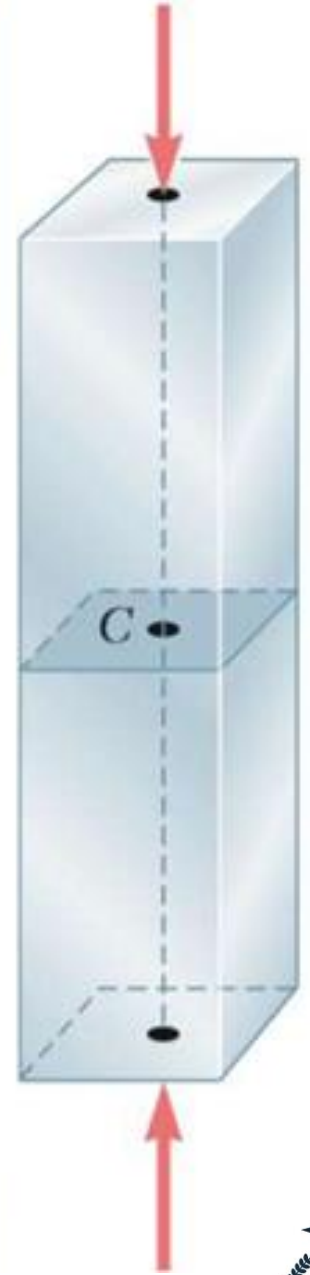
The applied compressive force is 15kN and the cross sectional area is 30 mm^2 Find stresses in given member, considering

a) Member is made up of steel

$$\sigma = \frac{15 * 10^3}{30} = 500 MPa$$

b) Member is made up of wood

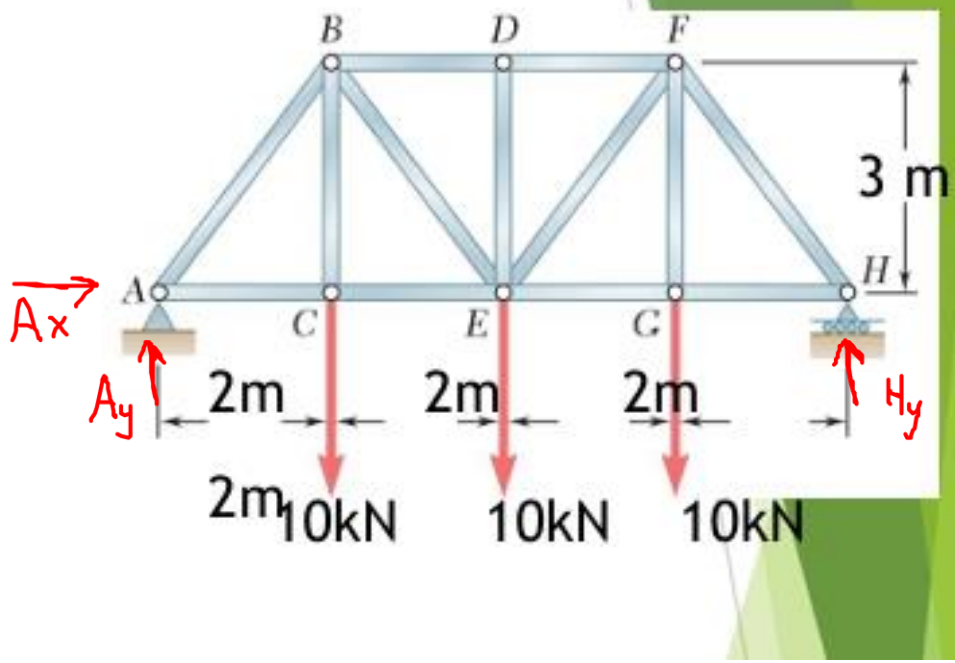
500MPa



الاجهاد Stress ← لا يعتمد على نوع المادة

Strength → أقصى اجهاد يتحمله المادة (يعتمد على نوع المادة)

