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STRENGTH OF MATERIAL

MECHANICAL ENGINEERING

Date of Test : 03/07/2025

ANSWER KEY ➤

- | | | | | |
|--------|---------|---------|---------|---------|
| 1. (a) | 7. (c) | 13. (a) | 19. (a) | 25. (b) |
| 2. (c) | 8. (a) | 14. (b) | 20. (d) | 26. (c) |
| 3. (c) | 9. (a) | 15. (b) | 21. (b) | 27. (a) |
| 4. (c) | 10. (b) | 16. (c) | 22. (a) | 28. (d) |
| 5. (b) | 11. (d) | 17. (a) | 23. (b) | 29. (a) |
| 6. (a) | 12. (d) | 18. (c) | 24. (b) | 30. (b) |

DETAILED EXPLANATIONS

1. (a)

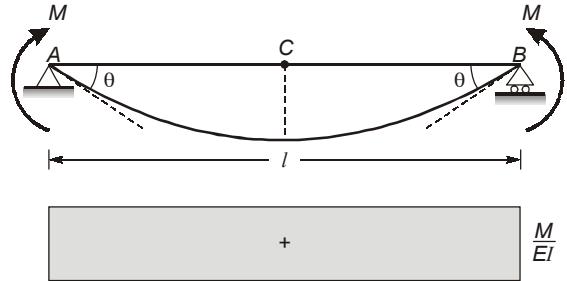
$$\theta_C - \theta_A = \text{Area of } \frac{M}{EI} \text{ diagram}$$

$$0 - \theta_A = +\frac{M}{EI} \times \frac{l}{2} = \frac{Ml}{2EI}$$

$$\theta_A = -\frac{Ml}{2EI}$$

$$\theta_A = \frac{Ml}{2EI} \text{ (Anticlockwise)}$$

$$\therefore \frac{M}{EI} = 2\theta_A = 2\theta$$



2. (c)

$$\text{Dilation, } \epsilon_v = \epsilon_x + \epsilon_y + \epsilon_z$$

$$= \frac{1-2\mu}{E} (\sigma_x + \sigma_y + \sigma_z)$$

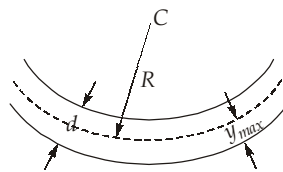
For uniaxial loading, $\sigma_y = \sigma_z = 0$

$$\text{So, } \epsilon_v = \frac{1-2 \times 0.3}{200 \times 10^3} \left(\frac{30 \times 10^3}{\frac{\pi}{4} \times 20^2} \right) = 1.9098 \times 10^{-4}$$

3. (c)

Diameter of wire, $d = 20 \text{ mm}$

$$\text{So, } y_{\max} = \frac{d}{2} = \frac{20}{2} = 10 \text{ mm}$$



Radius of curvature, $R = 10 \text{ m}$

Bending equation

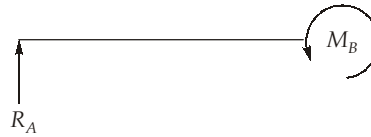
$$\frac{\sigma_{\max}}{y_{\max}} = \frac{E}{R}$$

$$\Rightarrow \frac{\sigma_{\max}}{10 \times 10^{-3}} = \frac{200 \times 10^3}{10}$$

$$\Rightarrow \sigma_{\max} = 200 \text{ MPa}$$

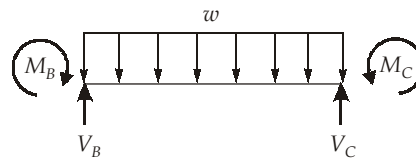
4. (c)

For sections AB and CD , the beam may be modeled as



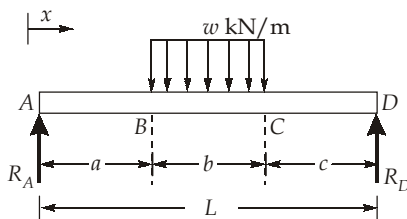
$M(x)$ is linear with respect to x .

For section BC , the beam is modeled as



$M(x)$ is parabolic, reaching a maximum near or at the center.

