DETAILED SOLUTIONS

MADE EASY

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MPSC 2019 : Main Exam
ASSISTANT ENGINEER

CIVIL ENGINEERING

Test 3

Subjectwise Test-3

Strength of Materials, Theory of Structure, Structural Analysis

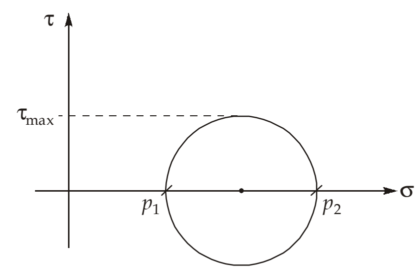
ANSWER KEY

1.	(b)	11.	(a)	21.	(c)	31.	(d)	41.	(d)
2.	(b)	12.	(d)	22.	(a)	32.	(c)	42.	(a)
3.	(c)	13.	(c)	23.	(a)	33.	(b)	43.	(a)
4.	(a)	14.	(c)	24.	(a)	34.	(a)	44.	(c)
5.	(d)	15.	(d)	25.	(b)	35.	(d)	45.	(a)
6.	(b)	16.	(b)	26.	(c)	36.	(d)	46.	(d)
7.	(c)	17.	(b)	27.	(a)	37.	(b)	47.	(a)
8.	(b)	18.	(a)	28.	(b)	38.	(a)	48.	(d)
9.	(b)	19.	(d)	29.	(d)	39.	(d)	49.	(a)
10.	(c)	20.	(d)	30.	(c)	40.	(c)	50.	(a)

DETAILED EXPLANATIONS

1. (b)

At plane of maximum shear stress,



$$\tau_{max} = \left(\frac{p_2 - p_1}{2}\right)$$

$$\sigma = \left(\frac{p_1 + p_2}{2}\right)$$

$$\text{Resultant stress} = \sqrt{\sigma^2 + (\tau_{max})^2}$$

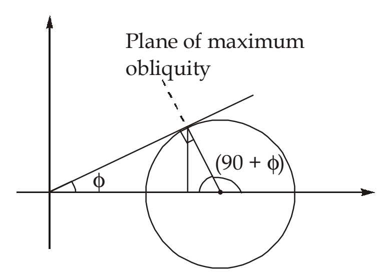
$$= \sqrt{\left(\frac{p_1 + p_2}{2}\right)^2 + \left(\frac{p_1 - p_2}{2}\right)^2}$$

$$= \sqrt{\frac{p_1^2 + p_2^2 + 2p_1p_2}{4} + \frac{p_1^2 + p_2^2 - 2p_1p_2}{4}}$$

$$= \sqrt{\frac{2p_1^2 + 2p_2^2}{4}} = \sqrt{\frac{p_1^2 + p_2^2}{2}}$$

2. (b)

Obliquity is the angle made between resultant stress and normal stress.



$$\tan\theta = \left(\frac{\sigma_t}{\sigma_n}\right)$$

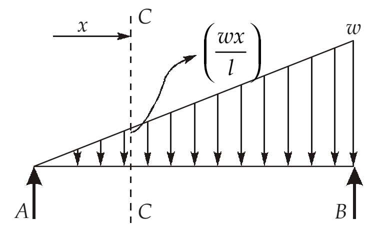
$$\theta_{max} = \frac{90 + \phi_{max}}{2}$$

$$\theta_{max} = \frac{\pi}{4} + \frac{\phi_{max}}{2}$$

4. **(a)**

For maximum bending moment, shear force = 0

At any section C-C



$$SF = R_A - \frac{1}{2}\times\left(\frac{wx}{l}\right)\times x$$

$$R_A = \frac{wl}{6}$$

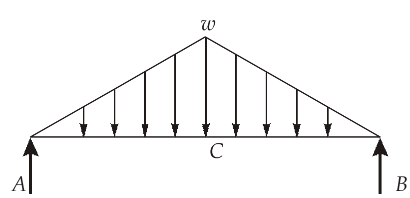
SF is 0 at $\Rightarrow$

$$R_A = \frac{1}{2}\frac{wx^2}{l}$$

$$\frac{wl}{6} = \frac{wx^2}{2l}$$

$$x = \frac{l}{\sqrt{3}}$$

5. **(d)**



Since it is symmetrical beam, maximum bending moment occurs at midpoint.