1.12 For the Pratt bridge truss and loading shown, determine the average normal stress in member BE, knowing that the cross-sectional area of that member is $15\ cm^2$



$$\Sigma M_A = 0$$

$$10*2 + 10*4 + 10*6 - H_y*8 = 0$$

$$H_y = 15\,kN$$

$$\Sigma F_y = 0$$

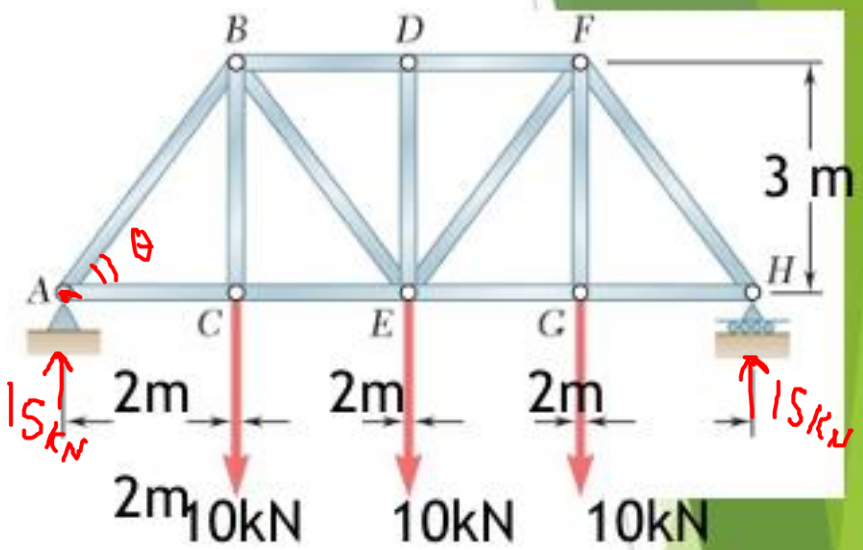
$$A_y - 10 - 10 - 10 + 15 = 0$$

$$A_y = 15\,kN$$

$$\Sigma F_x = 0$$

$$A_x = 0$$

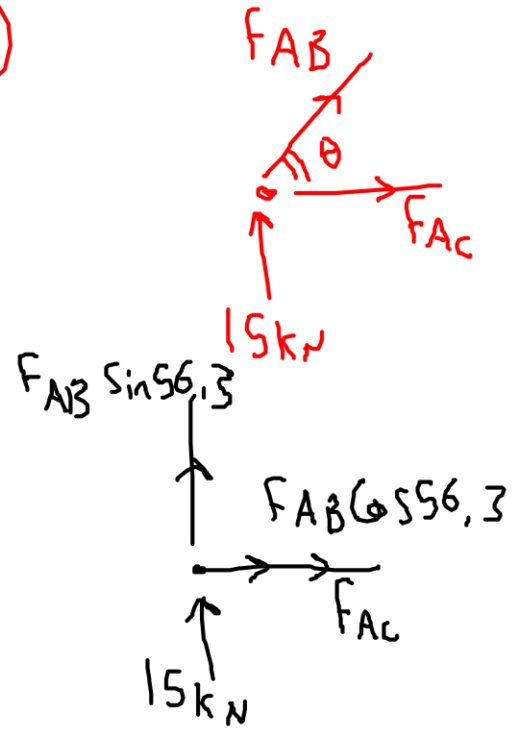
1.12 For the Pratt bridge truss and loading shown, determine the average normal stress in member BE, knowing that the cross-sectional area of that member is $15\ cm^2$



