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ESE- 2019 (Prelims) - Offline Test Series Test-3

CIVIL ENGINEERING

SUBJECT: SOLID MECHANICS AND CONSTRUCTION PRACTICE, PLANNING AND MANAGEMENT

SOLUTIONS

01. Ans: (c)

Sol: Free expansion of bar + compression due to reaction = 0

$$L\alpha\Delta T + \frac{4(-R)L}{\pi E d_1 d_2} = 0$$

$$R = \frac{\alpha E d_1 d_2 \Delta T.\pi}{4} \text{ (Thermal thrust)}$$

$$\sigma_{max} = \frac{R}{A_{min}}$$

$$= \frac{\alpha E d_1 d_2 \Delta T.\pi}{4 \times \left(\frac{\pi}{4} d_2^2\right)}$$

$$\sigma_{max} = \alpha E \Delta T \left(\frac{d_1}{d_2}\right)$$

02. Ans: (a)

Sol: General equations of normal stress and shear stress on any plane making angle 'θ'

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

$$\tau_\theta = \left(\frac{\sigma_x - \sigma_y}{2}\right)\sin 2\theta - \tau_{xy}\cos 2\theta$$

where $\sigma_x = \sigma$, $\sigma_y = -\sigma$, $\tau_{xy} = 0$

$\sigma_\theta = \sigma \cos 2\theta$

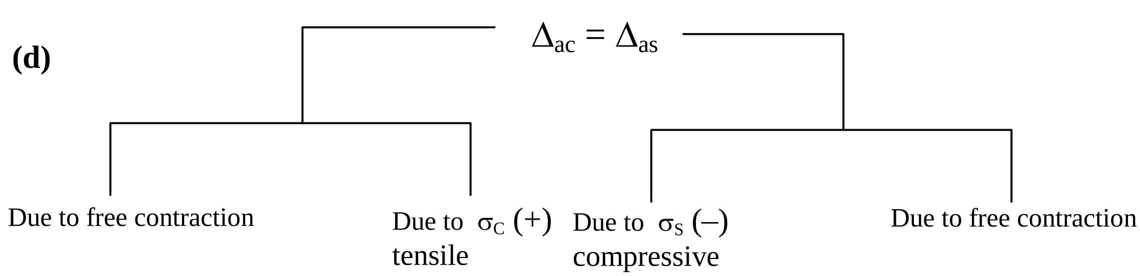
$\tau_\theta = \sigma \sin 2\theta$

$$\tan\phi = \frac{\tau_\theta}{\sigma_\theta} = \tan 2\theta$$

$\Rightarrow \phi = 2\theta$

03. Ans: (d)

Sol:



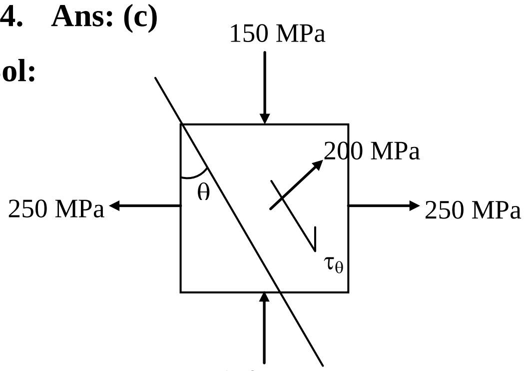
Actual contraction in copper and steel must be equal

$$-L\alpha_C\Delta T+\frac{\sigma_C}{E_C}L=-L\alpha_S\Delta T+\left(\frac{-\sigma_S}{E_S}\right)L$$

$$(\alpha_S-\alpha_C)\Delta T=-\left(\frac{\sigma_S}{E_S}+\frac{\sigma_C}{E_C}\right)$$

04. Ans: (c)

Sol:



Given: σ_x = 250 MPa, σ_y = –150 MPa, τ_{xy} = 0, σ_θ = 200 MPa

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

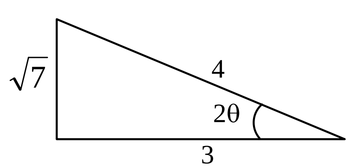
$$\sigma_\theta=\left(\frac{\sigma_x+\sigma_y}{2}\right)+\left(\frac{\sigma_x-\sigma_y}{2}\right)\cos 2\theta$$

$(\because \tau_{xy}=0)$

$$200=\left(\frac{250-150}{2}\right)+\left(\frac{250+150}{2}\right)\cos 2\theta$$

200 = 50 + 200 cos 2θ

$\cos 2\theta=\frac{3}{4}$



$\sin 2\theta=\frac{\sqrt{7}}{4}$

$$\tau_\theta=\left(\frac{\sigma_x-\sigma_y}{2}\right)\sin 2\theta-\tau_{xy}\cos 2\theta$$

$$\tau_\theta=\left(\frac{\sigma_x-\sigma_y}{2}\right)\sin 2\theta \qquad (\because \tau_{xy}=0)$$

$$\tau_\theta=\left(\frac{250+150}{2}\right)\left(\frac{\sqrt{7}}{4}\right)$$

$$\tau_\theta=50\sqrt{7}(T)$$

Also

$\sigma_1+\sigma_2=\sigma_\theta+\sigma_{90+\theta}$

$250-150=200+\sigma_{\theta+90}$

$\sigma_{\theta+90^\circ}=-100$ MPa

05. Ans: (b)

Sol: $\varepsilon_{0^\circ}=\varepsilon_x=600\times10^{-6}$

$\varepsilon_{90^\circ}=\varepsilon_y=400\times10^{-6}$

$\varepsilon_{45^\circ}=(\varepsilon_x+\varepsilon_y+\gamma_{xy})\,\frac{1}{2}$

$$500\times10^{-6}=\frac{1}{2}\left(1000\times10^{-6}+\gamma_{xy}\right)$$

$\gamma_{xy}=0$

∴ Shear strain in x-y plane is zero ε_x and ε_y itself are principal strain

$\varepsilon_1=600\times10^{-6}$

$\varepsilon_2=400\times10^{-6}$

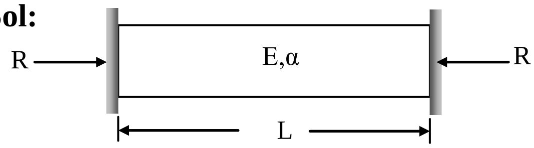
06. Ans: (b)

07. Ans: (b)

Sol: Fracture point coincides with ultimate stress point for brittle material like cast iron.