$$R_A = R_B = \frac{1}{2}\times\frac{w\times l}{2} = \frac{wl}{4}$$

$$M_C = \frac{wl}{4}\times\frac{l}{2} - \frac{1}{2}\times w\times\frac{l}{2}\times\frac{l}{6}$$

$$= \frac{wl^2}{8} - \frac{wl^2}{24} = \frac{wl^2}{12}$$

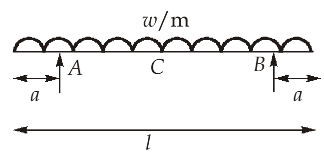
6. **(b)**

According to flexure formula

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

Hence $$M = \frac{EI}{R}$$

7. (c)



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

Given: $M_A = M_C$

To find $(l - 2a)$

$$M_A = \frac{wa^2}{2}$$

$$M_C = \frac{wl}{2} \times \frac{l}{4} - \frac{wl}{2}\left(\frac{l}{2} - a\right)$$

$$M_A = M_C$$

$$\frac{wa^2}{2} = \frac{wl^2}{8} - \frac{wl^2}{4} + \frac{\omega al}{2}$$

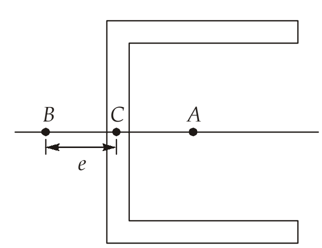
$$4a^2 = l^2 - 2l^2 + 4al$$

$$4a^2 - 4al + l^2 = 0$$

$\Rightarrow$ $$a = 0.207\, l$$

$$l - 2a = 0.586\, l$$

8. (b)



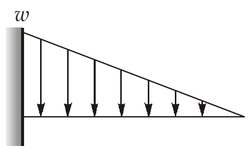
$$e = \frac{b^2 h^2 t}{4I}$$

B is the shear centre.

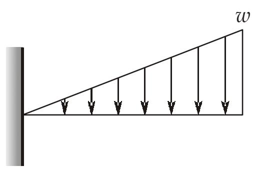
9. (b)

Use, $$\sigma = \frac{My}{I}$$

10. (c)



$$M_1 = \frac{1}{2}\times w\times l\times\frac{l}{3} = \frac{wl^2}{6}$$



$$M_2 = \frac{1}{2}\times w\times l\times\frac{2l}{3} = \frac{wl^2}{3}$$

$$\frac{M_2}{M_1} = \frac{wl^2/3}{wl^2/6} = 2$$

13. (c)

We have $\frac{T}{J} = \frac{\tau}{r} = \frac{G\phi}{l}$

For portion AB, $\frac{T}{J} = \frac{G\phi}{l/2}$

$$\phi_{AB} = \frac{Tl/2}{GJ} = \frac{T\times\frac{l}{2}\times 32}{G\times\pi d^4} = 16 \times \phi_{AB} = 1.6 \text{ radian}$$

14. (c)

For an isotropic material, elastic constants are same in all directions.

15. (d)

$$\frac{I_c}{I_s} = \frac{\pi d^4/64}{d^4/12} = \frac{\pi\times 12}{64} = \frac{3\pi}{16}$$

18. (a)

$$P = \frac{\pi^2 EI}{(l_{\text{eff}})^2}$$

For a hinged column, $l_{\text{eff}} = l$, hence, $P = \frac{\pi^2 EI}{l^2}$

19. (d)

An arch may be subjected to thrust, shear force and bending moment.

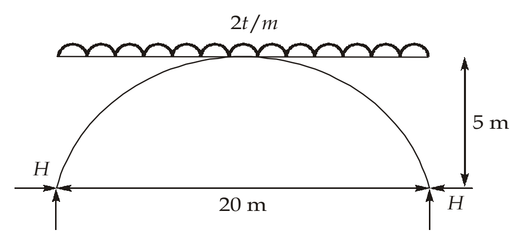
23. (a)

The elements of flexibility matrix are not necessarily dimensionally homogeneous as they represent either translation or rotation. For different released structures, different flexibility matrices are obtained.