Joint A

$\theta = \tan^{-1}\frac{3}{2}$

$\theta = 56,3°$



$\Sigma F_y = Zero$

$15 + F_{AB}\sin 56,3 = Zero$

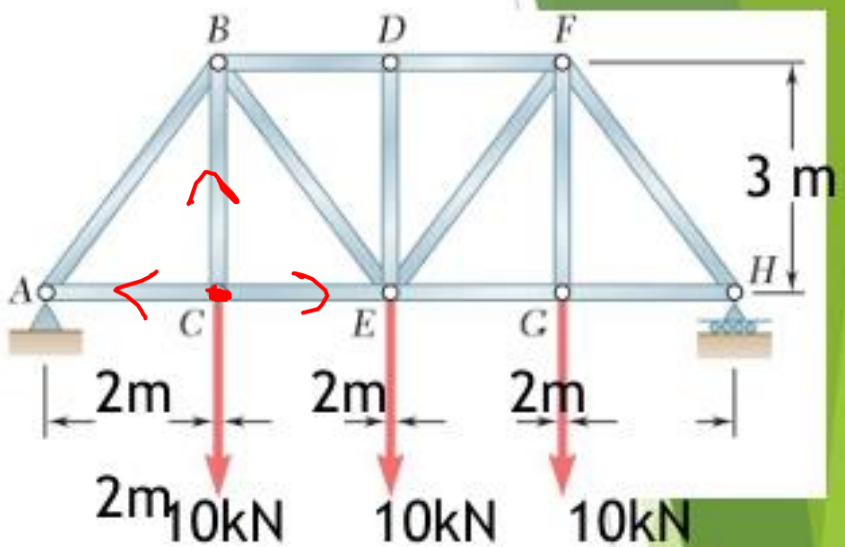
$F_{AB} = -18\,kN$ بعيد

$\Sigma F_x = Zero$

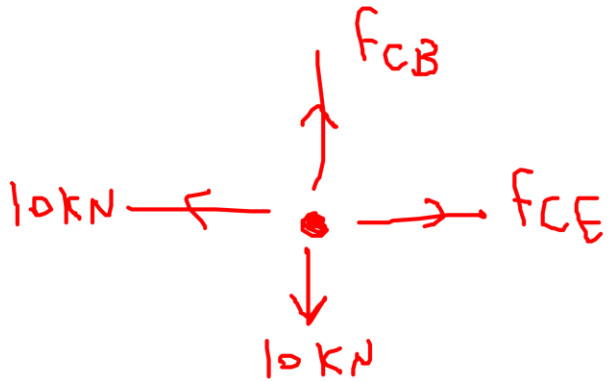
$F_{AC} - 18\cos 56,3 = Zero$

$F_{AC} = 10\,kN$

1.12 For the Pratt bridge truss and loading shown, determine the average normal stress in member BE, knowing that the cross-sectional area of that member is $15\ cm^2$



