S.E. (Mechanical) sem (III) (Rev. 2012) (CBSGS) / T 1479

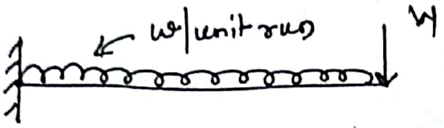
Strength of Materials.

Q.P. Code - 27344

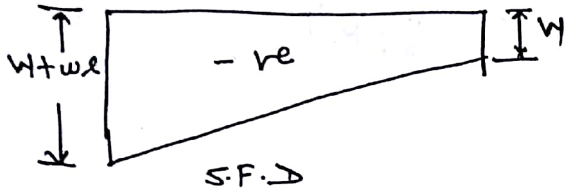
Total Marks - 80

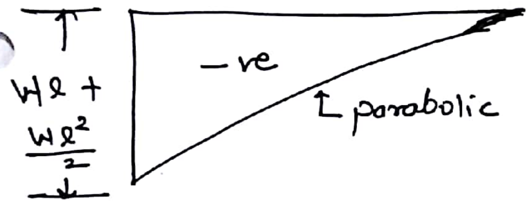
Answer key

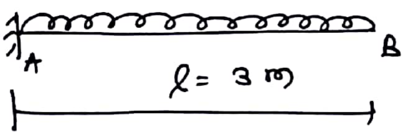
Q. 1

a) 

— 05





b) 

$$\theta_B = -\frac{w l^3}{6EI}$$

$$0.05236^c = -\frac{w \times (3)^3}{6EI}$$

$$\therefore w = -0.011636\ EI\ N/m$$ — 02

$$\therefore y_B = -\frac{w l^4}{8EI}$$

$$= -\frac{0.011636\ EI \times (3)^4}{8EI}$$

$$\boxed{y_B = 0.11781\ m\ \text{downward}}$$ — 03

c) Derivation

$$E = \frac{9KG}{3K+G}$$ — 05

d) strain Energy stored is due to torsion in a solid shaft –

The work done $= \frac{1}{2} T\theta$ is stored in a shaft as strain energy

$$\therefore T = \frac{\tau \times J}{R} \quad \& \quad \theta = \frac{\tau l}{G R}$$

$$J = \frac{\pi}{2} R^4$$

$$\therefore W.D. = \frac{1}{2} T \theta$$

$$= \frac{1}{4} \frac{\tau^2}{G} \times \pi R^2 l$$

$$\boxed{S.E. = \frac{\tau^2}{4G} \times \text{Volume}} \quad \text{— (05)}$$

e) $d = 12$ mm

$P = 20$ kN

$\delta d = 0.003$ mm

$G = 80$ GPa

(i) μ

(ii) E

(iii) K

$$A = \frac{\pi}{4}(12)^2 = 36\pi \ mm^2$$

$$\sigma = 20,000 / 36\pi = 176.84 \ MPa$$

$\therefore$ Lateral strain $= \mu$. Linear strain

$$\frac{\delta d}{d} = \mu \epsilon \quad i.e. \quad \frac{0.003}{12} = \mu \epsilon$$

$$\therefore \epsilon = 0.00025 / \mu$$

$$E = 2G(1+\mu) = 160000 + 160000\mu \quad -(i)$$

$$E = \frac{\sigma}{\epsilon} = \frac{176.84}{0.00025/\mu} = 707360\mu \quad -(ii)$$

equating (i) & (ii) we get $\boxed{\mu = 0.2923}$ — (03)

$$\boxed{\therefore E = 206741 \ MPa} \quad \text{— (01)}$$

$$\boxed{\therefore K = \frac{E}{3(1-2\mu)} = 165921 \ MPa} \quad \text{— (01)}$$

Q2a)

$T_1 = 40^\circ C$ $\quad \Delta T = 200^\circ C$

$T_2 = 240^\circ C$

Force on steel = force on gun metal

$$P_s = P_g$$

$$(\sigma A)_s = (\sigma A)_g$$ — 02

$$\sigma_s = 1.92\,\sigma_g \quad \text{—} ①$$

Expansion of steel = Expansion of gun metal. — 02

$$(\alpha T L)_s + \left(\frac{\sigma L}{E}\right)_s = (\alpha T L)_g - \left(\frac{\sigma L}{E}\right)_g$$

$$11\times10^{-6}\times200 + \frac{1.92\,\sigma_g}{205\times10^3} = 18\times10^{-6}\times200 - \frac{\sigma_g}{91.5\times10^3}$$

$$\left.\begin{aligned}\sigma_g &= 68.19 \ N/mm^2 \\ \sigma_s &= 130.93 \ N/mm^2\end{aligned}\right\} \text{Ans.}$$ — 03

