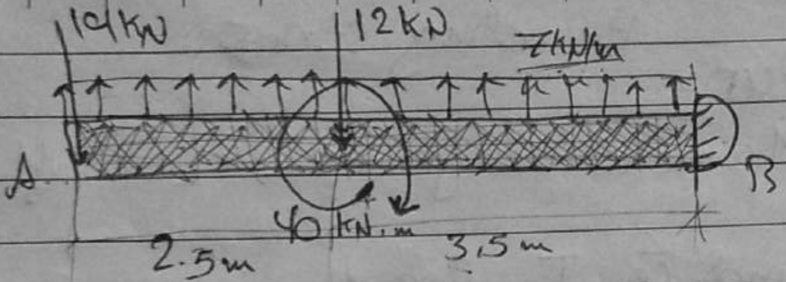
Mech Family

ملخص واسئلة مقترحة

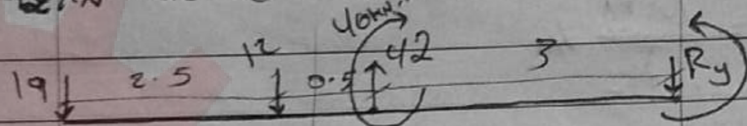
STRENGTH

اعداد يزن العقرباوي

(1)



$7 \times 6 = 42$ kN at centroid of force



$*\sum F_y = 0,$

$19 + 12 - 42 + R_y = 0 \Rightarrow R_y = 11$ kN

$*\sum M_B = 0,$

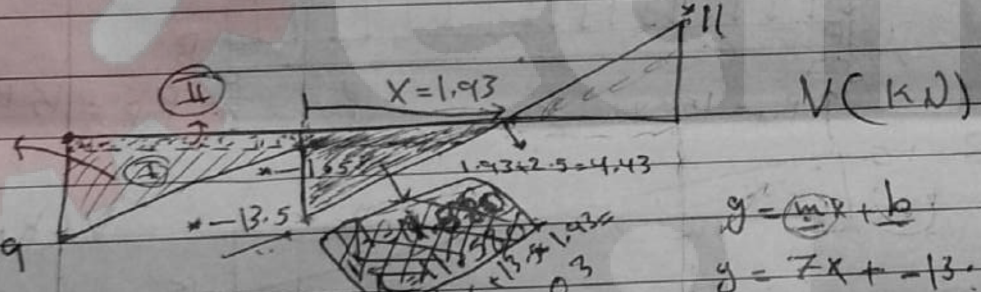
$M_B = 42 * 3 - 12 * 3.5 - 19 \times 6 + 40 = 10$ kN.m

$A = \text{I} + \text{II}$

$= \frac{1}{2}(2.5) \times (19 - 1.5)$

$+ 1.5 * 2.5$

$= 25.625$

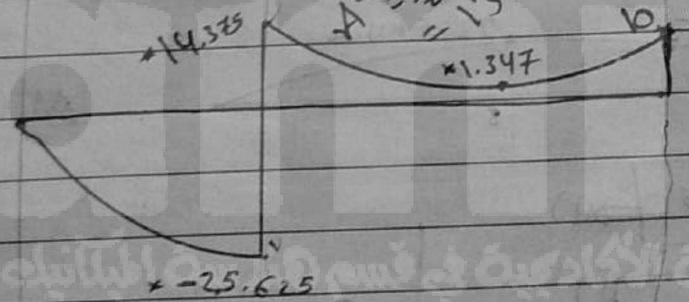


$y = mx + b$

$y = 7x + -13.5$

$0 = 7x - 13.5$

$\boxed{X = 1.93}$



(2)

Bending stress

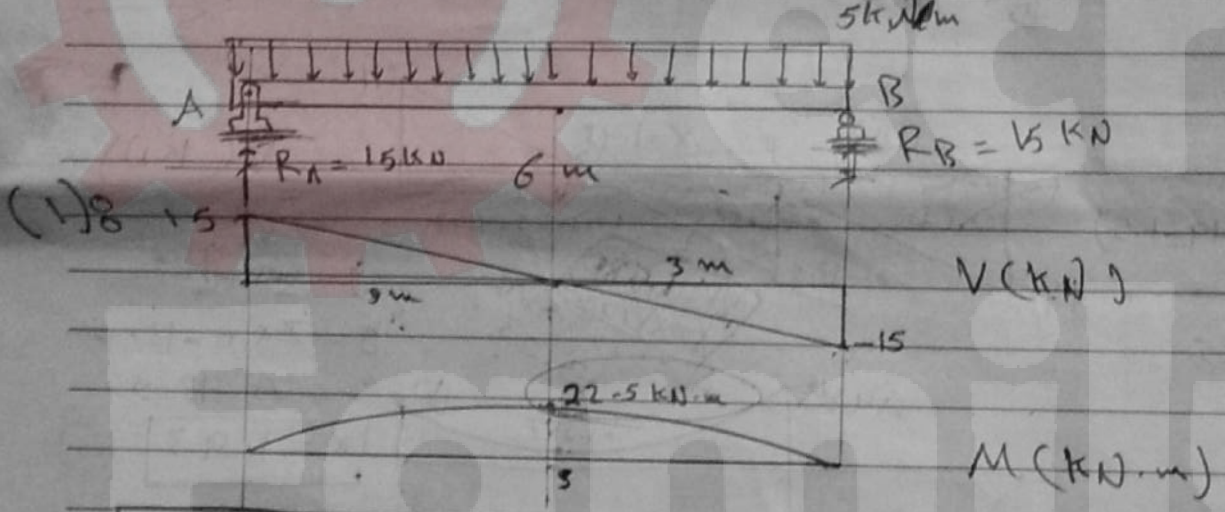
Procedure

1 - Moment Diagram → read $\underline{M}$

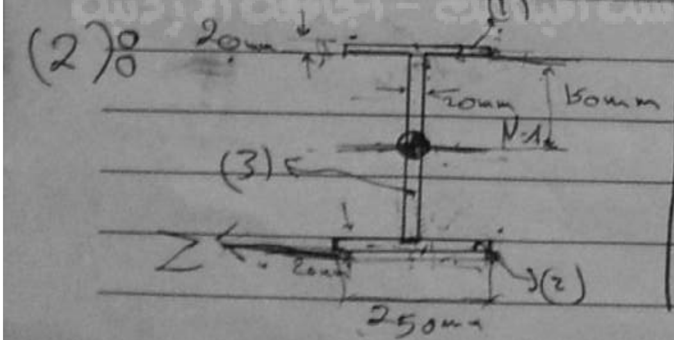
2 - Find $\bar{y}$, $\underline{I}$ for the cross section

3 - $\sigma_x = \dfrac{My}{I_z}$

determine the absolute maximum bending stress in the beam ~~and draw the shear stress distribution at this location~~



$\boxed{M_{max} = 22.5} \rightarrow (1)$



Part	A (m^2)	$\bar{y}'$ (m)	$A\bar{y}'$ (m^3)
(1)	5×10^{-3}	330×10^{-3}	1.65×10^{-3}
(2)	5×10^{-3}	10×10^{-3}	5×10^{-5}
(3)	6×10^{-3}	170×10^{-3}	1.02×10^{-3}
Σ	16×10^{-3}		2.72×10^{-3}

Cont. →

$\bar{y} = \dfrac{\Sigma A\bar{y}'}{\Sigma A} = \dfrac{2.72}{16} = 0.17 \simeq \boxed{170\text{mm}}$ (can be skipped

Part	$A (m^2)$	$\bar{y}'$	$A\bar{y}'$	$d_{cc'}$ (m)	$A d_{cc'}^2$ (m^3)	$\bar{I}'_{c'}$ (m^4)	$\bar{I} = \bar{I}'_{c'} + Ad^2$ (m^4)
(1)	5×10^{-3}			0.16	1.28×10^{-4}	$1.\overline{66}\times10^{-7}$	$1.281\overline{66}\times10^{-4}$
(2)	5×10^{-3}			0.16	1.28×10^{-4}	1.66×10^{-7}	$1.281\overline{66}\times10^{-4}$
(3)	6×10^{-3}			0.0	0.0	4.5×10^{-5}	4.5×10^{-5}
Σ							$301.\bar{3}\times10^{-6}$ m^4 $= \bar{I}$