Alternate solution:



$$\Sigma M_A = 0; R_D \times L = wb \left(a + \frac{b}{2} \right)$$

$$R_D = \frac{wb}{L} \left(a + \frac{b}{2} \right)$$

$$\Sigma F_V = 0; R_A + R_D = w \cdot b$$

$$R_A = \frac{wb}{L} \left(c + \frac{b}{2} \right)$$

Now, for $0 \leq x \leq a$

$$M_x = \frac{wb}{L} \left(c + \frac{b}{2} \right) x$$

$$\text{For } a \leq x \leq a + b \quad M_x = \frac{wx}{2l} (a^2 + L^2 - c^2) - \frac{wx^2}{2} - \frac{wa^2}{2}$$

$$\text{For } a + b \leq x \leq L \quad M_x = wb \left(a + \frac{b}{2} \right) x - \frac{wb}{L} \left(a + \frac{b}{2} \right) x$$

5. (b)

For a thin-walled cylinder of diameter d and internal pressure p ,

$$\sigma_{\text{long}} \leq (0.2)\sigma_{\text{yield}}$$

$$\frac{Pd}{4t} \leq (0.2)\sigma_{\text{yield}}$$

$$t \geq \frac{pd}{0.8\sigma_{\text{yield}}} = \frac{\left(7 \times 10^6 \frac{\text{N}}{\text{m}^2}\right)(1\text{m})}{(0.8)\left(200 \times 10^6 \frac{\text{N}}{\text{m}^2}\right)}$$

$$\geq 0.04375 \text{ m} = 43.75 \text{ mm} \approx 44 \text{ mm}$$

6. (a)

$$\Delta L_s = \Delta L_A$$

$$\Rightarrow \left(\frac{PL}{AE}\right)_S = \left(\frac{PL}{AE}\right)_A$$

$$\frac{P_s}{P_A} = \frac{A_s E_s / L_s}{A_A E_A / L_A} = \frac{0.5 \times 200 / 2}{2 \times 100 / 1} = 0.25$$

7. (c)

$$d_1 = 50 \text{ mm}; G = 27 \text{ GPa}$$

$$T = 4.0 \text{ kNm}, \epsilon_{\text{allow}} = 900 \times 10^{-6}$$

Allowable shear stress based on normal strain,

$$\epsilon_{\text{max}} = \frac{\gamma}{2} = \frac{\tau}{2G}$$

$$\tau = 2G\epsilon_{\text{max}}$$

$$(\tau_{\text{allow}}) = 2G\epsilon_{\text{allow}} = 2(27 \times 10^{-3})(900 \times 10^{-6})$$

$$= 48.6 \text{ MPa}$$

8. (a)

Rankine's buckling load, $P_R = 4000 \text{ N}$ Crushing load, $P_C = 5000 \text{ N}$

As we know, $\frac{1}{P_R} = \frac{1}{P_C} + \frac{1}{P_E}$

$$\frac{1}{4000} = \frac{1}{5000} + \frac{1}{P_E}$$

$$P_E = \frac{1}{\frac{1}{4000} - \frac{1}{5000}} = 20000 \text{ N}$$

$$P_E = 20 \text{ kN}$$

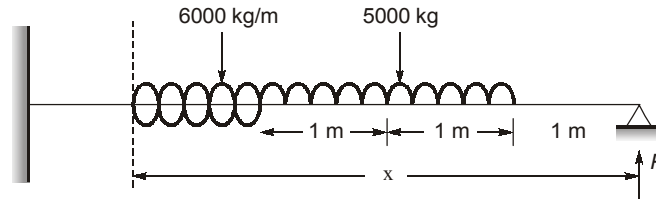
9. (a)

10. (b)

High carbon spring steel has maximum value of yield point strength.

11. (d)

Writing Macaulay's theorem at a distance 'x' from the right hand support



$$EI \frac{d^2 y}{dx^2} = M$$

$$EI \frac{d^2 y}{dx^2} = P[x] - 5000[x-2] - \frac{6000}{2}[x-1]^2 + \frac{6000}{2}[x-3]^2 \quad \dots(1)$$

$$EI \frac{dy}{dx} = \frac{P}{2}[x]^2 - 2500[x-2]^2 - 1000[x-1]^3 + 1000[x-3]^3 + A \quad \dots(2)$$

$$EIY = \frac{P}{6}[x]^3 - \frac{2500}{3}[x-2]^3 - 250[x-1]^4 + 250[x-3]^4 + Ax + B \quad \dots(3)$$

$$\text{At } x = 4 \text{ m; } \frac{dy}{dx} = 0 \Rightarrow 8P - 36000 + A = 0 \quad \dots(4)$$

$$\text{At } x = 4 \text{ m; } y = 0 \Rightarrow \frac{32}{3}P - \frac{80000}{3} + 4A = 0 \quad \dots(5)$$

$$\text{From equation (4), } \frac{32}{3}P - \frac{80000}{3} + 4(36000 - 8P) = 0$$

$$\Rightarrow P = 5500 \text{ kg}$$

12. (d)