Joint C



$\Sigma F_x = 0$ ←

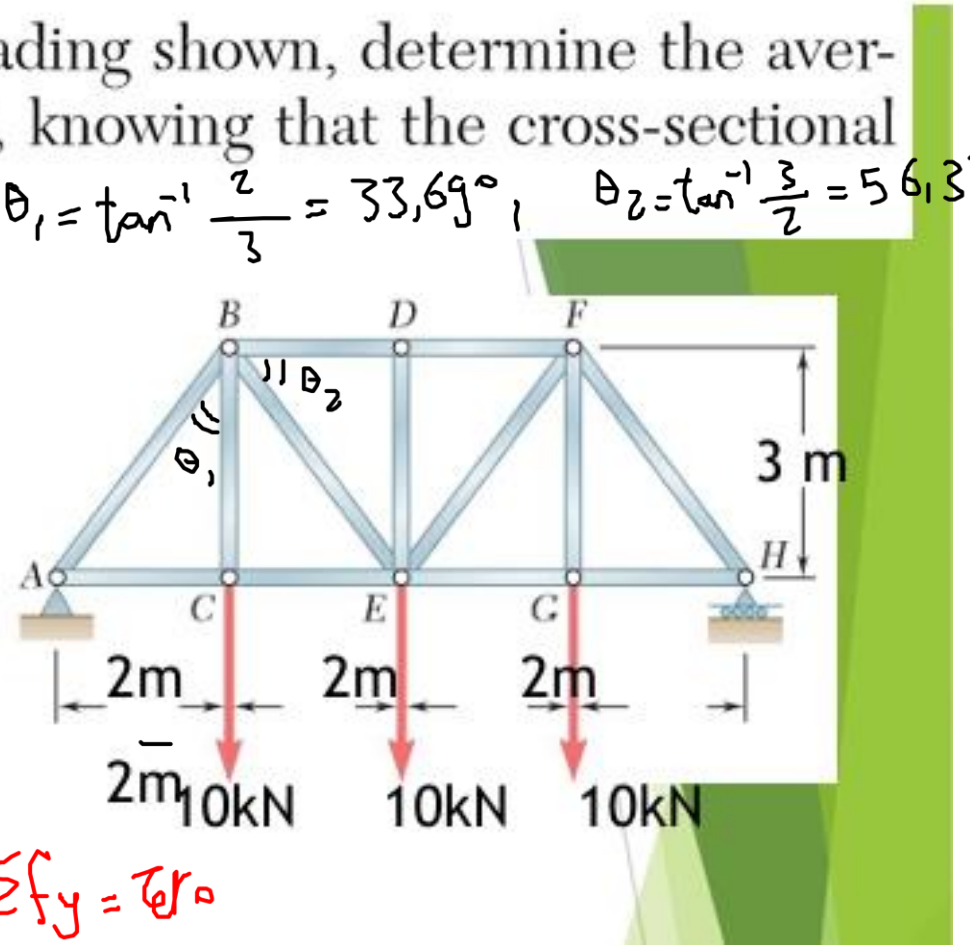
$$F_{CE} = 10\ kN \quad \text{(T)}$$

$\Sigma F_y = 0$ ↑

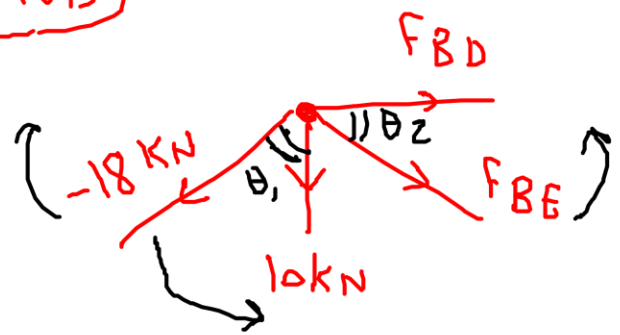
$$F_{CB} = 10\ kN \quad \text{(C)}$$

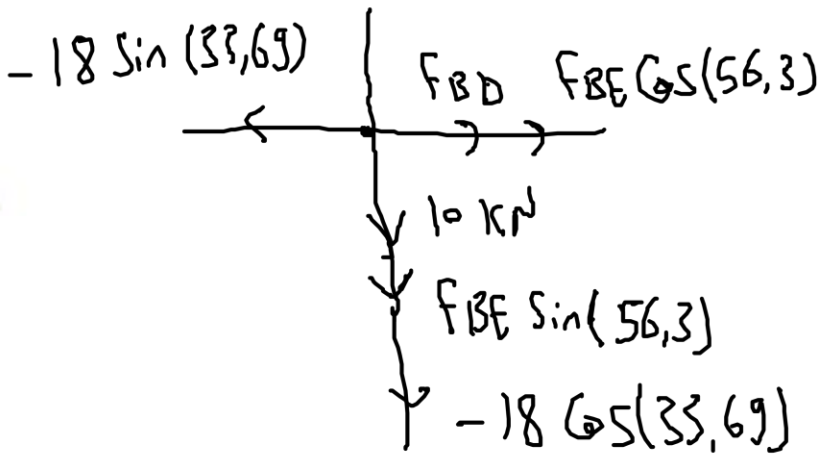
1.12 For the Pratt bridge truss and loading shown, determine the average normal stress in member BE, knowing that the cross-sectional area of that member is $15\ \text{cm}^2$

$\theta_1 = \tan^{-1}\frac{2}{3} = 33{,}69°$, $\theta_2 = \tan^{-1}\frac{3}{2} = 56{,}3°$



