10. Ans : (b)

Sol. We know the relation

E = 2G (1+μ)

E = 2G (1+μ)

$$\frac{G}{E} = 0.4$$

11. Ans : (a)

Sol. The bar is free to expand, no stresses are produced.

22. Ans : (c)

Sol. l = 250 mm

P = 20 × 10^3 N

E = 200 10^3 MPa

σ = 100 MPa

δl = 0.1 mm, A = ?

$$\sigma = \frac{P}{A} \Rightarrow 100 = \frac{20 \times 10^3}{A}$$

A = 200 mm^2 → (1)

$$\delta l = \frac{Pl}{AE} \Rightarrow 0.1 = \frac{(20 \times 10^3)(250)}{A \times 200 \times 10^3}$$

A = 250 mm^2 → (2)

Least cross-sectional area is maximum of above two values i.e. A = 250 mm^2

23. Ans : (d)

Sol. For a solid cube

$\varepsilon_v = \varepsilon_x + \varepsilon_y + \varepsilon_z$

For cube $\varepsilon_x + \varepsilon_y + \varepsilon_z$

∴ $\varepsilon_v = 3\varepsilon_x$

$$\frac{\varepsilon_v}{\varepsilon_x} = 3$$

25. Ans : (a)

Sol. $$\delta l = \frac{PL}{AE}$$

$$25 = \frac{(4.45 \times 10^3)(30{,}000)}{(28.5)(E)}$$

E = 187 × 10^3 MPa

= 187 GPa

26. Ans : (c)

Sol. In composite bar

$$\delta l_{steel} = \delta l_{brass}$$

$$\frac{(\sigma_s)(l)}{200} = \frac{(\sigma_b)(l)}{100}$$

$$\frac{\sigma_s}{\sigma_b} = \frac{200}{100} = 2$$

29. Ans : (b)

Sol. $$E = \frac{9KG}{3K + G}$$

$$100 = \frac{9K(40)}{3K + 40}$$

300K + 4000 = 360K

4000 = (360 – 300) K

$$K = \frac{4000}{60} = 66.67 \text{ GPa}$$

35. Ans : (b)

Sol: $P = 40 N/mm^2 \Rightarrow P = \frac{W}{2} = \frac{40}{2} = 20 N/mm^2$

suddenly = 2×gradual will be doubled

$$40 = 2 \times g \Rightarrow g = \frac{40}{2} = 20 N/mm^2$$

* If a load 'P' is applied suddenly to a bar then the stress and strain Induced will be doubled than those obtained by an equal load applied gradually

Suddenly = 2×Gradual

40 = 2×G ⇒ G=20N/mm^2

36. Ans : (d)

Sol. $E = 2G(1+\mu)$

$2 \times 10^5 = 2 \times 0.8 \times 10^5 (1+\mu)$

$\mu = 0.25$

43.Ans : (a)

Sol. $\mu = \left|\frac{\varepsilon_{lateral}}{\varepsilon_{longitudinal}}\right| \Rightarrow 0.2 = \left|\frac{-\varepsilon_{lat}}{0.25}\right|$

$\varepsilon_{lat} = 0.050$

47. Ans : (d)

Sol: $V = \tau A$

$V = 30 \times \pi \times D \times t$

$V = 30 \times \pi \times 20 \times 20$

$V = 37699.11$ kg

49.Ans : (a)

Sol. $\mu = \frac{\left(\frac{\delta d}{d}\right)}{\left(\frac{\delta l}{l}\right)}$

$\Rightarrow \frac{\delta l}{l} = \frac{P}{AE}$

$= \frac{80 \times 10^3}{\frac{\pi}{4} \times 8^2 \times 10^6}$

$= 1.59 \times 10^{-3}$

$\delta d = 0.00318$

52.Ans : (c)

Sol. Not yielding, $\delta = 0$

$\Delta = L\,\alpha\,t$

$\Rightarrow \alpha t = \frac{P}{AE}$

$P = \alpha t\, AE$

$= 12 \times 10^{-6} \times (100 - 20) \times 3 \times 10^2 \times 2.1 \times 10^5$

$= 60480$ N $= 6048$ kg

$\simeq 6057$ kg

55. Ans : (d)

Sol. Young's Modulus, E;

$E = \frac{\sigma}{\varepsilon} = \frac{P \times l}{A \times \delta l} = 8 \times 10^6$ kg/cm^2

$= \frac{16 \times 10^3 \times 20}{4 \times 0.01}$

$= 8 \times 10^6$ kg/cm^2

Rigidity modulus (G) ;

$E = 2G(1+\mu)$

$8 \times 10^6 = 2 \times G(1+1/4)$

$G = 3.2 \times 10^6$ kg/cm^2

57. Ans : (b)

Sol. $\varepsilon_y = 0$

$\varepsilon_y = \frac{\sigma_y}{E} - \mu\frac{\sigma_x}{E}$

$0 = \frac{\sigma_y}{2 \times 10^5} - 0.25 \times \frac{1000}{2 \times 10^5}$

$\sigma_y = 250$ kg/cm^2 (tensile)

59. Ans : (b)

Sol. Stress developed = E α t

$= 2 \times 10^6 \times 1.5 \times 10^{-6} \times 20$

$= 60$ kg/cm^2 (Compressive)

Compressive because bar is fixed at both ends

60.Ans : (a)

Sol. Maximum stress,

$\sigma = \frac{P}{A} = \frac{9 \times 10^3}{90 \times 10} = 10\,N/mm^2$

79. Ans : (a)

Sol. We know the relation

$E = 2G(1+\mu)$

$= 2G(1+0)$

$E = 2G$

82. Ans : (a)

Sol. Given : G = K

We know the relation

$E = 2G(1+\mu)$ .... (i)

We know the relation

$E = 3k(1-2\mu)$ .... (ii)

Equation (i) and (ii)

$2G(1+\mu) = 3K(1-2\mu)$

$2K(1+\mu) = 3K(1-2\mu)$

$2 + 2\mu = 3 - 6\mu$

$8\mu = 1$

$$\mu = \frac{1}{8}$$

83. Ans : (b)

Sol. We know the relation

$E = 2G(1+\mu)$

$1.25 \times 10^5 = 2G(1+0.34)$

$1.25 \times 10^5 = 2.68\,G$

$G = 0.4664 \times 10^5$ MPa

85. Ans : (No option is correct)

Sol. We know the relation

$E = 2G(1+\mu) = 2G(1+0.4)$

$E = 2.8\,G$

$$\frac{G}{E} = \frac{1}{2.8} = \frac{5}{14}$$

91. Ans : (c)

Sol. We know the relation

$E = 2g(1+\mu)$

$200 = 2 \times 80(1+\mu)$

$$\frac{200}{160} = 1+\mu$$

$\mu = 0.25$

95. Ans : (c)

Sol. K = E

We know the relation

$E = 3K(1-2\mu)$

$$\frac{1}{3} = 1 - 2\mu$$

$$2\mu = 1 - \frac{1}{3} = \frac{2}{3}$$

$$\mu = \frac{1}{3} = 0.33$$

97. Ans : (b)

Sol. We know the relation

$E = 2G(1+\mu)$

$125 = 2G(1+0.25)$

G = 50 Gpa

98.Ans : (c)

Sol. We know the relation

$E = 3K(1-2\mu)$

$E = 3K(1-2(0.25))]$

$$\frac{K}{E} = \frac{1}{3 \times 0.5} = \frac{1}{1.5} = \frac{2}{3}$$

99.Ans : (b)

Sol. The relationship between stress and modulus of elasticity

$\sigma = E\varepsilon$

$\sigma \propto E$

$\therefore (\sigma_1 > \sigma_2)$ when $(E_1 > E_2)$

100. Ans : (b)

Sol. $$\varepsilon = \frac{\delta L}{L}$$

102. Ans : (d)

Sol. $$\sigma \alpha \frac{1}{A} \Rightarrow \frac{\sigma_s}{\sigma_h} = \frac{A_h}{A_s}$$

$$\frac{P}{\sigma_h} = \frac{\frac{\pi}{4}\left(D^2 - \left(\frac{D}{2}\right)^2\right)}{\frac{\pi}{4}D^2}$$

$$\frac{P}{\sigma_h} = \frac{\frac{3}{4}D^2}{D^2}$$

$$\sigma_h = \frac{4}{3}P \ \ N/cm^2$$

105. Ans : (d)

Sol. $$\varepsilon_x = \frac{\delta l}{l} = \frac{2}{2000} = 1\times10^{-3}$$

$$\varepsilon_y = \frac{\delta l}{l} = \frac{-1}{1000} = -1\times10^{-3}$$

$$\varepsilon_x = \frac{\delta d}{d} = \frac{1}{1000} = 1\times10^{-3}$$

$\varepsilon_v = \varepsilon_x + \varepsilon_y + \varepsilon_z$

$= 1 \times 10^{-3} - 1 \times 10^{-3} + 1 \times 10^{-3}$

$= 1 \times 10^{-3}$

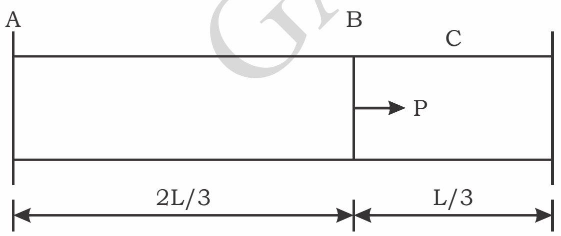
$$\varepsilon_v = \frac{\delta_v}{V}$$

$$1\times10^{-3} = \frac{\delta_v}{2000\times1000\times1000}$$

$\delta_v = 2 \times 10^6 \text{ mm}^3$

107. Ans : (b)

Sol.



$$R_{AB} = \frac{P\left(\frac{L}{3}\right)}{L}$$

$$R_{BC} = \frac{P\left(\frac{2L}{3}\right)}{L}$$

$$\frac{R_{AB}}{R_{BC}} = \frac{\frac{P\left(\frac{L}{3}\right)}{L}}{\frac{P\left(\frac{2L}{3}\right)}{L}} = \frac{1}{2}$$

108. Ans : (c)

Sol. $$\frac{\delta l_1}{\delta l_2} = \frac{4}{6}$$

$$\frac{E_1}{E_2} = \frac{\sigma_1}{\sigma_2} \times \frac{\Delta l_2}{\Delta l_1}$$

$$= \frac{F_1}{F_2} \times \frac{A_2}{A_1} \times \frac{\Delta l_2}{\Delta l_1}$$

$$\frac{E_1}{E_2} = \frac{6}{4}$$

116. Ans : (d)

Sol. $(\delta l)_{steel} = (\delta l)_{brass}$

$$\left[\frac{Pl}{AE}\right]_{Steel} = \left[\frac{Pl}{AB}\right]_{brass}$$

$$\frac{\sigma_{steel}}{200} = \frac{\sigma_{brass}}{100}$$

$$\frac{\sigma_{steel}}{\sigma_{brass}} = 2$$

117. Ans : (a)

Sol. $$\delta l = \frac{Pl}{AE} = \left(\frac{P}{A}\right)\frac{l}{E}$$

$$= 100 \times \frac{500}{2\times10^{11}\times10^{-6}}$$

$$= \frac{5\times10^4}{2\times10^5} = 0.25 \ \ mm$$

121. Ans : (c)

Sol. Load is suddenly applied,

Normal stress; $\sigma = \frac{2P}{A}$

$$= \frac{100 \times 1000}{1000} \times 2$$

σ = 200 N/mm^2

The maximum stress, σ_{max} = 200 N/mm^2

135. Ans : (c)

Sol. Free expansion of bar = $l\,\alpha\,t$

= (1000) (1.8 × 10^{-5}) (100)

= 1.8 mm

Yielding allowed = 1 mm

∴ Stress develops

Expansion prevented causes stress

$$1.8 - 1 = \frac{\sigma_t \times l}{E}$$

$$\sigma_t = \frac{(1.8-1)(120 \times 10^3)}{1000} = 96 \text{ MPa}$$

137. Ans : (c)

Sol: l = 1m A = 300 Sq.mm

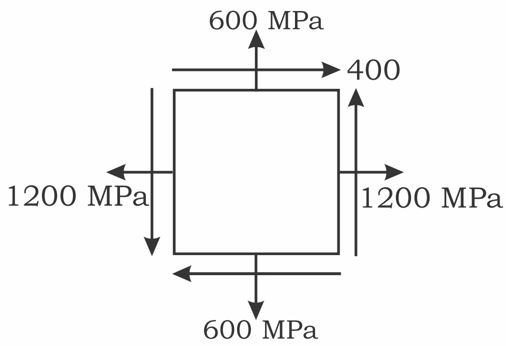
W = 6kN E = 200 GPa

$$\frac{WL}{2AE} = \frac{6 \times 10^3 \times 1}{2 \times 300 \times 200}$$

$$= \frac{1}{20} = 0.05 \text{ mm}$$

6. Ans : (d)

Sol.



