DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 10

Section A : Structural Analysis

Section B : CPM PERT-1 + Hydrology and Water Resource Engg.-1

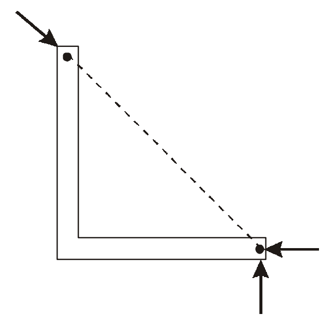
Section C : Design of Steel Structure-2 + Surveying and Geology-2

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

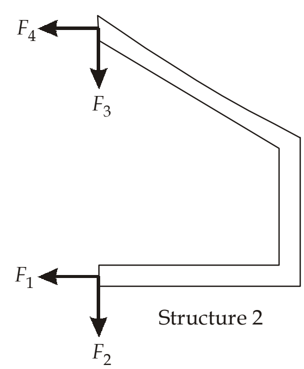
DETAILED EXPLANATIONS

Section A : Structural Analysis

1. (c)



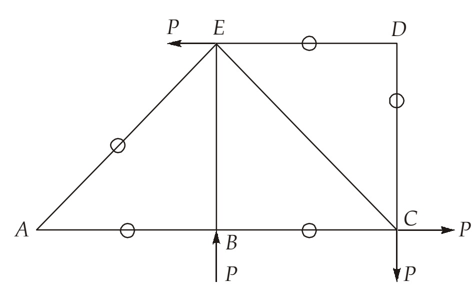
Structure 1 is unstable since the three reactions are concurrent at *B*.



Four non-concurrent and non-parallel forces. Hence, structure is stable.

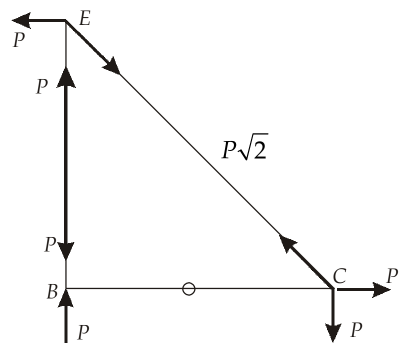
2. (d)

FBD of structure



Members *AE*, *ED*, *DC* and *AB* carry zero forces, as we know that, if only two non-collinear members form a truss joint and no external load or support reaction is applied to the joint, the members must be zero force member.

Truss may be simplified as



Analyse joint *B* and we can deduce forces in number *BE* and *BC*. *BE* carries compressive forces and CE carries tensile forces.

3. **(d)**

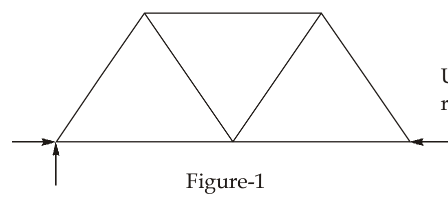


Figure-1

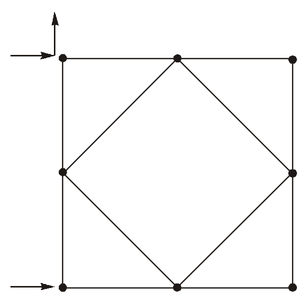


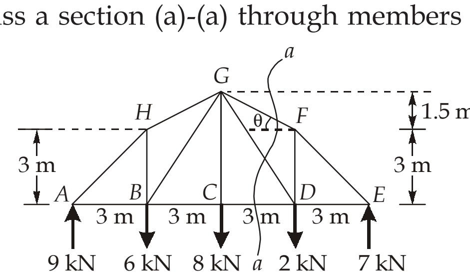
Figure-2

$$m + r - 2j = 12 + 3 - 2 \times 8 = -1$$

Hence unstable.