* $d_{cc'}$: is distance from the centroid of the Part (C') to the centroid of the whole cross-section (C)
* $\bar{I} = \bar{I}'_{c'} + Ad^2$

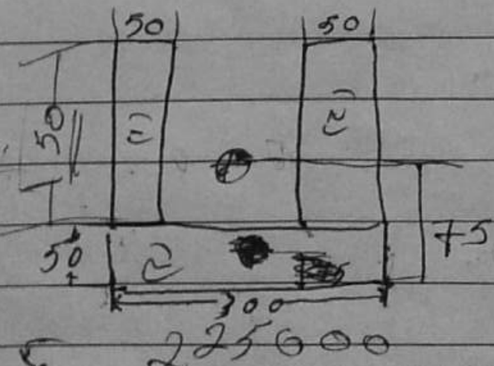
$$\boxed{\bar{y} = 170 \text{ mm} \quad \text{and} \quad \bar{I} = 301.3\times10^{-6} \ m^4} \Rightarrow (2)$$

(3): $\sigma_{max} = \dfrac{M_{max}\, y}{I}$

* here y : is distance from the centroid of the whole cross section (C) to the point we want to find σ at.
* Since we want σ maximum y will be 170mm to maximize σ

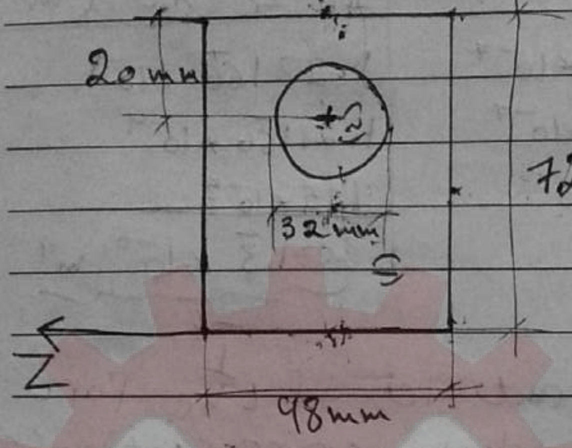
$$\boxed{\sigma_{max} = \frac{22.5\times10^{3}\times170\times10^{-3}}{301.\bar{3}\times10^{-6}} \approx 12.7 \ MPa} \Rightarrow \boxed{3}$$

finished



Part	A	$\bar{y}$	$A\bar{y}_1$
(1)	7,500	125	937,500
(2)	7,500	125	937,500
(3)	1,5000	25	3,75,000
Σ	30,000		2,250,000

$\bar{y} = \dfrac{2250000}{30000} = 75$ mm



Find the moment capacity of this beam if the max. stress is 150 MPa tension and 100 MPa in compression and draw the ~~shear~~ stress distribution.

$$\bar{y} = \frac{\Sigma \bar{y} A}{\Sigma A} = \frac{48 * 72 * 36 - \frac{\pi}{4} * (32)^2 * (52)}{48 * 72 - \pi/4 * (32)^2}$$

$$= \boxed{31.15} \text{ mm}$$

I: ~~b// rotat~~

b// axis about which the rotation will occure

$$I = \frac{48*10^{-3} * (72*10^{-3})^3}{12} + (36*10^{-3} - 31.15*10^{-3})^2 * 48*10^{-3} * 72*10^{-3}$$

$$- \frac{\pi}{64} * (32*10^{-3})^4 - (40.853*10^{-3} - 20*10^{-3})^2 * \frac{\pi}{4} * (32*10^{-3})^2$$

$$= 1.1733 * 10^{-6} \text{ m}^4$$

$$\sigma = -\frac{My}{I} \Rightarrow M = \frac{\sigma I}{y}$$

top: $y = 40.85$ mm $\sigma = 150$ MPa

$\Rightarrow M = 4.3$ kN.m

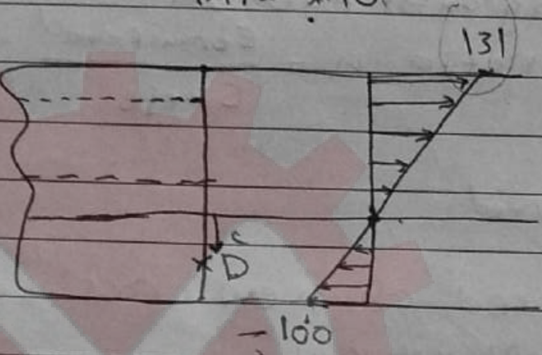
bottom: $y = 31.15$ mm, $\sigma = 100$ MPa

$\Rightarrow \boxed{M = 3.77 \text{ kN.m}}$

So 3.77 controls

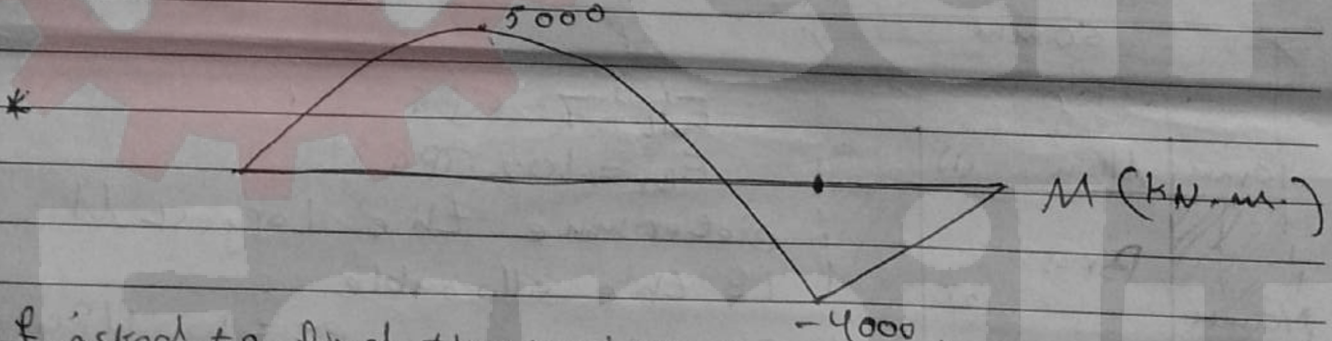
$\sigma_{comp} = 100\,MPa$

$$\sigma_{tens} = \frac{3.77*10^{3} * 40.853*10^{-3}}{1.1733*10^{-6}} = 131\,MPa$$