08. Ans: (b)

Sol:



Free expansion due rise in temperature + compression due to thermal thrust = 0

$$\alpha L\Delta T - \frac{RL}{AE} = 0$$

$$\alpha\Delta T = \frac{\sigma_t}{E} \leftarrow \text{Thermal strain}$$

$$\sigma_t = E\alpha\Delta T \leftarrow \text{Thermal stress}$$

09. Ans: (b)

Sol: $U = U_1 + U_2$

$$= \frac{P^2}{2E}\left(\frac{L_1}{A_1} + \frac{L_2}{A_2}\right) = \frac{(1000)^2}{2\times 4.1\times 10^6}\left(\frac{10}{16} + \frac{5}{4}\right)$$

$$= \frac{1}{8.2}\left(\frac{10+20}{16}\right) = 0.23 \text{ kg-cm}$$

10. Ans: (c)

Sol: For the given conditions ratio of power transmitting capacity of solid to hollow shaft is given by

$$\frac{P_s}{P_H} = \frac{\sqrt{1-K^2}}{1+K^2}$$

where $K = \frac{d_i}{d_o} = \frac{d_o}{3d_o} = \frac{1}{3}$

$$\therefore \frac{P_s}{P_H} = \frac{\sqrt{1-\frac{1}{9}}}{1+\frac{1}{9}} = \frac{\sqrt{\frac{8}{9}}}{\frac{10}{9}} = \frac{3\sqrt{2}}{5}$$

11. Ans: (b)

Sol: Transmission efficiency (η) of the construction equipment is given by

$$\eta = \frac{\text{output}}{\text{input}} = \frac{F\times V}{\text{Engine power}}$$

$$0.85 = \frac{F(kN)\times\left(35\times\frac{5}{18}\right)(m/sec)}{350(kW = kN - m/sec)}$$

$\therefore$ F = 30.6 kN say 31 kN

$\therefore$ Rimpull of the dump truck = 31 kN

12. Ans: (a)

Sol:

Cycle time = Fixed time + Dozing time + Return time

Production rate =

$$\frac{\text{Volume of work}}{\text{cycletime}}\times(\text{Factorsif any})$$

Here fixed time = 0.05 minutes

$$\text{Dozing time} = \frac{60(\text{meter})}{4\times\left(\frac{1000m}{60\,\text{min}}\right)} = \frac{60\times 60}{4\times 1000}$$

= 0.9 minutes

$$\text{Return time} = \frac{60\times 60}{8\times 1000} = 0.45 \text{ minutes}$$

$\therefore$ Cycle time = 0.05 + 0.9 + 0.45

= 1.4 minutes

Production capacity of dozer

$$= \frac{8(Lm^3)}{1.4\times\frac{1hr}{60}}\times 0.833 = 286\ Lm^3/hr$$

13. Ans: (c)

Sol: A-4: Scraper → Bowl

Bowl is a part of scraper. Bowl is the loading and carrying component. It has a cutting edge across the front bottom for loading loose material and raise it for carrying and lower the material at desired dump and spread.

B-3: Drag line → Fair lead

Drag line is a power shovel by installing ropes attached bucket to handle loose material under water to long distance. Hence Drag line is fair lead excavation equipment.

C-1:Bucket wheel excavator → Dribble belt

Dribble belt is a part of B.W.E (Bucket wheel excavator) to convey excavated material from the hump to the load point.

D-2: Rope shovel → Dipper stick

Rope shovel consists rigid boom called dipper stick, which consists movable arms, end a dipper (Bucket) is attached. Dipper stick provides greater forces to the bucket teeth to excavate greater depths.

14. Ans: (b)

Sol:

Total volume of work to be dozed = 3000 ccy

Capacity of the each dozer = 120 ccy/hr

∴ No. of dozers required in 7 hours

$$= \frac{3000\text{ccy}}{\left(120\frac{\text{ccy}}{\text{hr}}\right)\times(7\text{hrs})}$$

= 3.6 Dozers say 4 dozers

15. Ans: (c)

Sol: Area of the civil drawing plan is

$$= \left(50\text{cm}^2\right)\left(\frac{1000\,\text{cm}}{1\text{cm}}\right)^2 \times \left(\frac{1\text{m}}{100\text{cm}}\right)^2$$

$$= (50)(1000)^2\left(\frac{1}{100}\right)^2$$

$= 5000\ \text{m}^2$

Volume of overburden excavated work

$= 5000\ \text{m}^2 \times 10\ \text{m}$

$= 50000\ \text{m}^3$

Cost of excavation = Rs $40/\text{m}^3 \times 50000\ \text{m}^3$

= Rs 40 × 50000

= Rs 2000000

= Rs 20×10^5

= Rs 20 lakhs

16. Ans: (c)

Sol: M = 400 kN-m T = 300 kN-m

According to Maximum principal stress theory $\sigma_{max} = \sigma_1$

$$\sigma_1 = \frac{\sigma_b}{2} + \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + \tau^2}$$

$$= \frac{16M}{\pi d^3} + \sqrt{\left(\frac{16M}{\pi d^3}\right)^2 + \left(\frac{16T}{\pi d^3}\right)^2}$$

$$\sigma_1 = \frac{16}{\pi d^3}\left[M + \sqrt{M^2 + T^2}\right]$$

$$\sigma_1 = \frac{900 \times 16}{\pi d^3}$$

$$\sigma_2 = \frac{16}{\pi d^3}\left[M - \sqrt{M^2 + T^2}\right]$$

$$\sigma_2 = \frac{-1600}{\pi d^3}$$

According to Maximum Shear stress theory

$$\tau_{max} = \left[\frac{\sigma_1 - \sigma_2}{2}\right] = \frac{8000}{\pi d^3}$$

$$\therefore \frac{\sigma_{max}}{\tau_{max}} = \frac{900 \times 16}{8000} = \frac{9}{5}$$