4. **(b)**

Using method of sections, pass a section (a)-(a) through members *GF*, *GD* and *CD*.



$$\Sigma M_A = 0$$

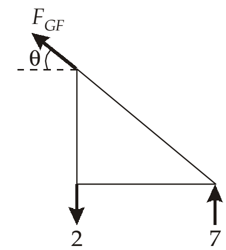
$$\Rightarrow \quad 6 \times 3 + 8 \times 6 + 2 \times 9 = F_E \times 12$$

$$\Rightarrow \quad F_E = 7 \text{ kN}$$

$$\therefore \quad F_A = (6 + 8 + 2) - 7$$

$$= 9 \text{ kN}$$

Consider the right side of section (a)-(a)



$$\Sigma M_D = 0$$

$$\tan\theta = \frac{1.5}{3}$$

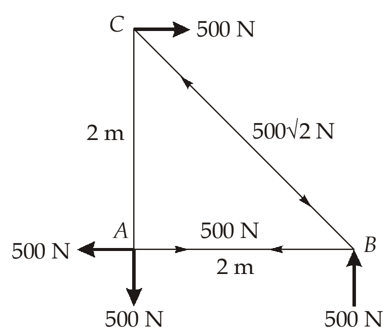
$$\therefore \quad \cos\theta = \frac{3}{\sqrt{3^2+1.5^2}} = 0.89$$

$$F_{GF}\cos\theta \times 3 + 7 \times 3 = 0$$

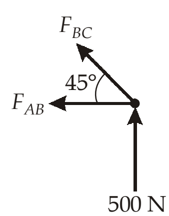
$$\Rightarrow \quad F_{GF} = \frac{-7}{\cos\theta} = \frac{-7}{0.89}$$

$$= -7.87 \text{ kN} = 7.87 \text{ compressive}$$

5. (c)



Consider joint B,

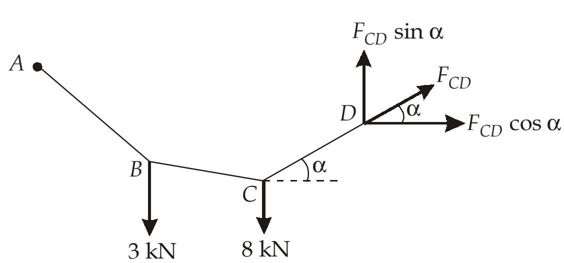


$$F_{BC}\sin 45 + 500 = 0$$

$$F_{BC} = -500\sqrt{2} \text{ N i.e. compression}$$

$$\therefore \quad \text{Strain energy stored in } BC = \frac{P^2L}{2AE} = \frac{(-500\sqrt{2})^2 \times 2\sqrt{2}}{2\times 250\times 1000} = 2\sqrt{2} \text{ N-m}$$

6. (c)



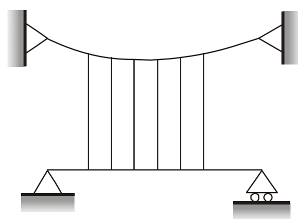
$$\Sigma M_A = 0$$

$$\Rightarrow \quad 3 \times 2 + 8 \times 4 - F_{CD} \cos\alpha \times 2 - F_{CD} \sin\alpha \times 5.5 = 0$$

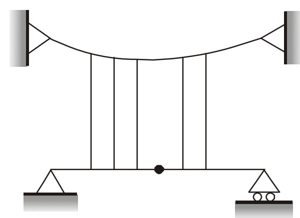
$$F_{CD} = 6.79 \text{ kN}$$

7. (c)

If the girder is simply supported as well as supported by the cable, the analysis will be statically indeterminate to the first degree. However, if the girder has an internal pin at some intermediate point along its length, then this would provide a condition of zero moment at pin location, and so a determinate structural analysis of the girder can be performed.