Bending moment at section x-x:

$$M_x = Fr \sin \theta$$

Bending strain energy,

$$U = \int_0^{\pi/2} \frac{M_x^2}{2EI} dS \quad (dS = r d\theta)$$

$$= \int_0^{\pi/2} \frac{F^2 r^2 \sin^2 \theta r d\theta}{2E \frac{\pi}{64} d^4} = \frac{32F^2 r^3}{\pi d^4 E} \int_0^{\pi/2} \sin^2 \theta d\theta$$

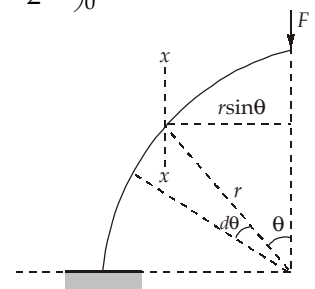
$$= \frac{16F^2 r^3}{\pi d^4 E} \int_0^{\pi/2} (1 - \cos 2\theta) d\theta = \frac{16F^2 r^3}{\pi d^4 E} \left[\theta - \frac{\sin 2\theta}{2} \right]_0^{\pi/2}$$

$$U = \frac{8F^2 r^3}{d^4 E}$$

Strain energy stored = Work done by external load

$$\frac{1}{2} F \Delta = \frac{8F^2 r^3}{d^4 E}$$

$$\text{Deflection, } \Delta = \frac{16Fr^3}{d^4 E}$$



13. (a)

Given, a biaxial stress system,

$$\sigma_x = 100 \text{ MPa}, \sigma_y = 60 \text{ MPa}$$

For maximum obliquity of the resultant with the normal to a plane is given by

$$\tan \theta = \sqrt{\frac{\sigma_x}{\sigma_y}} = \sqrt{\frac{100}{60}} = 1.29$$

or

$$\theta = 52.24^\circ$$

Direct stress,

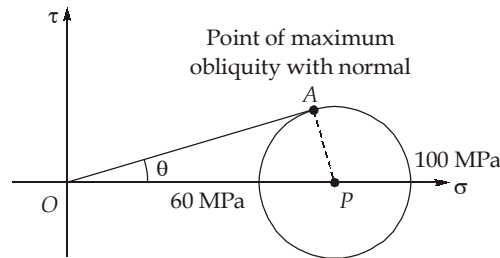
$$\begin{aligned}\sigma_\theta &= \sigma_x \cos^2 \theta + \sigma_y \sin^2 \theta \\ &= 100 \cos^2 52.24^\circ + 60 \sin^2 52.24^\circ \\ &= 100 \times 0.375 + 60 \times 0.625 = 37.5 + 37.5 = 75 \text{ MPa}\end{aligned}$$

Shear stress,

$$\begin{aligned}\tau_\theta &= -\frac{1}{2}(\sigma_x - \sigma_y) \sin 2\theta \\ &= -\frac{1}{2}(100 - 60) \sin 104.48^\circ = -19.365 \text{ MPa}\end{aligned}$$

Resultant stress,

$$\sigma_r = \sqrt{\sigma_\theta^2 + \tau_\theta^2} = \sqrt{75^2 + 19.365^2} = 77.46 \text{ MPa}$$

Alternate Solution:

$$\sigma_1 = \sigma_x = 100 \text{ MPa}$$

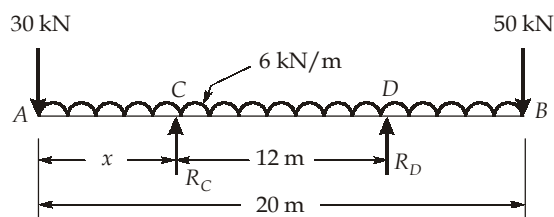
$$\sigma_2 = \sigma_y = 60 \text{ MPa}$$

$$AP = \tau_{\max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{100 - 60}{2} = 20 \text{ MPa}$$

$$OP = \frac{\sigma_1 + \sigma_2}{2} = \frac{100 + 60}{2} = 80 \text{ MPa}$$

$$\sigma_\sigma = \sqrt{OP^2 - AP^2} = \sqrt{80^2 - 20^2} = 77.46 \text{ MPa}$$

14. (b)

Let the left support C be at a distance x meters from A.