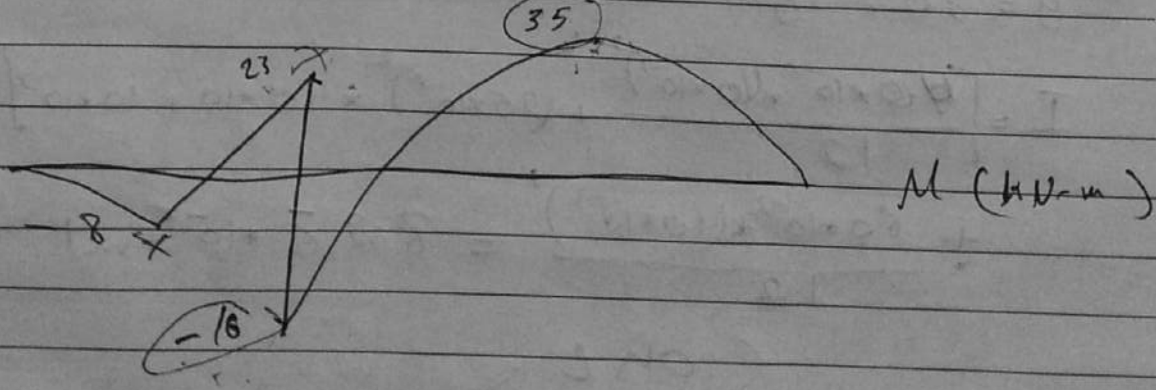
* ask at another point D for example

$$\sigma = \frac{Mc}{I}$$

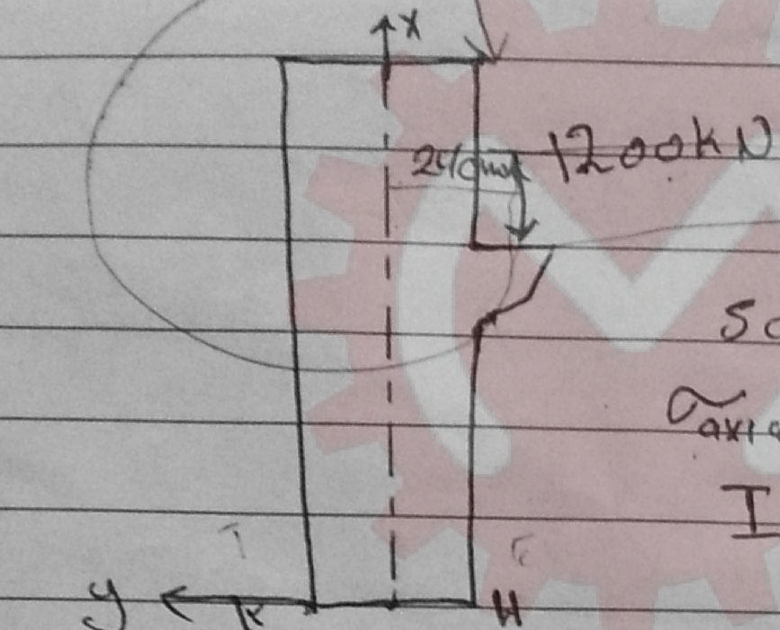


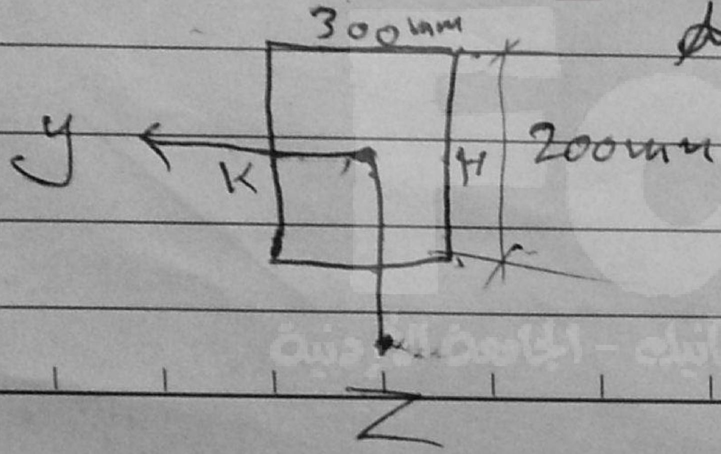
if asked to find the maximum σ you have to check both the 4000 and the 5000 Moments.

DON'T Think!!



Eccentric Axial   Find σ_K , σ_H





Soln. $A = 0.06\ m^2$

$\sigma_{axial} = \frac{F}{A} = 20\ MPa$ $\boxed{C}$

$I = \frac{bh^3}{12} = \frac{0.2*(0.3)^3}{12} = 4.5*10^{-4}\ m^4$

$M = 1200*10^3 * 240*10^{-3} = 288\ kN\cdot m$

$\sigma_{Bend} = \frac{My}{I} = \frac{288*10^3 * 150*10^{-3}}{4.5*10^{-4}}$

$= 96\ MPa$

$\boxed{T} \to K\ \ 96-20 = \underline{76}\ MPa$

$\boxed{C} \to H = \cancel{-20-96} = 116\ MPa$

No.

Comments:

1- if two conditions were given:

(1) * $\sigma = 150$ MPa $\boxed{T}$

(2) * $\sigma = 100$ MPa $\boxed{C}$

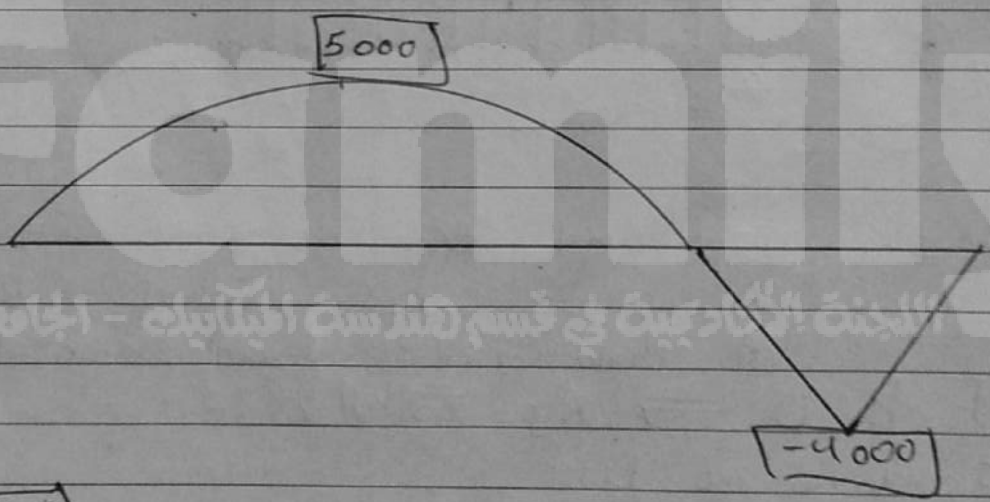
we solve for both of them then we take the safer (more safe) value

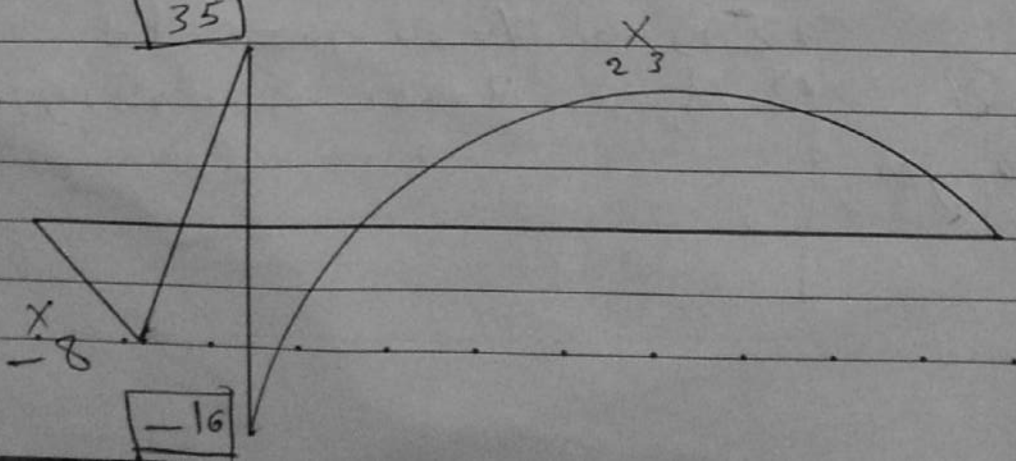
F, M, σ, τ, d_i - we take smallest

D, d_o, thickness - we take largest

2- if asked not for maximum but for specified point then find the Moment at that point using equations (not graphs.)

3- if asked for σ_{max} then check for all extreme values that is (Don't think)





No transverse shear

Procedure

1. Shear force diagram $\longrightarrow$ find V
2. Find $\bar{y}$, I, Q, t
3. $\tau = \frac{VQ}{It}$

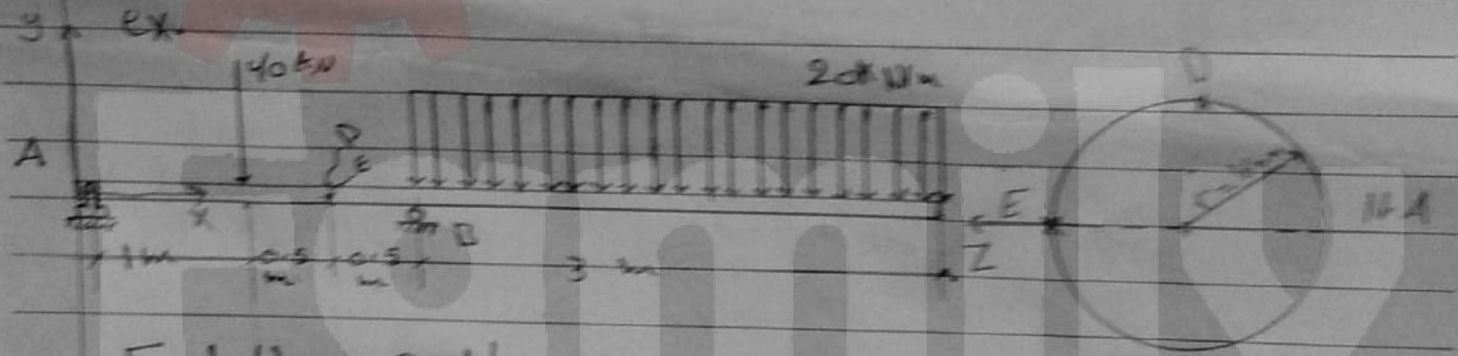
$\boxed{* \; Q = A' \bar{y}'}$

A': is the Area from point of interest and Away from the centroidal axis.