24. (a)

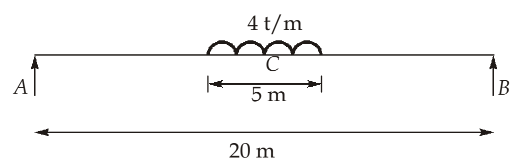
In unstable structure, e.g. a strut subjected to an axial force approaching the buckling load, the elements of stiffness matrix on the main diagonal may be negative.

26. (c)



$$H = \frac{wl^2}{8H} = \frac{2\times 20^2}{8\times 5} = 20\text{t}$$

29. (d)

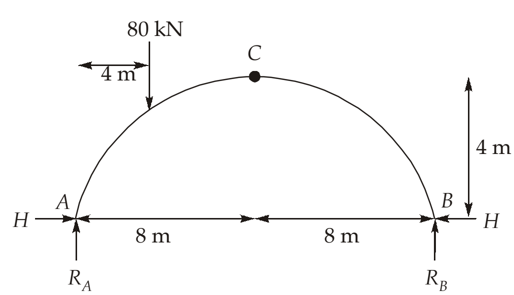


$$R_A = R_B = \frac{4\times 5}{2} = 10\text{t}$$

$$M_{\max} = M_C = R_A \times 10 - 4 \times \frac{5}{2} \times \frac{5}{4}$$

$$= 10 \times 10 - \frac{25}{2} = 87.5 \text{ kNm}$$

30. (c)



$$\Sigma M_B = 0$$

$$\Rightarrow \quad R_A = \frac{80\times 12}{16} = 60 \text{ kN}$$

$$\Sigma M_C = 0$$

$$\Rightarrow \quad 8R_A = 80 \times 4 + 4H$$

$$8 \times 60 = 80 \times 4 + 4H$$

$$4H = 480 - 320$$

$$H = \frac{160}{4} = 40 \text{ kN}$$

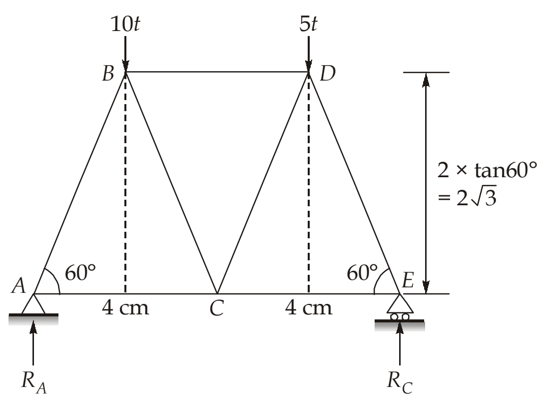
32. (c)

$\Sigma M_A = 0$

$$\Rightarrow \quad R_C \times 8 = 5 \times 6 + 10 \times 2 = 50$$

$$R_C = \frac{50}{8} = 6.25t$$

$$\therefore \quad R_A = 15 - 6.25 = 8.75t$$



At joint A,

$$\Sigma F_y = 0$$

$$\Rightarrow \quad F_{AB} \sin 60 + R_A = 0$$

$$F_{AB} = -\frac{8.75}{\sin 60^\circ} = -\frac{8.75 \times 2}{\sqrt{3}}$$

$\Sigma F_x = 0$

$$\Rightarrow \quad F_{AB} \cos 60 + F_{AC} = 0$$

$$-\frac{8.75 \times 2}{\sqrt{3}} \times \frac{1}{2} = -F_{AC}$$

$$F_{AC} = \frac{8.75t}{\sqrt{3}} \quad \text{(Tensile)}$$

33. (b)

