

ANSWER KEY > Structure Analysis

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

DETAILED EXPLANATIONS

1. (b)

Here

∴

$$D_s = 3C - R'$$

$$C = 3$$

$$R' = 7$$

$$D_s = 2$$

(where R' = no. of released reactions)

$$(2 + 2 + 2 + 1)$$

2. (b)

$$D_s = 3C - R'$$

$$= 3 \times 1 - 4 = -1$$

$D_s < 0$ ∴ unstable.

3. (a)

$$D_k = 3j - R_e$$

$$= 3 \times 5 - 6 = 9$$

5. (c)

$$\delta_B = 0$$

$$\frac{-M^2}{2EI} + \frac{R_B l^3}{3EI} = 0$$

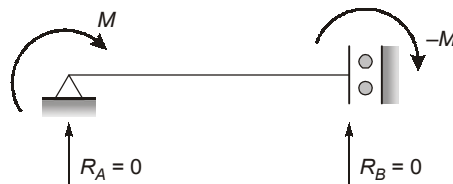
$$\therefore R_B = \frac{3M}{2l}$$

Now

$$R_A + R_B = 0$$

$$\therefore R_A = -R_B = -\frac{3M}{2l} \text{ (downward)}$$

6. (a)



$$\therefore \text{COF} = -1$$

7. (c)

$$k_A = \frac{4(3EI)}{l} + \frac{4(2EI)}{2l} + \frac{3EI}{l}$$

$$k_A = \frac{12EI}{l} + \frac{4EI}{l} + \frac{3EI}{l} = \frac{19EI}{l}$$

8. (b)

$$F_{BD} \cos\theta = 80$$

$$F_{BD} \times \frac{8}{10} = 80$$

$$F_{BD} = 100 \text{ kN (compressive)}$$

10. (d)

Degree of static indeterminacy

$$D_s = m + r_e - 2j$$

Here, $m = 12$, $j = 9$ and $r_e = 6$

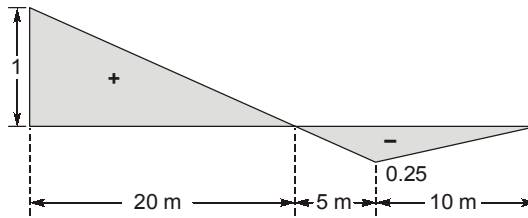
$$\therefore D_s = 12 + 6 - 2 \times 9 = 0$$

Degree of kinematic indeterminacy

$$\begin{aligned} D_k &= 2j - r_e - m \\ &= 2 \times 9 - 6 - 0 = 12 \end{aligned}$$

 \therefore Thus truss is statically determinate and kinematically indeterminate.

11. (c)



$$\begin{aligned} \text{Shear force at A} &= 2 \times \left[\frac{1}{2} \times 20 \times 1 - \frac{1}{2} \times 15 \times 0.25 \right] \\ &= 16.25 \text{ tonne} \end{aligned}$$

12. (c)

The moment at crown being zero. Consider AC

$$H_A \cdot 2R = V_A \cdot 2R \Rightarrow H_A = V_A$$

For BC

$$H_B R = V_B R \Rightarrow H_B = V_B$$

As

$$H_A = H_B \Rightarrow V_A = V_B$$

Now

$$V_A + V_B = W \Rightarrow V_A = V_B = W/2$$

$$\text{Inclination of RA with horizontal} = \frac{V_A}{H_A} = 1$$

∴

$$\text{Inclination} = 45^\circ$$

13. (b)

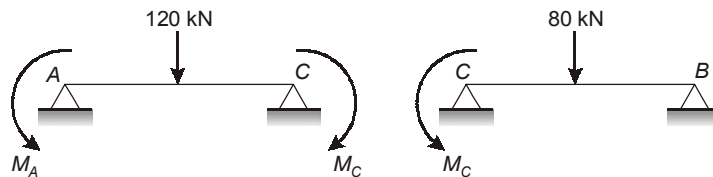
$$\begin{aligned} D_k &= 3_i - R_e - m \\ &= 3 \times 5 - 6 - 4 = 5 \end{aligned}$$

14. (d)

$$\begin{aligned} D_k &= 3i + r - R_e \\ &= 3 \times 9 + 3 - 9 \\ D_k &= 21 \end{aligned}$$

16. (c)