Maximum Normal stress 'σ'

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

$$= \frac{1200 + 600}{2} + \sqrt{\left(\frac{1200 - 600}{2}\right)^2 + 400^2}$$

= 900 + 500 = 1400 MPa

8. Ans : (a)

Sol. Radius of Mohr's circle

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2}$$

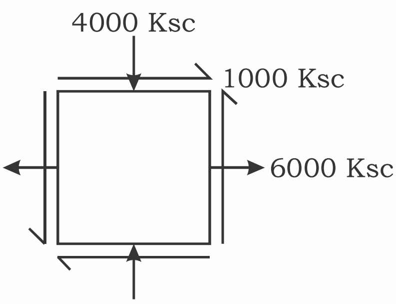
$$= \frac{150 - (-50)}{2} = 100 \text{ MPa}$$

16. Ans : (d)

Sol. σ_x = 6000 Ksc

σ_y = –4000 Ksc

τ_{xy} = 100 Ksc



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

$$= \frac{6000 - 4000}{2} + \sqrt{\left(\frac{6000 + 4000}{2}\right)^2 + 1000^2}$$

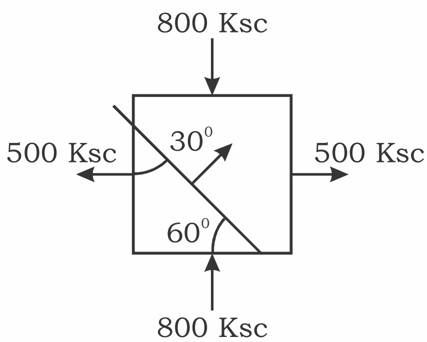
= 6099.1 Ksc

18. Ans : (d)

Sol. $$\sigma_{60°} = \frac{\sigma_x + \sigma_y}{2} + \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos 2\theta + \tau_{xy}\sin\theta$$

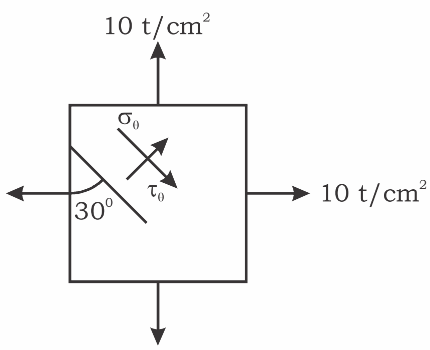
$$= \left(\frac{500 + 800}{2}\right) + \left(\frac{500 - 800}{2}\right)\cos 120°$$

= 725 Ksc



20. Ans : (c)

Sol.



$$\sigma_{30°} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$$

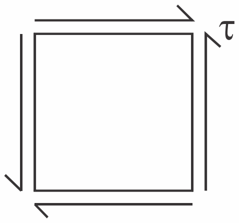
$$= \frac{10+10}{2}$$

$$= 10 \text{ t/cm}^2$$

$$\tau_{30^\circ} = \left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta - \tau_{xy}\sin 2\theta = 0$$

21. Ans : (b)

Sol.



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

$$= 0 \pm \sqrt{0 + 5^2}$$

σ_1, σ_2 = ± 5 t/cm²

$$\tan 2\theta = \frac{2\tau}{\sigma_x - \sigma_y}$$

tan 2θ = 0

2θ = 90°

θ = 45°

σ_1 = +5 t/cm² (tensile)

σ_2 = –5 t/cm² (Compression)

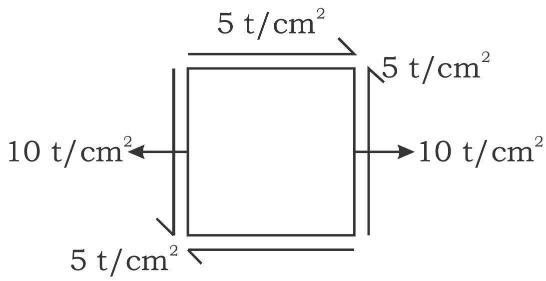
In pure shear condition, principal stresses are equal to shear stress only

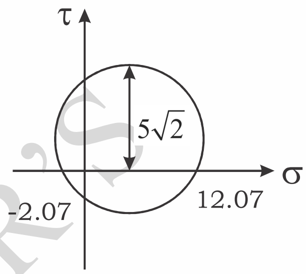
22. Ans : (b)

Sol. Centre of Mohr's circle = ?

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

$$= \frac{10}{2} + \sqrt{\left(\frac{10}{2}\right)^2 + 5^2}$$





$$= 12.07 \text{ t/cm}^2$$

$$\sigma_2 = 5 - \sqrt{5^2 + 5^2} = -2.07 \text{ t/cm}^2$$

$$\tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^{\ 2}} = 5\sqrt{2} \text{ t/cm}^2$$

24. Ans : (b)

Sol. Maximum shear stress,

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{3-(-3)}{2}$$

τ_{max} = 3MPa

26. Ans : (a)

Sol. Maximum shear stress,

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2}$$

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

$$= \frac{P+P}{2} \pm \sqrt{\left(\frac{P-P}{2}\right)^2 + 0}$$

σ_1, σ_2 = P

$$\tau_{max} = \frac{P-P}{2} = 0$$

28. Ans : (b)

Sol. Given

σ_x = 120 MPa, σ_y = 40 MPa, τ_{xy} = 30 MPa

We know principal stresses σ_1, σ_2

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

$$= \frac{120+40}{2} \pm \sqrt{\left(\frac{120-40}{2}\right)^2 + 30^2}$$

= 130 MPa, 30 MPa, (both tensile)

29. Ans : (d)

Sol. Volume = 10^6 mm^3

Hydrostatic pressure, P = 90 MPa

Bulk modulus, k = 180 kN/m^3

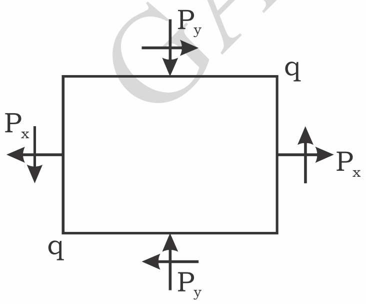
$$k = \frac{P}{\varepsilon_y} = \frac{P}{(\delta_v / V)}$$

$$180 \times 10^3 = \frac{90}{\left(\delta_v / 10^6\right)}$$

δ_v = 500 mm^3

32. Ans : (d)

Sol.



$$\left.\begin{matrix}\sigma_1\\ \sigma_2\end{matrix}\right\} = \frac{P_x + P_y}{2} \pm \sqrt{\left(\frac{P_x - P_y}{2}\right)^2 + q^2}$$

$$= \frac{P_x + P_y}{2} \pm \sqrt{\left(\frac{P_x - P_y}{2}\right)^2 + P_x P_y}$$

$$= \frac{P_x + P_y}{2} \pm \sqrt{\frac{P_x^2 + P_y^2 - 2P_xP_y + 4P_xP_y}{4}}$$

$$= \frac{P_x + P_y}{2} \pm \sqrt{\left[\frac{P_x + P_y}{2}\right]^2}$$

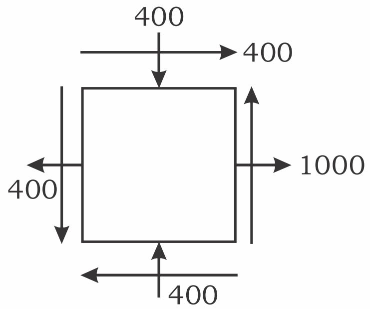
$$= \frac{P_x + P_y}{2} \pm \left[\frac{P_x + P_y}{2}\right]$$

$$\therefore \sigma_1 = \left[\frac{P_x + P_y}{2}\right] + \left[\frac{P_x + P_y}{2}\right] = P_x + P_y$$

$$\sigma_2 = \left[\frac{P_x + P_y}{2}\right] - \left[\frac{P_x + P_y}{2}\right] = 0$$

34. Ans : (a)

Sol.



$$\sigma_1 = \frac{1000+400}{2} + \sqrt{\left(\frac{1000-400}{2}\right)^2 + 400^2}$$

$$= 700 + \sqrt{9 \times 10^4 + 16 \times 10^4}$$

= 700 + 500 = 1200 MPa

35. Ans : (d)

Sol. $$\tan 2\alpha = \frac{2\tau_x}{\sigma_x - \sigma_y} = \frac{2 \times 7.5}{35 - 20} = 1$$

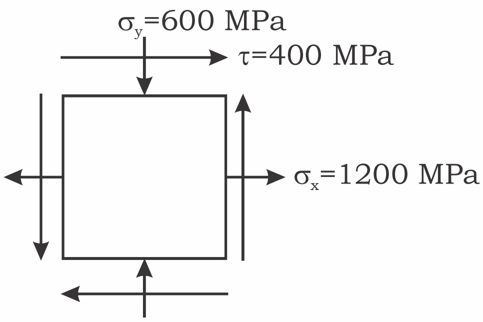
tan 2α = 1

2α = 45°

$$\alpha = \frac{45°}{2} = 22.5$$

37. Ans : (d)

Sol.



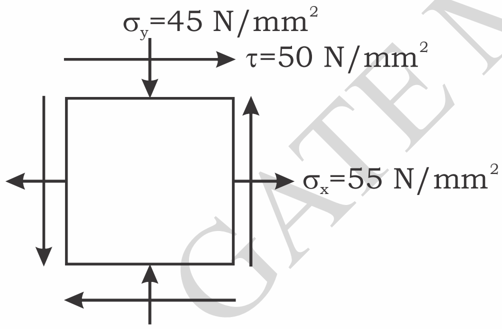
$$\tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \left(\tau_{xy}\right)^2}$$

$$= \sqrt{\left(\frac{1200-600}{2}\right)^2 + (400)^2}$$

= 500 MPa

39. Ans : (b)

Sol.



Minor principal stress, σ_2

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

$$= \frac{55-45}{2} - \sqrt{\left(\frac{55-45}{2}\right)^2 + (50)^2}$$

σ_2 = 65.71 N/mm² compressive

41. Ans : (a)

Sol: $\tau_{max} = \frac{100-0}{2} = 50\,\text{MPa}$

43. Ans : (c)

Sol: $\text{Radius} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}}$

$\sigma_x = 100\,\text{MPa};\ \sigma_y = -20\text{MPa}\ \ \tau_{xy} = 0$

$\text{Radius} = \sqrt{\left(\frac{100+20}{2}\right)^2 + 0} = 60\,\text{MPa}$

55. Ans : (b)

Sol: $\tau_{max} = 35\,\text{MPa} \quad \sigma_2 = -20\,\text{MPa}$

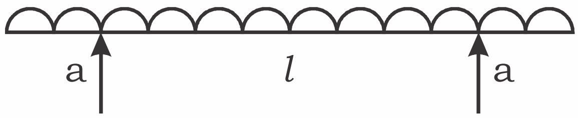
$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} \Rightarrow 35 = \frac{\sigma_1 + 20}{2}$

$70 = \sigma_1 + 20 \Rightarrow \sigma_1 = 70 - 20$

$\sigma_1 = 50\,\text{MPa}$

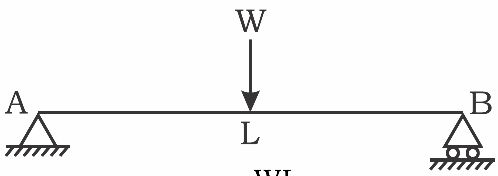
10. Ans : (b)

Sol. If a = $l/2$ BM at mid span is zero

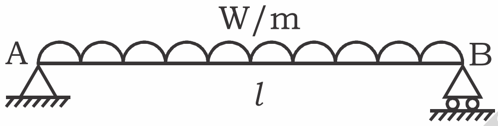


12. Ans : (c)

Sol.



$$M = \frac{WL}{4}$$

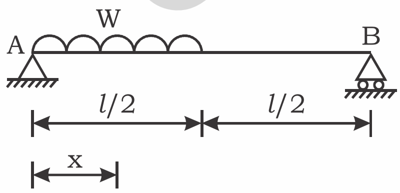


$$M_U = \frac{wl^2}{8} = \frac{WL}{8} = \frac{WL}{4 \times 2}$$

$$M_U = \frac{M}{2}$$

23. Ans : (c)

Sol.