* Change in length

$$= (\alpha T L)_s + \left(\frac{\sigma L}{E}\right)_s$$

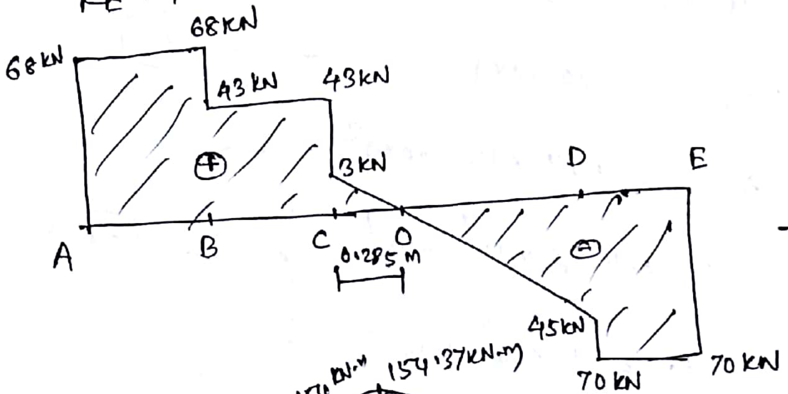
$$= 2.96 \ mm$$ — Ans. — 03

Q2b) Reactions.

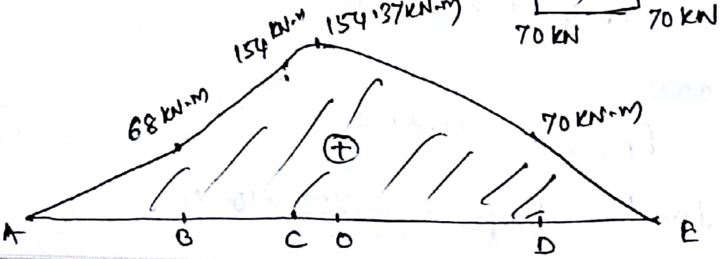
$R_A = 68$ KN — 02

$R_E = 70$ KN

SFD — 04



BMD — 04



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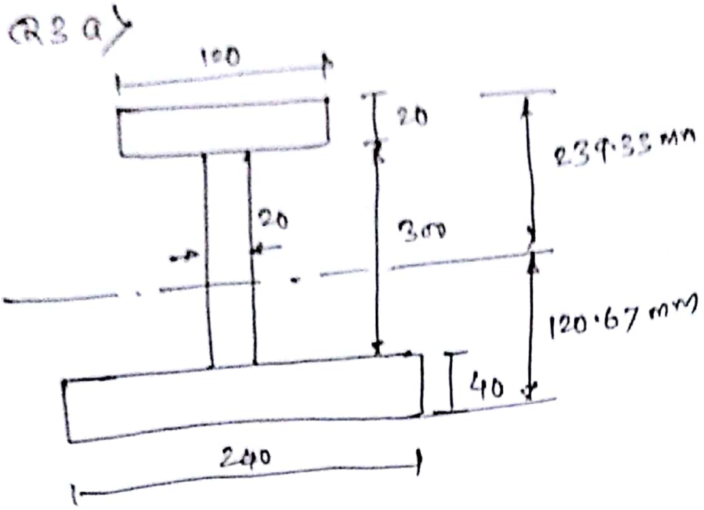
Q3 a)



— (01)

$y_t = 120.67$ mm — (02)

$y_c = 239.33$ mm

MI

$I_{NA} = 298.711 \times 10^6$ mm^4 — (03)

Permissible stress

$\sigma_t = 30$ N/mm^2 — (02)

$\sigma_c = 22.38$ N/mm^2

Moment of resistance

$\frac{M}{I} = \frac{\sigma_t}{y_t}$ $M = 74.263$ kN.m

Max. BM.

$M_{max} = \frac{WL^2}{8}$ — (02)

$W = 9.28$ kN/m — Ans.

Q3b) End condition :- Both end is fixed

$L_e = \frac{L}{2} = 2000$ mm — (01)

Area $A = 25.447 \times 10^3$ mm^2 —

$I = 234.748 \times 10^6$ mm^4 — (01)

$k^2 = 9.2249 \times 10^3$ mm^2

Rankine load

$P_{Rankine} = 11.0116 \times 10^6$ N — (03)

Safe load $P_{safe} = 2.753 \times 10^6$ N

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* Slenderness ratio

$= \frac{L_e}{K} = 20.82$ Ans — (01)

* Euler's critical load

$P_{cr} = 46.337 \times 10^6$ N — (02)

* Ratio of $\frac{P_E}{P_R} = 4.208$ — (02)

Q4 a)

Torque

$T_{mean} = 52.087 \times 10^6$ N-mm — (03)

$T_{max} = 62.504 \times 10^6$ N-mm

* Shear stress consideration.