Let redundant be M_A and M_C



$$\theta_{CA} = \frac{M_A \times 6}{6EI} + \frac{M_C \times 6}{3EI} - \frac{120 \times 6^2}{16EI}$$

$$\theta_{CB} = \frac{80 \times 6^2}{16EI} - \frac{M_C \times 6}{3EI}$$

$$\theta_{CA} = \theta_{CB}$$

⇒

$$M_A + 4 M_C = 450$$

...(i)

$$\theta_A = 0$$

$$\therefore \frac{-120 \times 6^2}{16EI} + \frac{6 \times M_A}{3EI} + \frac{M_C \times 6}{6EI} = 0$$

$$\Rightarrow 2M_A + M_C = 270 \quad \dots(ii)$$

Solving (i) and (ii),

$$M_A = M_C = 90 \text{ kNm}$$

17. (d)

$M_{FAB} = -80$, $M_{FBA} = 80$, solving by moment distribution method

A	B
-80	80
-	-60
-30	-
-	-
-110	+20
	-20

$$\therefore M_A = -110 \text{ kNm}$$

18. (a)

Using the concept of symmetry

$$\text{Stiffness of } BC = \frac{2E(2I)}{8}$$

$$\text{Stiffness of } BA = \frac{2EI}{4}$$

\therefore Distribution factor for $BC = DF$ for $BA = 0.5$

$$M_{FBC} = -20 \text{ kNm}$$

$$M_{FBA} = +20 \text{ kNm}$$

Since the joint is balanced no. need to draw moment distribution table

$$\therefore M_{BC} = M_{FBC} = -20 \text{ kNm}$$

19. (b)

Since clockwise moment is positive

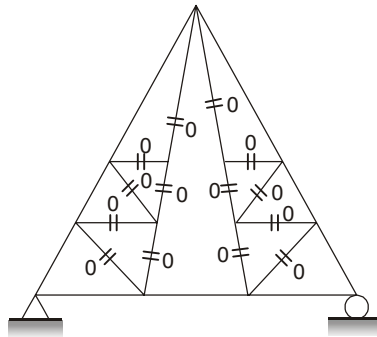
$$M_{FAB} = \frac{-Wl^2}{20} = -7.2 \text{ kNm}$$

$$M_{FAD} = \frac{+Wl^2}{12} = 13.33 \text{ kNm}$$

20. (b)

Joint	Member	Stiffness	D.F
B	BA	$\frac{4E(2l)}{4}$	0.47
	BE	$\frac{4E(2l)}{5}$	0.38
	BC	$\frac{4EI}{6}$	0.16

22. (d)



No. of zero force member = 14.

23. (d)

$$R_P = 50 \text{ kN}$$

$$R_Q = 40 \text{ kN}$$

At point P,

$$F_{PR} = -\frac{R_P}{\sin 45^\circ} = -50\sqrt{2}$$

At joint T,

$$F_{RT} = 60 \text{ kN}$$

(tensile)

At joint Q,

$$-F_{SQ} \sin 45 = R_Q$$

$$F_{SQ} = -40\sqrt{2}$$

At joint S,

$$F_{SU} = -F_{SQ} \sin 45$$

∴

$$F_{SU} = 40 \text{ kN}$$

(tensile)

$$F_{RS} = F_{SQ} \cos 45$$

$$F_{RS} = -40 \text{ kN}$$

24. (c)

At joint D ($\Sigma F_v = 0$)

$$F_{OC} - 15 T = 0$$

$$F_{DC} = 15 T.$$

25. (b)

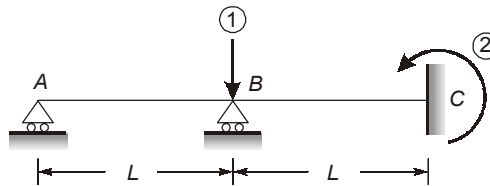
Stiffness of spring system,

$$K_{eq} = 0.5 K + K + K = 2.5 K$$

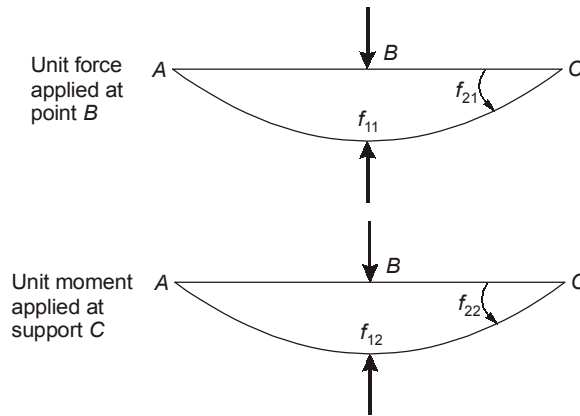
Stiffness of beam, $K_{Beam} = \frac{3EI}{l^3}$ $\left[\because \text{Deflection, } \Delta = \frac{Pl^3}{3EI} \Rightarrow \frac{P}{\Delta} = \text{Stiffness} = \frac{3EI}{l^3} \right]$

