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ESE 2026 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 10

Section A : Structural Analysis [All Topics]

Section B : CPM PERT-I + Hydrology and Water Resource Engineering-I [Part Syllabus]

Section C : Design of Steel Structure-II + Surveying and Geology-II [Part Syllabus]

1.	(c)	16.	(d)	31.	(a)	46.	(a)	61.	(d)
2.	(d)	17.	(c)	32.	(c)	47.	(b)	62.	(b)
3.	(d)	18.	(c)	33.	(b)	48.	(a)	63.	(b)
4.	(a)	19.	(a)	34.	(a)	49.	(d)	64.	(b)
5.	(b)	20.	(c)	35.	(a)	50.	(d)	65.	(c)
6.	(c)	21.	(b)	36.	(a)	51.	(c)	66.	(d)
7.	(c)	22.	(d)	37.	(a)	52.	(c)	67.	(b)
8.	(b)	23.	(c)	38.	(d)	53.	(c)	68.	(c)
9.	(a)	24.	(c)	39.	(a)	54.	(b)	69.	(a)
10.	(a)	25.	(c)	40.	(b)	55.	(a)	70.	(d)
11.	(b)	26.	(d)	41.	(b)	56.	(a)	71.	(c)
12.	(b)	27.	(c)	42.	(d)	57.	(a)	72.	(a)
13.	(b)	28.	(d)	43.	(c)	58.	(c)	73.	(a)
14.	(c)	29.	(a)	44.	(c)	59.	(c)	74.	(b)
15.	(c)	30.	(b)	45.	(a)	60.	(d)	75.	(b)

DETAILED EXPLANATIONS

Section A : Structural Analysis

1. (c)

Static indeterminacy for 2 D frame is given by

$$D_s = (3m + R_e) - (3j + r_r)$$

m = Total number of members = 12

R_e = Total number of external support reactions = 10

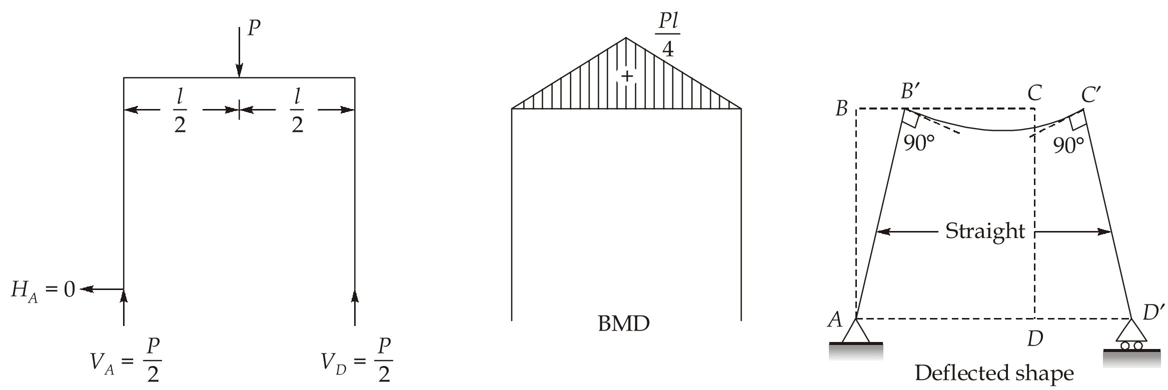
j = Total number of joints = 12

r_r = Total number of released reactions = $\Sigma(m' - 1)$ = 1

$\therefore$ $$D_s = (3 \times 12 + 10) - (3 \times 12 + 1)$$

$\Rightarrow$ $$D_s = 9$$

2. (d)

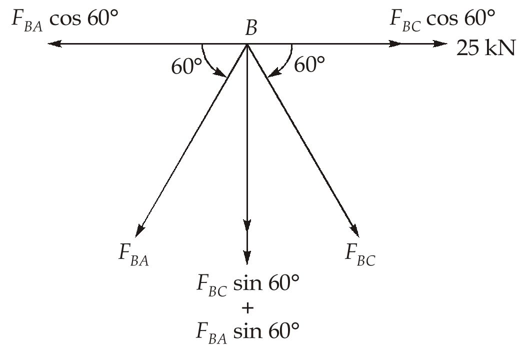


3. (d)

The fundamental principle of static equilibrium requires that at any joint in a truss, the sum of all forces in both the horizontal and vertical directions must be equal to zero ($\Sigma F_x = 0$ and $\Sigma F_y = 0$). The only way to satisfy both equilibrium equations simultaneously is that if the force in both members is zero. There is no external force to be counteracted.

4. (a)

FBD of joint '*B*'



$$\Sigma f_y = 0$$

$$\Rightarrow \quad F_{BC} \sin 60° + F_{BA} \sin 60° = 0$$

$$F_{BC} = -F_{BA} \quad \text{...(i)}$$

$$\Sigma f_x = 0$$

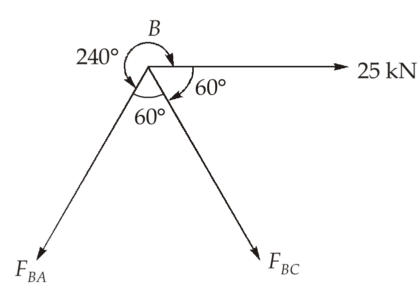
$$\Rightarrow \quad F_{BA} \cos 60° = F_{BC} \cos 60° + 25$$

$$\Rightarrow \quad F_{BA}\left(\frac{1}{2}\right) = -F_{BA}\left(\frac{1}{2}\right) + 25$$

$$\Rightarrow \quad F_{BA} = 25 \text{ kN (tensile)}$$

Alternate solution:

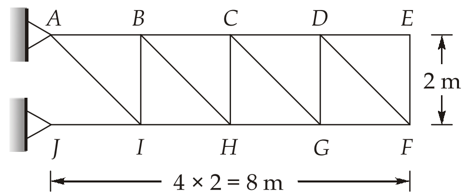
$$\frac{F_{BA}}{\sin 60°} = \frac{F_{BC}}{\sin 240°} = \frac{25}{\sin 60°} \quad \text{(Lami's theorem)}$$



$$\Rightarrow \quad \frac{F_{BA}}{\sin 60°} = \frac{25}{\sin 60°}$$

$$\Rightarrow \quad F_{BA} = 25 \text{ kN (tensile)}$$

5. (b)

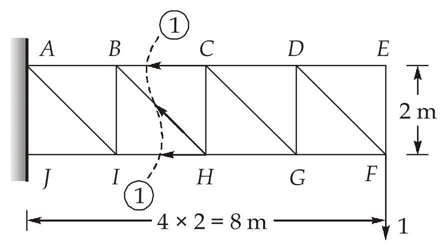


$$(\Delta_F)_r = \text{Vertical deflection of joint } F$$

$$= \sum \frac{Pkl}{AE} = \sum k \cdot \delta$$

$$\delta_{BC} = \text{Elongation in member } BC = +12 \text{ mm}$$

$$\delta = 0 \text{ for all other members}$$



Using method of sections,

Taking moments about H

$\therefore \quad \Sigma M_B = 0$

$\Rightarrow \quad -K_{BC} \times 2 + 1 \times 4 = 0$

$\Rightarrow \quad K_{BC} = 2$

So, $\quad (\Delta_F)_v = \Sigma k\delta = +2 \times (12) = 24 \text{ mm} (\downarrow)$

6. (c)

Taking moments about A,

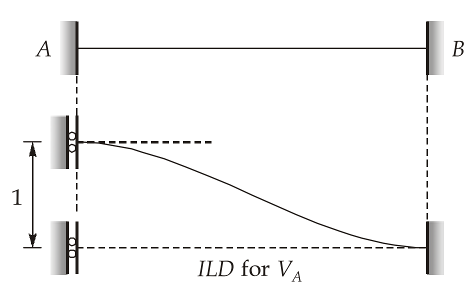
$\Sigma M_A = 0$

$\Rightarrow \quad 5 \times 6 + 10 - R_D \times 2 = 0$

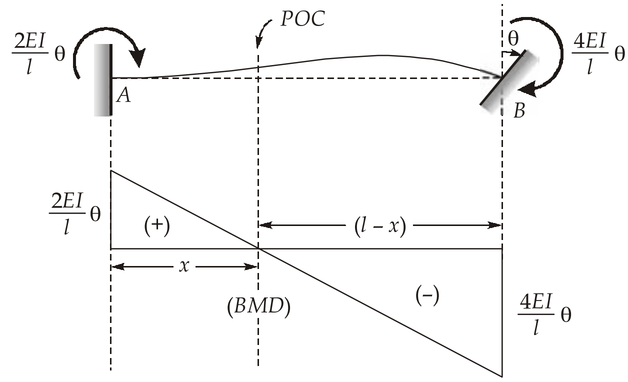
$\Rightarrow \quad R_D = 20 \text{ kN} (\uparrow)$

7. (c)

As per Muller Breslau Principle,



8. **(b)**



From bending moment diagram

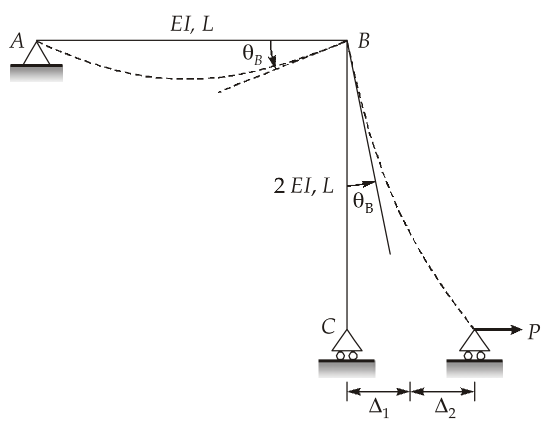
$$\frac{\frac{4EI}{l}\theta}{(l-x)} = \frac{\frac{2EI}{l}\theta}{x}$$

$\Rightarrow$ $$\frac{2}{(l-x)} = \frac{1}{x}$$

$\Rightarrow$ $$2x = l - x$$

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

9. **(a)**



$$\Delta = \Delta_1 + \Delta_2$$

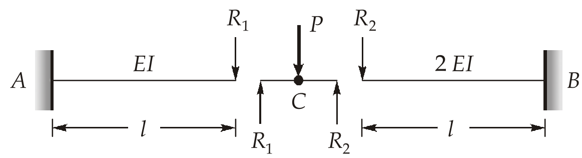
$\Rightarrow$ $$\Delta = \theta_B \times L + \frac{PL^3}{3(2EI)}$$

$\Rightarrow$ $$\Delta = \frac{PL^2}{3EI} \times L + \frac{PL^3}{6EI} = \frac{PL^3}{2EI}$$

$\Rightarrow$ $$P = \frac{3EI\Delta}{2L^3}$$

$\because$ $\Delta = 1$, $\therefore$ $$P = \frac{3EI}{2L^3}$$

10. (a)



$\because \quad \Sigma f_y = 0 \quad \Rightarrow \quad R_1 + R_2 = P \quad$ ...(i)

Deflection at C for both portions of beam (AC and CB) will be same.