Now,

$$R_C = R_D \text{ (Given)}$$

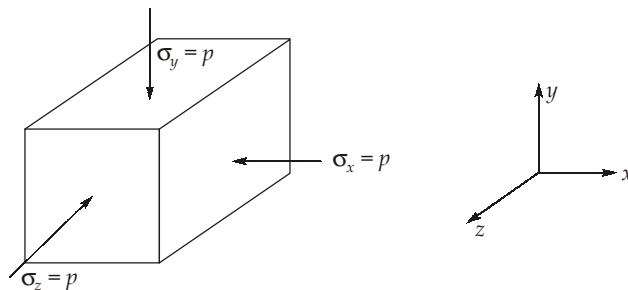
$$\Sigma V = 0$$

$$\begin{aligned}
 R_C + R_D - 30 - 6 \times 20 - 50 &= 0 \\
 \Rightarrow 2R_C &= 30 + 120 + 50 \\
 \Rightarrow R_C &= 100 \text{ kN} \\
 \therefore R_D &= 100 \text{ kN} \\
 \Sigma M_A &= 0 \\
 100x + 100(12 + x) - 6 \times 20 \times 10 - 50 \times 20 &= 0 \\
 200x &= 1000 \\
 x &= 5 \text{ m}
 \end{aligned}$$

15. (b)

Under water, the solid will be subjected to hydrostatic pressure (compressive) of equal magnitude on all sides as shown in figure. In the three principal directions, the strains will be

$$\epsilon_x = \frac{\sigma}{E}(1 - 2\mu) = \epsilon_y = \epsilon_z$$



Therefore,

$$\epsilon_v = \epsilon_x + \epsilon_y + \epsilon_z = \frac{3p}{E}(1 - 2\mu)$$

$$\text{Change in volume, } \epsilon_v = \frac{0.05}{100} = \frac{3p}{E}(1 - 2\mu)$$

$$p = \frac{0.05}{100} \times \frac{E}{3(1 - 2\mu)} = \frac{0.05 \times 200,000}{100 \times 3(1 - 2 \times 0.3)} = 83.33 \text{ N/mm}^2 \quad \dots(1)$$

$$\text{Pressure at any depth, } p = wh = 10,080h \text{ N/m}^2 \quad \dots(2)$$

From eq. (1) and (2) we get,

$$10,080h = 83.33 \times 10^6$$

$$\Rightarrow h = 8267 \text{ m}$$

16. (c)

Impact loading

$$\delta = \text{Max. instantaneous extension} = 1.25 \text{ mm}$$

$$W = Mg = 60 \times 9.81 = 588.6 \text{ N}$$

$$\therefore \sigma = E \frac{\delta}{L} = \frac{2.05 \times 10^5 \times 1.25}{2.5 \times 10^3} = 102.5 \text{ N/mm}^2$$

Now potential energy lost by weight = Strain energy stored in bar.

$$\therefore W(h + \delta) = \frac{\sigma^2}{2E} \times V$$

$$\text{or } 588.6(h + 1.25) = \frac{(102.5)^2}{2 \times 2.05 \times 10^5} \left[\frac{\pi}{4} (40)^2 \times 2500 \right]$$

$$\begin{aligned} \text{or} \quad h + 1.25 &= 136.78 \\ \Rightarrow h &= 136.78 - 1.25 = 135.53 \text{ mm} \end{aligned}$$

17. (a)

Length of the rod, $l = 6000 \text{ mm}$ Fall of temperature, $T = 120 - 40 = 80^\circ\text{C}$

When the ends yield by 1.1 mm.