$\bar{y}'$: is the distance from the centroidal axis to the centroid of (A')

t: thickness (Parallel to the centroidal axis)

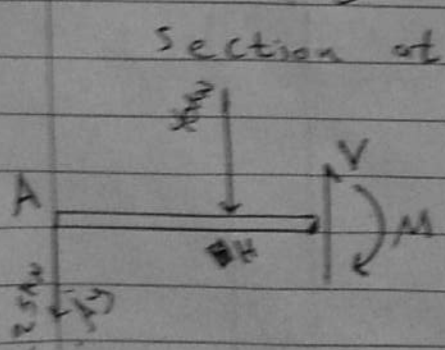
ex.



Find the ① Normal stress at point D, E
② Shear stress at Point D, E
③ Draw normal stress and shear stress distribution

F.B.D $\Longrightarrow A_y = 25\,kN \downarrow$

Section at D, E



$* \sum F_y = 0, \; V = 25 + 40 = 65\,kN$

$* \sum M_H = 0, \; M = (65 \times 0.5) + (25 \times 1) = 57.5$

No.

$I = \frac{\pi}{2} r^4 = 1.02944 * 10^{-7} \; m^4$

$\bar{y} = 0.016 \, m$

Bending:-

Point D:-

$* \; y = c = 0.016,$

$* \; \sigma = \frac{57.5 * 10^3 * 0.016}{1.02944 * 10^{-7}} = 8.93 \, GPa \quad \boxed{T}$

Point E

$* \; y = 0,$ (Nutral axis)

$* \; \sigma = 0,$

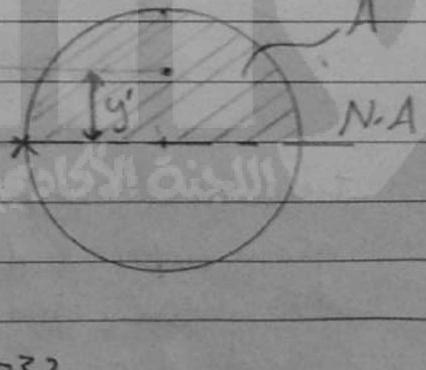
Shear:

Point D:-

$* \; Q = 0,$

$* \; \tau = 0,$

Point E:



$Q = A' y'$

$= \frac{\pi r^2}{2} * \frac{4r}{3\pi}$

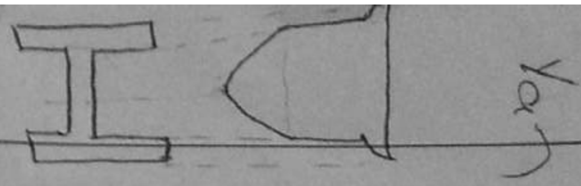
$= 2.731 * 10^{-6} \, m^3$

$t = 0.016 * 2 = 0.032$

$\tau_E = \frac{VQ}{It} = \frac{65 * 10^3 * 2.731 * 10^{-6}}{1.02944 * 10^{-7} * 0.032}$

$= 5.38 \, MPa$

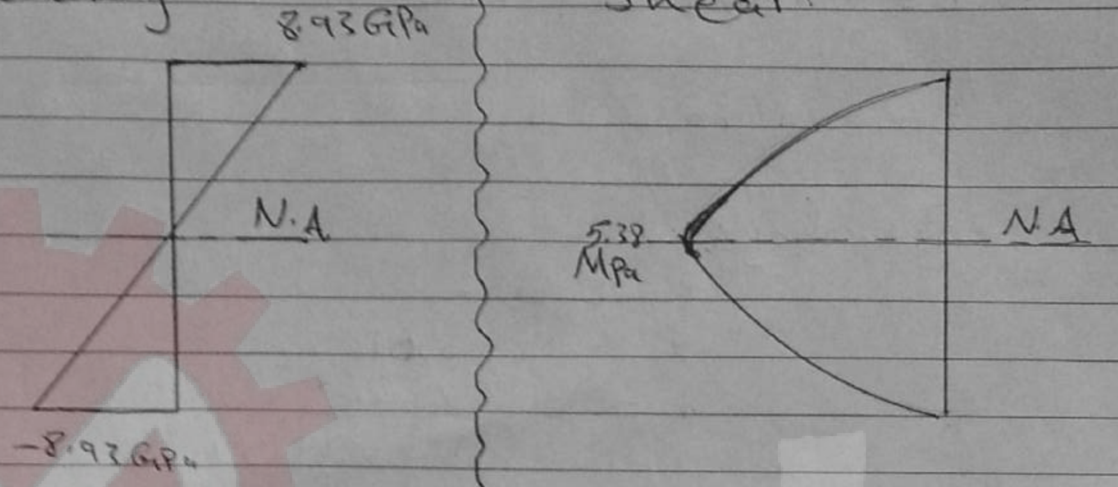
** note for an I-beam



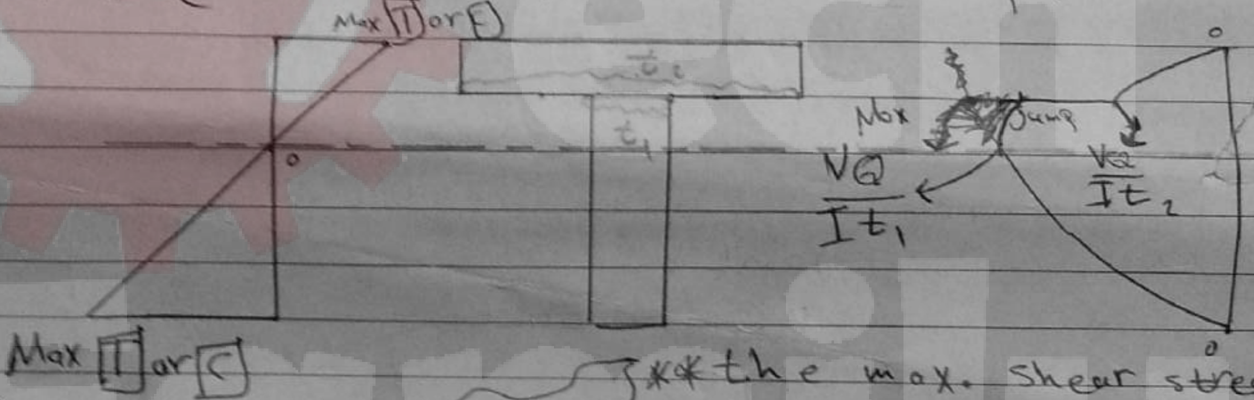
No.

③

Bending | Shear



IF the cross section was a T shape



** Q : selection :-

the Property Q is the moment of Area that is from the Point of intrest and Away from the N.A, when the point of intrest at the surface of the beam Q is said to be zero and no τ Presents)

** the max. shear stress value occures at the N.A wher Q is the moment of the Area above or under N.A Also when the thickness suddenly changes a jump on the shear distribution will happen we calculate τ for both thicknesses then we draw the diagram.

However, care should be practiced when choosing the surface which makes Q=0 since it must be either facing or opposing →

No.

the shear force and Perpendicular to it when the shear force and the surface are Parallel to each othe $Q \neq 0$ and it's value should be calculated. see M9.7 in mecmovies

* Shear flow.