$$\therefore \quad (\Delta_C)_{AC} = (\Delta_C)_{CB}$$

$$\Rightarrow \quad \frac{R_1 l^3}{3EI} = \frac{R_2 l^3}{3(2EI)}$$

$$\Rightarrow \quad R_2 = 2R_1$$

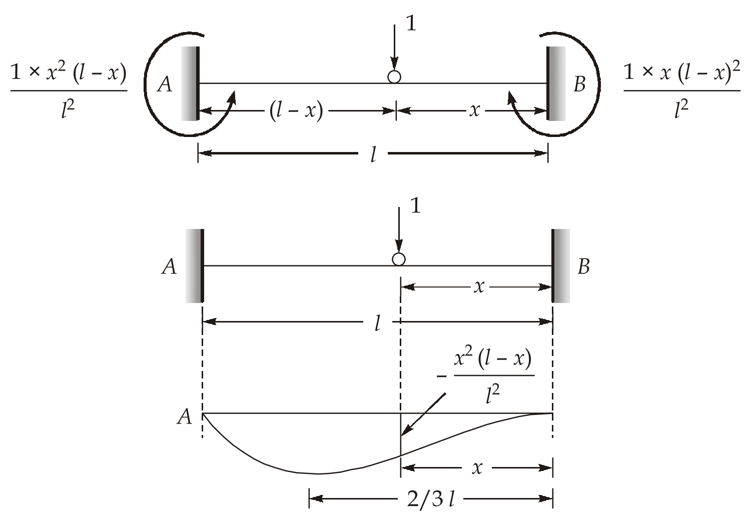
From equation (i)

$$R_1 + 2R_1 = P$$

$$\Rightarrow \quad R_1 = \frac{P}{3} \text{ and } R_2 = \frac{2P}{3}$$

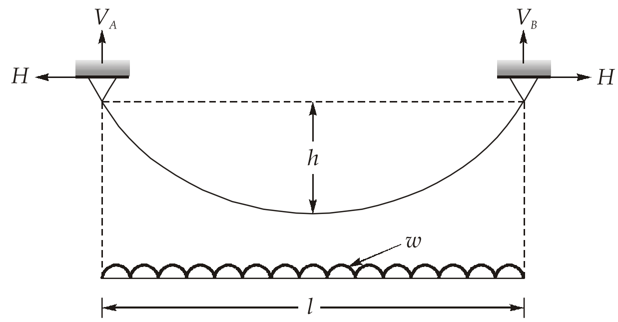
Fixed end moment at B, $\quad M_B = R_2 \times l = \frac{2Pl}{3}$

11. (b)



Influence line for fixed end moment M_A

12. (b)



$$V_A = V_B = \frac{wl}{2}$$

$$H = \frac{wl^2}{8h}$$

Maximum tension $$T_{max} = \sqrt{V_A^2 + H^2}$$

$\Rightarrow$ $$T_{max} = \sqrt{\left(\frac{wl}{2}\right)^2 + \left(\frac{wl^2}{8h}\right)^2} = \frac{wl^2}{8h}\left[1 + \frac{w^2l^2}{4} \times \frac{64h^2}{w^2l^4}\right]^{1/2}$$

$\Rightarrow$ $$T_{max} = \frac{wl^2}{8h}\left(1 + \frac{16h^2}{l^2}\right)^{1/2}$$

$$T_{max} = \frac{wl^2}{8h}\left(1 + \frac{8h^2}{l^2}\right)$$ (Ignoring the higher power terms)

$\Rightarrow$ $$T_{max} = \frac{wl^2}{8h} + wh$$

Minimum tension $$T_{min} = H = \frac{wl^2}{8h}$$

$\therefore$ $$T_{max} - T_{min} = \left(\frac{wl^2}{8h} + wh\right) - \frac{wl^2}{8h} \simeq wh$$

13. (b)

Statement 3 is incorrect because the numerical values (elements) within the flexibility matrix depend entirely on the specific coordinate system chosen for the analysis. Changing the coordinates system changes the matrix elements.

14. (c)

An increase in temperature in a two-hinged arch induces a maximum bending moment at the crown. This occurs because thermal expansion is constrained by the fixed supports, creating internal stresses.

15. (c)

External indeterminacy:

$$D_{se} = R_e - 3 = 5 - 3 = 2$$

Internal indeterminacy:

$$D_{si} = m - (2j - 3)$$

$\Rightarrow$ $$D_{si} = 15 - (2 \times 9 - 3)$$

$\Rightarrow$ $$D_{si} = 0$$

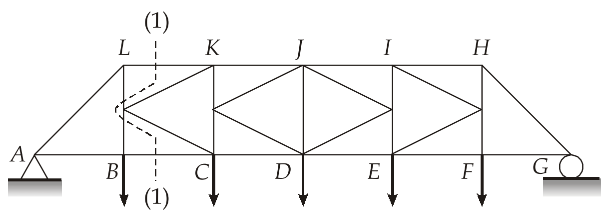
$\therefore$ Degree of static indeterminacy

$$D_s = D_{se} + D_{si} = 2$$

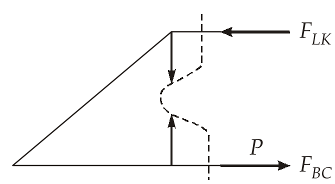
16. (d)

Applying method of sections,

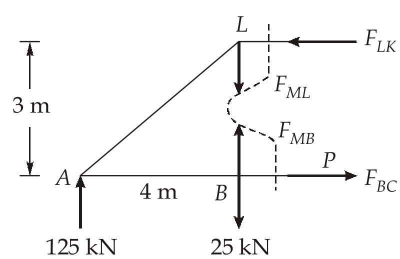
Consider section (1)-(1) as shown in figure.



Consider the FBD of left portion of section (1)-(1).



