Assignment # 05

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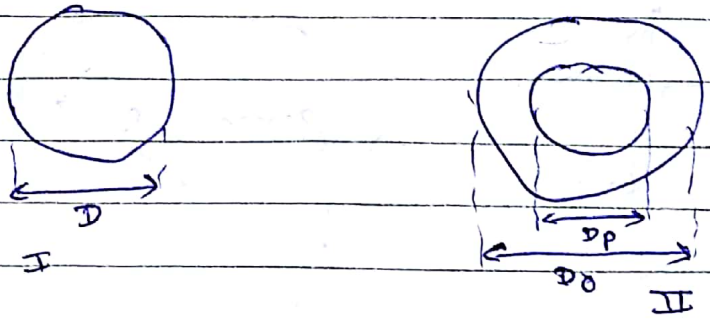
Sol. 1.



Section modulus $Z = \frac{I}{y_{max}}$

$$Z_1 = \frac{(\pi/64)\, D^4}{D/2} \qquad Z_2 = \frac{\frac{\pi}{64}(D_0^4 - D_p^4)}{D_0/2}$$

$$Z_1 = \frac{\pi D^3}{32}, \qquad Z_2 = \frac{\pi}{32}\,\frac{(D_0^4 - D_p^4)}{D_0}$$

$$\frac{Z_1}{Z_2} = \frac{D^3 D_0}{(D_0^4 - D_p^4)} \quad \text{---} \quad (1)$$

length and weight are same:
Material is same:
then $(Volume)_I = (Volume)_{II}$

$$\frac{\pi}{4} D^2 \times L = \frac{\pi}{4}(D_0^2 - D_p^2) \times L$$

$$\Rightarrow D^2 = D_0^2 - D_p^2 \quad \text{--} \quad (2)$$

From (1): $\frac{Z_1}{Z_2} = \frac{D^3 D_0}{(D_0^2 + D_p^2)(D_0^2 - D_p^2)}$

From (2):

$$\frac{Z_1}{Z_2} = \frac{D^3 D_0}{D^2 (D_0^2 + D_p^2)}$$

$$\boxed{\frac{Z_1}{Z_2} = \frac{D D_0}{(D_0^2 + D_p^2)}}$$

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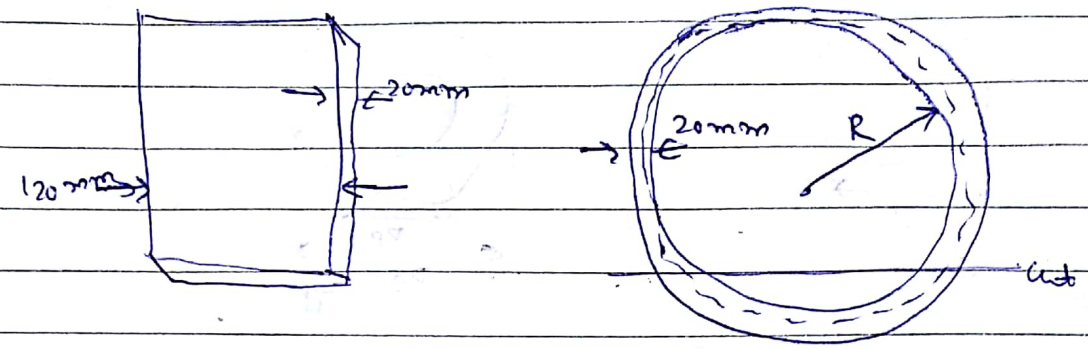
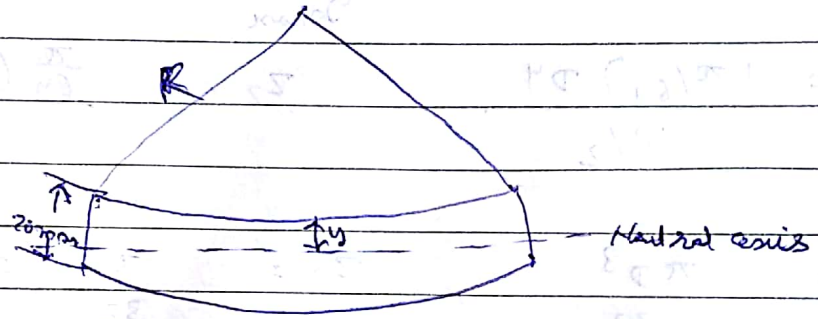
Sol 2.