17. Ans: (b)

Sol: For Simply supported Beam with point load at mid centre

$$\delta_1 = \frac{WL^3}{48EI}$$

For Simply Supported Beam with UDL

$$\delta_2 = \frac{5}{384}\frac{WL^3}{EI}$$

Percentage reduction in deflection

$$= \frac{\delta_1 - \delta_2}{\delta_1} \times 100 = \frac{\frac{1}{48} - \frac{5}{384}}{\frac{1}{48}} \times 100 = 37.5\%$$

18. Ans: (c)

Sol: Given p = 500 N/m^2

Diameter d = 0.6 m

Tensile stress (σ_t) = 9000 N/m^2

For thin cylinder,

Maximum tensile stress = Hoop stress

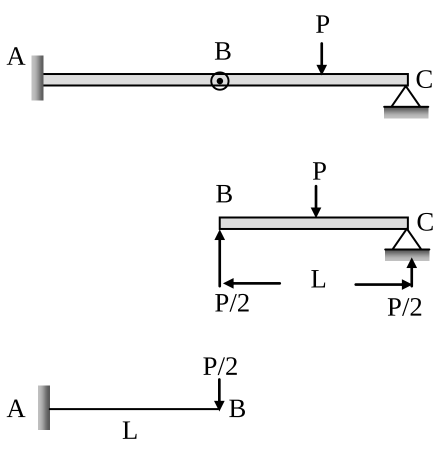
$$\sigma_t = \sigma_h = \frac{pd}{2t}$$

$$\Rightarrow t = \frac{pd}{2\sigma_t} = \frac{500 \times 0.6}{2 \times 9000}$$

t = 17 mm

19. Ans: (c)

Sol: The beam can be divided into a simply supported beam and cantilever at the point of hinge.



$\therefore$ Bending moment at fixed end = $\frac{PL}{2}$

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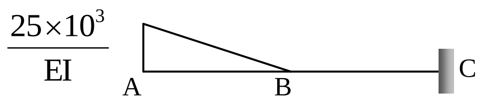
20. Ans: (a)

Sol: Using Conjugate beam method:

Equivalent conjugate beam



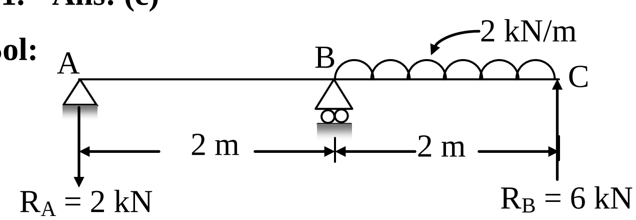
Deflection at the free end of the actual beam = Bending moment at 'C' of the conjugate beam.

$$\delta_c = \frac{1}{2}\left(\frac{25\times10^3}{EI}\right)\times 50\times\left(50+\frac{2}{3}(50)\right)$$

$$= \frac{1}{2}\left(\frac{25\times10^3}{100\times10^6}\right)\times 50\times 83.33 = 0.52 \text{ mm}$$

21. Ans: (c)

Sol:



No support on load at C

∴ Statement I, II and III are wrong

22. Ans: (b)

Sol: $T = \frac{\pi}{16}\times\tau_{permissible}\times d^3$

$$5\times10^3 = \frac{\pi}{16}\times\frac{160}{2}\times d^3$$

$$\left(\because \tau_{permissible} = \frac{\text{allowable shear stress}}{\text{F.O.S}}\right)$$

d = 6.83 mm ≈ 6.9mm

23. Ans: (c)

24. Ans: (a)

Sol: Limit of μ is $0 \le \mu \le 0.5$

$$G = \frac{E}{2(1+\mu)}$$

If $\mu = 0$ then $G = \frac{E}{2}$ and

If $\mu = 0.5$ then $G = \frac{E}{3}$

$$\therefore \frac{E}{3} \le G \le \frac{E}{2}$$

25. Ans: (c)

Sol: Shear strain in x-y plane,

$$\phi_{xy} = \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}$$

$$= (7\times10^{-3}) + (-2\times10^{-3})$$

$$= 5\times10^{-3}$$

$\therefore \tau_{xy} = G\times\phi_{xy}$

$\tau_{xy} = 100\times10^3 \text{ MPa } \times 5\times10^{-3}$

$\tau_{xy} = 500$ MPa

26. Ans: (d)

Sol: When gap is just filled

$\delta_{AB} + \delta_{BC} = \text{gap}$

$R_A = P$, and $R_D = 0$

$\therefore \delta_{AB} + \delta_{BC} = \text{gap}$

$$\frac{P(1m)}{1cm^2\times E} + \cancel{\delta_{BC}}^{\,0} = 0.25$$

$$P = \frac{0.25mm \times 100mm^2 \times 200 \times 10^3 N/mm^2}{1000mm}$$

P = 5 kN

27. Ans: (b)

Sol: Since AE = Constant, we can follow the following short method.