Joint B





$\Sigma f_y = 0$

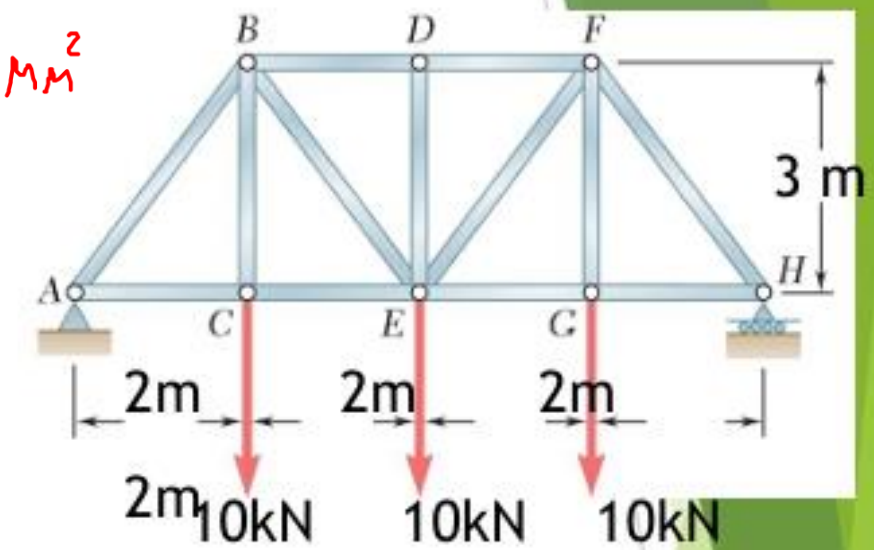
$-10 - F_{BE}\,\text{Sin}(56{,}3) + 18\,\text{Cos}(33{,}69) = 0$

$F_{BE} = 5{,}98\ \text{kN} \simeq \boxed{6\ \text{kN}}$ ↑

1.12 For the Pratt bridge truss and loading shown, determine the average normal stress in member BE, knowing that the cross-sectional area of that member is $15\ cm^2$

$$\sigma = \frac{6 * 10^3}{15 * 10^2} = 4\ MPa$$

$cm^2 \xrightarrow{10^2} mm^2$



Shear stress

القوة مماسية المساحة - عمودية على محور العمود

The units are **MPa**

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

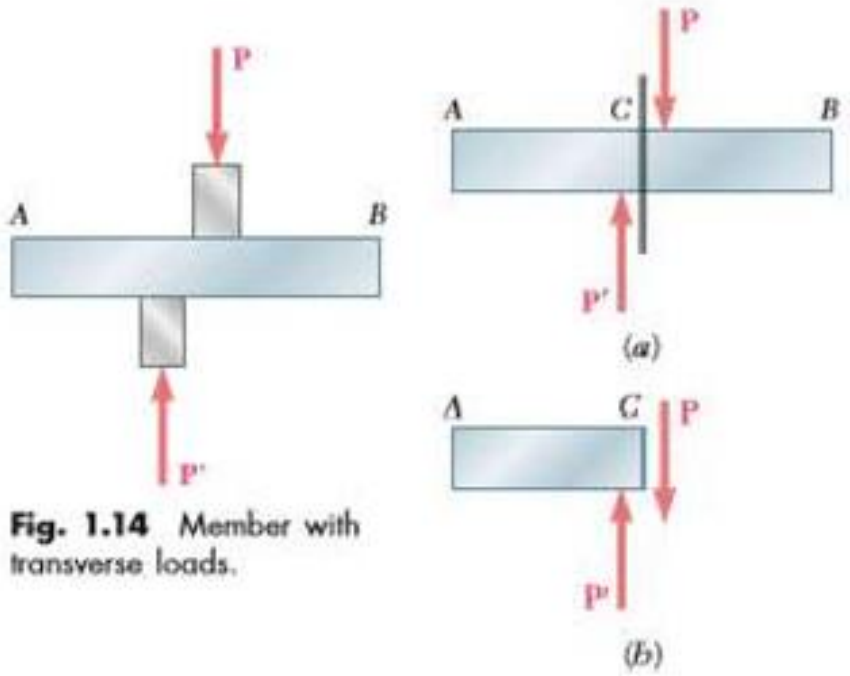


Fig. 1.14 Member with transverse loads.

Based on number of areas under shear, the shear stress may called as

Single

$$\tau_{ave} = \frac{P}{A} = \frac{F}{A}$$

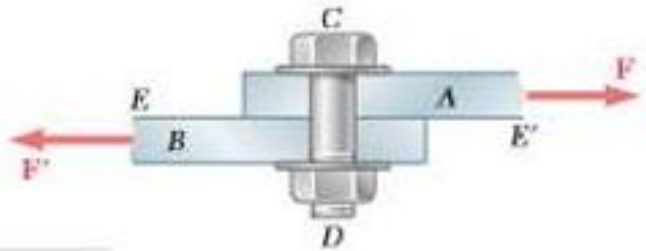


Fig. 1.16 Bolt subject to single shear.