Here $R = 10m = 10,000mm$



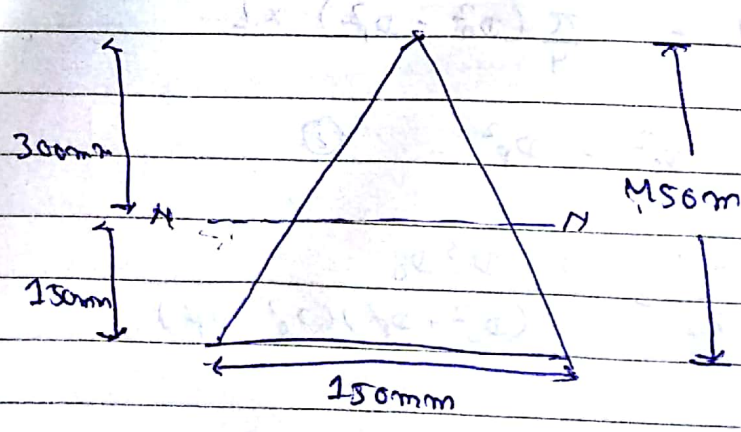
$E = 2 \times 10^5 \ N/mm^2$

$y_{max} = 10 \ mm$

$$\sigma = \frac{E}{R} \times y = \frac{2 \times 10^5}{10,000} \times 10$$

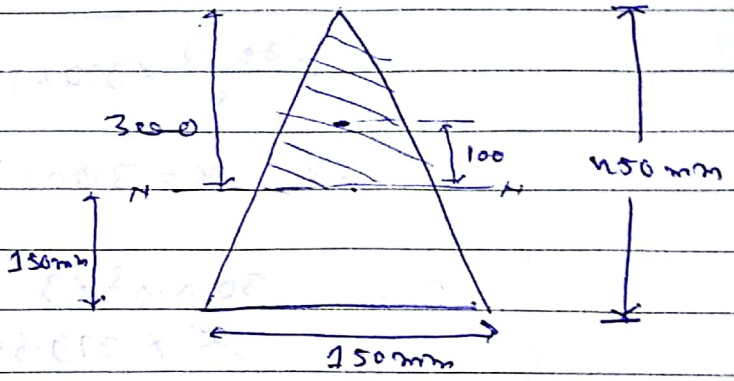
$$= 200 \ MPa$$

Sol 3:



(i) $\tau = \frac{F}{zI} A\bar{y}$

$F = 30\,kN$



$z = \frac{300}{450} \times 150$

$z = 100\,mm$

$I = \frac{150 \times (450)^3}{36} = 379.68 \times 10^6\ mm^4$

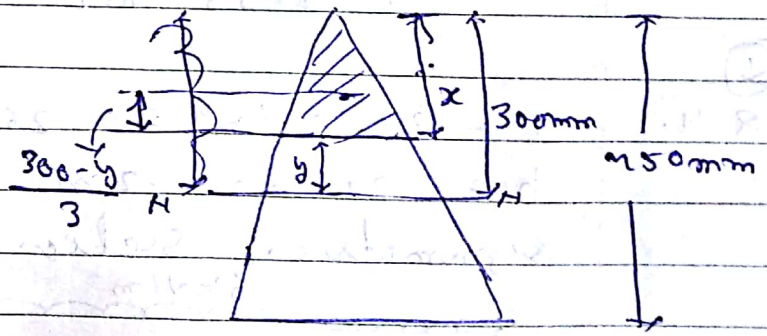
$A\bar{y} = \left(\frac{1}{2} \times 100 \times 300\right) \times 100$

$= 15 \times 10^5\ mm^3$

$\tau = \frac{30 \times 10^3 \times 15 \times 10^5}{100 \times 379.68 \times 10^6}$

$= 1.185\ MPa$

(ii) $\tau = \frac{F}{zI} A\bar{y}$



$F = 30\,kN$

$z = \frac{300-y}{450} \times 150$

$z = \frac{300-y}{3}$

$I = 379.68 \times 10^6\ mm^4$

$A = \frac{1}{2} \times \frac{300-y}{3} \times 300-y = \frac{(300-y)^2}{6}$

$\bar{y} = \frac{2y+300}{3}$

$$\tau = \frac{30\times10^3}{\frac{300-y}{3}\times379.68\times10^6}\times\frac{(300-y)^2}{6}\times\left(\frac{2y+300}{3}\right)$$

take $x = 300-y$

$$\tau = \frac{30\times10^3\times3}{x\times379.68\times10^6}\times\frac{x^2}{6}\times\frac{(900-2x)}{3}$$

$$\tau = (\text{Constant})\times x(900-2x)$$

$$\frac{d\tau}{dx}=0 \Rightarrow x(0-2)+(900-2x)=0$$

$$\Rightarrow 900-4x=0$$

$$\Rightarrow \boxed{x = 225\ mm}$$

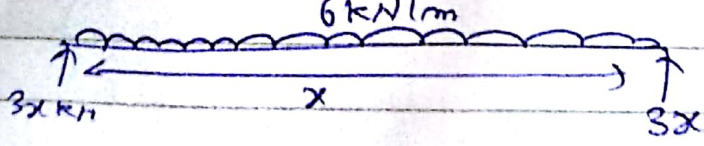
(iii) $$\tau_{max} = \frac{30\times10^3\times3\times225\times(900-450)}{379.68\times10^6\times18}$$