Reaction at end 'A'

$$R_A = \frac{10(2L+L)-20(L)}{L+2L+L}$$

$$R_A = \frac{10}{4}(\leftarrow) = 2.5kN$$

Reaction at end 'D'

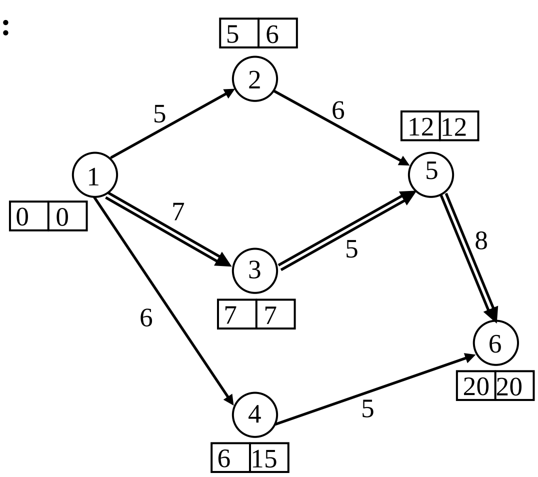
$$R_D = \frac{-20(2L+L)+10(L)}{4L}$$

$$R_D = \frac{-50}{4}(\rightarrow) = 12.5 \text{ kN}$$

28. Ans: (d)

29. Ans: (c)

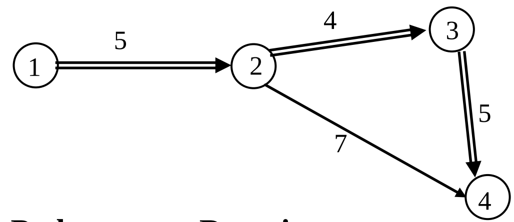
Sol:



Slack @ 2 = 6 – 5 = 1

30. Ans: (b)

Sol:



Path	**Duration**
1–2–3–4	14
1–2–4	12

To reduce the project duration

Critical Activity	Cost slope (Rs./day)
1-2	250
2-3	150
3-4	190

Minimum amount to be spent to reduce the project duration by 1 day = Rs. 150/-

31. Ans: (b)

32. Ans: (c)

Sol: Initial cost (P) = 5000

Salvage value (SV) = 5000

Life period (n) = 10 years

Annual depreciation (D) = $\frac{P-SV}{n}$

$= \frac{50000-5000}{10}$

= 4500

Book value after 3 years (BU_3) = P – 3D

= 50000 – 3(4500) = 36500

33. Ans: (d)

Sol: 10th day (9 – 10)

Activity	**Resources**
B – D	9
B – E	8
C – E	6
C – F	10

	33

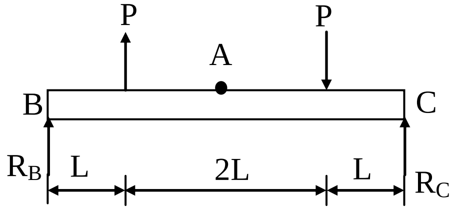
16th day (15 – 16)

Activity	**Resources**
E – F	9
D – F	6

	15
	----

34. Ans: (d)

Sol:



Reactions at supports

$R_B + R_C = 0$

$\Sigma M_B = 0$

$R_C \times 4L - P \times 3L + P \times L = 0$

$$R_C = \frac{2PL}{L} = \frac{P}{2}$$

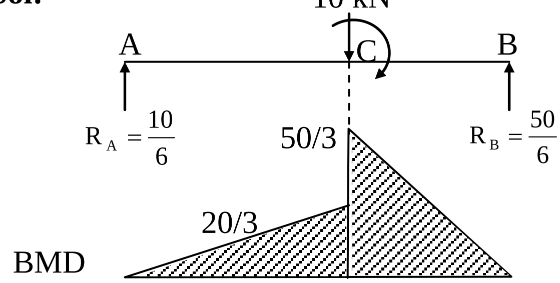
$$R_B = -\frac{P}{2}$$

Bending moment at A = $\frac{P}{2} \times 2L - P \times L = 0$

$\therefore$ Bending stress is zero at A

35. Ans: (b)

Sol:



36. Ans: (c)

Sol: L.H.S moment = $w \times x \times \frac{x}{2} = \frac{wx^2}{2}$

R.H.S moment = $(3w) \times y \times \frac{y}{2} = \frac{3}{2} wy^2$

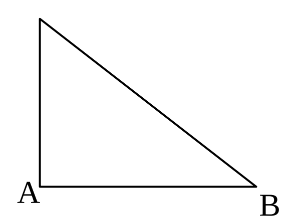
For stable condition

$$\frac{3}{2} wy^2 = \frac{wx^2}{2}$$

$$\sqrt{3} y = x$$

37. Ans: (b)

Sol:

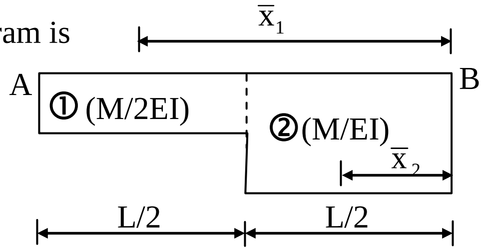


As $F \rightarrow \frac{dM}{dx}$

If shear force magnitude increases from B to A then slope of BMD also increases from B to A.

38. Ans: (c)

Sol: The $\frac{M}{EI}$ diagram for the above loading diagram is



$$y_B = A_1 \times \bar{x}_1 + A_2 \times \bar{x}_2$$

$$y_B = \left[\left(\frac{M}{2EI}\right)\left(\frac{L}{2}\right)\times\left(\frac{L}{4}+\frac{L}{2}\right)\right]+\left[\left(\frac{M}{EI}\right)\left(\frac{L}{2}\right)\left(\frac{L}{4}\right)\right]$$

$$y_B = \frac{5}{16}\frac{ML^2}{EI}$$

39. Ans: (d)

Sol: Location of vertical plane with σ_x = 10 MPa (C) and τ_{xy}= (8 MPa) (Anticlockwise) is represented by points C and D on Mohr's circle.