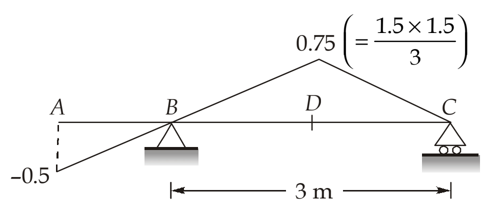


Simply supported girder supported by cable



Simply supported girder supported by cable and has an internal hinge. (Statically determinate structure)

8. (d)



ILD for BM at D

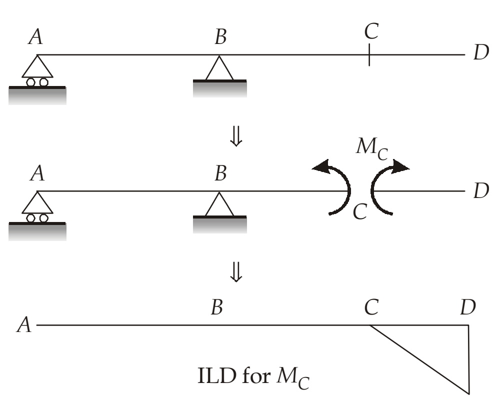
For maximum bending moment at D, the point load 8 kN is placed at D.

$$\text{B.M. due to 8 kN load} = 0.75 \times 8 = 6 \text{ kN-m}$$

$$\text{BM due to dead load} = \left[\frac{1}{2} \times 3 \times 0.75 - \frac{1}{2} \times 1 \times 0.5\right] \times 8 = 7 \text{ kN-m}$$

$$\therefore \quad \text{Maximum BM at } D = 7 + 6 = 13 \text{ kN-m}$$

9. (d)



ILD for M_C

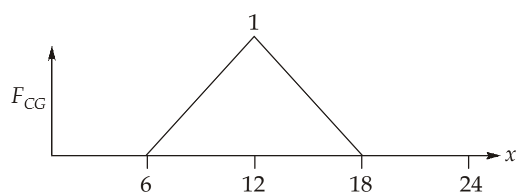
10. (a)

"The absolute moment in a simply supported beam occurs under one of the concentrated forces, such that this force is so positioned on the beam so that this load and the resultant force of the system are equidistant from the beam's mid-span".

11. (b)

Distance from support $A(m)$	F_{CG} unit
0	0
6	0
12	1
18	0
24	0

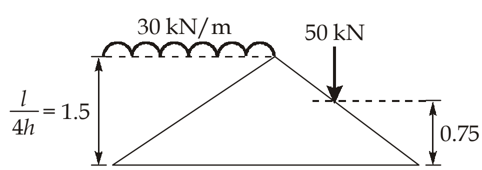
All statically determinate beams will have influence lines that consist of straight line segments.



ILD for CG

12. (c)

ILD of horizontal thrust

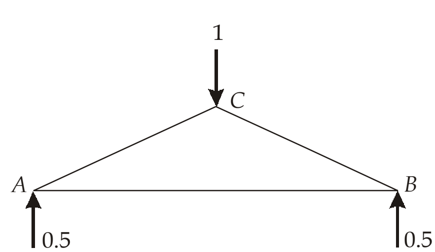


$$\therefore \quad H = \frac{1}{2} \times 12 \times 1.5 \times 30 + 0.75 \times 50 = 307.5 \text{ kN}$$

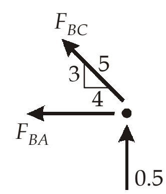
13. (b)

In portal method, the shear at interior column hinges is twice that at exterior column hinges. The rationale behind it is that the interior columns would represent the effect of two portal columns and would therefore carry twice the shear as the two exterior columns.

14. (c)



Joint B,



$$\Sigma F_y = 0$$

$$\Rightarrow \quad F_{BC} \times \frac{3}{5} + 0.5 = 0$$

$$\Rightarrow \quad F_{BC} = \frac{-2.5}{3}$$

$$\Sigma F_x = 0$$

$$\Rightarrow \quad F_{BC} \times \frac{4}{5} + F_{BA} = 0$$

$$\Rightarrow \quad \frac{-2.5}{3} \times \frac{4}{5} + F_{BA} = 0$$

$$\Rightarrow \quad F_{BA} = \frac{2}{3}$$

$$\Rightarrow \quad 1 \times \Delta_{cv} = \sum u_i \left(\cancelto{0}{\frac{P_i L_i}{A_i E_i}} + \cancelto{0}{L_i \alpha_i \Delta T_i} + \lambda_i \right)$$