$$= 1.33\ MPa$$

Q.4. $I = 2640\ cm^4 \equiv 2640\times10^{-8}\ m^4$

$h = 20\ cm = .2\ m$

symmetrical section $\Rightarrow y_{max} = .1\ m$



$$M = \frac{6\times x^2}{8} = \frac{3x^2}{4}$$

$$\frac{\sigma}{y} = \frac{M}{I} \Rightarrow \frac{120\times10^3}{.1} = \frac{3x^2\times10^3}{4\times2640\times10^{-8}}$$

$$\Rightarrow x^2 = \sqrt{42.24} = 6.49\ m$$

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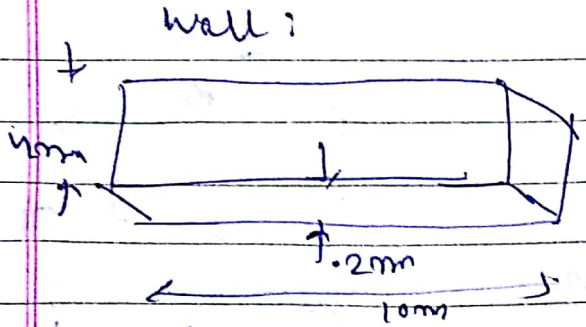
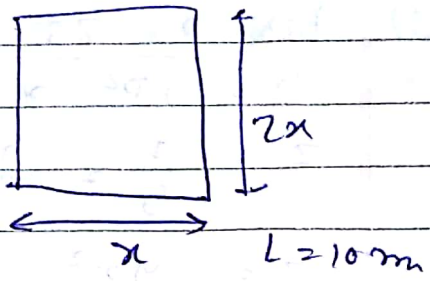
Sol 5.

Wall :

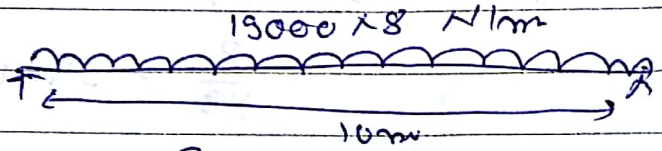




$d = 1900\ kg/m^3$

$\Rightarrow 1900 \times .8\ kg/m$

$\Rightarrow 19000 \times 8\ N/m$



$$M = \frac{WL^2}{8}$$

$$= \frac{19000 \times 100 \times 8}{8} = 19 \times 10^4\ N\text{-}m$$

For timber joist -

$$\frac{M}{I} = \frac{\sigma}{y}$$

$$\Rightarrow \frac{19 \times 10^4 \times 12}{x \times (2x)^3} = \frac{8 \times 10^6}{x}$$

$$\Rightarrow x^3 = \frac{19 \times 12}{64 \times 10^2}$$

$$\Rightarrow x = 0.329 \simeq 0.33\ m$$

$$x = 330\ mm$$

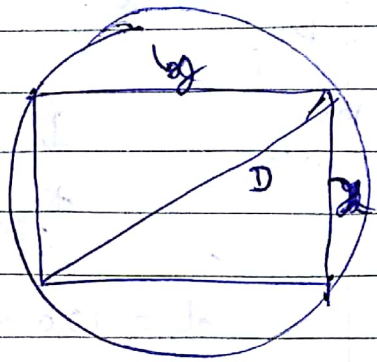
$$2x = 660\ mm$$

Sol. 6.(i) Here $D = 25\ cm$

$y = \sqrt{D^2 - x^2}$

$Z = \frac{I}{y} = \frac{yx^3 \times 2}{12 \times x}$

$Z = \frac{yx^2}{6} = \frac{y(D^2 - y^2)}{6}$



For strongest section

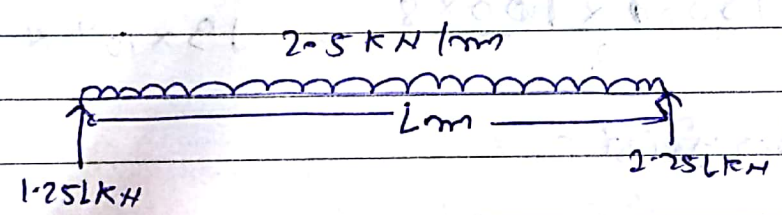
$\frac{dz}{dy} = 0 \Rightarrow y(-2y) + (D^2 - y^2) = 0$

$D^2 = 3y^2$

$y = \frac{D}{\sqrt{3}} = 14.43\ cm$

$x = 20.41\ cm$

(ii)



$M = \frac{2.5 \times 10^3 \times L^2}{8} = 312.5 L^2\ N\text{-}m$

$\frac{M}{I} = \frac{\sigma}{y} \Rightarrow \frac{312.5 L^2 \times 12}{(.1443) \times (.2041)^3} = \frac{10 \times 10^6}{.102}$

$\Rightarrow L = 5.663\ m$

(iii) $\frac{M}{I} = \frac{\sigma}{y} \Rightarrow \frac{312.5 L^2 \times 64}{3.14 \times (.25)^4} = \frac{10 \times 10^6 \times 2}{.25}$

$\Rightarrow L = 7\ m$