D = 172.74 mm — (02)

d = 64.78 mm

* Twist consideration

D = 177.69 mm — (03)

d = 66.63 mm

Diameter of shaft will be larger value.

D = 177.69 mm } Ans. — (02)

d = 66.63 mm

Q4 b)

Area of critical section

$A = 2000\ mm^2$

CG of section at xx

$Y_1 = 120$ mm — (02)

$Y_2 = 80$ mm

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MI about NA.

$I_{xx} = 10.063 \times 10^6 mm^4$ — (02)

eccentricity of load from N.A.

$e = 20$ mm

* Direct stress

$\sigma_d = 45$ N/mm^2 — (02)

* Bending stress

$\sigma_{b/bottom} = 21.465$ N/mm^2 — (02)

$\sigma_{b/Top} = 14.309$ N/mm^2

* Resultant stresses

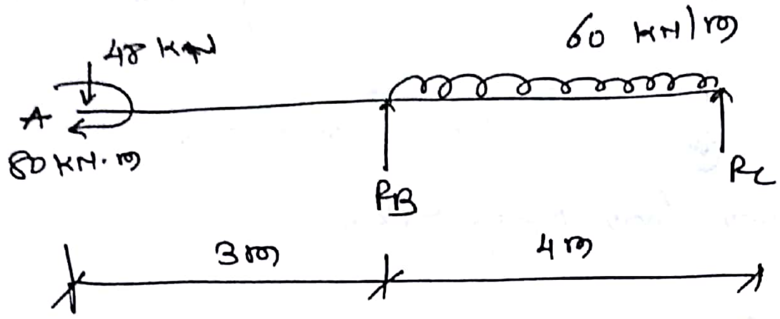
$\sigma_{max} = 66.465$ N/mm^2 — (02)

$\sigma_{min} = 30.691$ N/mm^2

Q.5

a) $EI = 1.2 \times 10^5 \ N\text{-}m^2$

$\delta_{max} = ?$



$\Sigma F_y = 0$ & $\Sigma M_C = 0$

$\boxed{\therefore R_B = 184 \text{ kN}}$ — 02

$\boxed{R_C = 104 \text{ kN}}$

$$EI \frac{d^2y}{dx^2} = -48x + 80(x-0)^0 \Big| + 184(x-3) \Big| - \frac{60(x-3)^2}{2}$$

$$\therefore EI \frac{dy}{dx} = C_1 - 24x^2 + 80(x-0) \Big| + 92(x-3)^2 \Big| - 10(x-3)^3 \quad \text{— (A)}$$

$$EI \cdot y = C_2 + C_1 x - \frac{24x^3}{3} + \frac{80(x-0)^2}{2} \Big| + \frac{92(x-3)^3}{3} \Big| - \frac{10(x-3)^4}{4} \quad \text{— (B)}$$

For eqns marks — 03

Applying BCs.

$\boxed{C_2 = 0}$ $\boxed{\therefore C_1 = -76.95 \simeq -77}$ — 01

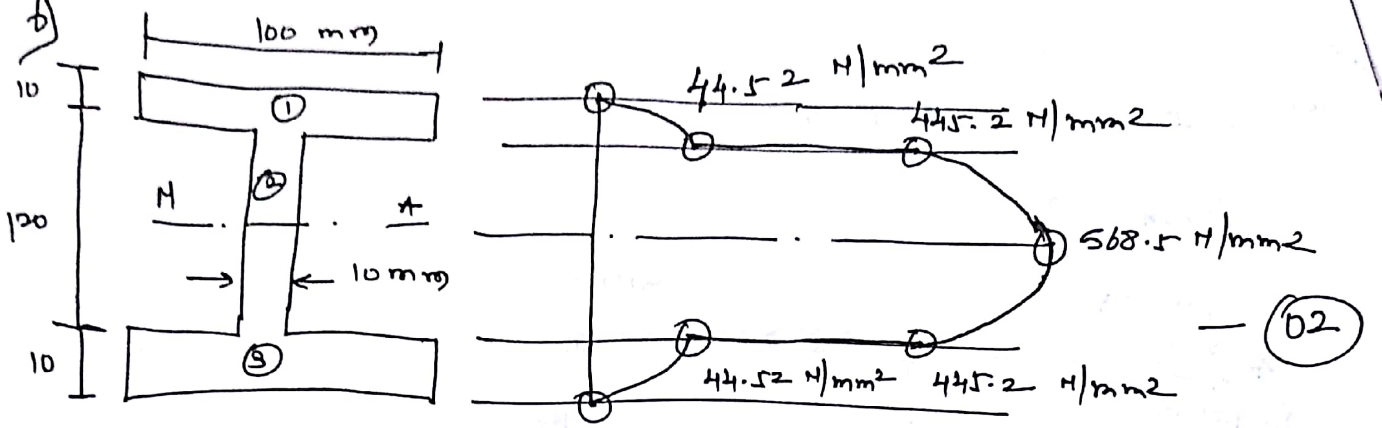
Assuming max^m defl^n will be in the udl part.