Due to symmetry, vertical reactions, $V_A = V_G = 125$ kN



Taking moments about L, $\Sigma M_L = 0$

$\Rightarrow$ $$F_{BC} \times 3 = 125 \times 4$$

$\Rightarrow$ $$F_{BC} = 166.67 \text{ kN } (T)$$

17. (c)

Joint	Member	stiffness	Total stiffness	D.F.
B	BA	$\frac{4EI}{4} = EI$	$2EI$	0.5
	BC	$\frac{3EI}{3} = EI$		0.5

$$M_{BA} = (DF)_{BA} \times M_o = 0.5 \times 20$$

$\Rightarrow$ $$M_{BA} = 10 \text{ kNm}$$

$\because$ $$M_{AB} = (COF) \times M_{BA} = \frac{1}{2} \times 10$$

$\Rightarrow$ $$M_{AB} = 5 \text{ kNm}$$

18. (c)

$$\Sigma K_O = K_{OA} + K_{OB} + K_{OC} + K_{OD}$$

$$\Sigma K_O = \frac{EI}{L}(4+3+1+0) = \frac{8EI}{L}$$

Distribution factor for OC member,

$$DF_{OC} = \frac{K_{OC}}{\Sigma K_O} = \frac{EI/L}{\frac{8EI}{L}} = \frac{1}{8}$$

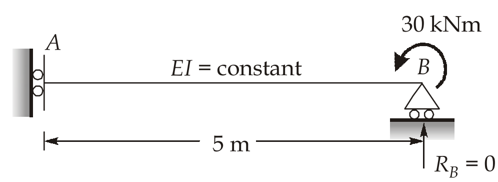
$\therefore$ $$M_{OC} = \frac{1}{8} \times 240 = 30 \text{ kNm}$$

Carryover factor at C = – 1

Magnitude of moment at end C = –30 kNm

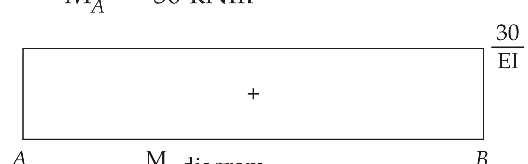
= 30 kNm (Anticlockwise)

19. (a)



$\Sigma F_y = 0$ $\Rightarrow$ $$R_B = 0$$

$$M_A = 30 \text{ kNm}$$



$\frac{M}{EI}$ diagram

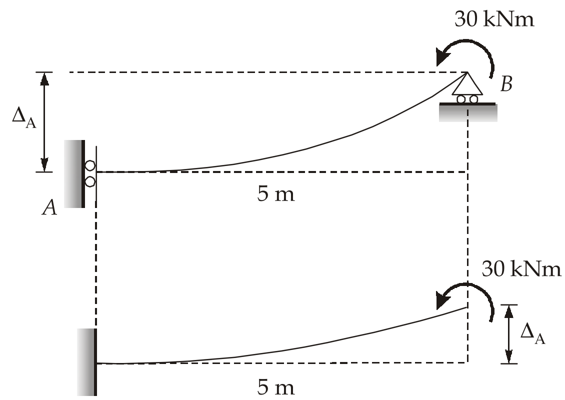
$$\Delta_A = t_{BA} = \text{Deflection at } B \text{ with respect to tangent at } A$$

$\Rightarrow$ Δ_A = Moment of area of $\frac{M}{EI}$ diagram between A and B about point B

$$\Rightarrow \quad \Delta_A = \left(\frac{30}{EI} \times 5\right) \times \frac{5}{2}$$

$$\Rightarrow \quad \Delta_A = \frac{375}{EI}$$

Alternate solution

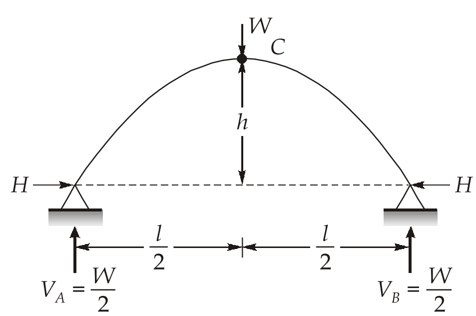


$$\Delta_A = \frac{ML^2}{2EI} = \frac{30 \times 5^2}{2EI} = \frac{375}{EI}$$

20. (c)

The maximum bending moment occurs when the load is positioned such that the section divides the load in the same ratio as it divides the span.

21. (b)



Vertical support reaction, $V_A = V_B = \dfrac{W}{2}$

Taking moments about C,

$$H \times h = V_A \times \frac{l}{2}$$

$$\Rightarrow \quad H \times h = \frac{Wl}{4}$$

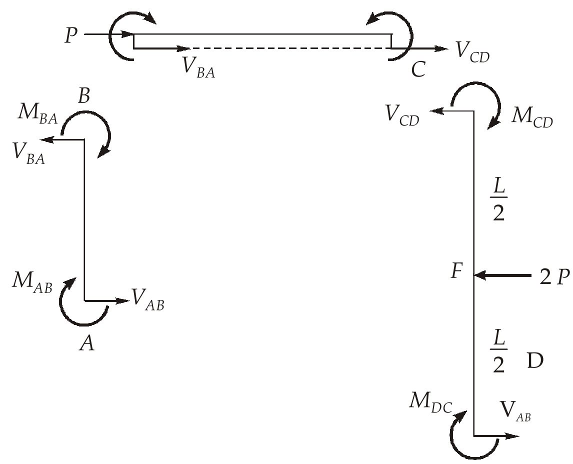
$$\Rightarrow \quad H = \frac{Wl}{4h}$$

22. (d)

Degree of kinematic indeterminacy

$$D_k = 2j - R_e - m$$
$$= 2 \times 8 - 3 - 0 = 13$$

23. (c)



$\Sigma f_x = 0 \quad \Rightarrow \quad V_{BA} + V_{CD} + P = 0$ ...(i)

Taking moments about A,

$$M_{AB} + M_{BA} - V_{BA}\left(\frac{L}{2}\right) = 0$$

$$\Rightarrow \quad V_{BA} = \frac{2(M_{AB} + M_{BA})}{L}$$

Taking moments about D,

$$M_{DC} + M_{CD} - 2P\left(\frac{L}{2}\right) - V_{CD}(L) = 0$$

$$\Rightarrow \quad V_{CD} = \frac{M_{DC} + M_{CD}}{L} - P$$

On putting the values of V_{BA} and V_{CD} in equation (i),

$$\frac{2(M_{AB} + M_{BA})}{L} + \frac{M_{DC} + M_{CD}}{L} - P + P = 0$$

$$\Rightarrow \quad 2M_{AB} + 2M_{BA} + M_{DC} + M_{CD} = 0$$

24. (c)