Now location of maximum shear stress plane on the biaxial state of stress

$$\tan 2\theta = \frac{\sigma_y - \sigma_x}{2\tau_{xy}} = \frac{-10+10}{2(8)} = 0$$

$\Rightarrow 2\theta = 0$

or $\theta_3 = 0$ from vertical plane

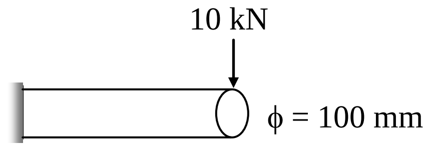
$\theta_4 = 0 + 90^o = 90^o$ from vertical plane

$\therefore$ An angular difference of 'θ' in biaxial state of stress is equivalent to angular difference of 2θ in Mohr's circle.

$\therefore$ Location of τ_{max} planes is points C and D on Mohr's circle

40. Ans: (d)

Sol:



Maximum shear force = 10 kN

Cross-sectional area = $\frac{\pi}{4}(100)^2$

$$\therefore \tau_{avg} = \frac{\text{maximum shear force}}{\text{c/s area}}$$

$$= \frac{10\times10^3}{\frac{\pi}{4}(10)^4} = \frac{4}{\pi}\text{N/mm}^2$$

For circular c/s

$$\tau_{max} = \frac{4}{3}\tau_{avg} = \frac{4}{3}\times\frac{4}{\pi} = \frac{16}{3\pi}\text{MPa}$$

41. Ans: (d)

Sol: If the composite beam is converted to equivalent wooden section

Width of wooden portion remains same = b

Width of each of the steel strips increases by 'm' times = 2 × m × t

$\therefore$ Total width of equivalent wooden section = b + 2mt

Option (d) is correct.

42. Ans: (a)

Sol: $$\sigma_n = \frac{\sigma_x+\sigma_y}{2}+\frac{\sigma_x-\sigma_y}{2}\cos 2\theta$$

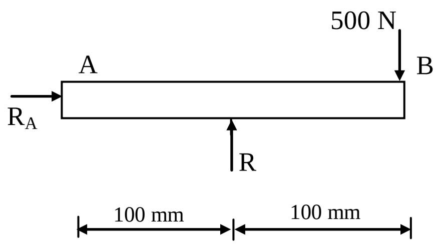
$$= \frac{3+(-7)}{2}+\frac{3-(-7)}{2}\cos(2\times30)$$

= 0.5 MPa

43. Ans: (d)

44. Ans: (d)

Sol:



From the Free body diagram of the beam,

$\sum M_A = 0$

$R(100) = 500(200)$

$R = 1000$ N

$$K = \frac{R}{\delta}$$

$$\delta = \frac{R}{K} = \frac{1000}{200} = 5\,\text{mm}$$

From similar triangles

$$\frac{5}{100} = \frac{\delta_B}{200}$$

$\delta_B = 10$ mm

45. Ans: (d)

Sol: $\varepsilon_v = 2\,\varepsilon_h + \varepsilon_l$

$$\Rightarrow 2\varepsilon_h = \left(\frac{\sigma_h}{E} - \frac{\mu\sigma_\ell}{E}\right)\times 2$$

$$\Rightarrow \varepsilon_\ell = \frac{\sigma_\ell}{E} - \frac{\mu\sigma_h}{E}$$

$$\varepsilon_v = \frac{2\sigma_h}{E} - \frac{2\mu\sigma_\ell}{E} + \frac{\sigma_\ell}{E} - \frac{\mu\sigma_h}{E}$$

$$= \frac{2PD}{2tE} - \frac{2\mu PD}{4tE} + \frac{PD}{4tE} - \frac{\mu PD}{2tE}$$

$$\Rightarrow \frac{PD}{4tE}[4 - 2\mu + 1 - 2\mu]$$

$$\Rightarrow \frac{PD}{4tE}[5 - 4\mu]$$

46. Ans: (c)

Sol: Critical stress $\sigma_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2 EI}{L^2 A}$

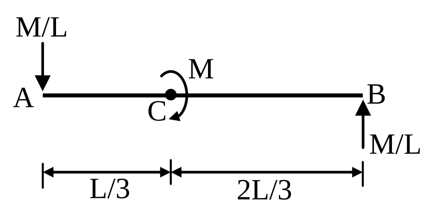
For the same material, column length and its end conditions $\sigma_{cr} \propto \frac{I}{A}$

$$\therefore \frac{(\sigma_{cr})_{square}}{(\sigma_{cr})_{circular}} = \frac{I_s}{A_s} \times \frac{A_c}{I_c}$$

$$= \frac{\left(10\times 10^3\right)/12}{10\times 10} \times \frac{\pi/4\times 10^2}{\pi/64\times 10^4} = \frac{4}{3}$$

47. Ans: (b)

Sol: $R_A = R_B = \frac{\text{Net moment on beam}}{\text{length of beam}} = \frac{M}{L}$



Strain energy,

$$U_{total} = \int_0^{L/3} \frac{\left(-\frac{M}{L}x\right)^2 dx}{2EI} + \int_0^{2L/3} \frac{\left(\frac{M}{L}x\right)^2 dx}{2EI}$$

$$U_T = \frac{M^2 L}{18\,EI}$$

$\therefore$ Angular rotation at C = $\frac{dU_T}{dM} = \frac{ML}{9EI}$

48. Ans: (c)

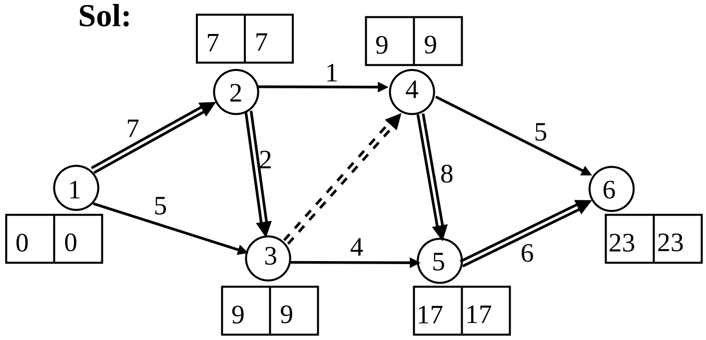
Sol: Shear force on a beam at a section x-x is the algebraic sum of transverse loads either on RHS or LHS of the section, including transverse loads acting on the section.