$\therefore$ At max^m defl^n $\left(\frac{dy}{dx}\right) = 0$

Substituting in eqn (A) we get — $\boxed{x = 4.87 \text{ m}}$ — 02

$\therefore y\Big|_{x = 4.87 \text{ m}} =$ $y_{max} = -1.5 \times 10^{-3}$ m

$\boxed{y_{max} = -1.5 \text{ mm}}$ — 02 b)



— (02)

N.A. will lie 70 mm from top or bottom

$I = I_1 + I_2 + I_3$

$= 2I_1 + I_2 \quad (I_1 = I_3)$

$= 2\left[\frac{1}{12} \times 100 \times 10^3\right] + \left[\frac{10 \times 120^3}{12}\right]$

$\boxed{\therefore I = 1.46 \times 10^6 \ mm^4}$ — (02)

(1) q at bottom of top flange $= \frac{F}{bI} \times a\bar{y}$

$= \frac{100 \times 10^3}{100 \times 1.46 \times 10^6} \times (100 \times 10)(70 - 5)$

$\boxed{\therefore q = \cancel{2893.84}\ 44.52 \ N/mm^2}$ — (02)

(2) q at the same level but in the web $= \frac{F}{by} a\bar{y}$

$= \frac{100 \times 10^3}{10 \times 1.46 \times 10^6} (100 \times 10)(70 - 5)$

$\boxed{q = 445.2 \ N/mm^2}$ — (02)

(3) q at N.A. =

$a\bar{y}$ = $a\bar{y}$ of the top flange + $a\bar{y}$ of the portion above N.A.

$= (100 \times 10)(70 - 5) + \left[10 + (70 - 10) \times \frac{(70-10)}{2}\right]$

$= 83000 \ mm^3$

$\therefore q_{N.A.} = \frac{F}{bI} a\bar{y}$

$$\boxed{\therefore q_{NA} = 568.5 \ N/mm^2}$$ — 02

At top & Bottom fibres $q = 0$

Q.6 a) $P = 150 \ kN$

$E = 200 \times 10^3 \ N/mm^2$

$\therefore$ Total S.E $= S.E.|_{AB} + S.E.|_{BC}$ — 02

$= \frac{f_1^2}{2E} \times vol^m$ of AB $+ \frac{f_2^2}{2E} \times vol^m$ of BC

$A_1 = \frac{\pi}{4} d_1^2 = 706.86 \ mm^2$

$A_2 = \frac{\pi}{4} d_2^2 = 1963.5 \ mm^2$ — 02

$f_1 = \frac{P}{A_1} = 212.2 \ N/mm^2$

$f_2 = \frac{P}{A_2} = 76.39 \ N/mm^2$ — 03

$\therefore S.E. = \frac{(212.2)^2}{2E} \times (706.86 \times 1000) + \frac{(76.39)^2}{2E} \times (1963.5)(1000)$

$$\boxed{\therefore S.E. = 108.22 \times 10^3 \ N\text{-}mm}$$ — 03

b) $E = \frac{\text{stress}}{\text{strain}}$

$\therefore f_{max} = \frac{\delta l}{l} \times E$

$= \frac{2.5}{3000} \times 2 \times 10^5$

$$\boxed{\therefore f_{max} = 166.67 \ N/mm^2}$$ — 05

Equating loss of P.E. to the strain Energy stored by rod

$$P(h+\delta l) = \frac{1}{2}\frac{f^2}{E} \times Al$$

$$P(22+2.5) = \frac{1}{2} \times \frac{(166.67)^2}{2\times10^5} \times 500 \times 3000$$

$$\boxed{\therefore P = 4251.87\ N}$$ — 05

——— x ——— x ——— x ———