Force method	Displacement method
(i) Also known as compatibility method or method of consistent deformation or flexibility method	Also known as equilibrium method or stiffness method
(ii) Forces (BM, SF) are taken as unknowns.	Displacements (Δ, θ) are taken as unknowns.
(iii) Compatibility equations are written to find redundants	Equilibrium equations are written to find redundants
(iv) BM, SF are found using equilibrium equations	Δ, θ are found using load displacement equations.
(v) Used when $D_s < D_k$	Used when $D_k < D_s$
(vi) Other force methods are: Castigliano's theorem, Strain energy method, Virtual work method, Claperon's three moment theorem (continuous beams), Column analogy method (rigid frame with fixed support), flexibility matrix method.	Other displacement methods are: slope deflection, moment distribution, Kani's method, stiffness matrix method.

25. (c)

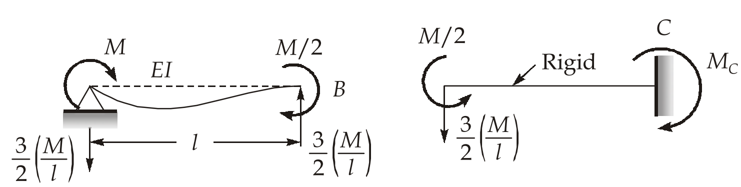
According to Maxwell's reciprocal theorem

$$-2 \times 5 = 10\,\Delta_x$$

$$\Rightarrow \quad \Delta_x = -1 \text{ mm}$$

(-ve sign indicates that deflection occurs opposite to the load direction)

26. (d)



From BC portion of beam,

Taking moments about C, $\Sigma M_C = 0$

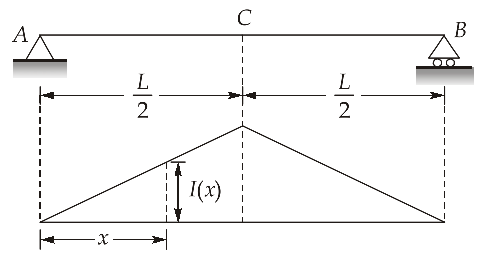
$$\Rightarrow \quad \frac{M}{2} + \frac{3}{2}\left(\frac{M}{l}\right) \times l - M_C = 0$$

$$\Rightarrow \quad M_C = 2\text{ M}$$

$$\text{Carry over factor, } C_{AC} = \frac{\text{Carry over moment at } C}{\text{Applied moment at } A}$$

$$\Rightarrow \quad C_{AC} = \frac{2M}{M} = 2$$

27. (c)



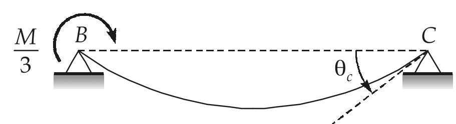
ILD for $(BM)_C$

Ordinate at C,
$$y_c = \frac{\frac{L}{2}\times\frac{L}{2}}{L} = \frac{L}{4}$$

At a distance, x
$$I(x) = \frac{x}{2} \qquad \left(0 \le x \le \frac{L}{2}\right)$$

28. (d)

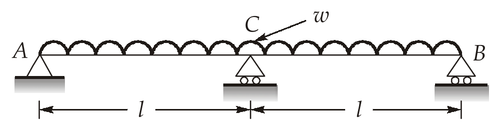
Joint	Member	Stiffness	Total stiffness	D.F.
B	BA	$\frac{3(2EI)}{L}$	$\frac{9EI}{L}$	$\frac{6}{9}=\frac{2}{3}$
	BC	$\frac{3EI}{L}$		$\frac{3}{9}=\frac{1}{3}$



Slope at C is given by,
$$\theta_c = \frac{M_{BC}l_{BC}}{6(EI)_{BC}}$$

$$\Rightarrow \qquad \theta_c = \frac{\left(\frac{M}{3}\right)L}{6(EI)} = \frac{ML}{18EI} \ (\circlearrowleft)$$

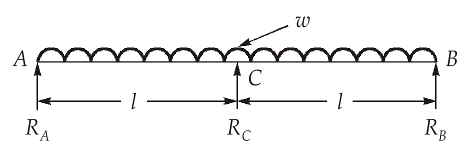
29. (a)



	A	B		C
D.F.		$\frac{1}{2}$	$\frac{1}{2}$	
F.E.M.	$-\frac{wL^2}{12}$	$+\frac{wL^2}{12}$	$-\frac{wL^2}{12}$	$+\frac{wL^2}{12}$
Balancing Moment	$+\frac{wL^2}{12}$	0	0	$-\frac{wL^2}{12}$
C.O.M.	0	$+\frac{wL^2}{24}$	$-\frac{wL^2}{24}$	0
Final End Moment	0	$+\frac{wL^2}{8}$	$-\frac{wL^2}{8}$	0

Hence, *BM* at central support, $M_C = \frac{wl^2}{8}$ (Hogging)

Alternate solution



Due to symmetry, $R_A = R_B$

Deflection at C will be zero.

$$\therefore \quad \frac{R_c(2l)^3}{48\,EI} = \frac{5w(2l)^4}{384\,EI}$$

$$\Rightarrow \quad R_c = \frac{5wl}{4}$$

$$\because \quad R_A + R_B + R_C = 2\,wl$$

$$\Rightarrow \quad 2\,R_A + \frac{5wl}{4} = 2\,wl$$

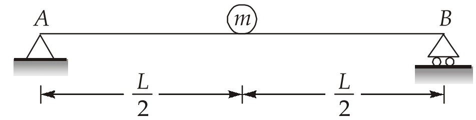
$$\Rightarrow \quad R_A = \frac{3}{8}wl(\uparrow)$$

