

# Chapter 1: Stress

Equilibrium Equations :-

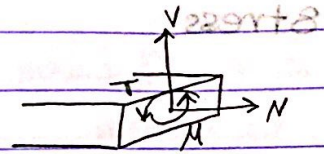
$$\sum F_x = 0$$

$$\sum F_y = 0$$

$$\sum M_p = 0 \quad (\text{Moment around a point})$$

## Internal Resultant Loadings

I will explain how to find them in the next page.



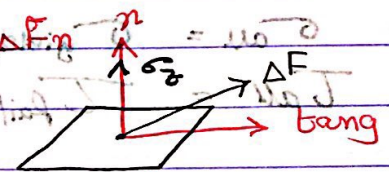
## Average Stress :-

Unit: Pascal

Normal stress  $\sigma$  :-

$$\sigma_{avg} = \frac{F_n}{A}$$

(Avg)  $\sigma$  هو القوة المتوسطة على المساحة



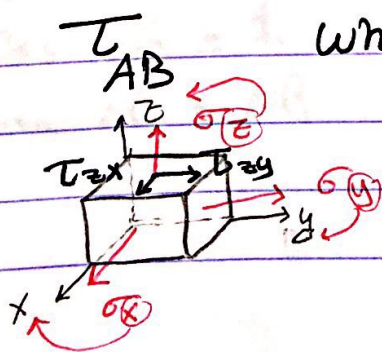
stress can be: tensile or compression.

Shear stress  $\tau$  :-

$$\tau_{avg} = \frac{F_{tang}}{A}$$

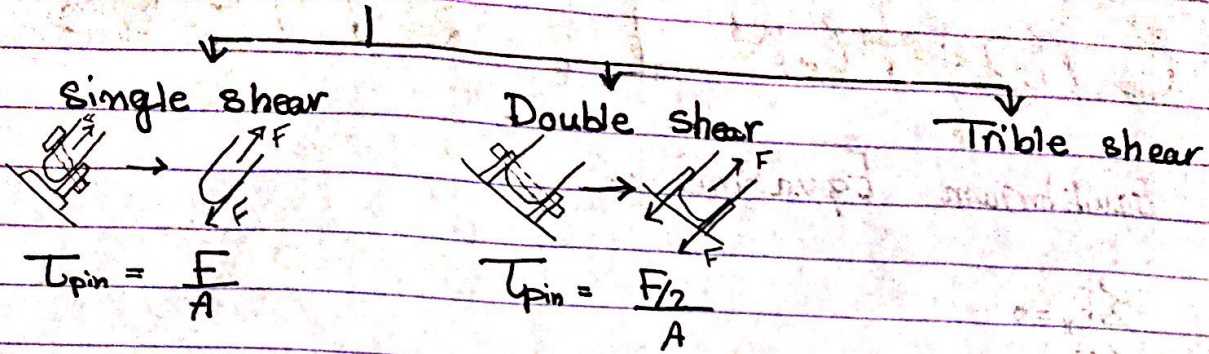
$\tau$  هو القوة المتوسطة الموازية للمساحة

Determination of the direction of  $\tau$ :



where: A: the direction of  $\sigma$   
B: " " of the axis

## Shear Stress :-



## Axially loaded bar

→ The stress here is Normal Stress



## Allowable stress :-

$$\sigma_{all} = \frac{\sigma_{yield (fail)}}{F.S}$$
$$\tau_{all} = \frac{\tau_{fail}}{F.S}$$