We know

$$R_A + R_B = \frac{wl}{2}$$

Taking moments about A

$$R_B \times l = w\frac{l}{2} \times \frac{l}{4}$$

$$R_B = \frac{wl}{8}, R_A = \frac{3wl}{8}$$

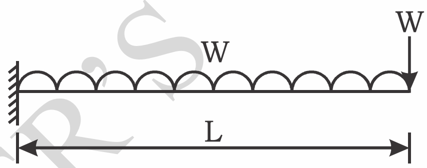
For maximum B.M, S.F must be change sign Shear force at x = $R_A - wx = 0$

$$\frac{3wl}{8} - wx = 0$$

$$\therefore x = \frac{3l}{8}$$

30. Ans : (b)

Sol.



Given :

W = wL

The maximum bending moment always occurs at fixed support = WL + W L/2

= 1.5 WL

31. Ans : (b)

Sol. In economical design, support must be placed at a distance of 0.207 l from free ends

34. Ans : (d)

Sol:

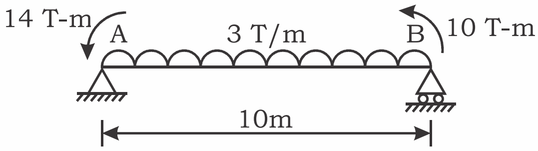
$$(M_{max})_1 = \frac{w\ell^2}{2}$$

$$(M_{max})_2 = \frac{w\ell^2}{8}$$

$$\frac{M_1}{M_2} = \frac{\frac{w\ell^2}{2}}{\frac{w\ell^2}{8}} = 4:1$$

35. Ans : (b)

Sol.



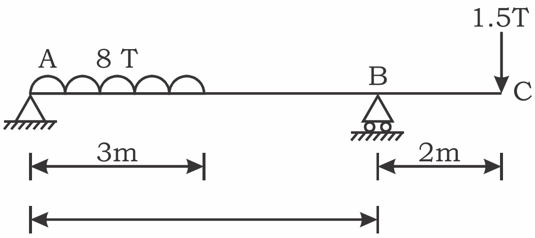
Take moment at B;

$$10+3\times10\times\frac{10}{2}+14-R_A\times10=0$$

R_A = 17.4 T

36. Ans : (c)

Sol.



Take moment at B,

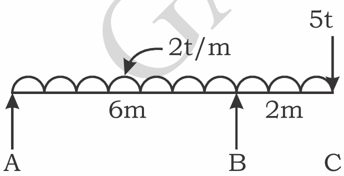
$\Sigma M_B = 0$

$R_A \times 6 - 8 \times 4.5 + 1.5 \times 2 = 0$

$R_A = 5.5$ T

37. Ans : (c)

Sol.



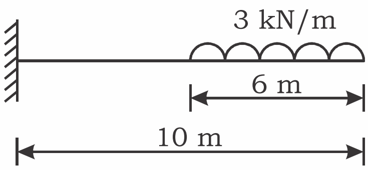
The beam BC part is subjected to hogging moment

The hogging moment at B

$$= 5\times2+2\times2\times\frac{2}{2}=14 \text{ t-m}$$

45. Ans : (b)

Sol.

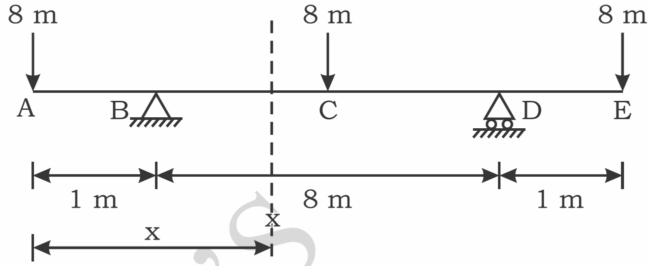


In cantilever maximum B.M. occurs always at fixed end.

Maximum B.M. = 3 × 6 × (4+3) = 126 kN.m

47. Ans : (d)

Sol.



It is symmetrical section

$\therefore R_D = R_D = 12$ kN

P.O.C occurs at a section XX from left and at a distance x from left end

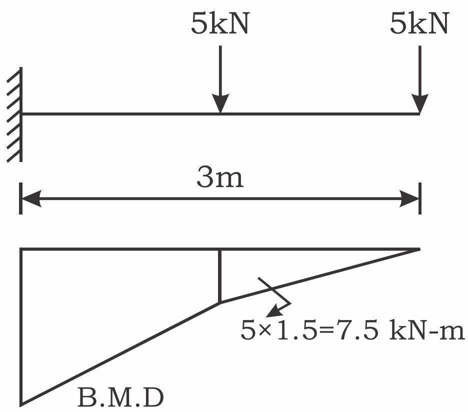
B.M @ XX = $-8x + R_B \times (x-1) = 0$

$8 \times x = 12x - 12$

$\therefore x = 3$ m

60. Ans : (c)

Sol.



65. Ans : (b)

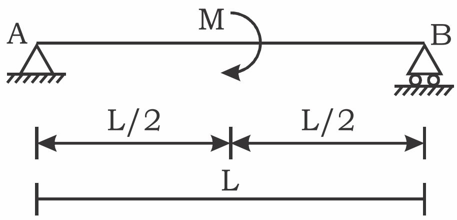
Sol. We know

$$\text{Maximum B.M} = \frac{Wab}{l}$$

$$= \frac{100\times2\times3}{5} = 120 \text{ kN}-\text{m}$$

71. Ans : (a)

Sol.



Bending moment at L/4,

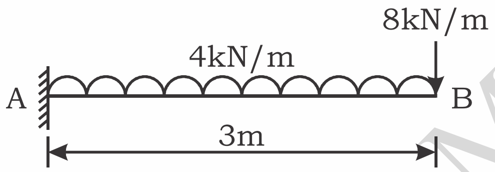
$$M_{L/4} = R_B \times \frac{L}{4}$$

$$= \frac{M}{L} \times \frac{L}{4}$$

$$M_{L/4} = 0.25\ M$$

84. Ans : (d)

Sol.

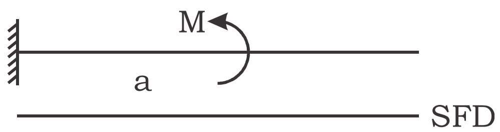


Maximum shear force will occur at t he support

$$R_A = 4 \times 3 + 8 = 20\ kN$$

86. Ans : (c)

Sol.

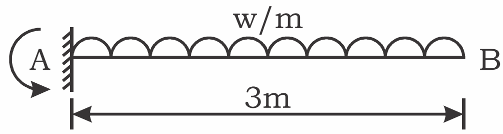


87. Ans : (d)

Sol. $$\frac{(\delta F_{max})_{Fix}}{(\delta F_{max})_{SS}} = \frac{\frac{wl}{2}}{\frac{wl}{2}} = 1$$

99. Ans : (a)

Sol.



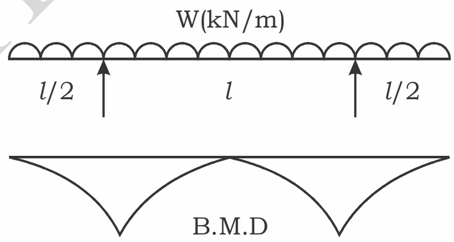
Taking moment at 'A'

$$w \times 3 \times \frac{3}{2} = 9$$

$$w = 2kN/m$$

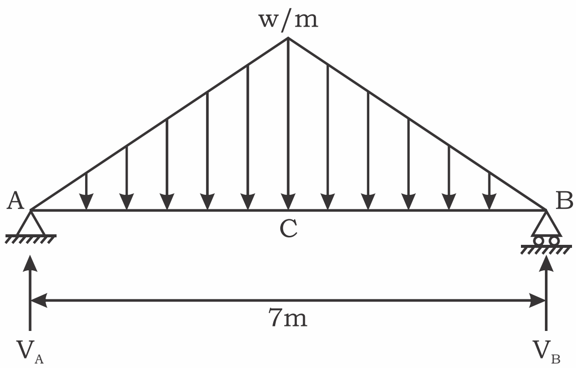
101. Ans : (b)

Sol. The B.M at the centre of the beam will be zero for $a = \frac{l}{2}$



108. Ans : (b)

Sol.



Take moment at A;

$$V_B(7) - \frac{1}{2} \times w \times 3.5\left(3.5 + \frac{3.5}{3}\right)$$

$$-\frac{1}{2} \times w \times 3.5 \times \frac{2}{3} \times 3.5 = 0$$

$7V_B - 8.167w - 4.083w = 0$

$V_B = 1.75\text{ w}$

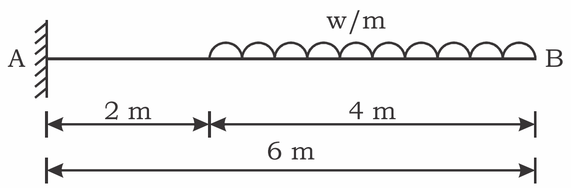
$V_A = V_B = 1.75w$

Maximum shear force will act at the supports.

$\therefore$ Maximum shear force = 1.75 w

109. Ans : (a)

Sol.



The maximum bending moment will occurs at fixed end.

$$M_A = w \times 4 \times \left(2 + \frac{4}{2}\right)$$

$M_{max} = 16\text{ W}$

112. Ans : (a)

Sol: $$M_x = R_A \times x - \frac{1}{2} \times x \left[\frac{w}{\ell} \times x\right] \times \frac{x}{3}$$

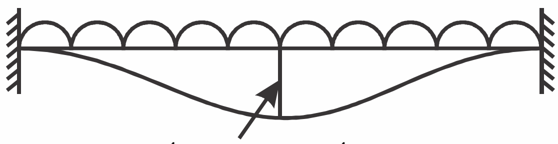
$$M_x = \frac{w\ell x}{6} - \frac{wx^3}{6L}$$

$$M_x = \frac{10 \times 6 \times 4}{6} - \frac{10 \times (4)^3}{6 \times 6} \quad (\because\ x = 4m)$$

$M_x = 22.22\text{ kN-m}$

16. Ans : (c)

Sol.



$$y_{max} = \frac{wl^4}{384EI} = \frac{(6)(4)^4}{384(20\times10^3)} = 0.2 \text{ mm}$$

18. Ans : (d)

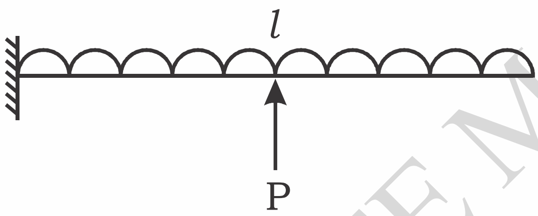
Sol. $y\alpha\frac{1}{1}$ and $y\alpha\frac{1}{d^3}$

$$y\alpha\frac{1}{2^3}\alpha\frac{1}{8}$$

Reduced by 8 times

19. Ans : (d)

Sol.