$\therefore$ $(SF)_{x\text{-}x} = 100 \sin 30° + 50 = 100$ kN

49. Ans: (c) **50. Ans: (a)** **51. Ans: (c)**

52. Ans: (c)

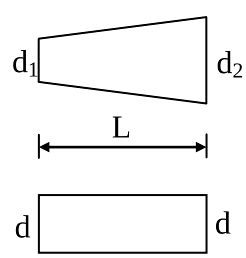
Sol:



53. Ans: (c)

54. Ans: (b)

Sol: Both bars are subjected to same load P(say) and elongate by the same amount.



Elongation of the tapered bar,

$$\delta\ell_1 = \frac{4PL}{\pi d_1 d_2 E}$$

Elongation of the uniform bar,

$$\delta\ell_2 = \frac{PL}{\left(\frac{\pi d^2}{4}\right)E} = \frac{4PL}{\pi d^2 E}$$

Equating both,

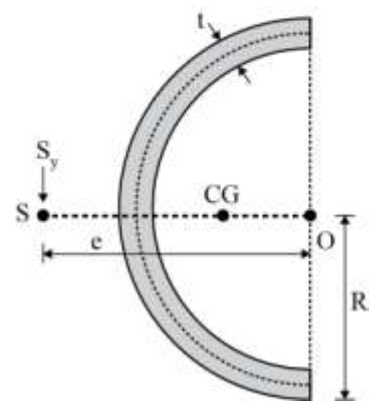
$$\frac{4PL}{\pi d_1 d_2 E} = \frac{4PL}{\pi d^2 E}$$

$d^2 = d_1\, d_2$

$$d = \sqrt{d_1\, d_2}$$

55. Ans: (b)

Sol:



For a semicircular section of radius 'R', shear centre is located at a distance of 4R/Π from the centre of arc.

e = (4x5)/ π = 20/π

56. Ans: (a)

Sol: Shear flow is shear force per unit length and is given by $q = \frac{VA\bar{y}}{I}$

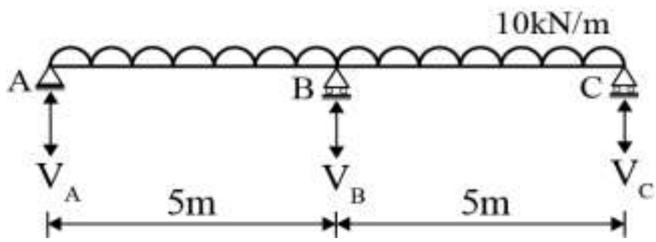
Shear stress is shear force per unit area $\tau = \frac{VA\bar{y}}{Ib}$

57. Ans: (c)

Sol: For a section made of two narrow rectangles, the shear centre lies on the junction of two rectangles. Hence the possible location of shear centre is C.

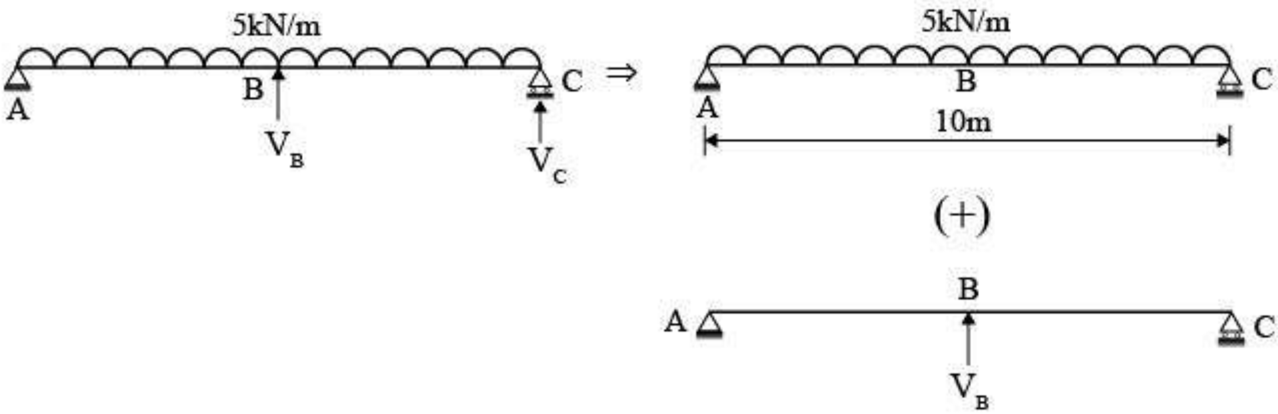
58. Ans: (b)

Sol:



Since prop is introduced at 'B', net deflection is zero at 'B'. Let reaction at 'B' be 'V_B'.