## Bearing stress :-

area on area

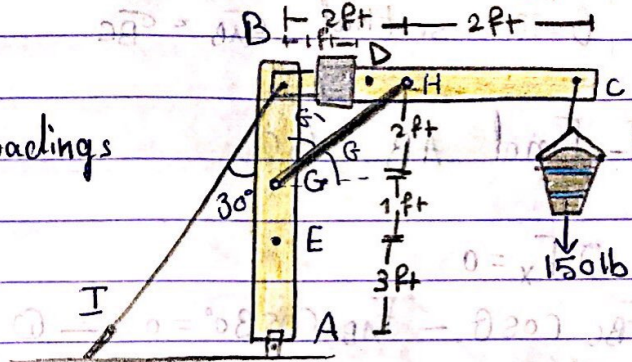
# Examples of Chapter 1

Ninth Edition

Fig. #

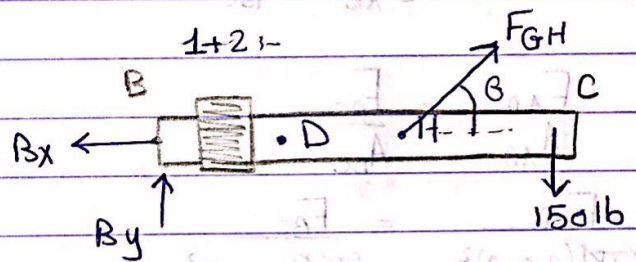
1-15,

→ Determine internal loadings on D



1- We split the Body at B (B is a pin joining BC and BA)

2- We find Reactions at B :-



$$\sum M_B = 0$$

$$F_{GH} \sin \theta (2) - 150 (4) = 0$$

From Fig #:

$$\tan^{-1} \left( \frac{2}{2} \right) = \theta = 45^\circ$$

$$\theta = 90^\circ - 45^\circ = 45^\circ$$

$$F_{GH} = 424.26 \text{ lb}$$

$$\sum F_x = 0$$

$$F_{GH} \cos 45^\circ - B_x = 0$$

$$B_x = 300 \text{ lb}$$

$$\sum F_y = 0$$

$$-150 + F_{GH} \sin 45^\circ + B_y = 0$$

$$B_y = 150 \text{ lb}$$

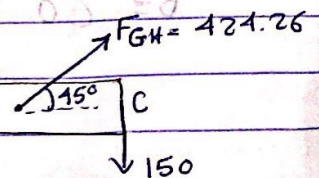
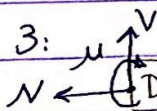
3- Take a Cross section at D and choose a segment

$$\sum F_x = 0$$

$$N = F_{GH} \cos 45^\circ = 300 \text{ lb}$$

$$\sum F_y = 0$$

$$V + F_{GH} \sin 45^\circ - 150 = 0 \Rightarrow V = -150 \text{ lb}$$



$$\sum M_D = 0$$

$$-M + (F_{GH} \sin 45^\circ)(1) - (150)(2) = 0$$

$$M = -150 \text{ lb} \cdot \text{ft}$$

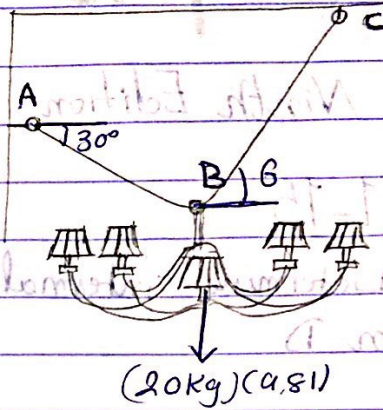
1-46:

$$d_{AB} = 3 \text{ mm}$$

$$d_{BC} = 4 \text{ mm}$$

$$\theta = ?? \text{ so that } \sigma_{AB} = \sigma_{BC}$$

Q- Find  $\theta$ ,  $BC$



$$\sum F_x = 0$$

$$F_{BC} \cos \theta - F_{AB} \cos 30^\circ = 0 \quad \text{--- ①}$$

② - Use  $\sigma_{AB} = \sigma_{BC}$

$$\frac{F_{AB}}{A_{AB}} = \frac{F_{BC}}{A_{BC}}$$

$$\frac{F_{AB}}{(\frac{\pi}{4})(0.003)^2} = \frac{F_{BC}}{(\frac{\pi}{4})(0.004)^2}$$

$$F_{AB} = 0.5625 F_{BC} \quad \text{--- ②}$$

③ put Equation 2 in 1

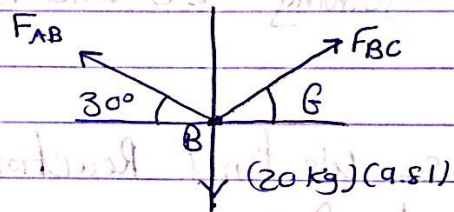
$$F_{BC} \cos \theta = (0.5625 F_{BC}) \cos 30^\circ = 0$$