Deflection at free end due to vertical load

$$\delta_1 = \frac{wl^4}{8EI}$$

Deflection at free end due to support P

$$\delta_2 = \frac{P\left(\frac{l}{2}\right)^3}{3EI} + \frac{P\left(\frac{l}{2}\right)^2}{2EI}\left(\frac{l}{2}\right)$$

$$= \frac{Pl^3}{24EI} + \frac{Pl^3}{16EI} = \frac{2Pl^3+3Pl^3}{48EI} = \frac{5Pl^3}{48EI}$$

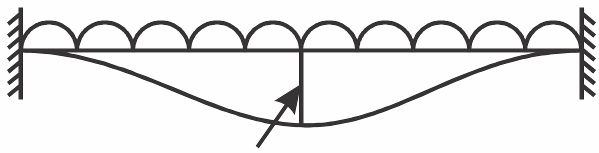
$\therefore$ The deflection at free end is zero

$$\frac{wl^4}{8EI} + \frac{5Pl^3}{48EI}$$

$$\frac{wl}{8} + \frac{5}{6} = 0.83$$

20. Ans : (c)

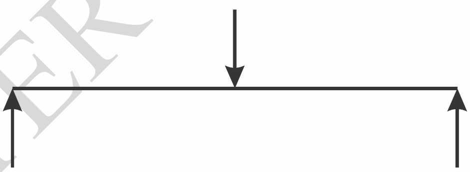
Sol.



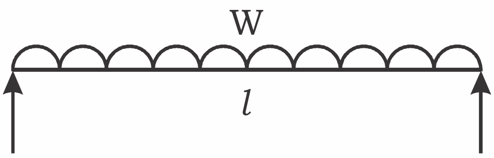
$$y_{max} = \frac{1}{5}\left[\frac{5wl^4}{384EI}\right] = 0.0026\left(\frac{wl^4}{EI}\right)$$

21. Ans : (d)

Sol.



1. $y_{max} = \dfrac{wl^3}{48EI}$



2. $y_{max} = \dfrac{5wl^3}{384EI}$

$$\frac{y_1}{y_2} = \frac{1}{48}\cdot\frac{384}{5} = \frac{8}{5} = 1.6$$

$$(y_{max})_{conc.} = \frac{wl^3}{48EI}$$

$$(y_{max})_{udl} = \frac{5(wl)l^3}{384EI}$$

$$\frac{(y_{max})_{conc}}{(y_{max})_{udl}} = \frac{1}{48}\cdot\frac{384}{5} = \frac{8}{5} = 1.6$$

26. Ans : (d)

Sol. Central deflection of a simply supported beam carrying point load 'w' at mid span

$$y = \Delta = \frac{5wl^4}{384EI} = \frac{5wl^4 \times 12}{384E \times bd^3}$$

$$\Delta \propto \frac{1}{b}$$

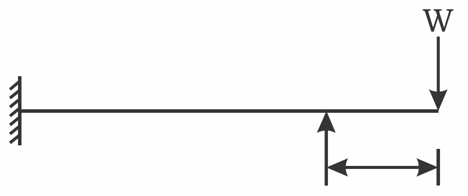
$$\frac{\Delta_2}{\Delta_1} = \frac{b_1}{b_2}$$

$$\frac{\Delta_2}{\Delta_1} = \frac{b_1}{2b_1}$$

$$\Delta_2 = \frac{\Delta_1}{2}$$

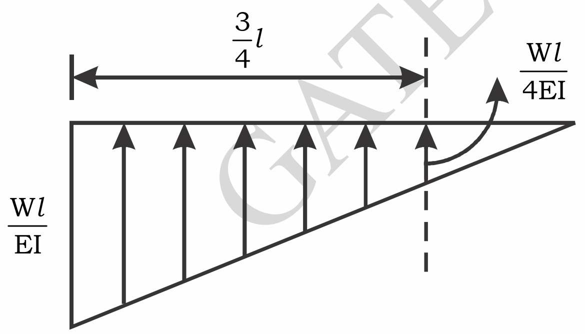
27. Ans : (c)

Sol.



The deflection at P = 0

Downward deflection due to load W



$$\delta_1 = \frac{1}{4}\frac{wl}{EI} \times \frac{3}{4}l \times \frac{3}{8}l + \frac{1}{2}\frac{3}{4}\frac{wl}{EI} \times \frac{3}{4}l \times \frac{2}{3}\left(\frac{3}{4}l\right)$$

$$= \frac{9wl^3}{128EI} + \frac{27wl^3}{192EI}$$

$$\delta_1 = \frac{27wl^3 + 54wl^3}{384EI} = \frac{81wl^3}{384EI}$$

$$\therefore \delta_2 = \frac{P\left(\frac{3}{4}l\right)^3}{3EI} = \frac{27Pl^3}{192EI} \qquad \therefore \delta_1 = \delta_2$$

$$\frac{81wl^3}{384EI} = \frac{27Pl^3}{192EI}$$

$$P = \frac{3}{2}w$$

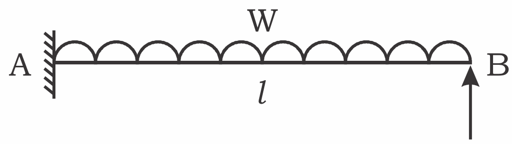
34. Ans : (c)

Sol.

$$\frac{y_A}{y_B} = \frac{I_A}{I_B} = \frac{\frac{b(2d_2)^3}{12}}{\frac{b(d_2)^3}{12}} = 8$$

37. Ans : (b)

Sol.



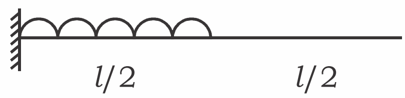
Total deflection at free end.

$$y_{max} = -\frac{wl^3}{3EI} + \frac{wl^3}{8EI}$$

$$y_{max} = -\frac{5wl^3}{24EI} \text{ (upward)}$$

40. Ans : (b)

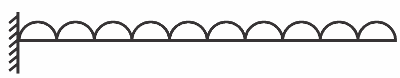
Sol.



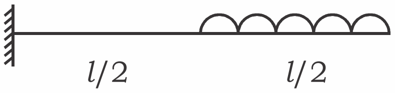
$$y_{max} = \frac{w(l/2)^4}{8EI} + \frac{w(l/2)^3}{6EI}\left(\frac{l}{2}\right)$$

$$= \frac{wl^4}{EI}\left[\frac{1}{128} + \frac{1}{96}\right]$$

$$y_{max} = \frac{7wl^4}{384EI}$$



$$y_{max} = \frac{wl^4}{8EI}$$

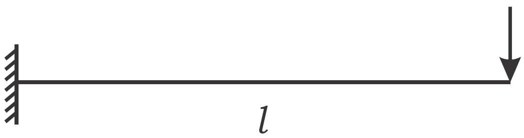


$$y_{max} = \frac{wl^4}{8EI} - \frac{7wl^4}{384EI}$$

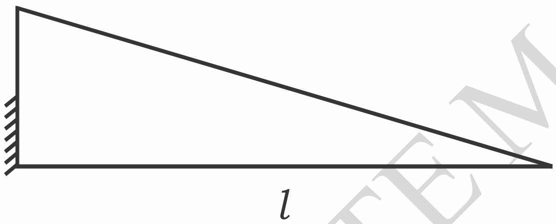
$$= \frac{41wl^4}{384EI}$$

41. Ans : (b)

Sol.



$$\frac{wl^3}{3EI} = 1 \rightarrow \frac{wl^3}{EI} = 3$$



Total load, $W = \frac{1}{2} wl \Rightarrow wl = 2W$

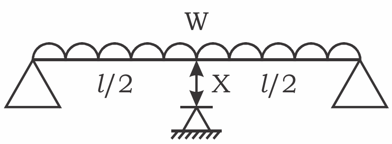
$$\delta = \frac{wl^4}{30EI} = \frac{2W \times l^3}{30EI}$$

$$\delta = \frac{wl^3}{15EI} = \frac{3}{15}$$

$\delta = 0.2$ cm

42. Ans : (b)

Sol.



$$\frac{5wl^4}{384EI} = \frac{Wl^3}{48EI} + x$$

But central support takes a load of $\frac{wl}{3}$

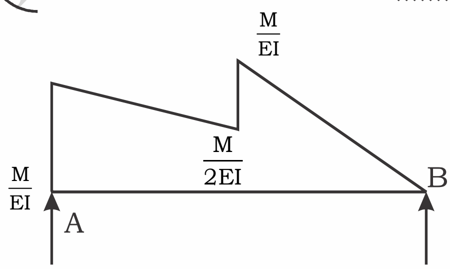
$$\therefore \frac{5wl^4}{384EI} = \frac{\left(\frac{wl}{3}\right)l^3}{48EI} + x$$

$$\frac{wl^4}{EI}\left[\frac{5}{384} - \frac{1}{48 \times 3}\right] = x$$

$$x = \frac{7wl^4}{1152EI}$$

43. Ans : (a)

Sol.



$$R_B \times l = \frac{1}{2}\frac{M}{EI} \times \frac{l}{2} \times \left(\frac{l}{2} + \frac{1}{3}\frac{l}{2}\right) + \frac{1}{2}\frac{M}{2EI} \times \frac{l}{2} \times \frac{1}{3}\left(\frac{l}{2}\right) + \frac{M}{2EI} \times \frac{l}{2} \times \frac{l}{4}$$

$$R_B \times l = \frac{Ml^2}{6EI} + \frac{Ml^2}{48EI} + \frac{Ml^2}{16EI}$$

$$R_B \times l = \frac{8Ml^2 + Ml^2 + 3Ml^2}{48EI} = \frac{12Ml^2}{48EI} = \frac{Ml^2}{4EI}$$

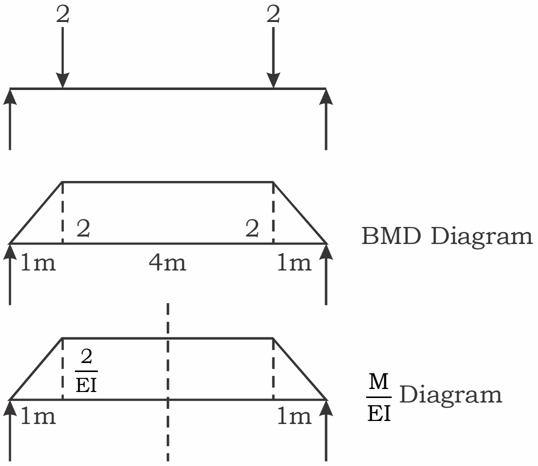
$$R_B = \theta_B = \frac{Ml}{4EI}$$

44. Ans : (a)

Sol. $M = \frac{6EI\delta}{l^2}$ $(\delta = 4–2 = 2\text{cm})$

45. Ans : (b)

Sol.



Slope at B = due to symmetry

$(\frac{1}{2} \times \text{Area of } \frac{M}{EI} \text{ diagram})$

$$= \frac{1}{2} \times \frac{2}{EI} \times 1 + \frac{2}{EI} \times 2$$

$$= \frac{5}{EI} \text{ radians} = \frac{5}{EI} \times \frac{180}{\pi}$$

$$= \frac{900}{\pi EI} \text{ degree}$$

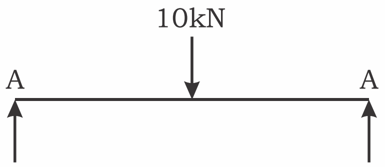
48. Ans : (b)

Sol. $\delta = \frac{1}{4} \times \frac{wl^4}{48EI} = \frac{120 \times 16 \times 4}{4 \times 48 \times 2000}$

$$= \frac{1000}{50} = 20 \text{ mm} = 2 \text{ cm}$$

55. Ans : (c)

Sol.



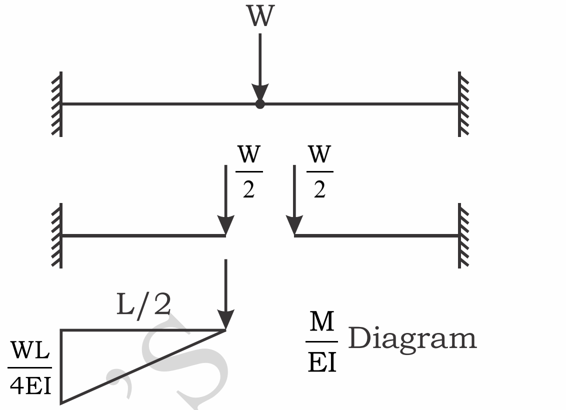
$EI = 1060 \times 10^5$

$$\theta_A = \frac{Wl^2}{16EI} = \frac{10 \times 25 \times 12}{16 \times 1060 \times 10^5 \times 0.15 \times 0.25^3}$$

$= 0.000754$ radians

64. Ans : (a)

Sol.