$$\begin{aligned} \text{Thermal strain} &= \frac{\text{Contraction prevented}}{\text{Original length}} = \frac{\alpha T l - \delta}{l} = \frac{12 \times 10^{-6} \times 80 \times 6000 - 1.1}{6000} \\ &= \frac{4.66}{6000} = 7.7667 \times 10^{-4} \end{aligned}$$

Thermal stress = Thermal strain $\times$ Young's modulus

$$= \frac{4.66}{6000} \times 210 \times 10^3 \text{ N/mm}^2 = 163.1 \text{ N/mm}^2 = 163.1 \text{ MPa}$$

18. (c)

Considering a ring element of thickness dr at a distance r from the centre of the shaft.

$$T_1 = \int_0^{R/3} \tau (2\pi r dr) r = \int_0^{R/3} \frac{\tau_{\max}}{R} \cdot r (2\pi r dr) r$$

$$T_1 = \frac{2\pi\tau_{\max}}{R} \int_0^{R/3} r^3 dr = \frac{2\pi\tau_{\max}}{R} \left(\frac{r^4}{4} \right)_0^{R/3}$$

$$T_1 = \left(\frac{\pi\tau_{\max}R^3}{2 \times 3^4} \right) \quad \dots\dots(i)$$

$$T = \frac{\tau_{\max}}{R} \times \frac{\pi R^4}{2}$$

$$T = \left(\frac{\pi\tau_{\max}R^3}{2} \right) \quad \dots\dots(ii)$$

From equations (i) and (ii), we get

$$\frac{T_1}{T} = \frac{1}{3^4} = \frac{1}{81} = 0.012$$

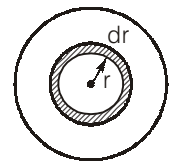
Alternate:

$$\frac{\tau}{r} = \frac{T}{J} = \frac{G\theta}{L}$$

$$\therefore T \propto J$$

$$\therefore \frac{T_1}{T} \propto \frac{J_1}{J} \propto \left(\frac{D_1}{D} \right)^4$$

$$\therefore \frac{T_1}{T} \propto \left[\left(\frac{R/3}{R} \right) \right]^4 \propto \left(\frac{1}{3} \right)^4 = 0.012$$



19. (a)

For a rectangular strain rosette

$$\begin{aligned}\epsilon_x &= \epsilon_{0^\circ} = 400 \times 10^{-6}, \epsilon_y = \epsilon_{90^\circ} = -100 \times 10^{-6} \\ \text{and} \quad \gamma_{xy} &= 2\epsilon_{45^\circ} - \epsilon_x - \epsilon_y \\ \gamma_{xy} &= 2 \times 200 \times 10^{-6} - 400 \times 10^{-6} + 100 \times 10^{-6} = 100 \times 10^{-6}\end{aligned}$$

$$\begin{aligned}\text{Principal strains, } \epsilon_1, \epsilon_2 &= \frac{1}{2}(\epsilon_x + \epsilon_y) \pm \frac{1}{2}\sqrt{(\epsilon_x - \epsilon_y)^2 + \gamma_{xy}^2} \\ &= \frac{10^{-6}}{2} \left[(400 - 100) \pm \sqrt{(400 + 100)^2 + 100^2} \right] \\ &= 404.95 \times 10^{-6} \text{ and } -104.95 \times 10^{-6}\end{aligned}$$

Principal stresses

$$\begin{aligned}\sigma_1 &= \frac{E(\mu\epsilon_2 + \epsilon_1)}{1 - \mu^2} = \frac{210000(-0.3 \times 104.95 + 404.95) \times 10^{-6}}{1 - 0.3^2} = 86.2 \text{ MPa} \\ \sigma_2 &= \frac{E(\mu\epsilon_1 + \epsilon_2)}{1 - \mu^2} = \frac{210000(0.3 \times 404.95 - 104.95) \times 10^{-6}}{1 - 0.3^2} = 3.82 \text{ MPa}\end{aligned}$$

20. (d)

Total length, $L = 2000 \text{ mm}$

Uniform stress, $\sigma = 0.3 \text{ MPa}$

Weight density, $w = 7.644 \times 10^{-5} \text{ N/mm}^3$

Diameter at bottom, $d_1 = 60 \text{ mm}$

$$\text{Area at bottom, } A_1 = \frac{\pi}{4} \times d_1^2 = \frac{\pi}{4} \times 60^2 = 2827.433 \text{ mm}^2$$

