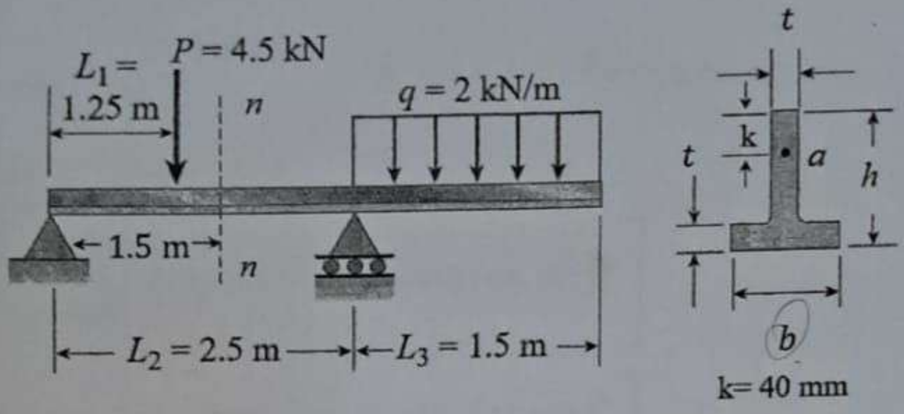
ME 224-STRENGTH OF MATERIALS

2nd Midterm Exam

Duration: 100 min

Date: 10.06.2025

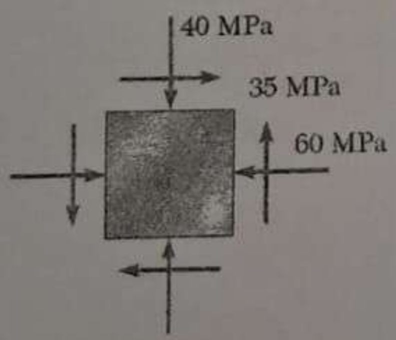


1. A beam of T-section is supported and loaded as shown in the figure above. The cross section has width $b = 65$ *mm*, height $h = 75$ *mm*, and thickness $t = 13$ *mm*. Determine the maximum tensile and compressive stresses in the beam. (***Hint***: Start by drawing the shear- bending moment diagrams.)

2. By using *n-n* section on the beam above, determine:

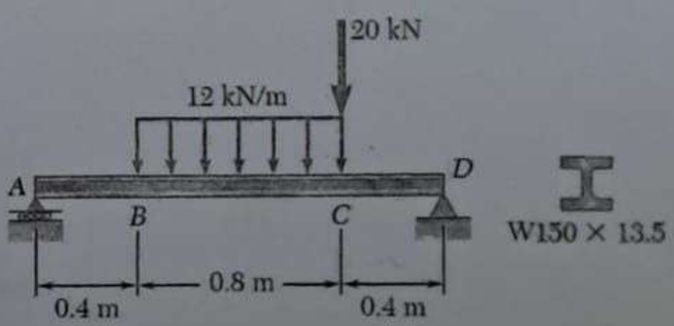
   (a) maximum shearing stress (τ_{max}),

   (b) shearing stress at point *a* in the cross-section given above.



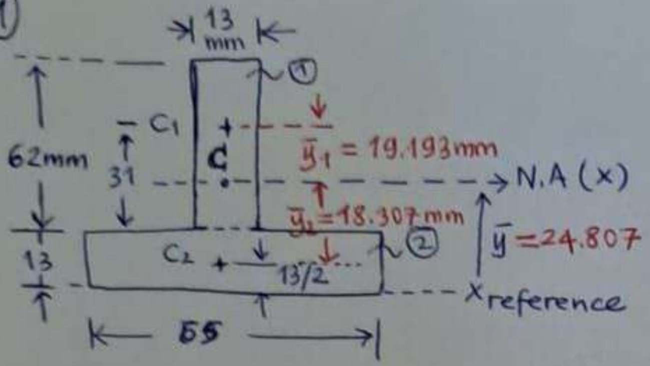
3. For the given state of stress, determine (a) the orientation of the planes of maximum in-plane shearing stress, (b) the maximum in-plane shearing stress, (c) the corresponding normal stress.

4. For the beam and loading shown, determine (a) the slope at end A, (b) the deflection at point C. Use E =200 GPa, $I_x = 6.83x10^6\ mm^4$. Use the singularity function method only.