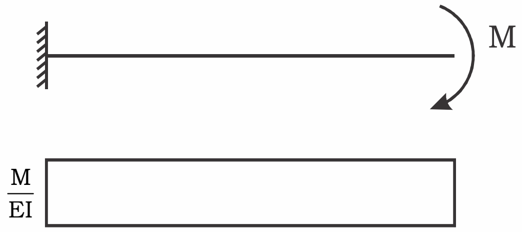


$$\text{Deflection at hinge} = \frac{1}{2} \times \frac{WL}{4EI} \times \frac{L}{2} \times \frac{2}{3}\left(\frac{L}{2}\right)$$

$$= \frac{WL^3}{48EI}$$

69. Ans : (b)

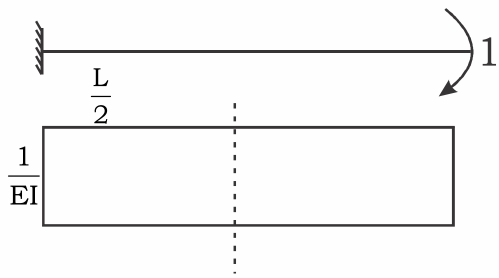
Sol.



$$\delta = \frac{M}{EI} \times L \times \frac{L}{2} = \frac{ML^2}{2EI} = 0.5ML^2$$

71. Ans : (b)

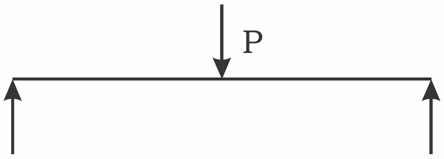
Sol.



$$\delta = \frac{1}{EI} \times \frac{L}{2} \times \frac{L}{4} = \frac{L^2}{8EI}$$

73. Ans : (c)

Sol.



$$\text{Slope} = \frac{Pl^2}{16EI}$$

$$\text{Deflection} = \frac{Pl^3}{48EI}$$

77. Ans : (b)

Sol. Maximum deflection (y)

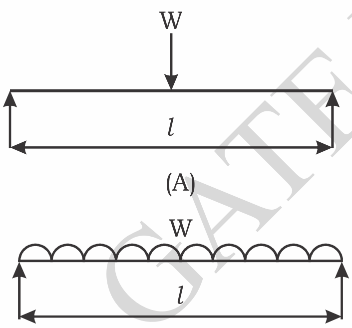
$$= \frac{wl^3}{48EI}$$

$$= \frac{4.8\times10^3}{48\times2\times10^8\times20\times10^{-8}}$$

$= 2.5$ m

79. Ans : (b)

Sol.



Maximum deflection of beam A,

$$y_A = \frac{Wl^3}{48EI}$$

Maximum deflection of beam B,

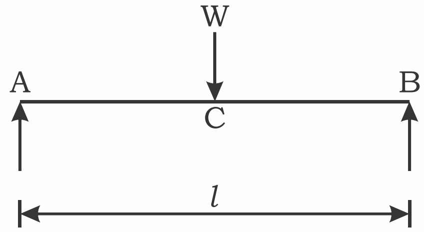
$$y_B = \frac{5Wl^3}{384EI}$$

$$\frac{y_A}{y_B} = \frac{\dfrac{Wl^3}{48EI}}{\dfrac{5Wl^3}{384EI}}$$

$$= \frac{384}{48\times5} = \frac{8}{5}$$

80. Ans : (d)

Sol.



Deflection at C;

$$y = \frac{5wl^3}{48EI}$$

$$y \propto \frac{1}{I};\ y \propto \frac{1}{d^3}$$

$$\frac{y_2}{y_1} = \left(\frac{d_1}{d_2}\right)^3$$

$$\frac{y_2}{y_1} = \left(\frac{d_1}{2d_1}\right)^3$$

$$y_2 = \frac{1}{8}\times y$$

81. Ans : (b)

Sol.

(i)

Width b, depth d

Max deflection =

$$\frac{Pl^3}{3EI} = \frac{Pl^3}{3E\left[\dfrac{bd^3}{12}\right]} = \frac{4Pl^3}{Ebd^3} = 4y$$

(ii)

$$\text{Width} = \frac{b}{2},\ \text{depth} = 2d$$

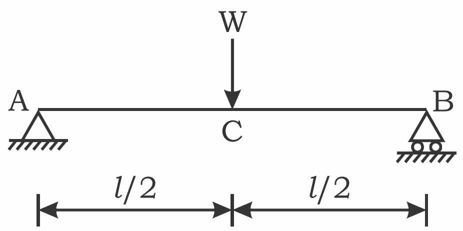
$$\text{Max deflection} = \frac{Pl^3}{3EI} = \frac{Pl^3}{3E\left[\frac{\left(\frac{b}{2}\right)(2d)^3}{12}\right]}$$

$$= \frac{Pl^3}{Ebd^3} = y$$

Max deflection reduced by $\frac{3}{4}$th times

84. Ans : (a)

Sol.



Deflection of the beam at point C

$$y = \frac{Wl^3}{48EI}$$

$$y \propto \frac{1}{I}$$

$$y \propto \frac{1}{b}$$

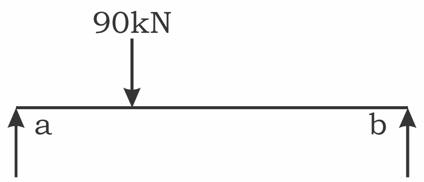
$$\frac{y_2}{y_1} = \frac{b_1}{b_2}$$

$$\frac{y_2}{y_1} = \frac{b}{2b}$$

$$y_2 = \frac{1}{2}y$$

85. Ans : (c)

Sol.



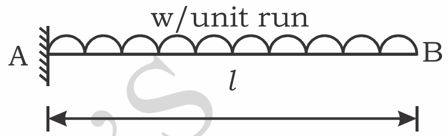
$$M_A = \frac{Wab^2}{l^2}$$

$$= \frac{90 \times 2 \times 16}{36} = 80 \text{ kN} - \text{m}$$

$$M_B = \frac{Wa^2b}{l^2} = \frac{90 \times 4 \times 4}{36} = 40 \text{ kN-m}$$

93. Ans : (a)

Sol.



Upward deflection due to prop $= \frac{R_B l^3}{3EI}$

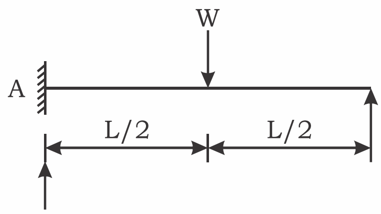
Download deflection due to U.D.L $= \frac{wl^4}{8EI}$

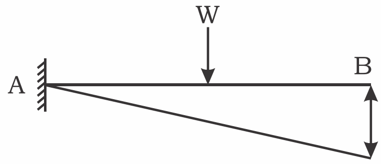
Upward deflection = Download deflection

$$\frac{R_B l^3}{3EI} = \frac{wl^4}{8EI}$$

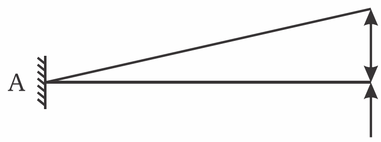
94. Ans : (c)

Sol.





$$y_b = \frac{5wL^3}{48EI}$$



$$y_b = \frac{V_B L^3}{3EI}$$

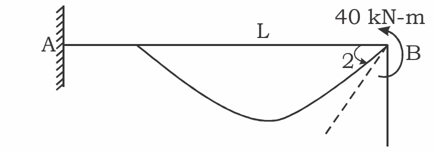
Equating upward and downward deflection

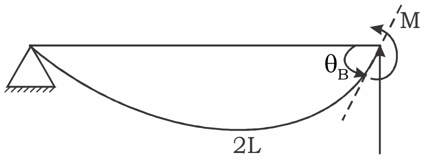
$$\frac{V_B L^3}{3EI} = \frac{5wL^3}{48EI}$$

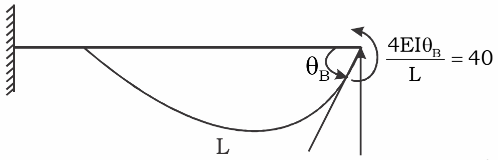
$$V_B = \frac{5}{16}W$$

96. Ans : (a)

Sol:



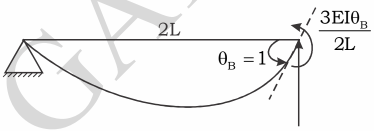




$$\frac{4EI(2)}{L} = 40$$

$$\frac{EI}{L} = 5$$

$$M = \frac{3EI}{L}\theta_B$$



$$= \frac{3 \times 5}{2}$$

M = 7.5 kN–m

97. Ans : (b)

Sol: ω = 20 kN/m = 20×10^3 N/m, l = 5m

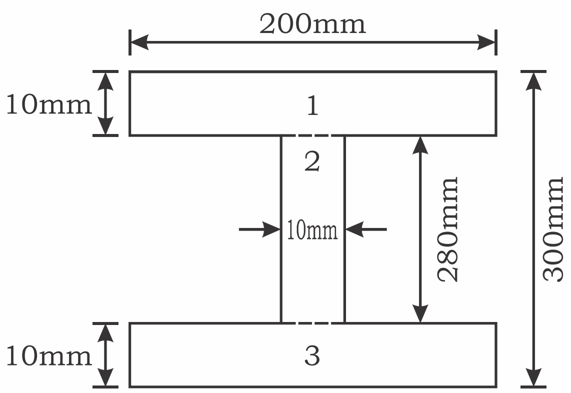
EI = 30000 kN.m^2 = 30000×10^3 N–m^2

$$\delta_{max} = \frac{5\omega\ell^4}{384EI} = \frac{5\times20\times10^3\times(5)^4}{384(30000\times10^3)}$$

$$\delta_{max} = 5.42\,mm$$

4. Ans : (b)

Sol.



Due to symmetry,

$\bar{x}$ = 100 mm

$\bar{y}$ = 150 mm

$$I_{xx} = \left(\frac{200\times10^3}{12}+(200\times10)(145)^2\right)\times2+\left(\frac{10\times280^3}{12}\right)$$

I_{xx} = 102426666.7 mm^4

$$Z = \frac{I_{xx}}{\bar{y}} = \frac{102426666.7}{150} = 682844.44 \text{ mm}^3$$

Bending stress

M = fZ

$100 \times 10^6 = f \times 682844.44$

f = 146.44 N/mm^2

5. Ans : (a)

Sol. Maximum tensile stress,

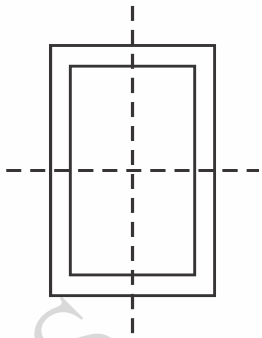
$$f = \frac{M}{Z}$$

$$= \frac{10\times10^6}{\left(\frac{\pi\times200^3}{32}\right)}$$

f = 12.73 MPa

9. Ans : (b)

Sol.



$$M = f\times\frac{I}{y}$$

$$= 100\times\frac{1}{12}(50^4-40^4)\times\frac{1}{25}$$

$$= \frac{369}{3}\times10^4 = 1.23 \text{ kN-m}$$

10. Ans : (b)

Sol. For circle we know

$$I_{xx} = \frac{\pi d^4}{64},\ I_{yy} = \frac{\pi d^4}{64}, I_p = I_{xx}+I_{yy} = \frac{\pi d^4}{32}$$

$$I_{diagonal} = \frac{\pi d^4}{64}$$

$$\frac{I_p}{I_{diagonal}} = \frac{\frac{\pi d^4}{32}}{\frac{\pi d^4}{64}} = 2$$

11. Ans : (d)

Sol. Square size (d) = 10 mm

$$I = \frac{a^4}{12} = \frac{10^4}{12} = 833.33 \text{ mm}^4$$

12. Ans : (c)

Sol: $$\frac{\frac{a^3}{6\sqrt{2}}}{\frac{a^4}{12}} = \frac{a^3}{6\sqrt{2}}\times\frac{12}{a^4}\frac{2}{\sqrt{2}} = 1.414$$