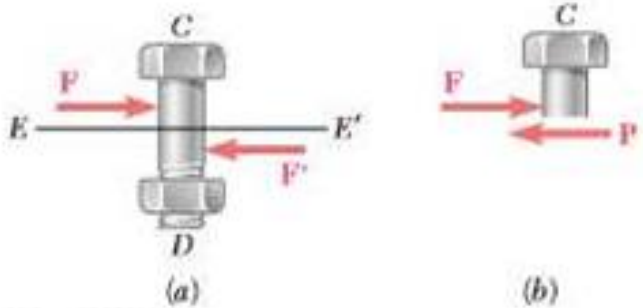


Fig. 1.17

Double

$$\tau_{ave} = \frac{P}{A} = \frac{F/2}{A} = \frac{F}{2A}$$

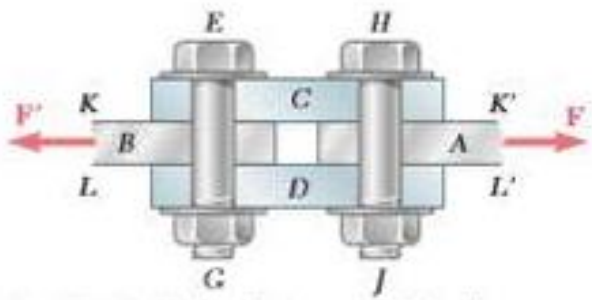


Fig. 1.18 Bolts subject to double shear.

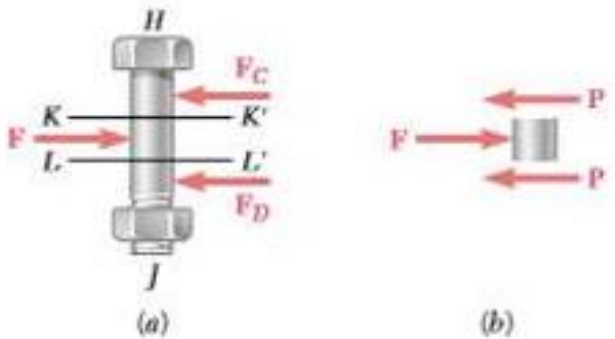
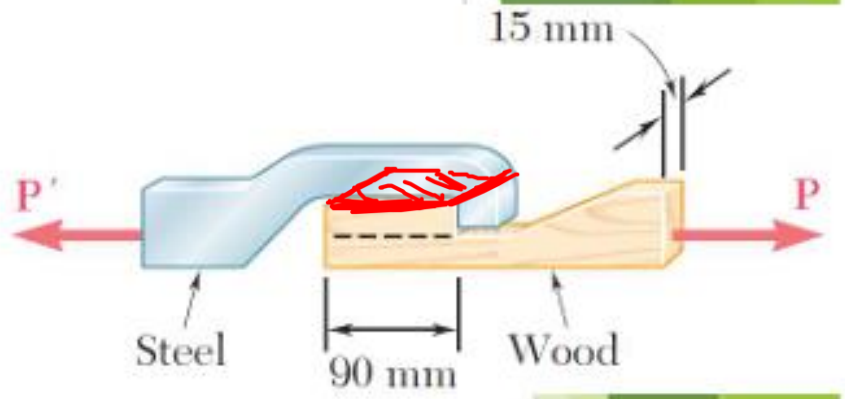


Fig. 1.19

Shearing Stresses

1.15 When the force **P** reached 8 kN, the wooden specimen shown failed in shear along the surface indicated by the dashed line. Determine the average shearing stress along that surface at the time of failure.



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

$$\tau = \frac{8 * 10^3}{90 * 15} = 5,925\ MPa$$

Shearing Stresses

1.17 A load **P** is applied to a steel rod supported as shown by an aluminum plate into which a 12 mm -diameter hole has been drilled. Knowing that the shearing stress must not exceed 180 MPa in the steel rod and 70 MPa in the aluminum plate, determine the largest load **P** that can be applied to the rod.