$$F_{BC} (\cos \theta - 0.4871) = 0 \quad \text{--- ③}$$

$$\cos \theta = 0.4871$$

$$\theta = 60.85^\circ$$

Point B (Zooming) :-

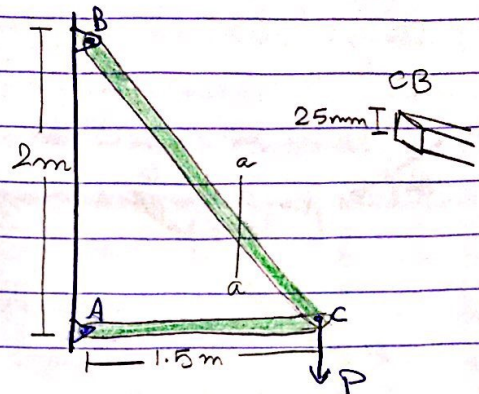


1- GG:

$$\sigma_{aa} = 150 \text{ MPa}$$

$$\tau_{aa} = 60 \text{ MPa}$$

1- Find F, V from  $\sigma, \tau$



$$\sigma_{aa} = \frac{F}{A}$$

$$156375$$

$$F = (150 \times 10^6)(0.025)^2 = 156.375 \text{ KN}$$

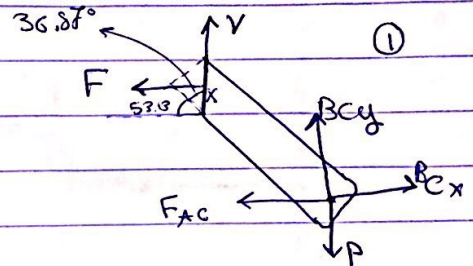
$$\tau_{aa} = \frac{V}{A}$$

$$62550$$

$$V = (60 \times 10^6)(0.025)^2 = 62.550 \text{ KN}$$

$$\sin 36.8^\circ = \frac{0.025}{x}$$

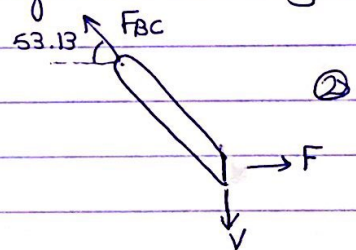
$$x = 0.0417$$



We start with the value of F

2- Find BC from the other segment using F

$$F_{BC} \cos 53.13 = F \Rightarrow F_{BC} = 260.624 \text{ KN}$$



→ Back to Point C:-

$$\sum F_{y_c} = 0 \Rightarrow F_{BCy} = P$$

$$P = 260.624 \times 10^3 \sin 53.13 = 208.33 \text{ KN}$$

Now using the value of V:-

$$\sum F_{y_{aac}} = 0$$

$$V + F_{BCy} - P = 0$$

from ②

$$F_{BC} \sin 53.13 = 62.550 \text{ KN}$$

$$F_{BC} = 78.187 \text{ KN}$$

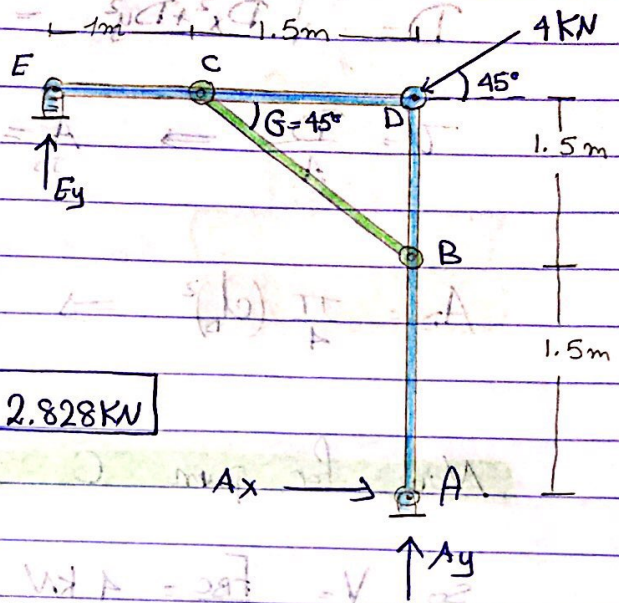
$$\Rightarrow P = (78.187)(\sin 53.13)$$

$$P = 62550 \text{ N} \quad \text{The answer}$$

1-84:-

$\tau_{allow} = 40 \text{ MPa}$  (P.D.)  
Pin C: double shear  
Pin D: Single shear