19. Ans : (b)

Sol. The strength of section is uniform

M = f × Z

$$M = f \times \frac{bd^2}{6}$$

$M \propto b$

$M \propto d^2$;

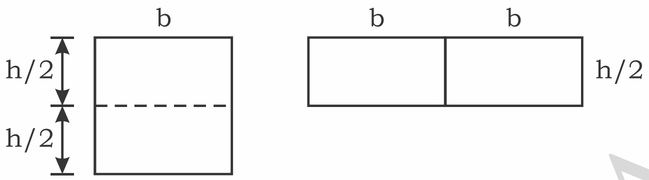
$d \propto \sqrt{M}$

21. Ans : (d)

Sol. For strongest beam, $b = \frac{D}{\sqrt{3}} = \frac{400}{\sqrt{3}}$ mm

22. Ans : (c)

Sol.



$$\frac{(str)_2}{(str)_1} = \frac{2b\left(\frac{h}{2}\right)^2}{(b)(h^2)} = \frac{1}{2}$$

25. Ans : (c)

Sol: $\sigma_{concrete} = 5N/mm^2$

$$\frac{E_{steel}}{E_{concrete}} = 15$$

$$E = \frac{\sigma}{\varepsilon}$$

$$\frac{f_1}{f_2} = \frac{E_1}{E_2} = m \qquad \frac{f_1}{f_2} = m$$

$$\frac{E_{strong}}{E_{weak}} = m$$

$$\frac{5}{f_2} = \frac{1}{m}$$

$$\frac{5}{f_2} = \frac{1}{15}$$

$f_2 = 5 \times 15 = 75\ N/mm^2$

33. Ans : (b)

Sol. $Z_{circle} = Z_{square}$

$$\frac{\pi d^3}{32} = \frac{a^3}{b}$$

$$a^3 = \frac{6\pi}{32}.d^3$$

a = 0.838 d

$$\frac{\text{weight of circular beam}}{\text{weight of square beam}} = \frac{\text{Area of circular beam}}{\text{Area of square beam}}$$

$$= \frac{\frac{\pi d^2}{4}}{a^2} = \frac{\pi d^2}{4a^2} = \frac{\pi d^2}{4 \times (0.838d)^2}$$

$k = 1.118$

34. Ans : (d)

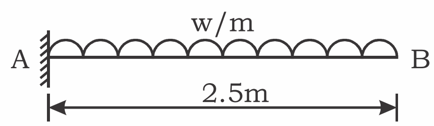
Sol. Bending equation

$$\frac{E}{R} = \frac{M}{I} = \frac{f}{y}$$

$$\frac{M}{2127} = \frac{300}{7}$$

M = 91,157.143 kg-cm

= 911.571 kg-m



Maximum bending moment occurs at A.

$$M_A = w \times 2.5 \times \frac{2.5}{2}$$

$M_A = 3.125$ w

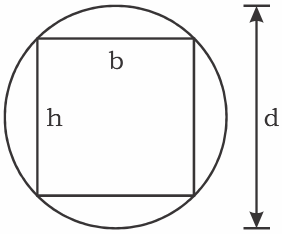
Substituting M value,

3.125 w = 911.571

w = 291.7 kg/m

35. Ans : (d)

Sol.



$$b=\frac{d}{\sqrt{3}};\quad h=\sqrt{\frac{2}{3}}.d$$

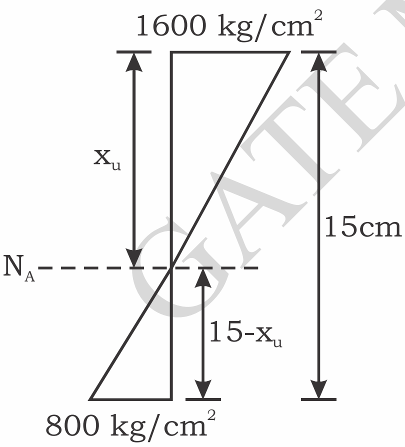
$$b=\frac{30}{\sqrt{3}}=17.32\text{ cm}$$

43. Ans : (a)

Sol. $$\frac{\rho_{loose}}{\rho_{Integral}}=\frac{\rho_{Integral}}{\rho_{loose}}=\frac{b(nd)^3}{n(bd)^3}=n^2=3^2=9$$

44. Ans : (b)

Sol.



By similar triangle

$$\frac{1600}{x_u}=\frac{800}{15-x_u}$$

$24{,}000 - 1600\,x_u = 800\,x_u$

$x_u = 10$ cm

47. Ans : (c)

Sol. $$\frac{f}{y}=\frac{E}{R}$$

$$\Rightarrow \frac{400}{1}=\frac{2\times10^6}{R}$$

$$R=\frac{10000}{7}\text{cm}$$

50. Ans : (b)

Sol: Bending moments are equal.

$$\sigma_A Z_z=\sigma_B Z_B$$

$$\sigma_B\times\frac{b\times b^2}{4\times b}=\sigma_n\times\frac{b\times b^2}{2\times 6}$$

$$\sigma_A=2\sigma_B$$

51. Ans : (d)

Sol. Bending equation

$$\frac{E}{R}=\frac{M}{I}=\frac{f}{y}$$

$$f=\frac{Ey}{R}=\frac{2\times10^5\times50}{10000}$$

$= 1000\ \text{N/mm}^2$

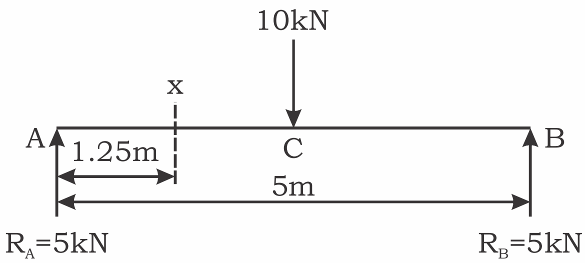
62. Ans : (b)

Sol. BM, M = 2 × 2 kN-m

$$f=\frac{2\times2\times10^6}{(40\times60^2/6)}=166.67\ \text{N/mm}^2$$

63. Ans : (c)

Sol.



Moment at quarter span,

M = 5 × 1.25 = 6.25 kN-m

Maximum bending stress,

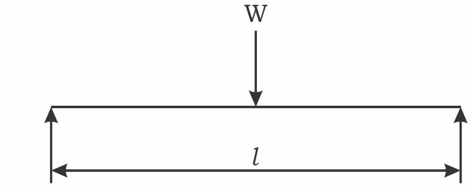
M = fZ

$$6.25\times10^6=f\times\frac{200\times400^2}{6}$$

$f = 1.172\ \text{N/mm}^2$

67. Ans : (c)

Sol.



$$\frac{E}{R} = \frac{M}{I} = \frac{F}{y}$$

$$M = \frac{Wl}{4}$$

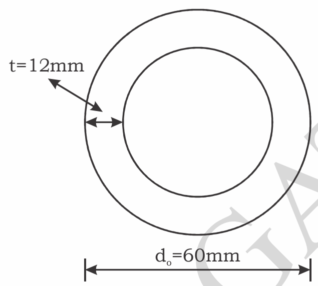
$$\frac{\left(\frac{Wl}{4}\right)}{\frac{bd^3}{12}} = \frac{P}{\frac{d}{2}}$$

$$\frac{3Wl}{2bd^2} = P$$

$$\Rightarrow d = \sqrt{\frac{3Wl}{2bP}}$$

79. Ans : (a)

Sol.



Internal diameter,

$d_i = d_o - 2t$

$= 60 - 2(12)$

$= 36$ mm

Section modulus of hollow cost iron pipe,

$$Z = \frac{\pi\left(d_o^4 - d_i^4\right)\times 2}{64\times d_o}$$

$$= \frac{\pi\times\left(60^4 - 36^4\right)\times 2}{64\times 60}$$

$Z = 18{,}457.49$ mm^3

81. Ans : (b)

Sol. Bending equation

$$\frac{E}{R} = \frac{M}{I} = \frac{F}{y}$$

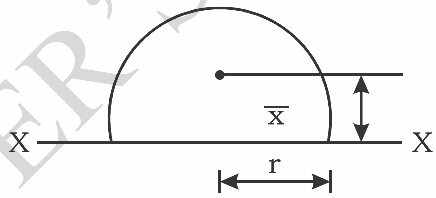
$$R = \frac{Ey}{f} = \frac{2\times 10^5\times 260}{110\times 2}$$

$R = 236.36\times 10^3$ mm

$R = 236.36$ m

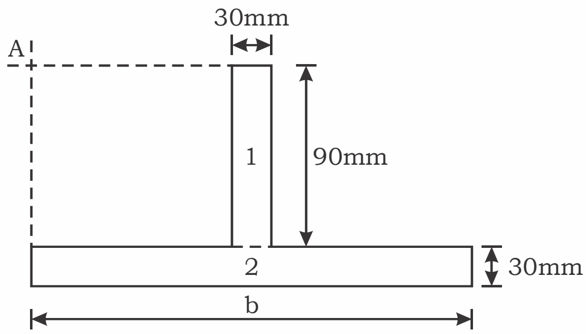
85. Ans : (b)

Sol. $I_X = 0.11924\ r^4$



86. Ans : (a)

Sol.



$A_1 = 30\times 90 = 2700$ mm^2; $y_1 = 45$ mm

$A_2 = 30\times b = 30\,b$; $y_2 = 90 + \frac{30}{2} = 105$ mm

$$\bar{y} = \frac{A_1y_1 + A_2y_2}{A_1 + A_2}$$

$$90 = \frac{(2700\times 45) + (30b\times 105)}{2700 + 30b}$$

$243000 + 2700\,b = 12500 + 3150b$

$b = 270$ mm

127. Ans : (a)

Sol. Modular ratio = 20

Width of the equivalent section

$$= \frac{8}{20} = 0.4 \text{ cm}$$

5. Ans : (b)

Sol. Maximum shear stress

$$\tau_{max} = \frac{3}{2}\frac{F}{bh}$$

$$3 = \frac{3}{2} \times \frac{F}{100 \times 200}$$

$F = 40 \times 10^3 N$

$= 40$ kN

17. Ans : (c)

Sol. $\% \text{ more} = \frac{\tau_{max} - \tau_{av}}{\tau_{av}}$

$$= \frac{\frac{4}{3}\tau_{max} - \tau_{av}}{\tau_{av}} = \frac{1}{3} = 33.33\%$$

21. Ans : (a)

Sol. $\max \text{ SF} = \frac{wl}{2} = \frac{40 \times 4}{2} = 80 \text{ kN}$

$$\tau_{max} = \frac{3}{2}(\tau_{avg}) = \frac{3}{2}\left(\frac{80 \times 10^3}{200 \times 400}\right)$$

$= 1.5$ MPa

23. Ans : (a)

Sol. $\tau_{avg} = 5 \text{ N/mm}^2$

$\tau_{max} = ?$

For circular section, $\tau_{max} = \frac{4}{3}\tau_{avg}$

$$= \frac{4}{3} \times 5$$

$= 6.67 \text{ N/mm}^2$

24. Ans : (d)

Sol. $\tau_{max} = ?$

$E = 2 \times 10^6 \text{ kg(f)/m}^2$

Shrinkage factor = 0.002

$$\tau = \frac{\sigma}{2} = \frac{\varepsilon E}{2}$$

$$= \frac{0.02 \times 2 \times 10^6}{2} = 2000 \quad \text{kg(f)/m}^2$$

27. Ans : (d)

Sol. $$\frac{\tau_{solid}}{\tau_{hallow}} = \frac{\frac{\pi}{32}\left[D^4 - \left(\frac{D}{2}\right)^4\right]}{\frac{\pi}{32}(D^4)}$$

$$= \frac{15}{16} = 0.94$$

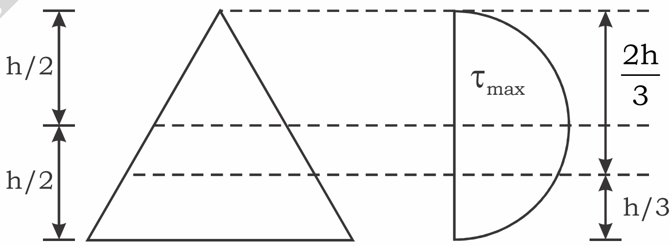
29. Ans : (a)