Key equations.

$$q = \frac{VQ}{I} = \frac{nF}{s}$$ usually (2)

q: is a measure of the force Per unit length of a beam.

q ✓ V ✓ Q ✓ I ✓ n: no. of nails ~~F: force~~

F: shear force by each nail S: spacing

ex: a simply supported beam carries a load of 10kN at the centre of 4m span.

Provided that each nail can transmit 0.5kN calculate

a) the horizontal force transfered from each flange to the web

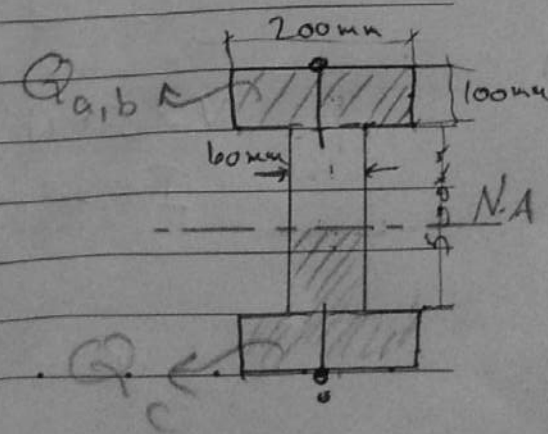
b) the maximum spacing S

c) maximum horizontal shear stress

soln. a) calculate $q = \frac{VQ}{I}$ then multiply by length 4m

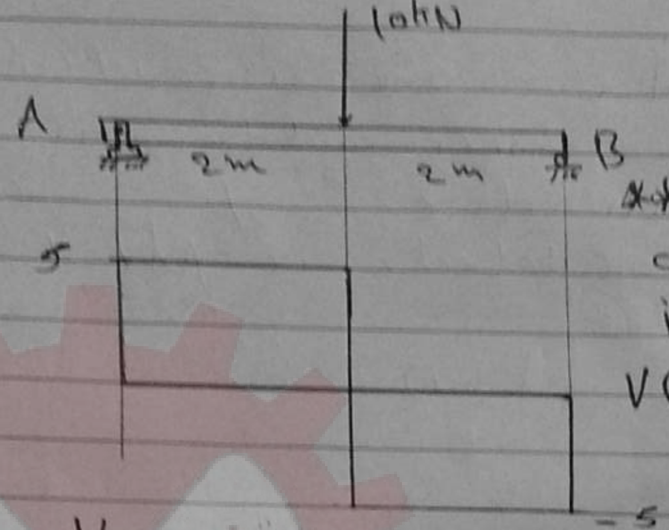
b)

$$q = \frac{VQ}{I} = \frac{nF}{s}$$



cont →

No.



$R_A = R_B = 5kN$

** Q: is always the area that is to slide if there was no nails

V(kN)

So $V = 5kN$, $Q = \underbrace{0.1 * 0.2}_{A'} * \underbrace{0.3}_{\bar{y}'}$

$= 6 * 10^{-3}$

$I = 2 * [\underbrace{0.2 * (0.1)^3 * \frac{1}{12}}_{\frac{bh^3}{12}} + \underbrace{0.2 * 0.1}_{A} * \underbrace{(0.3)^2}_{\bar{y}^2}]$

$+ 0.1 * (0.5)^3 * \frac{1}{12}$

$= 4.675 * 10^{-3} m^4$

$n = 1$ $F = 0.5\ kN$

$\frac{VQ}{I} = \frac{nF}{s} \Rightarrow s = \frac{nFI}{VQ}$

$77.91 * 10^{-3}\ m \simeq 77\ mm$

round to a less number

c) $\tau = \frac{VQ}{It}$ wher

$V = 5kN$ $Q = 0.1 * 0.25 * 0.125 + 0.1 * 0.0025$

I: same $t = 0.1$

No. Deflection

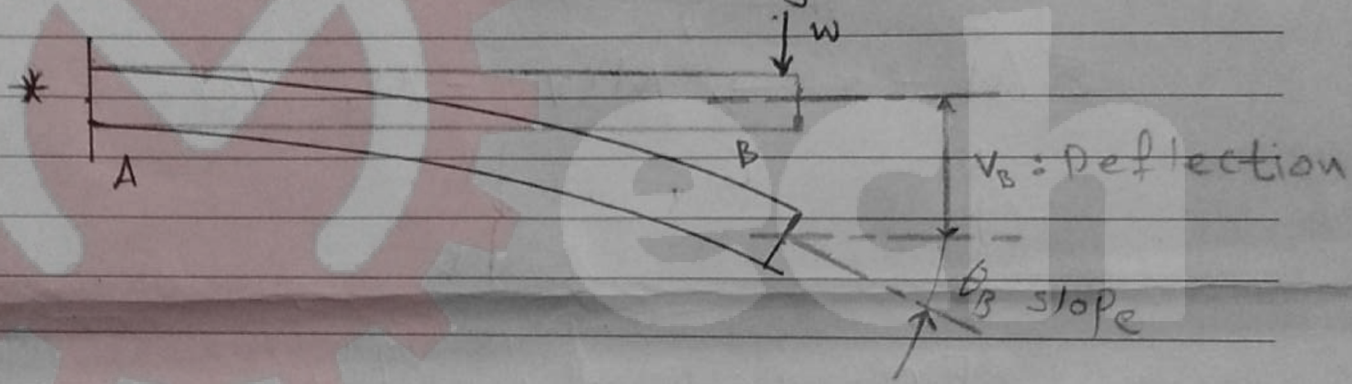
I) integration method

Procedure

1- obtain an equ. for the beam's internal Moment

2- $EI\frac{d^2 v}{dx^2} = M \xrightarrow{\text{integrate}}$ slope equ $\xrightarrow{\text{integrate}}$ deflection

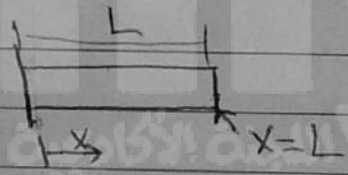
3- Apply boundary conditions to evaluate the constants of integration C_1 and C_2

*


* boundary conditions are point where the slope and/or the deflection is known

see M 10.1 in mecmovies

* Fixed support

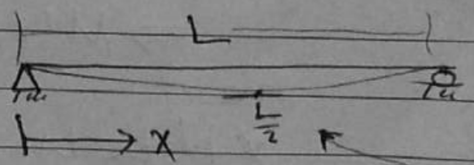


$V(0) = 0$, $\theta(0) = 0$

$M(L) = 0$, $V(L) = 0$

shear force

*Simply supported



$V(0) = 0$, $V(L) = 0$

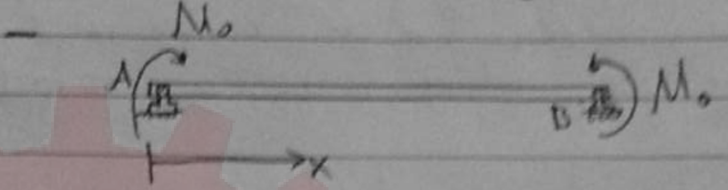
$M(0) = 0$, $M(L) = 0$

- if the load is uniform of concentrated at the centre then anew condition is $\theta(\frac{L}{2}) = 0$

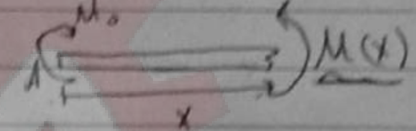
No.