WY 830 S = 8 T 1mm



First: Find Reactions

$$\sum F_x = 0$$

$$(4 \text{ kN}) \cos 45^\circ = A_x \Rightarrow A_x = 2.828 \text{ kN}$$

$$\sum M_A = 0$$

$$(-E_y)(2.5) + (4 \text{ kN}) \cos 45^\circ (3) = 0$$

$$E_y = 3.394 \text{ kN}$$

$$\sum F_y = 0$$

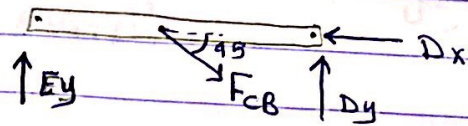
$$E_y + A_y - (4 \text{ kN}) \sin 45^\circ = 0$$

$$A_y = -565.68 \text{ N} = 0.5657 \text{ kN} \downarrow$$

Second: Taking Member ED (To find  $d_D$ )

$$D_x = F_{CB} \cos 45^\circ$$

$$\sum F_y = 0 \Rightarrow E_y - F_{CB} \cos 45^\circ + D_y = 0$$



$$\sum M_D = 0 \Rightarrow (F_{CB} \sin 45^\circ)(1.5) - (E_y)(2.5) = 0$$

$$F_{CB} = 8000 = 8 \text{ kN}$$

$$D_x = 5656.7 = 5.6567 \text{ kN}$$

and  $D_y = 2.263 \text{ kN}$

$D = \sqrt{D_x^2 + D_y^2} = 6.092 \text{ kN}$

$\tau = \frac{D}{A} \Rightarrow A = \frac{6.092 \cdot K}{40 \text{ M}} = 1.523 \times 10^{-4}$

$A_D = \frac{\pi}{4} (d_D)^2 \Rightarrow d_D = 0.013929 \text{ m}$

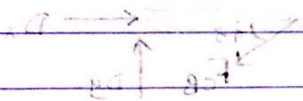
Now for pin C it is Double Shear

$V = \frac{F_{BC}}{2} = 4 \text{ kN}$

$\tau = \frac{F_{BC}}{A_c} \Rightarrow A_c = 1 \times 10^{-4}$

$A_c = \left(\frac{\pi}{4}\right) (d_c)^2 \Rightarrow d_c = 0.011287 \text{ m}$

(at level of)



$0 = (3.5)(\sqrt{2}) - (2)(\sqrt{2}) \Rightarrow 0 = 2.5\sqrt{2}$

$2.5\sqrt{2} = 3.5\sqrt{2} = 4.95 \text{ kN}$

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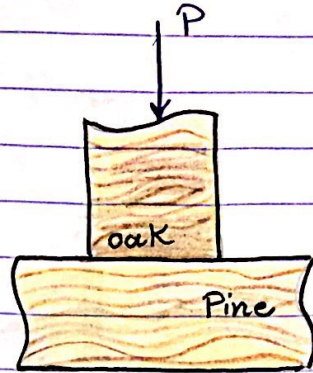
## Example for Bearing stress:-

1-83:-

$$\sigma_{\text{oak}} = 43 \times 10^6 \text{ Pa}$$

$$\sigma_{\text{pine}} = 25 \times 10^6 \text{ Pa}$$

$P = ?$  Area of plate between them?



$P_{\text{max}}$  for the oak:-

$$\sigma_{\text{oak}} = \frac{P}{A}$$

$$43 \times 10^6 = \frac{P}{(60 \times 60) \times 10^{-6}}$$

$$P = 154.8 \text{ kN}$$

$P_{\text{max}}$  for the pine:-

$$\sigma_{\text{pine}} = \frac{P}{A}$$

$$P = (25 \times 10^6)(60 \times 60) \times 10^{-6}$$

$$P = 90 \text{ kN}$$

$$\text{Max } P = 154.8 \text{ kN}$$

• ليس نحننا الأكبر؟ لأنوني هذا السؤال

زريد أنه نضع قهوة للقوى ال Pine

ليتحمل الك 154.8

$$\text{So } A = \frac{154.8 \text{ kN}}{25 \times 10^6} \Rightarrow A = 6.19 \times 10^{-3}$$