Sol. Triangular section :

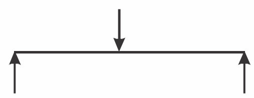
$$\tau_{max} = \frac{3S}{bh}$$

$= \frac{3}{2}\tau_{avg}$ at $\frac{h}{2}$ from apex or base

$$\tau \text{ at N.A} = \frac{8s}{3bh} = \frac{4}{3}\tau_{avg}$$



36. Ans : (c)



Sol: Max.shear stress $\tau_{max} = \frac{3}{2}\tau_{avg}$

$$3 = \frac{3}{2}\tau_{avg}$$

$\tau_{avg} = 2$ MPa

$$\frac{\text{Load}}{\text{C/s area}} = 2 \Rightarrow \frac{W}{2 \times 100 \times 2000} = 2$$

W=80kN

6. Ans : (a)

Sol. $$\frac{(\text{strength})_B}{(\text{strength})_A} = \frac{(Z_p)_B}{(Z_p)_A}$$

$$= \frac{\frac{\pi}{16}\times(D_B)^3}{\frac{\pi}{16}\times(D_A)^3}$$

$$= \frac{(D/2)^3}{D^3} = \frac{1}{8}$$

8. Ans : (c)

Sol. Given,

P = 540 kW

N = 720 r.p.m

$$P = \frac{2\pi NT}{60}$$

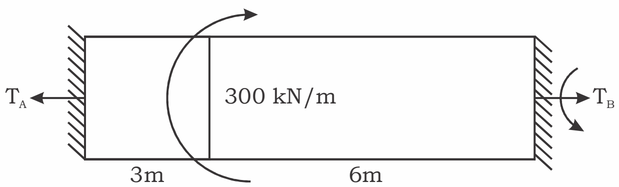
$$540\times1000 = \frac{2\pi\times720\times T}{60}$$

$$T = \frac{540\times1000\times60}{2\pi\times720}$$

T = 7162 N-m

10. Ans : (d)

Sol.



$$T_A = \frac{300\times6}{9} = 200 \text{ kN-m}$$

$$T_B = \frac{300\times3}{9} = 100 \text{ kN-m}$$

∴ Maximum torque = 200 kN-m

15. Ans : (c)

Sol. $$\frac{(\text{Strength})s}{(\text{Strength})h} = \frac{16}{15} = 1.07$$

$$= \frac{Z_s}{Z_h} = \frac{D^4}{D^4 - \left(\frac{D}{2}\right)^4} = \frac{16}{15} = 1.07$$

16. Ans : (d)

Sol. Given :

d = 200 mm

G = 100 GPa

Torsional rigidity = GJ

$$= 1\times10^5\times\frac{\pi}{32}\left(202^4 - 200^4\right)$$

= $6.378 \times 10^6 \times 10^5$ N-mm²

= 637.8 G N-mm²

25. Ans : (b)

Sol. Given, d=10 cm

l = 2m =200 cm

T = 800 kg-m

T = 800×100 kg-cm

$$\tau_{max} = \frac{16T}{\pi d^3}$$

$$= \frac{16\times80000}{\pi\times10^3}$$

$$= \frac{16\times80}{\pi} = 407.43 \text{ kg/cm}^2$$

26. Ans : (d)

Sol. Given, P = 80 H.P

N = 60 r.p.m

$$P = \frac{2\pi NT}{4500}$$

$$80 = \frac{2\pi\times60\times T}{4500}$$

$$T = \frac{80 \times 4500}{2\pi \times 60}$$

$$T = \frac{3000}{\pi} kg - m$$

$$T_{max} = 1.3 \times \frac{3000}{\pi} = \frac{3900}{\pi} kg - m$$

28. Ans : (d)

Sol. Given $d = \frac{D}{2}$

$$\frac{T_s}{T_h} = \frac{(Z_p)_s}{(Z_p)_h} = \frac{\frac{\pi}{16}D^3}{\frac{\pi}{16D}(D^4 - d^4)} = \frac{D^4}{D^4 - d^4}$$

$$\frac{T_s}{T_h} = \frac{D^4}{D^4 - \left(\frac{D}{2}\right)^4} = \frac{D^4}{D^4 - \frac{D^4}{16}} = \frac{D^4}{\frac{15}{16}D^4}$$

$$\frac{T_s}{T_h} = \frac{15}{16}$$

$$T_s = \frac{16}{15}T_h$$

$$N = \frac{16}{15}$$

31. Ans : (b)

Sol. Given N = 150 r.p.m

T = 150 kg.m

$$P = \frac{2\pi NT}{4500}$$

Where, P = Power transmitted in H.P

N = r.p.m

T = Average torque in kg-m

$$P = \frac{2\pi \times 150 \times 150}{4500}$$

$$P = \frac{2\pi \times 150}{30}$$

$P = 10\pi$

37. Ans : (b)

Sol. Solid and hollow sections have same weight

$W_h = W_s$

$\gamma \times V_h = \gamma \times V_s$

$A_h = A_s$

$$\frac{\pi}{4} \times (D^2 - d^2) = \frac{\pi}{4} d_1^2$$

assume $k = \frac{d}{D}$

$D^2 (1-k^2) = d^2_1$

$$D\sqrt{(1-k^2)} = d_1$$

$$\frac{Z_h}{Z_s} = \frac{D^4 - d^4}{d_1^3 D}$$

$$= \frac{D^4(1-k^4)}{D^4\left(\sqrt{1-k^2}\right)(1-k^2)}$$

$$= \frac{1-k^4}{\left(\sqrt{1-k^2}\right)(1-k^2)} \quad \left[d = \frac{D}{2}, k = \frac{d}{D} \; k = \frac{1}{2}\right]$$

$$\frac{Z_h}{Z_s} = \frac{1+k^2}{\sqrt{1-k^2}} = \frac{1+\left(\frac{1}{2}\right)^2}{\sqrt{1-\left(\frac{1}{2}\right)^2}} = \frac{5\sqrt{3}}{6}$$

40. Ans : (b)

Sol. Power, $P = \frac{2\pi NT}{60}$

$$190 \times 10^3 = \frac{2\pi \times 200T}{60}$$

τ = 9.071 kN-m

$$\tau = \frac{16T}{\pi d^3} = \frac{16 \times 9071}{\pi \times 200^3} \times 10^3$$

$\tau = 5.78\ N/mm^2$

43. Ans : (b)

Sol. Torsional rigidity,

$$GJ = 100 \times 10^5 \times \frac{\pi \times (202^4 - 200^4)}{32}$$

$= 637.8 \times 10^9\ N\text{-}m^2$

$= 637.8\ GN\text{-}m^2$

51. Ans : (c)

Sol. $J \propto d^4$

65. Ans : (a)

Sol. Polar moment of inertia

$I_{zz} = I_{xx} + I_{xy}$

$= 1 \times 10^6 + 2 \times 10^6$

$I_{zz} = 3 \times 10^6$

10. Ans : (c)

Sol: left = 3m = 3000 mm

$$I = \frac{bd^3}{12} = \frac{(30)(30)^3}{12}$$

$$r_{min} = \sqrt{\frac{I}{A}} = \sqrt{\frac{\frac{(30)(30)^3}{12}}{30 \times 30}}$$

r_{min} = 8.66 mm

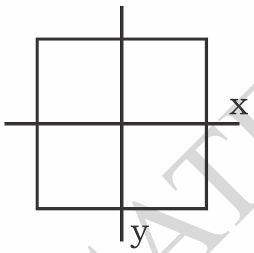
free standing column means fixed free condition

left = 2L = 2×3 = 6m = 6000mm

$$\lambda = \frac{left}{r_{min}} = \frac{6000}{8.66} = 692.84$$

16. Ans : (a)

Sol.



$$\sigma_z = \frac{P}{A} + \frac{M_x}{I_x}y + \frac{M_y}{I_y}(x)$$

$$= \frac{8}{4} + \frac{2M(x)}{I}$$

$\because$ (M_x=M_y. e_x=e_y, I_x = I_y)

$$= \frac{8}{4} + \frac{2 \times 8 \times 1 \times 1}{\frac{2^4}{12}}$$

$$= \frac{8}{4} + \frac{8 \times 2 \times 12}{16} = 2 + 12 = 14 \text{ kN/m}^2$$

18. Ans : (b)

Sol. Euler's load, $P_E = \frac{\pi^2 EI}{l^2}$

$$\frac{P_{hinged-hinged}}{P_{fixed-fixed}} = \left(\frac{l_{fixed-fixed}}{l_{hinged-hinged}}\right)^2$$

$$= \left(\frac{l/2}{l}\right)^2 = \frac{1}{4} \qquad \text{(i.e. 1:4)}$$

22. Ans : (d)

Sol. The equivalent length of column fixed at one end and free at the other is $2l$.

23. Ans : (a)

Sol. Given, l_{eff} = 4m

Cross sectional area, A = 145.3 cm^2

Radius of gyration, r = 6.25 cm

f_c = 5500 kg/cm^2

Rankine's coefficient $\alpha = \frac{1}{1600}$

Rankine's crippling load, $P_R = \frac{f_c A}{1 + \alpha\lambda^2}$

Slenderness ratio, $\lambda = \frac{l}{r_{min}} = \frac{400}{6.25} = 64$

$$P_R = \frac{5500 \times 145.3}{1 + \frac{1}{1600} \times (64)^2}$$

= 224.5 tonnes

25. Ans : (d)

Sol. Given

I = 1766 cm^4

l = 6 m

E = 0.8 × 10^6 kg/cm^2

Cross sectional area, A = 1.7 cm^2

Euler's crushing load,

$$P_e = \frac{\pi^2 EI}{l^2} = \frac{\pi^2 \times 0.8 \times 10^6 \times 1766}{(600)^2} = 38732$$

33. Ans : (c)

Sol. $P_{cr} \propto M.I$

For the given options

M.I of hollow > M.I of $I_{section}$

55. Ans : (c)

Sol. $P = \sigma A_c + m\sigma_c A_s$

$= 5 \times 10,000 + 20 \times 5 \times 1000$

$= 50,000 + 100000$

$= 150,000$ N = 150 kN

63. Ans : (a)

Sol: left =2m A = 1000 mm^2 I = 1×10^7mm^4

$$\lambda = \frac{\ell}{r_{min}}$$

$$r_{min} = \sqrt{\frac{I}{A}} = \sqrt{\frac{1\times10^7}{1000}} = 100\,mm$$

$$\lambda = \frac{2000}{100} = 20$$

72. Ans : (c)

Sol. $\lambda = l_{eff}/r_{min}$

$$r_{min} = \sqrt{I/A}$$

$$= \sqrt{\frac{40\times40^3}{12\times40\times40}} = \frac{40}{\sqrt{12}}$$

Free standing column means fixed free condition

$l_{eff} = 2L = 2 \times 4 = 8$ m

$$\therefore\ \lambda = \frac{8000}{40}\times\sqrt{12}$$

$= 692.8$

80. Ans : (c)

Sol: If both ends fixed

$$(P_{cr}) = \frac{4\pi EI}{\ell^2} = 50\ kN$$

If both ends hinged

$$(P_{cr})_2 = \frac{\pi^2 EI}{\ell^2} = \frac{50}{4} = 12.5\ kN$$

81. Ans : (a)

Sol: Dia of core = 2×eccentricity

$$= 2\times\frac{D^2+d^2}{8D}$$

$$= \frac{D^2+d^2}{4D}$$

$$= \frac{200^2+100^2}{800}$$

$$= \frac{500}{8} = 62.5\ mm$$

91. Ans : (c)

Sol: l = 4m A = 2000 mm^2 I_{xx}=720 cm^4,

I_{yy}=80 cm^4

left = 0.5L = 0.5×4=2m = 2000 mm

$$\lambda = \frac{left}{r_{min}}$$

$$r_{min} = \sqrt{\frac{I}{A}} = \sqrt{\frac{80\times10^4}{2000}} = 20\ mm$$

$$\lambda = \frac{2000}{20} = 100$$

92. Ans : (d)

Sol: l = 3m

$L_e = 2l = 2\times3 = 6$ m

93. Ans : (d)

Sol: Euler's Critical load,

$$P_e = \frac{\pi^2 EI}{l_{eff}^2}$$

$$\frac{P_{e_1}}{P_{e_2}} = \left[\frac{(l_{eff})_2}{(l_{eff})_1}\right]^2 = \left[\frac{\ell}{\ell/2}\right]^2 = 4$$