By principle of super position



Downward deflection at 'B' due to UDL $= \frac{5}{384}\frac{w\ell^4}{EI}(\ell = AC = 10m)$

Upward deflection at 'B' due to reaction V_B $= \frac{V_B\ell^3}{48EI}$

Net deflection at B, $\frac{5}{384}\frac{w\ell^4}{EI} - \frac{V_B\ell^3}{48EI} = 0$

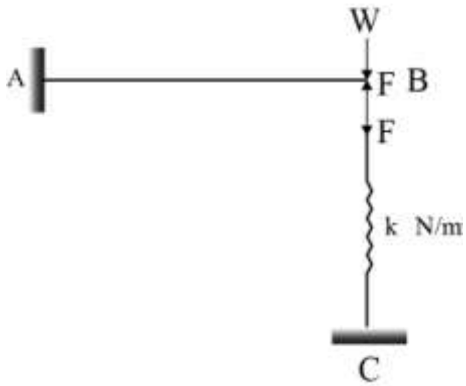
$\Rightarrow V_B = \frac{5}{8}w\ell$

$= \frac{5}{8}\times 10\times 10$

= 62.5kN

59. Ans: (a)

Sol: Let the resistance offered by spring be 'F'



Deflection at 'B' in beam AB = compression in spring

$$\Rightarrow \frac{(W-F)L^3}{3EI} = \frac{F}{k}$$

$$\Rightarrow \frac{wL^3}{3EI} = F\left(\frac{1}{k} + \frac{L^3}{3EI}\right)$$

$$\Rightarrow F = \frac{W}{\frac{3EI}{kL^3} + 1}$$

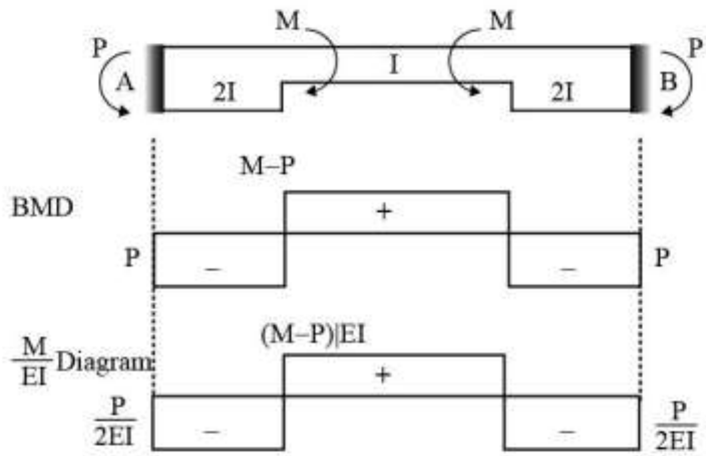
Stiffness is the force required to produce unit deflection $= \frac{W}{\delta}$

$$\Rightarrow \frac{W}{\left(\frac{F}{k}\right)} = \frac{W}{\frac{W}{\left(\frac{3EI}{kL^3} + 1\right)k}}$$

$$= k + \frac{3EI}{L^3}$$

60. Ans: (b)

Sol: Due to symmetry fixed end moment at A,B will be equal say 'P' kNm



From moment area theorem

$\theta_A - \theta_B$ = Area of $\frac{M}{EI}$ diagram between 'A' and 'B'

Since ends A,B are fixed

$\theta_A = 0$

$\theta_B = 0$

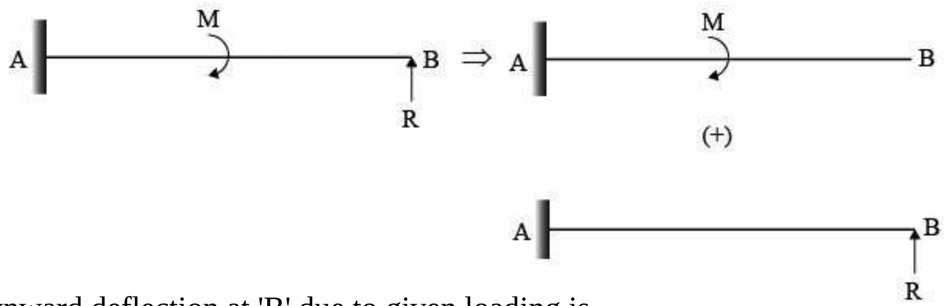
$$\Rightarrow 0 = \left(\frac{P}{2EI}\right)\left(\frac{\ell}{4}\right) + \left(\frac{M-P}{EI}\right)\frac{\ell}{2} - \left(\frac{P}{2EI}\right)\frac{\ell}{4}$$

$$\Rightarrow \frac{-P}{8} + \frac{M-P}{2} - \frac{P}{8} = 0$$

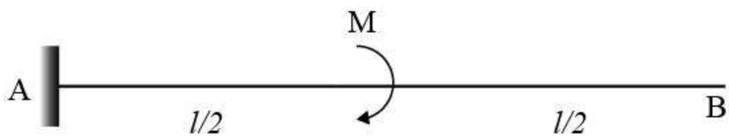
$$\Rightarrow P = \frac{2M}{3}$$

61. Ans: (b)

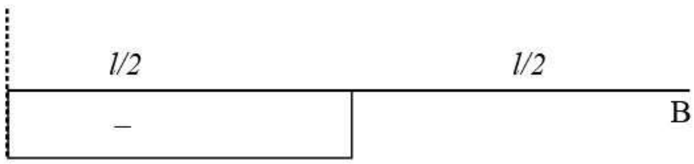
Sol: By principle of super position



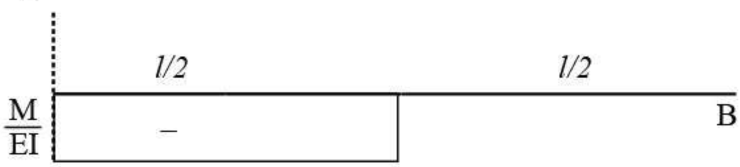
Downward deflection at 'B' due to given loading is



BMD



$\frac{M}{EI}$ Diagram



From moment area theorem, deflection of 'B' with respect to 'A' = moment of area of $\frac{M}{EI}$ diagram between 'A' and 'B' about 'B'

Since end 'A' is fixed $S_A = 0$

$$\Rightarrow S_B = \left(\frac{M}{EI}\right)\left(\frac{\ell}{2}\right)\times\left(\frac{\ell}{2}+\frac{\ell}{4}\right) = \frac{3M\ell^2}{8EI}$$