$$1 \times \Delta_{cv} = \Sigma u_i \times \lambda_i$$

$$\Rightarrow \quad 1 \times \Delta_{cv} = F_{BA}$$

$$\Rightarrow \quad 1 \cdot \Delta_{cv} = \frac{2}{3} \times (-3)$$

$$\Rightarrow \quad \Delta_{cv} = 2 \text{ mm (upwards)}$$

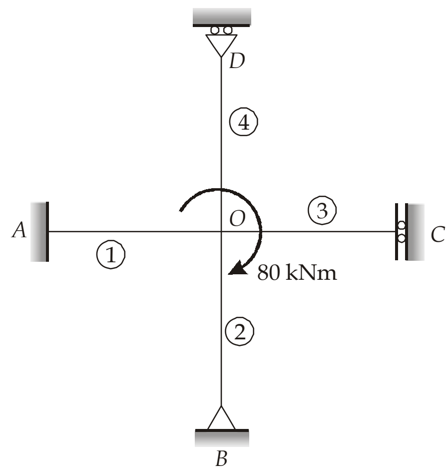
15. (d)

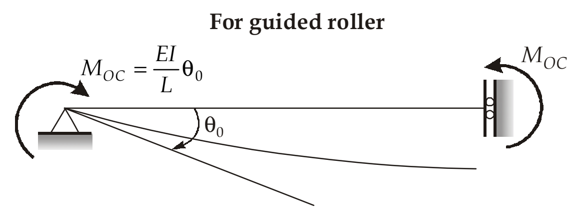
In displacement method, displacements are written in terms of the loads by using the load-displacement relations. It first requires satisfying equilibrium equations for the structure.

Force methods: Strain energy method, Castigliano's method, consistent deformation method, method of virtual work, flexibility matrix method etc.

Displacement methods: Slope deflection, moment distribution, Kani's method, stiffness matrix method etc.

16. (a)





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

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

$$M_{OC} = \frac{1}{8}\times 80 = 10 \text{ kNm}$$

Carryover factor at C = –1

Magnitude of moment at end C = 10 kNm

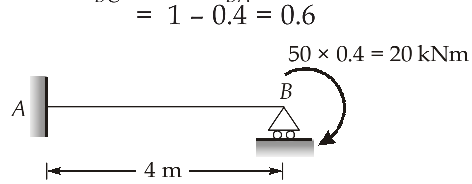
17. (c)

$$k_{BA} = \frac{4EI}{4} = EI$$

$$k_{BC} = \frac{3EI}{2} = \frac{3}{2}EI$$

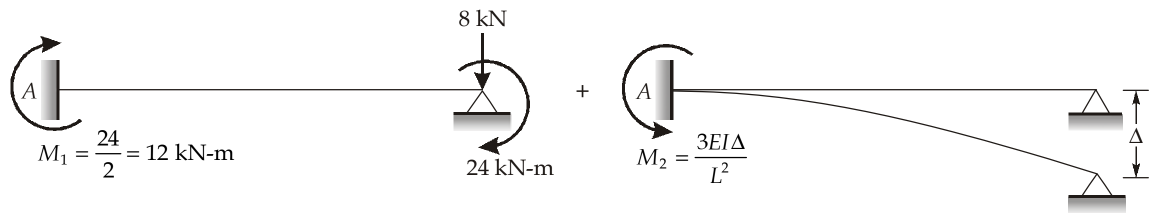
$$\therefore \quad d_{BA} = \frac{EI}{\frac{3}{2}EI + EI} = 0.4$$

$$d_{BC} = 1 - d_{BA} = 1 - 0.4 = 0.6$$



$$\therefore \quad M_{AB} = \frac{1}{2}M_{BA} = \frac{1}{2}(50\times 0.4) = 10 \text{ kNm}$$