Bendint moment at C

$$M_C = R_A l - \frac{wl^2}{2} = \frac{3}{8}wl \times l - \frac{wl^2}{2}$$

$$\Rightarrow \quad M_C = -\frac{wl^2}{8EI} = \frac{wl^2}{8EI} \text{ (Hogging)}$$

30. (b)



Stiffness of beam is,

$$K = \frac{\Delta}{P} = \frac{48EI}{L^3}$$

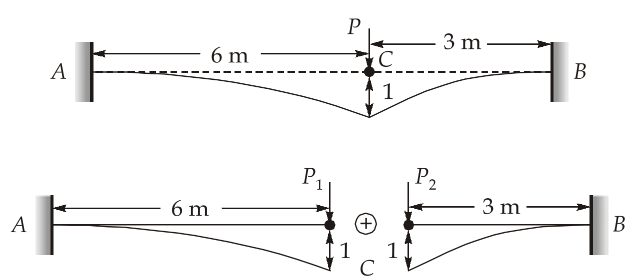
Natural frequency,

$$w_n = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$$

$$\Rightarrow \quad w_n = \frac{1}{2\pi}\sqrt{\frac{48EI}{mL^3}} = \frac{1}{2\pi}\left(\frac{4 \times 12EI}{mL^3}\right)^{1/2}$$

$$\Rightarrow \quad w_n = \frac{1}{\pi}\left(\frac{12EI}{mL^3}\right)^{1/2}$$

31. (a)



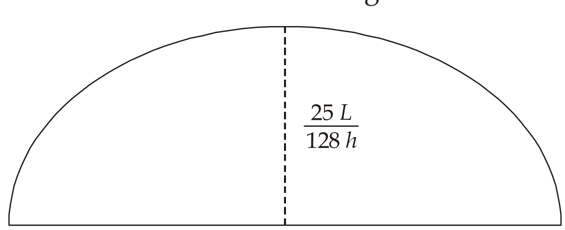
$$\because \quad k_{11} = P = P_1 + P_2$$

$$\Rightarrow \quad k_{11} = \frac{3EI}{L_{AC}^3} + \frac{3EI}{L_{CB}^3} = 3EI\left(\frac{1}{6^3} + \frac{1}{3^3}\right)$$

$$\Rightarrow \quad k_{11} = \frac{EI}{8}$$

32. (c)

Influence line diagram for horizontal thrust in two hinged arch is shown beloe.



$\therefore$ For 256 kN load, maximum horizontal thrust is,

$$H_{max} = \frac{25}{128} \times \frac{20}{5} \times 256 = 200 \text{ kN}$$

33. (b)

34. (a)

35. (a)

Diagonal elements of both flexibility as well as stiffness matrices are always positive.

This is because displacement along any coordinate due to unit load at that coordinate is always in the same direction of unit load.

Section B : CPM PERT-I + Hydrology and Water Resource Engineering-I

36. (a)

For equal engine power, a two-wheel tractor delivers higher rimpull because the full weight comes on the driving wheels, giving greater tractive force. Rolling resistance is lower in the two-wheel type due to the absence of one axle. The four-wheel tractor provides smoother travel on rough ground and has separate front wheels for steering thereby improving handling.

37. (a)

Since the critical path is the path having the longest time duration, it does not mean that the critical path will have the maximum number of activities.

38. (d)

$$T_E = 90 \text{ weeks}$$

$$\sigma_T = \sqrt{V_T} = \sqrt{16} = 4 \text{ weeks}$$

Now, probability factor,

$$z = \frac{T_S - T_E}{\sigma_T}$$

$$\Rightarrow \quad 1.647 = \frac{T_S - 90}{4}$$

$$\Rightarrow \quad T_S = 96.6 \text{ weeks}$$

39. (a)

- **Project reporting (briefing) stage:** Define project idea, scope and feasibility; prepare a concise project report and estimated cost.
- **Project planning stage:** Finalise project summary, carry out technical investigations, draw detailed plans/specifications and decide construction methodology.
- **Project tendering stage:** Prepare tender documents, invite/compare bids, assess contractors and award the contract.
- **Project construction stage:** Execute work as per drawings; implement CPM-based schedules (activity, material, worker, fund, equipment) and control quality, progress and coordination.
- **Project commissioning stage:** Test performance, carry out final inspections, prepare operation/maintenance manuals and handover with records and staff training.

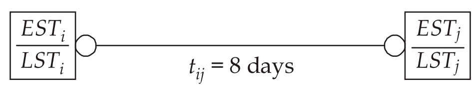
40. (b)

A scraper is a self-operating machine capable of cutting the ground, loading the loosened material, transporting it over moderate distances, dumping it at the required location, and spreading it in layers-all within one continuous cycle. It is suitable for soils that can be easily scraped and loaded but is not recommended for hard rock, dry coarse sands that do not pile, or wet and sticky materials that interfere with loading. Its performance depends on factors such as soil characteristics, borrow or cut conditions, loading zone slope, hauling distance, haul-road condition, climate and altitude, and management practices. Compared to bulldozers, scrapers become more economical for haul distances exceeding about 100 m and up to roughly 1500 m.

41. (b)

A-O-N system of the network completely eliminates the use of dummy activities.