Good luck

①



• Centroid of the crossection:

$$\bar{y} = \frac{\Sigma y.A}{\Sigma A} = \frac{(31+13)(62\times13)+(\frac{13}{2})(65\times13)}{(62\times13)+(65\times13)}$$

$\bar{y} = (24.807\text{mm})$ above the x reference ⑤

•• Moment of inertia about N.A .

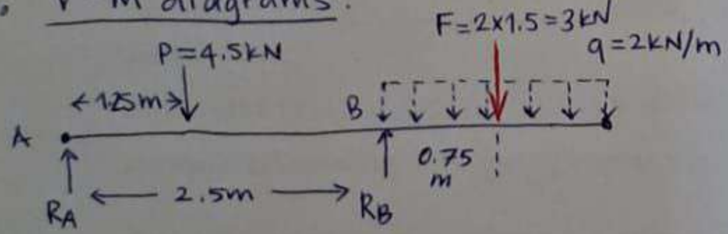
$$I_x = I_{x_1} + I_{x_2} = \left[\frac{1}{12}(13)(62)^3 + (13\times62)(19.193)^2\right]$$

$$+\left[\frac{1}{12}(65)(13)^3 + (65\times13)(18.307)^2\right]$$

$$= \left[258.189\times10^3 + 296.907\times10^3\right] + \left[11.9\times10^3 + 283.198\times10^3\right]$$

$$\boxed{I_x = 850.195\times10^3\ \text{mm}^4} = 850.195\times10^{-9}\ \text{m}^4$$ ⑤

∴ V-M diagrams.



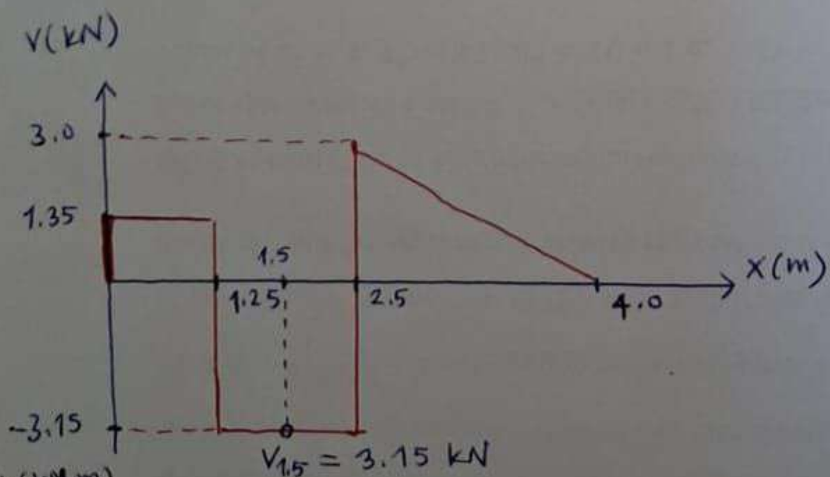
→ Applying equilibrium eqn.

$\circlearrowleft + \Sigma M_A = 0 \quad (2.5)R_B - (1.25)(4.5) - (3.25)(3) = 0$

$\boxed{R_B = 6.15\text{kN}}$

$\Sigma F_y = 0 \ : \ R_A + 6.15 - 4.5 - 3 = 0$

$\boxed{R_A = 1.35\text{ kN}}$



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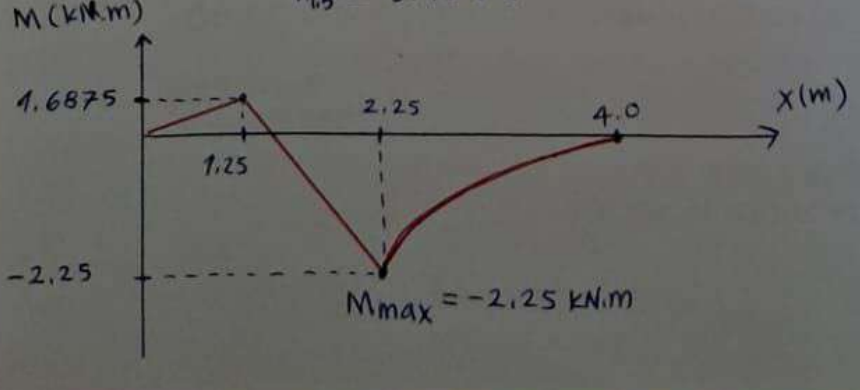
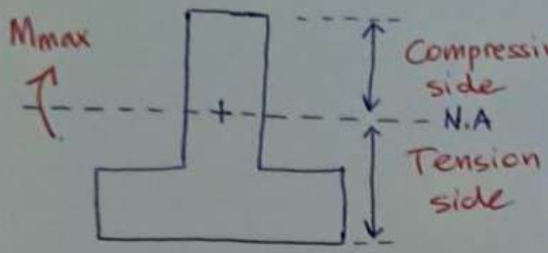