As we know,

$$\begin{aligned}\text{Area at top, } A_2 &= A_1 e^{wL/\sigma} = 2827.433 e^{\frac{7.644 \times 10^{-5} \times 2000}{0.3}} \\ A_2 &= 4706.62 \text{ mm}^2\end{aligned}$$

21. (b)

$$\Sigma F_x = 0,$$

$$\Rightarrow H_A = P$$

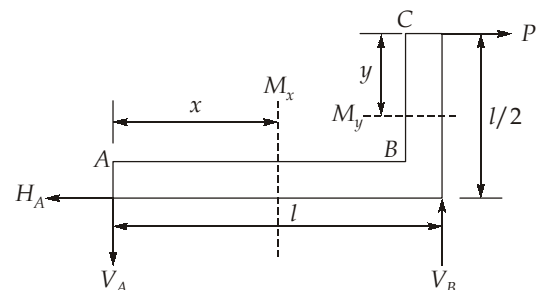
$$\Sigma M_A = 0$$

$$\Rightarrow V_B \times l = P \times \frac{l}{2}$$

$$V_B = \frac{P}{2}$$

$$\Sigma F_y = 0$$

$$\Rightarrow V_A = V_B = \frac{P}{2}$$



Strain energy stored by the bracket,

$$U = U_{AB} + U_{BC}$$

$$= \int_0^l \frac{M_x^2 dx}{2EI} + \int_0^{l/2} \frac{M_y^2 dy}{2EI} = \int_0^l \frac{\left(-\frac{Px}{2}\right)^2 dx}{2EI} + \int_0^{l/2} \frac{(Py)^2 dy}{2EI}$$

$$= \frac{P^2}{8EI} \left[\frac{x^3}{3} \right]_0^l + \frac{P^2}{2EI} \left[\frac{y^3}{3} \right]_0^{l/2}$$

$$= \frac{P^2}{8EI} \times \frac{l^3}{3} + \frac{P^2 (l/2)^3}{6EI} = \frac{P^2 l^3}{24EI} + \frac{P^2 l^3}{48EI}$$

$$U = \frac{P^2 l^3}{16EI}$$

Horizontal deflection at C,

$$\delta_C = \frac{\partial U}{\partial P} = \frac{\partial}{\partial P} \left(\frac{P^2 l^3}{16EI} \right)$$

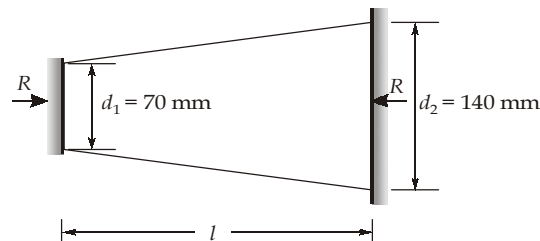
$$\delta_C = \frac{2Pl^3}{16EI}$$

$$\delta_C = \frac{Pl^3}{8EI}$$

22. (a)

Let R be the reaction developed at the ends.

$$\text{Decrease in the length due to support reaction} = \frac{4Rl}{\pi d_1 d_2 E} \quad \dots(1)$$



Due to free expansion,

$$\text{Increase in length} = \alpha t l$$

... (ii)

Since there is no change in length,

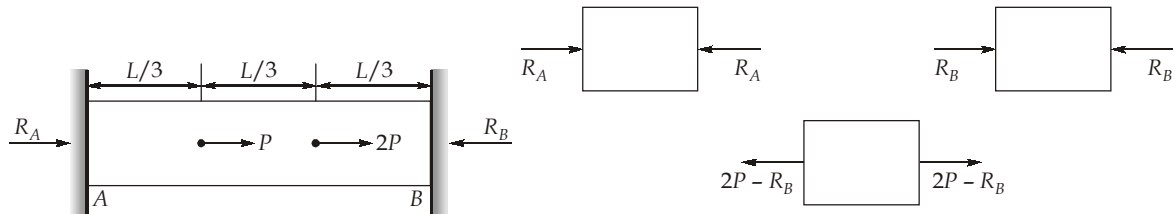
From (i) and (ii):

$$\frac{4Rl}{\pi d_1 d_2 E} = \alpha t l$$

$$R = \frac{\pi}{4} d_1 d_2 E \alpha t$$

$$\begin{aligned}\text{Maximum stress, } \sigma_{\max} &= \frac{R}{\frac{\pi}{4}d_1^2} = \frac{\frac{\pi}{4}d_1d_2E\alpha t}{\frac{\pi}{4}d_1^2} = \frac{d_2E\alpha t}{d_1} \\ &= \frac{140 \times 200 \times 10^3 \times 12 \times 10^{-6} \times 50}{70} = 240 \text{ MPa}\end{aligned}$$