1. Ans : (a)

Sol. $\sigma_{sudden} = 2 \times \sigma_{gradual}$

8. Ans : (d)

Sol. $E = 2 \times 10^5$ MPa

$\sigma = f_y = 250$ MPa

$$U_m = \frac{1}{2} \times \sigma \times \varepsilon \quad \left\{E = \frac{\sigma}{\varepsilon}, \varepsilon = \frac{\sigma}{E}\right\}$$

$$U_m = \frac{1}{2} \times \sigma \times \frac{\sigma}{E}$$

$$U_m = \frac{1}{2} \times 250 \times \frac{250}{2 \times 10^5}$$

$U_m = 0.156$ Nmm/mm^3

11. Ans : (No option is correct)

Sol. $\sigma = 10$ N/mm^2

$E = 1 \times 10^5$ N/mm^2

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

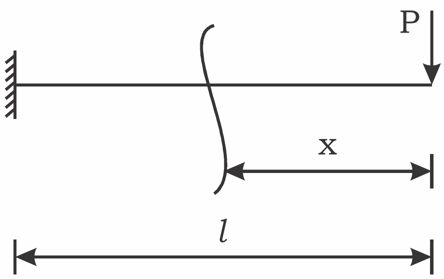
$$U = \frac{\sigma^2}{2E} \times V$$

$$U = \frac{10^2}{2 \times 1 \times 10^5} \times 2 \times 10^5$$

$= 100$ Nmm

12. Ans : (d)

Sol.



$$U = \frac{1}{2EI}\int M_x^2 dx$$

$$= \frac{1}{2EI}\int_0^l (-Px)^2 \, dx$$

$$= \frac{1}{2EI} P^2 \left[\frac{x^3}{3}\right]_0^l$$

$$= \frac{P^2}{2EI}\left[\frac{l^3}{3}\right] = \frac{P^2 l^3}{6EI}$$

17. Ans : (b)

Sol. Length = 1m

Area = 4 cm^2

Force = 80 kN

E = 200 kN/mm^2

Total strain energy stored $= \dfrac{P^2 l}{AE}$

$$\frac{80^2 \times 1}{4 \times 10^2 \times 200} = 80 \text{ kN-mm}$$

22. Ans : (a)

Sol: $\tau = 200\,\text{MPa}; \ \sigma = 100\,\text{GPa}$

$$U = \frac{\tau^2}{2G} \times \text{vol} = \frac{(200 \times 10)^2}{2 \times 100 \times 10^9} \times (50)^3$$

U = 25 N-m

2. Ans : (b)

Sol. Bursting pressure = P.D.L

$= 380 \times \frac{62}{1000} \times 1$

$= 23.56\ MN/m^2$

5. Ans : (b)

Sol. Hoop stress, $\sigma_h = \frac{PD}{2t}$

$= \frac{1.2 \times 1500}{2 \times 15} = 60\ N/mm^2$

6. Ans : (a)

Sol. $80 = \frac{P \times 2.5 \times 100}{2 \times 5 \times 10}$

$P = 3.2\ N/mm^2$

7. Ans : (a)

Sol. $\sigma_h = \frac{PD}{2t} = \frac{700 \times 10^3 \times 1000}{2 \times 25} = 14\ MPa$

8. Ans : (c)

Sol. $\sigma_1 = 30\ N/mm^2$; $\sigma_h = 45\ N/mm^2$

$D = 1250$ mm

$P = 2\ N/mm^2$

$\sigma_h = \frac{PD}{2t} = 45 = \frac{2 \times 1250}{2 \times t}$

= 27.7 mm = 2.77 cm

$\sigma_l = \frac{PD}{2t} = 30 = \frac{2 \times 1250}{4 \times t}$

t = 20.8 mm = 2.08 cm

Considering maximum thickness

9. Ans : (c)

Sol. Pressure in the pipe, $P = \gamma H$

$= 9810 \times 100$

$= 981000\ N/m^2$

$= 0.98\ N/mm^2$

Max permissible stress,

$20 = \frac{0.981 \times 800}{2 \times t}$

t = 19.6 = 2 cm

10. Ans : (b)

Sol. $\frac{300}{3} = \frac{1.5 \times D}{2 \times 1.5 \times 10 \times 0.8}$

D = 1600 mm = 160 cm

13. Ans : (a)

Sol: d=100 mm t= 5 mm P = 10 $N\text{-}mm^2$

$\sigma_h = \frac{pd}{2t} = \frac{10 \times 100}{2 \times 5} = 100 N - mm^2$

15. Ans : (c)

Sol: d = 1m t=1mm p=0.2 MPa

$\tau_{max} = \frac{Pd}{8t} = \frac{0.2 \times 1}{8 \times 1 \times 10^{-3}} = 25\,MPa$

17. Ans : (a)

Sol: $\sigma_h = 24 N/mm^2$

$\frac{\sigma_h}{\sigma_\ell} = 2 \Rightarrow \frac{24}{\sigma_\ell} = 2 \Rightarrow \frac{24}{2} = \sigma_\ell$

$\sigma_\ell = 12 N/mm^2$

22. Ans : (a)

Sol: $\frac{f}{y} = \frac{E}{R}$

$\frac{95}{y} = \frac{2 \times 10^5}{1800}$

y = 0.855 mm

Internal diameter = 3600 – 2×0.855

= 3598.29

26. Ans : (a)

Sol: P = 40 MPa $\sigma_\ell = 60\,MPa$ σ_c (or) σ_h

$\sigma_c = 2\sigma_\ell = 2 \times 60 = 120\ MPa$

4. Ans : (b)

Sol: $\tau_{max} = 5 N / mm^2$

dia(d) = 40 mm

T=?

$$\tau_{max} = \frac{16T}{\pi d^3} \Rightarrow \frac{\tau_{max} \times \pi d^3}{16} = T$$

T = 62.83 N–m

07. Ans : (c)

Sol. We know

Deflection, $\delta = \frac{64WR^3n}{Gd^4}$

Where n is the number of turns

$\therefore \delta \propto n$

$$\frac{\delta_A}{\delta_B} = \frac{n_A}{n_B}$$

Given, $n_A = \frac{n_B}{2}$

$$\therefore \frac{\delta_A}{\delta_B} = \frac{n_B/2}{n_B} = \frac{1}{2}$$

13. Ans : (b)

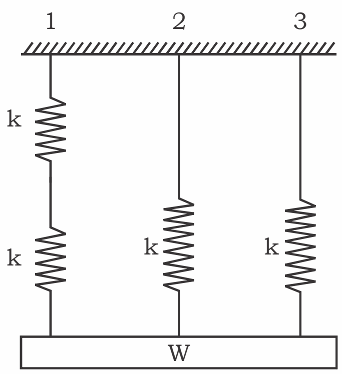
Sol. We know that

Stiffness k = $\frac{\text{axial load (w)}}{\text{elongation of spring } (\delta)}$

$$= \frac{100}{4} = 25 \text{ N/mm}$$

15. Ans : (a)

Sol.



Equivalent stiffness of 1st set of springs

$$\frac{1}{k_{e1}} = \frac{1}{k} + \frac{1}{k}$$

$$k_{e1} = 0.5k$$

The overall equivalent spring constant

$= k_{e_1} + k + k$

= 0.5 k + 2k

= 2.5 k

21. Ans : (c)

Sol: Given,

N = 100 r.p.m

P = 1 H.P

T = ?

$$P = \frac{2\pi NT}{4500}$$

$$1 = \frac{2\pi \times 100 \times T}{4500}$$

$$T = \frac{45}{2\pi} = 7.16 \text{ kg} - \text{m}$$

T= 7.16×100 kg-cm

T = 716 kg-cm

22. Ans : (b)

Sol. We know

Spring constant $k = \frac{Gd^4}{64R^3n}$

$k \propto \frac{1}{R^3}$ ($\because$ R = Radius of core)

$$\frac{k_1}{k_2} = \frac{R_2^3}{R_1^3}$$

$$\therefore \frac{k_1}{k_2} = \frac{\left(\frac{2.5}{2}\right)^3}{\left(\frac{1.25}{2}\right)^3} = \frac{1}{8}$$

Where $R_2 = \frac{D_2}{2} = \frac{1.25}{2}$

$$R_1 = \frac{D_1}{2} = \frac{2.5}{2}$$

23. Ans : (b)

Sol. Given :

Strain energy stored in spring U=80N-mm

Deflection (δ) = 4 mm

Stiffness (k) $= \frac{W}{\delta}$, $U = \frac{1}{2} W\delta$

$\therefore$ Axial load $W = \frac{2 \times 80}{4} = 40$ N

$\therefore$ $k = \frac{W}{\delta} = \frac{40}{4} = 10$ N/mm

24. Ans : (d)

Sol. $Ph = \frac{1}{2} W\delta$

$$1000 \times 10 = \frac{1}{2} \times K\delta^2$$

$$= \frac{1}{2} \times 200 \times \delta^2$$

δ = 100 cm

25. Ans : (b)

Sol. Assume dia of wire 'd'

Given

Axial load on spring W = 500 N

Mean diameter of coil D = 10d

$\therefore$ Mean radius of coil R = 5d

Since axial load on spring causes torque in spring wire.

Torque in spring wire (T) = WR

We know

Shear stress $\tau = \frac{16T}{\pi d^3}$

$$80 = \frac{16 \times 500 \times 5d}{\pi \times d^3}$$

$\therefore$ dia of wire d=12.6 mm

35. Ans : (c)

Sol. Deflection of a closely coiled helical spring is given by

$$\delta = \frac{64WR^3n}{Cd^4}$$

$$\delta \propto n$$

$$\frac{\delta_A}{\delta_B} = \frac{n_A}{n_B}$$

$$\frac{\delta_A}{\delta_B} = \frac{n_B}{2 \times n_B}$$

$$\frac{\delta_A}{\delta_B} = \frac{1}{2}$$

36. Ans : (a)

Sol: Deflection, $\delta = \frac{64WR^3n}{Gd^4}$

$$\delta \, \alpha \, n$$

$$\frac{\delta_A}{\delta_B} = \frac{n_A}{n_B}$$

Given $n_A = \frac{n_B}{2}$

$$\therefore \frac{\delta_A}{\delta_B} = \frac{\frac{n_B}{2}}{n_B} = \frac{1}{2}$$

66. Ans : (d)

Sol: $d = \frac{D}{3}$

$$\frac{T_h}{T_s} = \frac{(Z_P)_h}{(Z_P)_S} = \frac{\frac{\pi}{16D}\left(D^4 - d^4\right)}{\frac{\pi}{16}D^3} = \frac{D^4 - d^4}{D^4}$$

$$\frac{T_h}{T_s} = \frac{D^4 - \left(\frac{D}{3}\right)^4}{D^4}$$

$$\frac{T_h}{T_s} = \frac{D^4 - \frac{D^4}{81}}{D^4} = \frac{\frac{81D^4 - D^4}{81}}{D^4}$$

$$\frac{T_h}{T_s} = \frac{80}{81}$$

77. Ans : (d)

Sol:

$$T_e = \sqrt{m^2 + T^2} = \sqrt{8^2 + 6^2} = \sqrt{64 + 36}$$

$$= \sqrt{100} = 10 \text{ kN} - \text{m}$$

78. Ans : (b)

Sol: $\frac{W_{hollow}}{W_{solid}} = \frac{A_h}{A_s} = \frac{1-k^2}{\left(1-k^4\right)\frac{2}{3}} \quad k = \frac{d}{D}$

$$\frac{W_h}{W_S} = \frac{1 - \left(\frac{2D}{\sqrt{3}} / D\sqrt{3}\right)^2}{\left[1 - \left(\frac{2D/\sqrt{3}}{D/\sqrt{3}}\right)^4\right]\frac{2}{3}} = \frac{-3}{-6} = 1:2$$