$y_c = 75 - 24.807$
$= 50.193\,mm$

$y_t = 24.807\,mm$

$$* \ \sigma_t = \frac{M_{max} \cdot y_t}{I_x} = \frac{(2.25\times10^3)(24.807\times10^{-3})}{(850.195\times10^{-9})} = \boxed{65.652\times10^6\ Pa}$$ ⑤

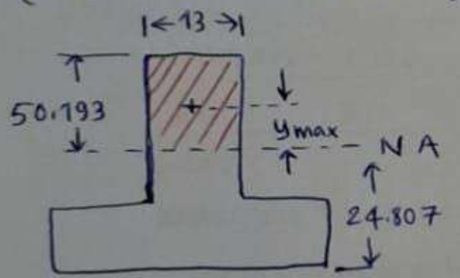
$$** \ \sigma_c = \frac{-M_{max} \cdot y_c}{I_x} = \frac{(-2.25\times10^3)(50.193\times10^{-3})}{(850.195\times10^{-9})} = \boxed{-132.833\times10^6\ Pa}$$ ⑤

-132.833 MPa

* Effort : ⑤ / ⑩ Correct strategy

② At n-n section $\underline{V_{1.5} = 3.15\,kN}$ from V-M diagram. ⑤

(a) Maximum shearing stress occurs on N.A.



⑩

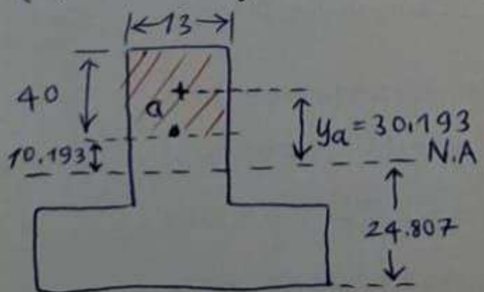
• $Q_{max} = (50.193)(13)\times\left(\frac{50.193}{2}\right) = 16.376\times10^3\ mm^3$

• $\tau_{max} = \frac{V \cdot Q_{max}}{I \cdot t} = \frac{(3.15\times10^3)(16.376\times10^{-6}m^3)}{(850.195\times10^{-9})(13\times10^{-3})}$

$= \boxed{4.66\times10^6\ Pa}$

4.66×10^6

(b) Shearing stress at point a;



⑩

• $Q_a = (40\times13)(30.193) = 15.7\times10^3\ mm^3$

• $\tau_a = \frac{(3.15\times10^3)(15.7\times10^{-6}m^3)}{(850.195\times10^{-9})(13\times10^{-3})}$