23. (b)



$$\begin{aligned}\Sigma F_x &= 0 \\ R_A + P + 2P - R_B &= 0 \\ \text{Total deformation, } \Delta &= 0\end{aligned} \quad \dots (i)$$

$$\begin{aligned}\Delta &= \Sigma \frac{PL}{AE} = 0 \\ -R_A \frac{L}{3} + (2P - R_B) \frac{L}{3} - R_B \frac{L}{3} &= 0 \\ -R_A + 2P - 2R_B &= 0 \\ R_A &= 2P - 2R_B\end{aligned} \quad \dots (ii)$$

From (i) and (ii)

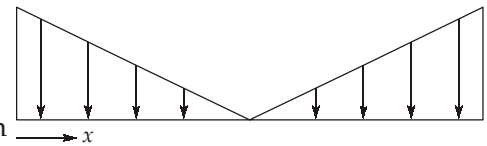
$$\begin{aligned}R_B &= \frac{5P}{3} & R_A &= -\frac{4P}{3} \\ \left| \frac{R_A}{R_B} \right| &= \left| \frac{-(4P/3)}{(5P/3)} \right| = 0.8\end{aligned}$$

24. (b)

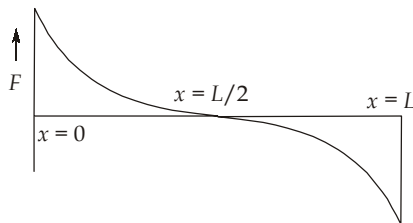
$$\frac{dF}{dx} = -w$$

Where,

$$\frac{dF}{dx} = \text{Slope of shear force diagram}$$



As load intensity, w decreases from w_0 at $x = 0$ to 0 at $x = L/2$, slope at $x = 0$ will be maximum and zero at $x = L/2$.



25. (b)

$$\frac{\epsilon_1}{\epsilon_2} = \frac{\left(\frac{\gamma_{\max,1}}{2}\right)}{\left(\frac{\gamma_{\max,2}}{2}\right)} = \frac{\left(\frac{\tau_{\max,1}}{G}\right)}{\left(\frac{\tau_{\max,2}}{G}\right)} = \frac{\tau_{\max,1}}{\tau_{\max,2}}$$

Torsion equation: $\frac{T}{J} = \frac{\tau_{\max}}{r}$

$$\Rightarrow \tau_{\max} = \frac{T}{J} \times r$$

$$\begin{aligned} \frac{\epsilon_1}{\epsilon_2} &= \frac{\frac{T}{J_1} \times r_1}{\frac{T}{J_2} \times r_2} = \frac{J_2}{J_1} \times \frac{r_1}{r_2} = \frac{\frac{\pi}{32} \times d_2^4}{\frac{\pi}{32} \times d_1^4} \times \frac{d_1/2}{d_2/2} \\ &= \left(\frac{d_2}{d_1}\right)^3 = (2)^3 = 8 \end{aligned}$$

26. (c)

Maximum shear stress theory states that

$$\left| \frac{\sigma_1 - \sigma_2}{2} \right| = \frac{\sigma_y}{2} \quad \dots (i)$$

σ_1 and σ_2 are the principal stresses

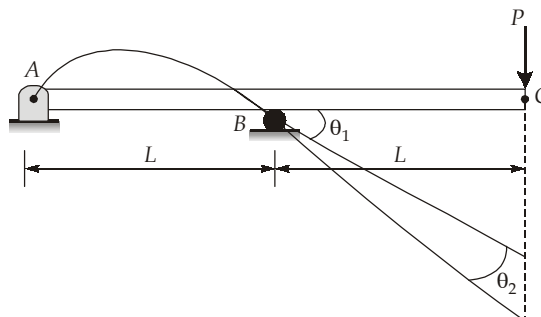
$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\left| \frac{\sigma_1 - \sigma_2}{2} \right| = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$\therefore$ Substituting in (i) and squaring