42. (d)



$$\text{Free float} = EST_j - EST_i - t_{ij}$$

$$\Rightarrow \quad 14 = EST_j - EST_i - 8$$

$$\Rightarrow \quad EST_j - EST_i = 22 \quad \text{...(i)}$$

$$\text{Total float} = LST_j - EST_i - t_{ij}$$

$$\Rightarrow \quad 14 = LST_j - EST_i - 8$$

$$\Rightarrow \quad LST_j - EST_i = 22 \quad \text{...(ii)}$$

$$\therefore \quad LST_j = EST_j$$

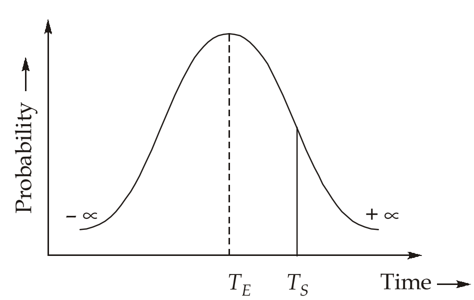
By definition,

$$LST_i = LST_j - t_{ij} \quad \text{...(iii)}$$

By (ii) and (iii) $\quad LST_i - LST_j = 22 - 8 = 14$ days

$\therefore$ Maximum delay in the occurrence of this activity = 14 days

43. (c)



- When z is positive ($T_S > T_E$), the probability of completing the project in scheduled time is greater than 50%.
- When z is negative ($T_E > T_S$), the probability of completing the project in scheduled time is less than 50%.
- When z is zero ($T_E = T_S$), the probability of completion of the project in scheduled time is 50%.

44. (c)

Given:

$$P = 15 \text{ cm}$$
$$R = 8.7 \text{ cm}$$
$$W\text{-index} = \frac{P-R}{t} = \frac{15-8.7}{8} = 0.7875 \text{ cm/hr}$$

This exceeds the rainfall in 1st and 8th hour.

$$\therefore \quad \phi\text{-index} = \frac{15-8.7-0.6-0.75}{8-2}$$

$$\Rightarrow \quad \phi\text{-index} = \frac{4.95}{6} = 0.825 \text{ cm/hr}$$

45. (a)

46. (a)

Maximum basin relief is the elevation difference between the catchment outlet and the highest point on the basin perimeter.

47. (b)

48. (a)

Differential meters have vertical shafts.

49. (d)

The mass inflow curve will continuously rise as it is the plot of accumulated inflow versus time.

50. (d)

Surcharge volume is the volume of water stored between the normal pool level and the maximum pool level.

51. (c)

Given,

$$f_i = 28 \text{ mm/hr}$$
$$f_c = 7 \text{ mm/hr}$$
$$k = 0.5 \text{ hr}^{-1}$$
$$t = 2 \text{ hours}$$

Now,

$$f_o = f_c + (f_i - f_c)\, e^{-kt}$$
$$\Rightarrow \quad f_o = 7 + (28 - 7)\, e^{-0.5\,t}$$
$$\Rightarrow \quad f_o = 7 + (21)\, e^{-0.5\,t}$$

Total infiltration,

$$F_t = \int_0^t f_t\,dt = \int_0^2 \left(7 + 21e^{-0.5t}\right) dt$$

$$\Rightarrow \quad F_t = \left[7t - \frac{21e^{-0.5t}}{0.5}\right]_0^2$$

$$\Rightarrow \quad F_t = \left[14 - \frac{42}{e}\right] - [0 - 42]$$

$$\Rightarrow \quad F_t = 56 - \frac{42}{e} = 56 - \frac{42}{2.72} \simeq 40.559 \text{ mm}$$

52. (c)

Potential maximum retention, $S = 254\left(\frac{100}{CN} - 1\right)$

$$\Rightarrow \quad S = 254\left(\frac{100}{75} - 1\right)$$

$$\Rightarrow \quad S = \frac{254}{3} = 84.67 \text{ mm}$$

53. (c)

A Lysimeter is used to measure actual evapotranspiration from soil and vegetation. Anemometer is used for measuring the wind speed. Infiltrometer is used for measuring rate of infiltration of water in soil.

54. (b)

55. (a)

Sandy soils have low capillary rise, so when the surface dries even slightly, they cannot supply water to the surface, causing evaporation to drop quickly. Clayey soils, with finer texture and larger capillary rise, can draw water from deeper layers and maintain evaporation longer. Clayey soils also have higher porosity and can store more water as compared to sandy soils.

Section C : Design of Steel Structure-II + Surveying and Geology-II

56. (a)

To avoid irreversible deformation under serviceability conditions, M_d shall be

(i) $1.2\, Z_e f_y/\gamma_{m0}$ for simply supported beams

(ii) $1.5\, Z_e f_y/\gamma_{m0}$ for cantilever beams

57. (a)

As per IS 800:2007, the following types of web stiffeners are identified based on the purpose for which a stiffener is being used:

(i) **Intermediate and longitudinal stiffener:** To improve the buckling strength of a slender web due to shear.

(ii) **Load-carrying stiffener:** To prevent web buckling due to concentrated load.

(iii) **Bearing stiffener:** To prevent local crushing of the web due to concentrated loads or reactions.

(iv) **Torsional stiffener:** To provide lateral restraint to beams and girders at support.

(v) **Diagonal stiffener:** To provide a sort of local reinforcement to the web under shear and bearing.

(vi) **Tension stiffener:** To transfer tensile forces applied to the web through a flange.

58. (c)

Ratio of inner diameter to outer diameter,

$$k = \frac{100}{200} = 0.5$$

Shape factor for hollow circular section,

$$S = 1.7\frac{(1-k^3)}{(1-k^4)}$$

$$\Rightarrow \quad S = 1.7\frac{(1-0.5^3)}{(1-0.5^4)} = 1.7\frac{(1-0.125)}{(1-0.0625)}$$

$$\Rightarrow \quad S = 1.586$$

59. (c)

Sag rods are tension members connecting successive purlins along the roof slope. They carry the component of roof load parallel to the sheeting, so each purlin segment between sag rods is relieved of this longitudinal force. At the same time, they keep purlins in proper alignment during erection and provide lateral support, helping smaller purlin sections to take loads safely.