* obtaining an eqn. for the internal Moment $M(X)$

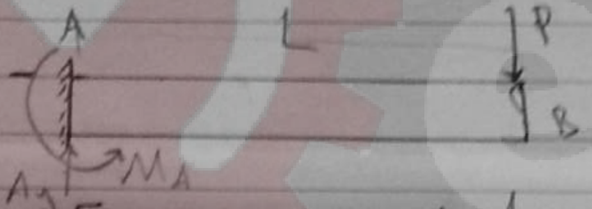
to obtain $M(x)$ you have to Draw a F.B.D



F.B.D



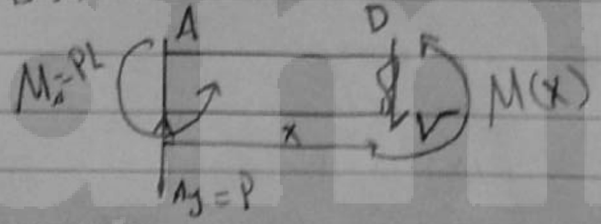
$\sum M = 0 \Rightarrow M(x) = M_o$ very simple



First we Find A_y, M_A

* $\sum F_y = 0 \rightarrow A_y = P \uparrow$
* $\sum M_A = 0 \rightarrow M_A = PL$

F.B.D



$\sum M_D = 0 = M_A + M(X) - A_y * X$

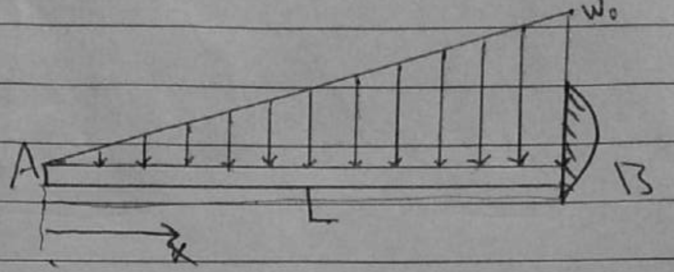
$\Rightarrow M(x) = PX - PL$

* Note that the F.B.D starts from $X=0$ and goes to the cut Point so All forces and Moments in the reigon ($x=0 \rightarrow$ cut) must be known.

* $\theta = \frac{dv}{dx}$ (always remember it)

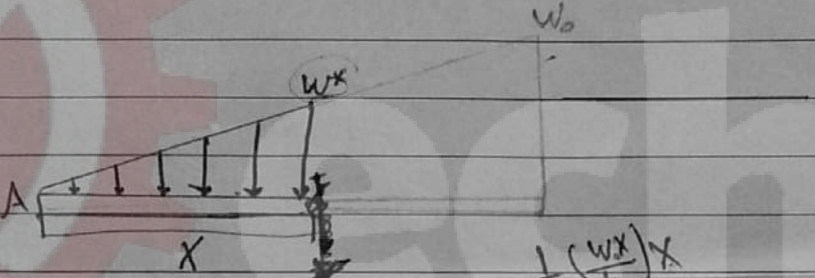
No.

ex. Find the elastic curve and V_{max} and θ_{max}



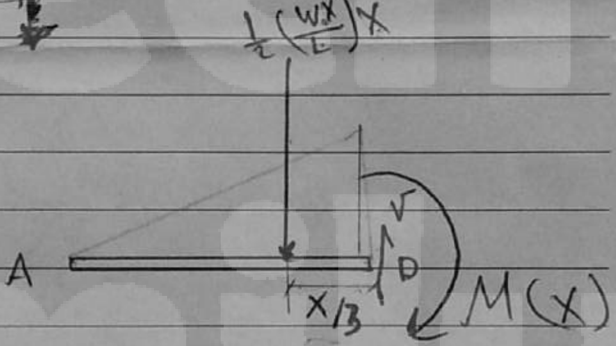
1 obtain $M(x)$:-

F.B.D



in our region w^* is unknown but $\frac{w_0}{L} = \frac{w^*}{X}$

$$\Longrightarrow w^* = \frac{w_0 X}{L}$$



* $\Sigma M_D = 0$

$$M(x) = \frac{1}{2}\left(\frac{-w_0 X}{L}\right) \cdot X \cdot \frac{X}{3}$$

$$= \frac{-w_0 X^3}{6L}$$ the ⊖ because M is clock wise

$$EI \frac{d^2 v}{dx^2} = \frac{-w}{6L} x^3$$

$$EI \frac{dv}{dx} = \frac{-w_0}{24L} X^4 + C_1$$

$$EI\, v = \frac{-w_0}{120L} x^5 + C_1 X + C_2$$

boundary cond.

$\theta(L) = \frac{dv}{dx}(L) = 0 \rightarrow C_1 = \boxed{\frac{w_0 L^3}{24}}$

$\theta = 0, X = L$

$V(L) = 0 \rightarrow C_2 = \boxed{\frac{-w_0 L^4}{30}}$

$V = 0, X = L$

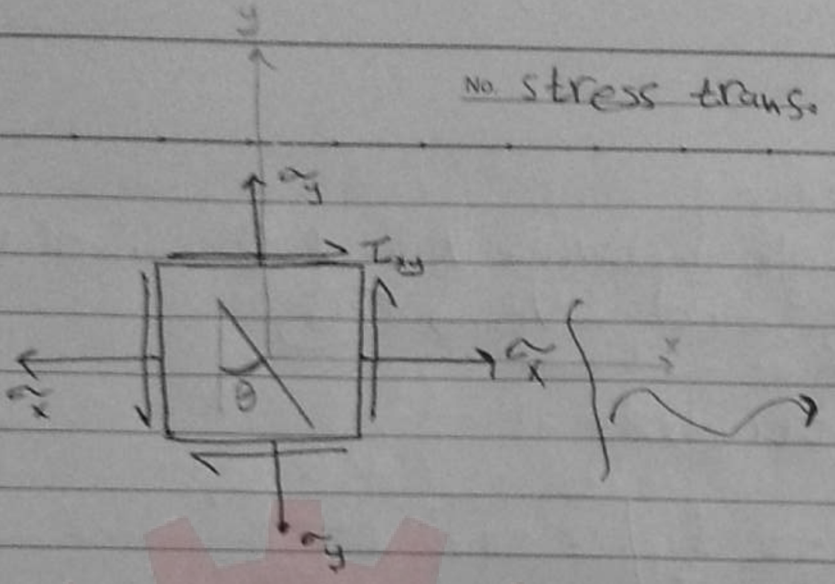
$$V = \frac{w_0}{120EIL}\left(-x^5 + 5L^4 x - 4L^5\right)$$

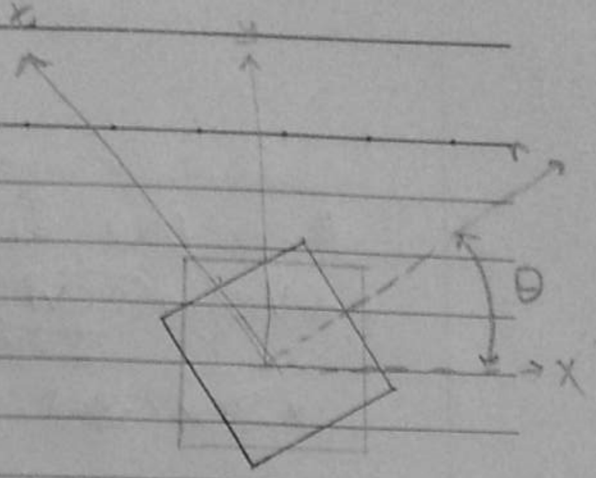
$$V_{max} = V(0) = \frac{-w_0 L^4}{30EI}$$

also $\theta = \frac{w_0}{24EIL}\left(L^4 - x^4\right)$

$$\theta_{max} = \theta(0) = \frac{dv}{dx}(0) = \frac{w_0 L^3}{24EI}$$

No. stress trans.