\therefore Total stiffness of system = $2.5K + \frac{3EI}{l^3}$

26. (d)



The elements of the flexibility matrix are obtained by applying unit values of redundants at the coordinates one after the other as shown below.



$$f_{11} = \frac{(2L)^3}{48EI} = \frac{L^3}{6EI}$$

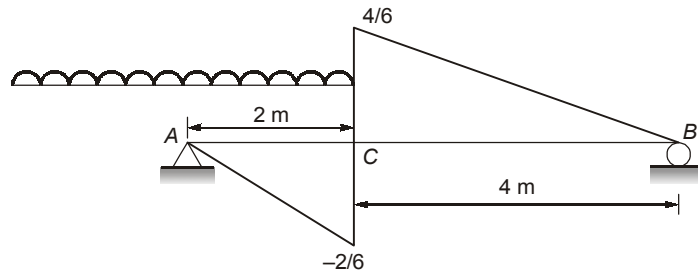
$$f_{21} = f_{12} = \frac{1(2L)^2}{16EI} = \frac{L^2}{4EI}$$

$$f_{22} = \frac{2L}{3EI}$$

\therefore

$$[F] = \frac{L}{12EI} \begin{bmatrix} 2L^2 & 3L \\ 3L & 8 \end{bmatrix}$$

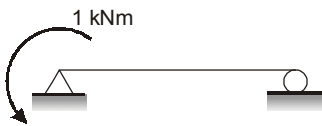
28. (a)



$$\begin{aligned} \text{Maximum negative shear force at } C &= \frac{1}{2} \times 2 \times \frac{-2}{6} \times 10 \\ &= \frac{-20}{6} = -3.33 \text{ kN} \end{aligned}$$

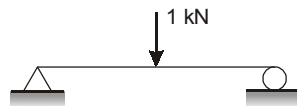
29. (d)

For development of flexibility matrix, a unit load is applied at the co-ordinate direction and the deformation produced in other co-ordinate direction is measured.



$$f_{11} = \frac{l}{3EI}$$

$$f_{21} = \frac{l}{6EI} = f_{12}$$



$$f_{13} = \frac{-l^2}{16EI} = f_{31}$$

$$f_{23} = \frac{-l^2}{16EI} = f_{32}$$

$$f_{33} = \frac{l^3}{48EI}$$

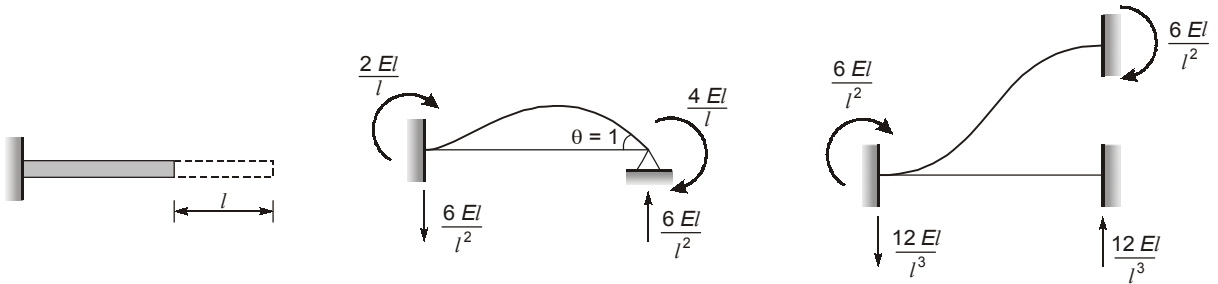


$$f_{22} = \frac{l}{3EI}$$

$$f = \begin{bmatrix} f_{11} & f_{21} & f_{31} \\ f_{12} & f_{22} & f_{32} \\ f_{13} & f_{23} & f_{33} \end{bmatrix}$$

30. (a)

For development of stiffness matrix, unit deformation is provided in one coordinate direction by restraining deformation in other co-ordinate direction. The force developed in the respective co-ordinate direction is the measure of stiffness matrix co-efficient.



$$k_{11} = \frac{AE}{l}$$

$$k_{21} = 0$$

$$k_{31} = 0$$

$$k_{13} = 0$$

$$k_{23} = \frac{6EI}{l^2}$$

$$k_{33} = \frac{4EI}{l}$$

$$k_{12} = 0$$

$$k_{22} = \frac{12EI}{l^3}$$

$$k_{32} = \frac{6EI}{l^2}$$