60. (d)

61. (d)

62. (b)

To avoid buckling of the compression flange into the web, IS 800 : 2007 specifies the following web thickness requirements:

(i) When transverse stiffeners are not provided

- $\frac{d}{t} \le 345\varepsilon_f^{\,2}$

(ii) When only transverse stiffeners are provided

- $\frac{d}{t} \le 345\,\varepsilon_f^{\,2}$ for $c \ge 1.5\,d$
- $\frac{d}{t} \le 345\,\varepsilon_f$ for $c < 1.5\,d$

where d = depth of the web

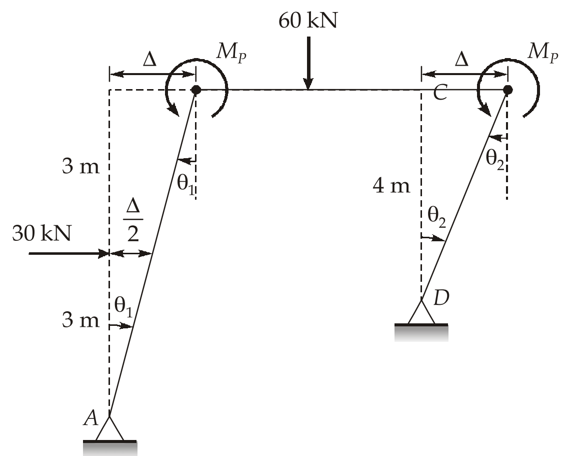
t = thickness of the web or spacing of the transverse stiffener

$$\varepsilon_f = \sqrt{\left(\frac{250}{f_{yf}}\right)}$$

f_{yf} = Yield stress of compression flange

63. (b)

Sway mechanism



Let M_P is the pastic moment for the given frame

$$\Delta = 6\,\theta_1 = 4\,\theta_2 \quad \Rightarrow \quad \theta_2 = 1.5\,\theta_1$$

By principle of virtual work.

$$\text{Internal work} = \text{External work}$$

$$\Rightarrow \quad M_P \times \theta_1 + M_P \times \theta_2 = 30 \times \frac{\Delta}{2}$$

$$\Rightarrow \quad M_P\theta_1 + M_P \times 1.5\,\theta_1 = 15 \times 6\theta_1$$

$$\Rightarrow \quad 2.5\,M_P = 15 \times 6$$

$$\Rightarrow \quad M_P = 36 \text{ kN-m}$$

64. (b)

Length of plastic hinge

$$L_P = L\left(1 - \frac{1}{S.F}\right)$$

For rectangular section, $SF = 1.5$

$$\Rightarrow \quad L_P = L\left(1 - \frac{1}{1.5}\right) = \frac{L}{3}$$

65. (c)

- Sidereal time at a place is defined as the hour angle of the first point of Aries (the vernal equinox).
- The local mean noon is the instant when the 'mean' sun is on the meridian. Mean sun is a fictitious sun imagined to move at a uniform rate along the equator, as apparent solar time is variable and cannot be recorded by our modern clocks.
- The equation of time is the difference between apparent solar time and mean solar time, and it arises due to two main reasons:
  - The obliquity of Earth's axis to the ecliptic
  - The ellipticity of Earth's orbit

66. **(d)**

A syncline is a fold in rock layers where the layers dip inward towards the center of the fold, forming a trough or U-shape. The youngest rock layers are found at the core of the syncline, and the layers get progressively older moving outwards from the center.

67. **(b)**

Overlaps are required to ensure complete coverage of the area and to ensure stereoscopic vision. Correcting distortions caused by lens imperfections is not the main reason for providing longitudinal and lateral overlaps in aerial photography.

68. **(c)**

- **Celestial horizon:** It is the great circle traced upon the celestial sphere by that plane which is perpendicular to the Zenith-Nadir line.
- **Observer's meridian:** The meridian of any particular point is that circle which passes through the Zenith and Nadir of the point as well as through the poles.

69. **(a)**

Longitudinal and lateral coverage on the ground for each photograph is,

$$l = \frac{23}{100} \times 11500 = 2645 \text{ m}$$

$$\text{Effective longitudinal coverage} = 0.4 \times 2645 = 1058 \text{ m}$$

$$\text{Effective lateral coverage} = 0.75 \times 2645 = 1983.75 \text{ m}$$

$$\text{Number of strips} = \frac{15 \times 1000}{1983.75} = 7.56 \simeq 8$$

$$\text{Number photographs per strip} = \frac{7 \times 1000}{1058} = 6.62 \simeq 7$$

$$\text{Total number of photographs} = 7 \times 8 = 56$$

70. **(d)**

Radius, $$R = \frac{22}{4} \times \frac{180}{\pi} = \frac{22}{4} \times \frac{180 \times 7}{22} = 315 \text{ m}$$

$$\text{Versine (mid-ordinate) distance} = R\left(1 - \cos\frac{\Delta}{2}\right)$$

$$\Rightarrow \quad V = 315\left(1 - \cos\frac{120}{2}\right) = 315\,(1 - \cos 60)$$

$$\Rightarrow \quad V = 157.5 \text{ m}$$

71. **(c)**

- A star is said to be at elongation when it is at its greatest distance east or west of the meridian, and in this position, its azimuth is maximum.
- A star is said to culminate or transit when it crosses the observer's meridian.
- Circumpolar stars are those which are always above the horizon. The declination of a circumpolar star is always greater than the co-latitude of the place of observation.

72. (a)

A compound curve consists of two or more simple arcs that turn in the same direction and join at common tangent points.

73. (a)

The base line is normally selected shorter because:

(i) It is usually not possible to get a flat site.

(ii) It is difficult and expensive to measure a long base-line

74. (b)

The GPS signal travels from satellites to receivers through atmosphere. As the density of our atmosphere is variable, the speed of signals is not constant. Hence, sometimes the signal gets delayed and the distance is overestimated.

75. (b)

Purlins are kept above nodes in the top chord in pin joined roof truss to provide restraint to principal rafter against buckling due to bending moment. The top chord is continuous through the nodes of the truss.

■■■■