* $\sigma_n = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$

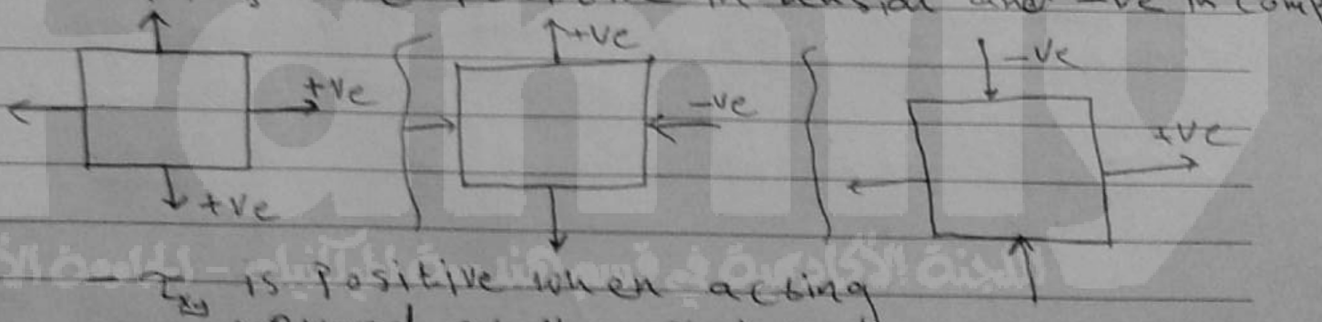
* $\sigma_t = \frac{\sigma_x + \sigma_y}{2} - \frac{\sigma_x - \sigma_y}{2}\cos 2\theta - \tau_{xy}\sin 2\theta$

* $\tau_{nt} = -\frac{\sigma_x - \sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta$

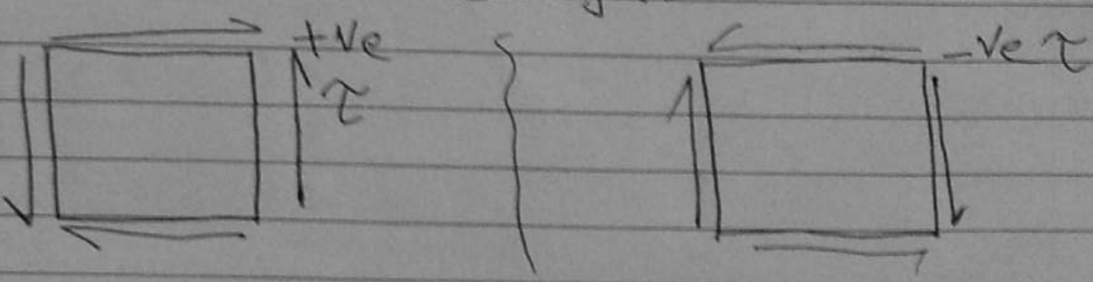
* $\sigma_x + \sigma_y = \sigma_n + \sigma_t$

Notes: (very very important)

- σ_x, σ_y are Positive in tension and -ve in comp.



- τ_{xy} is positive when acting upward at the right



θ is the angle between x and t and it is +ve → (CCW) and −ve → (CW)

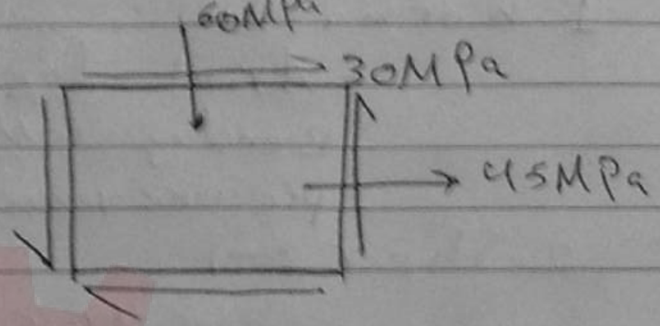
* Principal stresses

- $\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \underset{(2)}{\overset{(1)}{\pm}} \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$
- $\tau_{nt} = 0$
- $\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$ θ_p: $\theta \rightarrow$ Principal stress

* Max. and min. shear stresses

- $\tau_{\substack{max \\ min}} = \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$
- $\tan 2\theta_s = \frac{\sigma_y - \sigma_x}{2\tau_{xy}}$ or $\theta_s = \theta_p \pm 45°$
- $\sigma_n = \sigma_t = \sigma_{av} = \frac{\sigma_x + \sigma_y}{2}$

ex. Find the principal stresses and their orientation and the maximum shear stresses and their orientation.



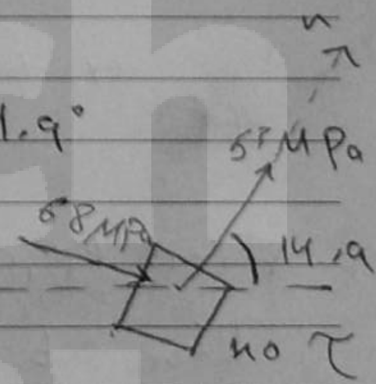
① $\sigma_x = 45\ MPa$, $\sigma_y = -60\ MPa$, $\tau_{xy} = 30\ MPa$

$\sigma_1 = -7.5 + 60.5 = 53\ MPa$

$\sigma_2 = -7.5 - 60.5 = -68\ MPa$

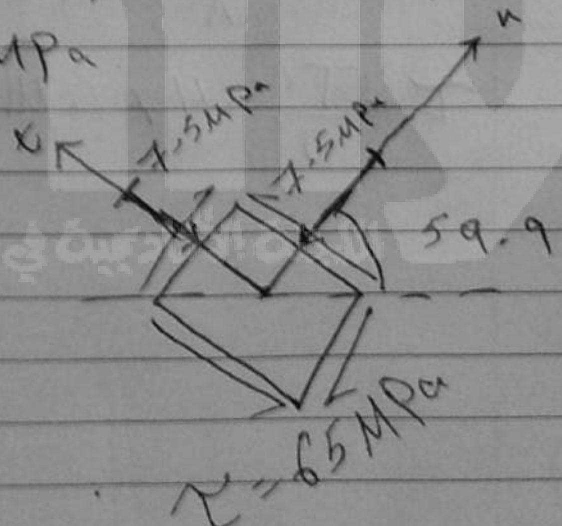
$\tan 2\theta_p = \frac{2 \times 30}{45 - 60} \Longrightarrow \theta_p = 14.9°$

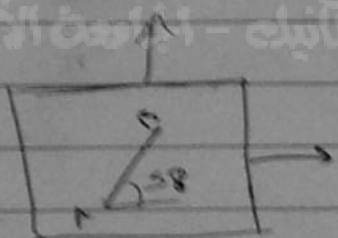
$\tau_{nt} = 0$



$\tau_{\substack{max \\ min}} = \pm 60.5$ $\quad \theta_s = \theta_p + 45 = 59.9$

$\sigma_n = \sigma_t = \sigma_{av} = -7.5\ MPa$





$\sigma_x = 400$ $\quad \tau_{(4R)} = 550$ $\quad \sigma_y = ??$

No.

Mohr's circle

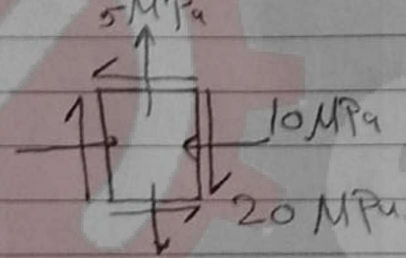
First we have to determine σ_x, σ_y, τ_{xy}

then we locate Points A, B, C
where

$A(\sigma_x, \tau_{xy})$ نقطة
$B(\sigma_y, -\tau_{xy})$ نقطة
$C(\sigma_{av}, 0)$ نقطة

$* \; \sigma_{av} = \dfrac{\sigma_x + \sigma_y}{2}$

ex.



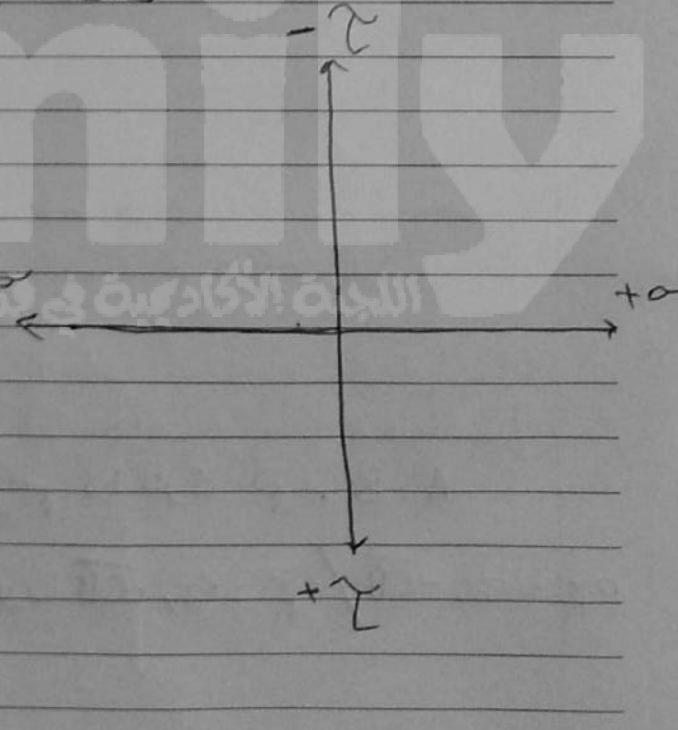
$\sigma_x = -10\,MPa$, $\sigma_y = +5\,MPa$, $\tau_{xy} = -20\,MPa$