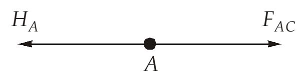
$$\Sigma F_x = 0$$

$$\Rightarrow \quad H_A + H_B = 4t$$

$$H_B = 0$$

$$H_A = 4t(\leftarrow)$$

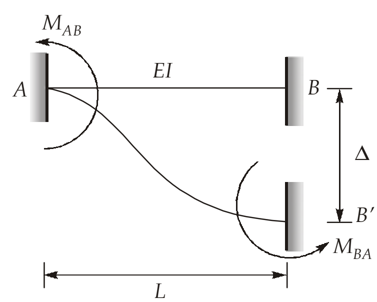
$$\Sigma F_x = 0, \text{ at joint } A,$$



$$H_A - F_{AC} = 0$$

$$F_{AC} = H_A = 4t \text{ (tensile)}$$

35. (d)



$$M_{AB} = M_{BA} = \frac{-6EI\Delta}{l^2}$$

$$\Sigma M_A = 0$$

$$R_B \times L + M_{BA} + M_{AB} = 0$$

$$R_B = \frac{-(M_{AB} + M_{BA})}{L} = \frac{-\left(\frac{12EI\Delta}{L^2}\right)}{L}$$

$$R_B = \frac{12EI\Delta}{L^3}$$

39. (d)

$$KDI = 3j - r_e$$

[Where, j = Number of joints, r_e = Number of reactions]

$$= 3 \times 3 - (2 + 1 + 1)$$

$$= 9 - 4 = 5$$

40. (c)

Relative stiffness of AB,

$$k_{AB} = \frac{4EI}{L} \quad [\because \text{ Fixed end}]$$

Relative stiffness of AC,

$$k_{AC} = \frac{3EI}{L} \quad [\because \text{ Hinged end}]$$

$$\text{Ratio} = \frac{k_{AB}}{k_{AC}} = \frac{4EI/L}{3EI/L}$$

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

41. (d)

The horizontal thrust due to rise in temperature is given by

$$\Delta h = \frac{4EI\alpha T}{\pi R^2}$$

$$\Delta h \propto \frac{1}{R^2}$$

43. (a)

In slope deflection method, deformations due to bending are only considered and axial deformation are neglected.

44. (c)

For moment distribution method, sum of distribution factors of all the members meeting at any joint is always 1.

45. (a)

$$\text{Fixed end moment } \bar{M}_{BA} = \frac{6EI\Delta}{L^2}$$

$$\text{Fixed end moment } \bar{M}_{CD} = \frac{3EI\Delta}{L^2} = \frac{3E(0.5I)\Delta}{(L/2)^2} = \frac{6EI\Delta}{L^2}$$

$$\frac{\bar{M}_{BA}}{\bar{M}_{CD}} = \frac{\left(6EI\Delta/L^2\right)}{\left(6EI\Delta/L^2\right)} = 1$$

46. (d)

$$\text{Strain energy stored} = \frac{1}{2} \times W \times \Delta$$

$$\text{Deflection, } (\Delta) = \frac{Wl^3}{48EI}$$

$$U = \frac{1}{2} \times W \times \frac{Wl^3}{48EI} = \frac{W^2 l^3}{96EI}$$

47. **(a)**

Slope deflection Equation

$$M_{ij} = \bar{M}_{ij} + \frac{2EI}{L}\left(2\theta_i + \theta j - \frac{3\Delta}{L}\right)$$

for member BC

$$M_{BC} = \bar{M}_{BC} + \frac{2EI}{L}\left(2\theta_B + \theta_C - \frac{3\Delta}{L}\right) \quad ...(1)$$

Fixed end moment, $\bar{M}_{BC} = \frac{-wl^2}{12} = \frac{-15\times 8^2}{12}$ = – 80 kNm

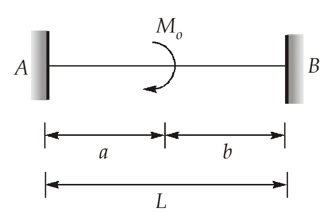
from eq. (1)

$$M_{BC} = -80 + \frac{2EI}{8}(2\theta_B + \theta_C)$$

$$M_{BC} = 0.25EI(2\theta_B + \theta_C) - 80$$

49. **(a)**

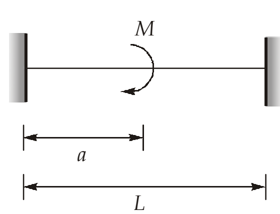
For fixed beam,



Fixed end moment at A

$$= \frac{-M_0 b}{L^2}(3a - L)$$

Hence for



$$\text{F.E.M. at } A = \frac{-M(L-a)}{L^2}(3a - L)$$

$$\bar{M}_A = \frac{M(L-a)}{L^2}\times(L-3a)$$