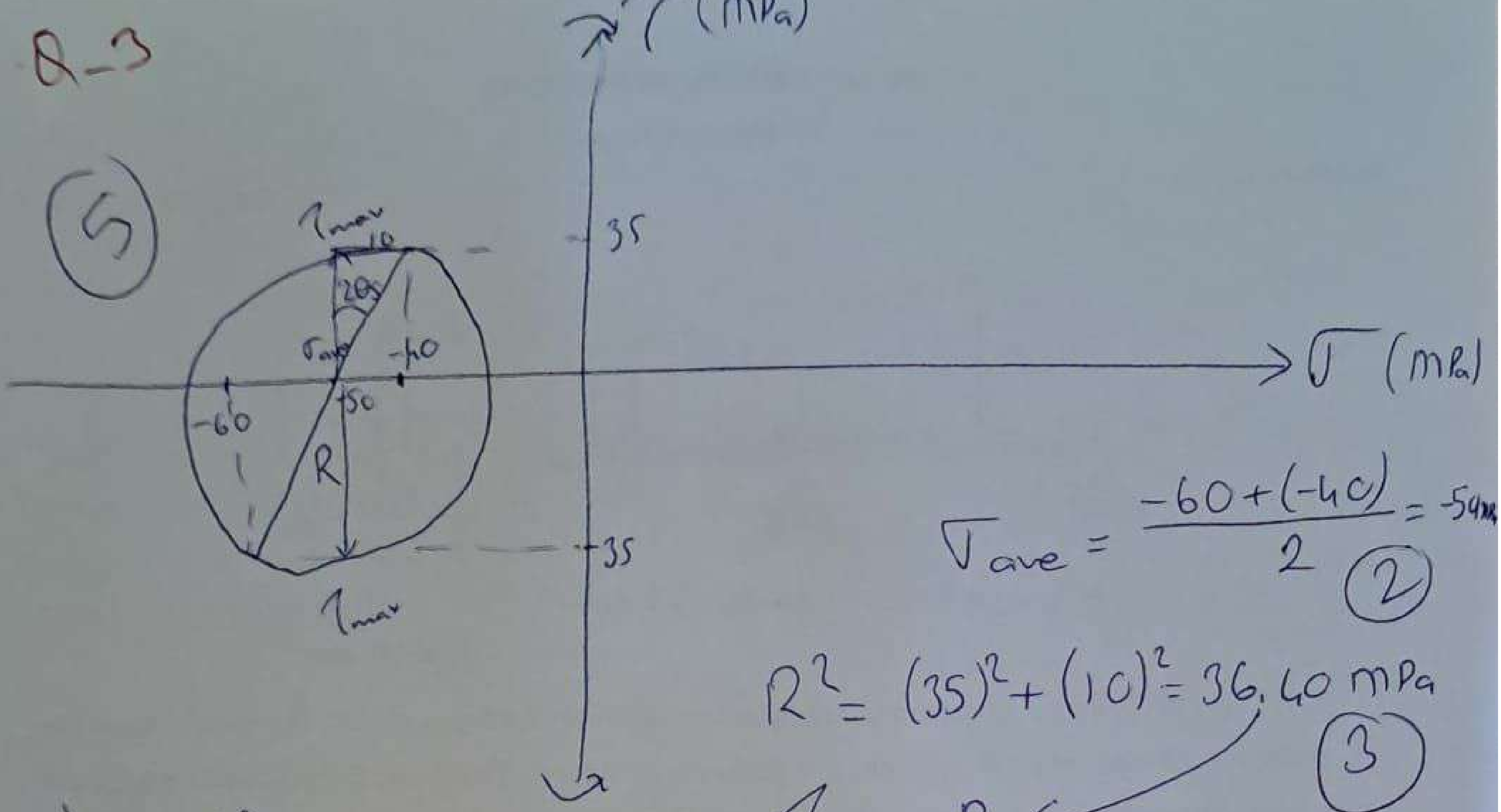
$= \boxed{4.47\times10^6\ Pa}$

4.47×10^6

Correct Solution strategy ⑩

Q-3

5



$$\sigma_{ave} = \frac{-60+(-40)}{2} = -50\,mPa$$

2

$$R^2 = (35)^2 + (10)^2 = 36.40\ mPa$$

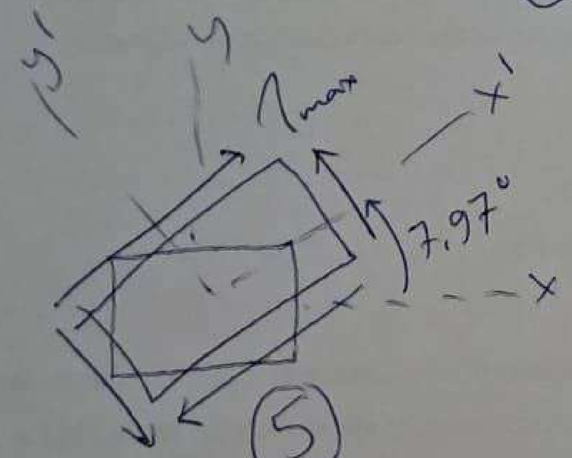
3

$$\tau_{max} = R$$

3

$$\tan 2\theta_s = \frac{10}{35} \rightarrow \theta_s = 7.97^\circ$$

2



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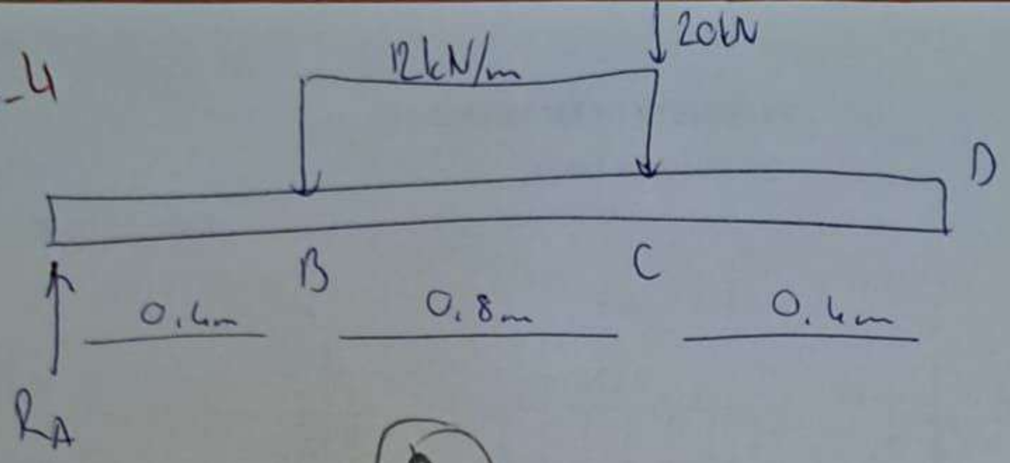
$$\cancel{\sigma_1 = \sigma_{ave} + R}$$

$$= \cancel{-50 + 36.40 = -13.6\ mPa}$$

$$\sigma_1 = \sigma_2 = -50\ mPa$$

5

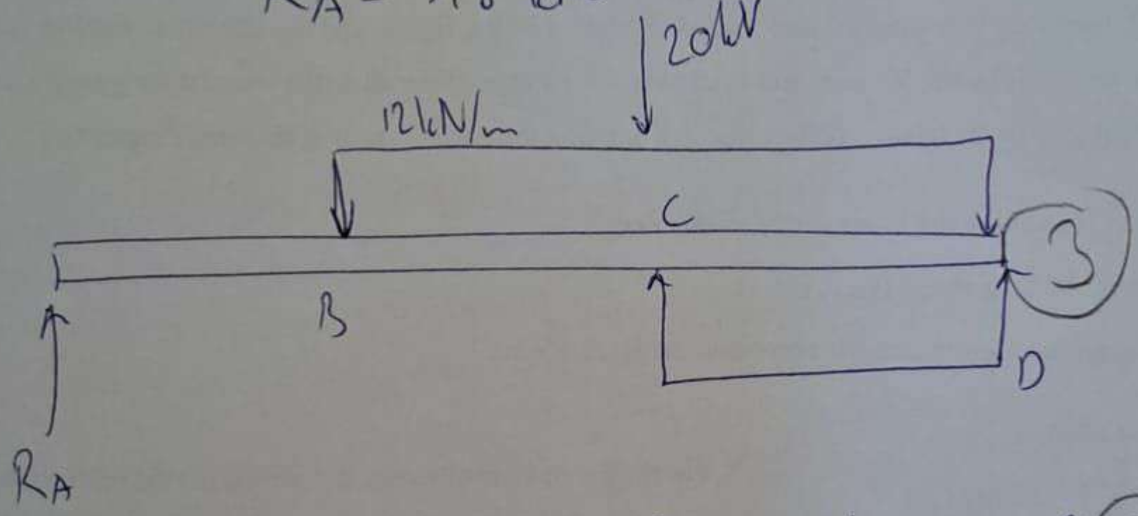
Q-4



$+\sum M_0 = 0$ 2

$R_A \times 1.6 - (12 \times 0.8) \times 0.8 - 20 \times 0.4 = 0$

$R_A = 9.8\ kN$



$w(x) = +12\langle x-0.4\rangle^0 - 12\langle x-1.2\rangle^0$ 3

$V(x) = -12\langle x-0.4\rangle^1 + 12\langle x-1.2\rangle^1 + 9.8 - 20\langle x-1.2\rangle^0$

$M(x) = -6\langle x-0.4\rangle^2 + 6\langle x-1.2\rangle^2 + 9.8x - 20\langle x-1.2\rangle^1$ 3

$EI\frac{dy}{dx} = -2\langle x-0.4\rangle^3 + 2\langle x-1.2\rangle^3 + 4.9x^2 - 10\langle x-1.2\rangle^2 + C_1$ 3

$EI\,y = -0.5\langle x-0.4\rangle^4 + 0.5\langle x-1.2\rangle^4 + \frac{4.9}{3}x^3 - \frac{10}{3}\langle x-1.2\rangle^3 + C_1x + C_2$

$y=0$ at $x=0 \rightarrow C_2 = 0$ 2 1

$y=0$ at $x=1.6 \rightarrow C_1$ 2 1

$y=0$ at x