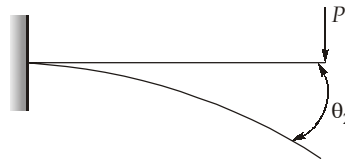
$$(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2 = \sigma_y^2$$

27. (a)



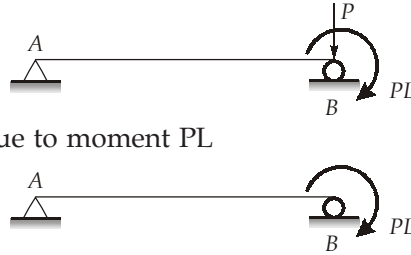
$$\theta_C = \theta_1 + \theta_2 \quad \dots (i)$$

For θ_2 , assume BC as a cantilever beam:



$$\theta_2 = \frac{PL^2}{2EI}$$

For θ_1 , AB is given as:



This beam will bend only due to moment PL

$$\theta_B = \theta_1 = \frac{ML}{3EI} = \frac{PL^2}{3EI}$$

Equation (i),

$$\theta_C = \theta_1 + \theta_2 = \frac{PL^2}{3EI} + \frac{PL^2}{2EI} = \frac{5PL^2}{6EI}$$

28. (d)

BM at distance x

$$M = \frac{wx^2}{2}$$

$$\sigma_{\max} = \frac{wx^2}{2 \times \frac{h_x^2 b}{6}} = \frac{3wx^2}{h_x^2 b} \quad \dots (i)$$

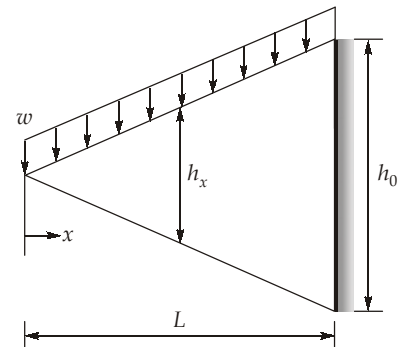
From figure,

$$h_x = \frac{h_0 x}{L} \quad \dots (ii)$$

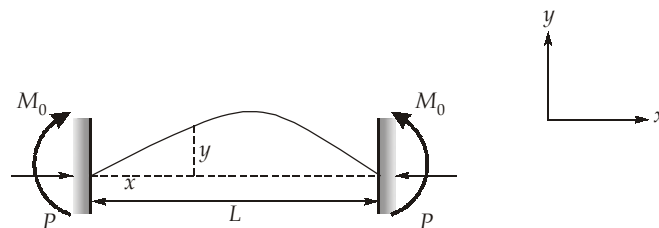
Substitute (ii) in (i)

$$\sigma_{\max} = \frac{3wx^2}{\frac{h_0^2 x^2}{L^2} b} = \frac{3wL^2}{h_0 b}$$

$\sigma_{\max}$ is independent of x . Thus it is a beam of uniform strength.



29. (a)



The bending equation is

$$EI \frac{d^2 y}{dx^2} = M$$

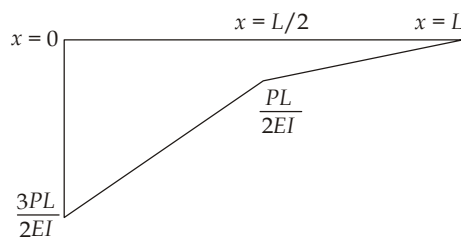
M is the bending moment at any cross-section,

$$M = M_0 - Py$$

$$\therefore EI \frac{d^2 y}{dx^2} = M_0 - Py$$

$$\text{or} \quad \frac{d^2 y}{dx^2} = -\frac{Py}{EI} + \frac{M_0}{EI}$$

30. (b)



Slope, $\theta_{x=L} = \text{Area of } \frac{M}{EI} \text{ diagram}$

$$= \frac{1}{2} \left[\frac{3PL}{2EI} + \frac{PL}{2EI} \right] \left(\frac{L}{2} \right) + \frac{1}{2} \left(\frac{PL}{2EI} \right) \left(\frac{L}{2} \right) = \frac{5PL^2}{8EI}$$

■■■■