$\tau_{steel} = 180\ MPa$

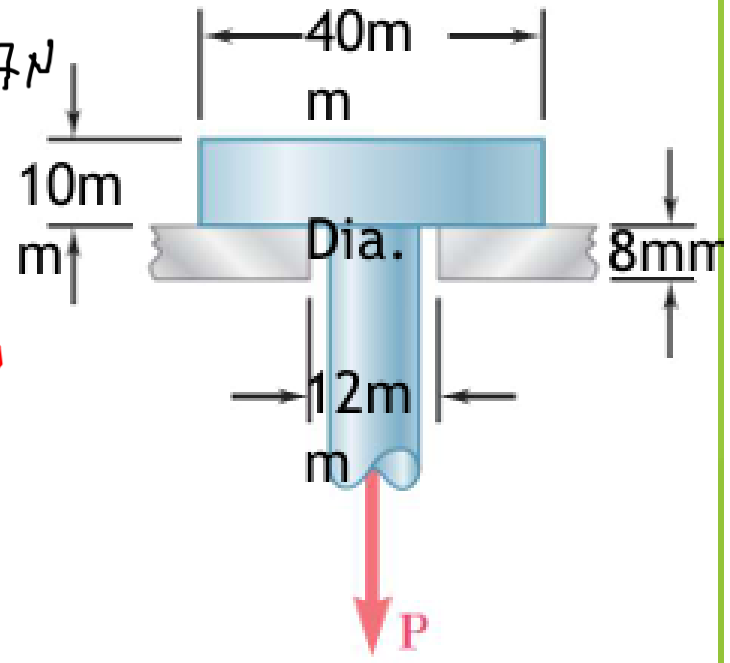
$\tau_{AL} = 70\ MPa$

$$\tau_{AL} = \frac{P}{\pi * 40 * 8} = 70 \qquad P = 70371{,}67\ N$$

$$\tau_{st} = \frac{P}{\pi \times 12 * 10} = 180$$

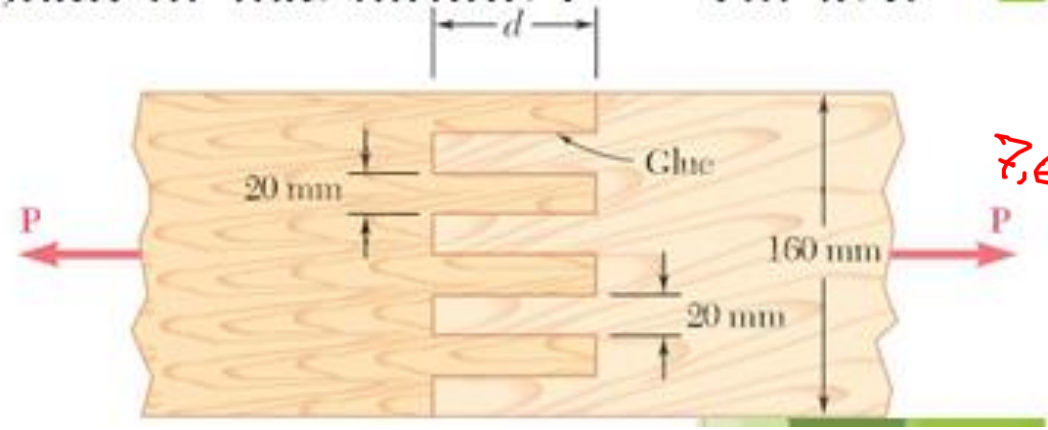
$P = 67858{,}4\ N$

اختار الأصغر



Shearing Stresses

1.18 Two wooden planks, each 22 mm thick and 160 mm wide, are joined by the glued mortise joint shown. Knowing that the joint will fail when the average shearing stress in the glue reaches 820 kPa, determine the smallest allowable length d of the cuts if the joint is to withstand an axial load of magnitude $P = 7.6$ kN.



$t = 22mm$, $\tau = 820\ kPa$

$7,6kN$

$$\tau = \frac{F}{A}$$

$$820 * 10^3 = \frac{7,6 * 10^3}{7 * d * 22 * 10^{-3}}$$

$$d = 0,06018\ M$$

$$= \boxed{60,18\ mm}$$