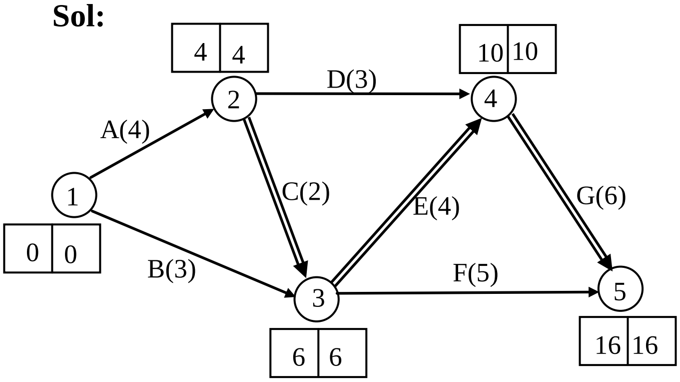
Upward deflection due to reaction 'R' $= \frac{R\ell^3}{3EI}$

Net deflection at B = 0

$$\Rightarrow \frac{3M\ell^2}{8EI} - \frac{R\ell^3}{3EI} = 0 \;\Rightarrow R = \frac{9M}{8\ell}$$

62. Ans: (a)

Sol:



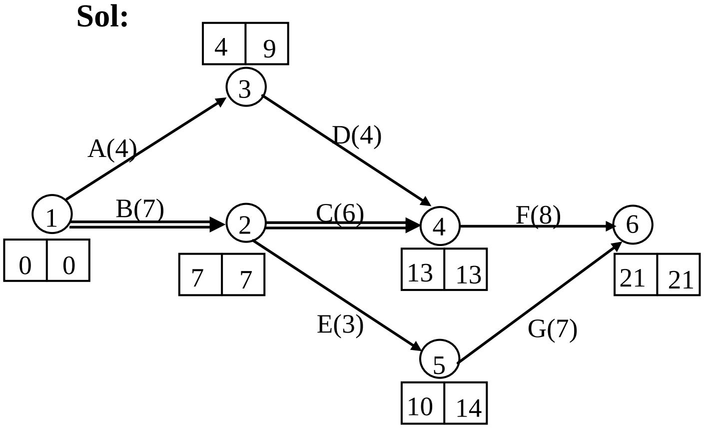
Total float for 'B' = (6 – 0) – 3 = 3

Total float for 'D' = (10 – 4) – 3 = 3

63. Ans: (d) **64. Ans: (b)**

65. Ans: (b)

Sol:



TF in 'A' = 9 – 0 – 4 = 5

TF in 'E' = 14 – 7 – 3 = 4

FF in 'G' = 21 – 10 – 7 = 4

66. Ans: (a)

67. Ans: (b)

Sol: Maximum bending moment occurs when the slope of bending moment diagram is zero. Since the slope of bending moment diagram gives shear force, shear force is either zero or changes sign when the bending moment is maximum.

Since the slope of bending moment is equal to the shear force, the shear force diagram will always have curves of one degree less than the curves of bending moment, i.e if the SF diagram is a horizontal line, the BMD will be a inclined line and if the SFD is a inclined line then BMD will be a 2 degree curve (parabola).

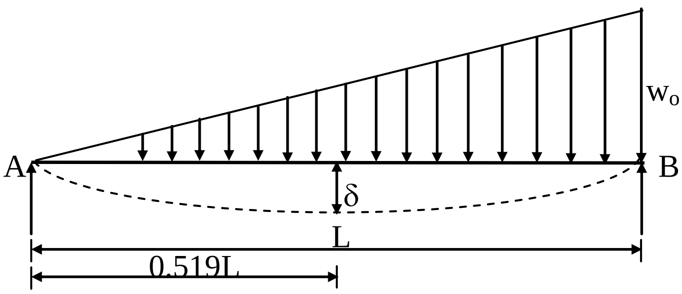
So both the statements are true but the second statement is not the correct reasoning for first statement.

68. Ans: (a)

Sol: Strain is independent quantity while stress is dependent on strain.

69. Ans: (d)

Sol: In a simply supported beam, when subjected to a uniformly varying load, the maximum deflection occurs at 0.519 L from one support where L is the span of the beam



Since the elastic curve slope becomes zero at the point of maximum deflection, the elastic curve slope becomes zero at 0.519 times the span.

Therefore the statement one is false and statement two is true.

70. Ans: (c)

Sol: **Statement I** is correct

Stresses are related to strains by a function called modulus of elasticity and not be yield stress of the material. Therefore reason is wrong.

71. Ans: (d)

Sol: Buckling load as per Euler's formula is

$$P_{cr} = \frac{\pi^2 EI}{\ell_c^2}$$

Where l_e is effective length l_e depends on the end conditions of the column.

$\therefore\ P_{cr} \alpha \frac{1}{\ell_e^2}$ if the column material, cross-section and end conditions are specified

i.e Buckling load is inversely proportional to the square of the length of the column.

Therefore the statement one is false and statement two is true.

72. Ans: (a)

73. Ans: (b)

Sol: Centrifugal pump, consists impeller fixed to motor. Mostly used in tunnels and foundation pits to handle sewage, or sludge liquids due to high discharge capacity, easy maintenance and low cost.

Priming involves filling the pump casing with liquid before the pump is started. This is done to prevent the casing becoming filled with vapours or gases that inhibit pumping and works up to designed capacity due many reasons like air leakage in suction side and low speed etc.

74. Ans: (b)

75. Ans: (a)

Sol: Power shovel can dig far more easily and faster the hard rocks due to bucket teeth harder and dipper stick provides greater penetration pressure into the loose rocks. Due to dipper stick greater forces possible to power shovels to excavate hard rocks.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