$\longrightarrow \sigma_{av} = \dfrac{-10+5}{2} = -2.5$

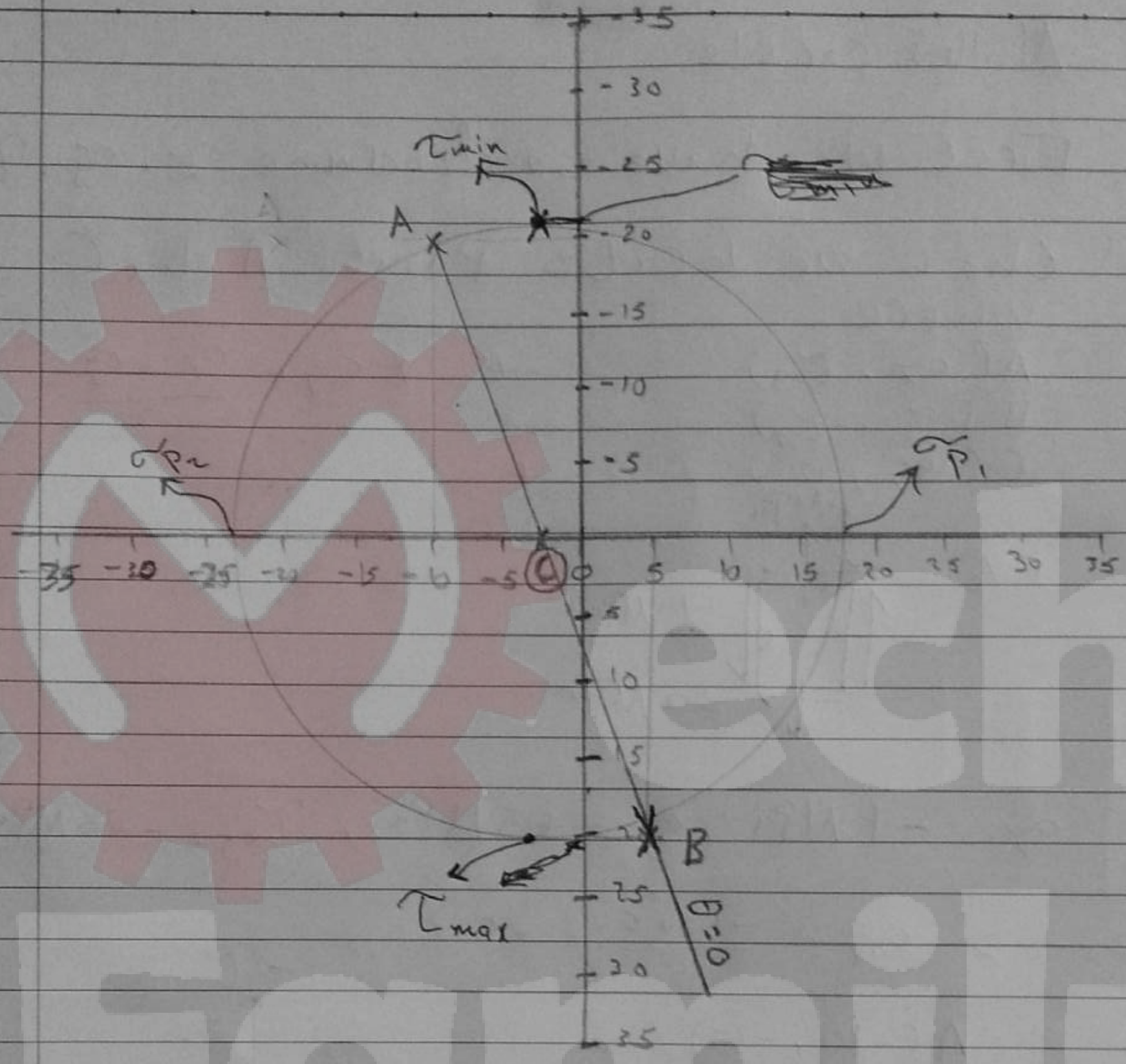
$A(-10, -20)$
$B(5, 20)$
$C(-2.5, 0)$

then stablis a coordinate system with (σ as x)

$\boxed{\ominus \tau \text{ as } y}$



No.



ارسم بتوا المسطرة ويتم أخذ scale مناسب
في هذه الرسمة scale ← كل 1 سم = 5MPa

ثم نعين النقاط A, B, C بدقة مع مراعاة
أن قيم τ السالبة في الأعلى والموجبة في الأسفل
ثم نركز الفرجار في (C) ونرسم دائرة تمر ب A, B
ثم نصل A, B, C بخط
ثم نجد طول الخط $\overline{CB}$ ليكون $\sigma_{p_1} = \sigma_{av} + \overline{CB}$ / $\sigma_{p_2} = \sigma_{av} - \overline{CB}$
وكذلك $\mp \overline{CB} = \tau_{max/min}$

No.

ثم نقيس بالمنقلة الزاوية بين الخط ~~A~~ $\overline{CB}$ ومحور
الـ $x(\sigma)$ فتكون الزاوية $2\theta_p$ نقسمها على 2 لنجد θ_p

* عشان نقيس الزاوية نضع خط المنقلة على CB ونقيس
منه أي ان الزاوية الخط $\overline{CB}$ هي الصفر ونقرأ على الاشارة
بحيث $(+\ CCW)$ و $(-ve\ CW)$

نجد $\theta_s = \theta_p \mp 45$

No.

Combined loading
types of loads

1- normals :-
- Axial $\left(\frac{P}{A}\right) = \sigma$
- Bending $\left(\frac{My}{I}\right) = \sigma$
- Pressure vessles. → later

2- Shear :-
- shear stress $\left(\frac{VQ}{It}\right) = \tau$
- torsional $\left(\frac{Tr}{J}\right) = \tau$

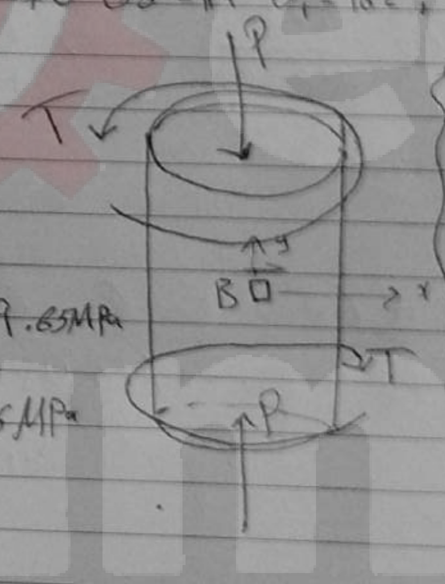
Add normal together and shear together

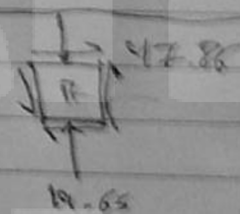
~~ex~~ shaft $d_o = 114$, $d_i = 102$, $T = 5\ kN.m$, $P = 40\ kN$

Find σ_1, σ_2

τ_{max} at B

- $\sigma_{axial} = \frac{P}{A} = 19.65\ MPa$
- $\tau = \frac{Tr}{J} = 47.86\ MPa$





$\sigma_1 = 39.03$
$\sigma_2 = -58.68$
$\tau = 0$

$\tau_{max} = 48.86$
$\sigma_n = \sigma_a = \sigma_{av} = 9.82$

ملاحظات هامة

يجب دراسة ال pressure vesseles من دوسة الدكتور هاشم الخالدي وحفظ القوانين الثلاث فيها

هام جدا وملزم: يجب دراسة جميع اسئلة الكومبايند لودينغ الموجودة على الميك موفيز دون استثناء لأن اسئلة الإمتحان ستكون شبيهة جدا جدا

يجب حل مجموعة من الأسئلة على مور سيركل