18. (c)



$$M_1 = \frac{24}{2} = 12 \text{ kN-m}$$

$$M_2 = \frac{3\times10^{12}\times80}{4000^2}\times10^{-6} \text{ kNm} = 15 \text{ kNm}$$

$$\therefore \quad M_A = M_2 - M_1 = 15 - 12 = 3 \text{ kNm}$$

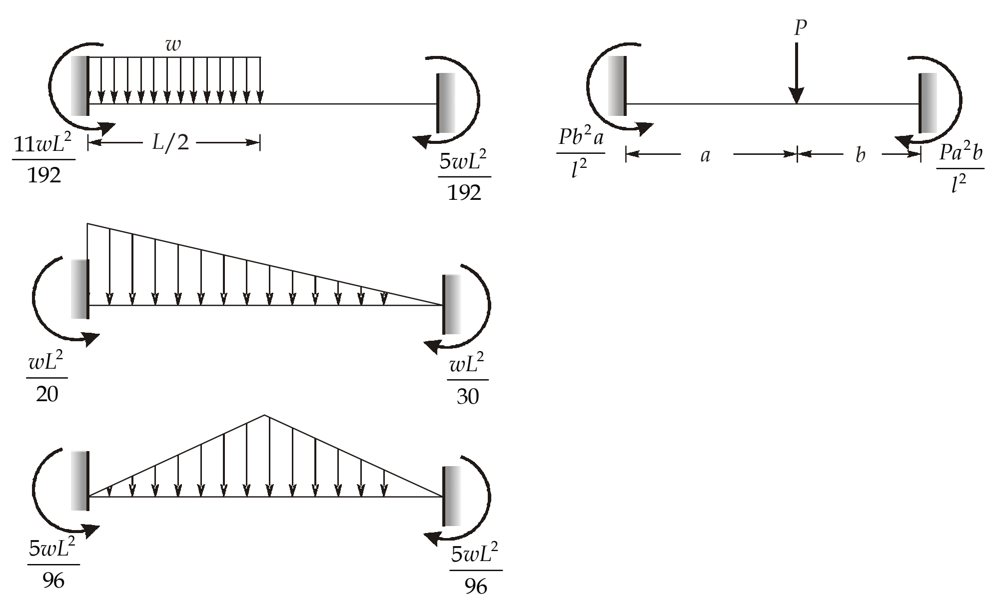
19. (c)

Castigliano's second theorem says:

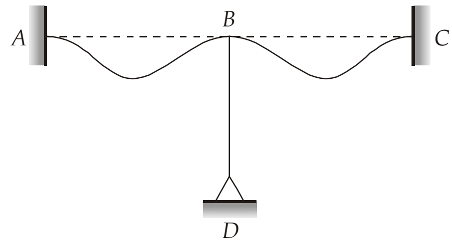
"If the strain energy of a linearly elastic structure can expressed as a function of generalised force then the first partial derivative of the strain energy with respect to generalised force gives the generalised displacement".

20. (d)

Standard results for fixed end moments.



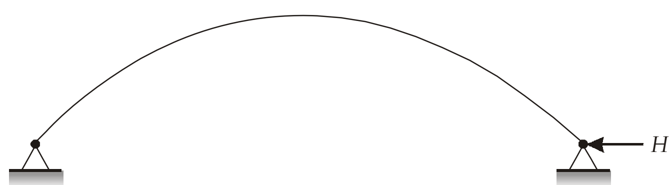
21. (a)



- Since all joints and chords rotations are zero, the member end moments at each end of beams AB and BC are equal to the fixed-end moments $\left(\frac{PL}{8}\right)$. In other words, joint B will act as rigid joint.

$$\therefore \quad M_A = M_{AB}^F = \frac{PL}{8} = \frac{16 \times 20}{8} = 40 \text{ kNm}$$

22. (c)



$$U = \int_0^l \frac{(M_s - Hy)^2\, dS}{2EI}$$

Given

$$\frac{\partial U}{\partial H} = -\delta$$

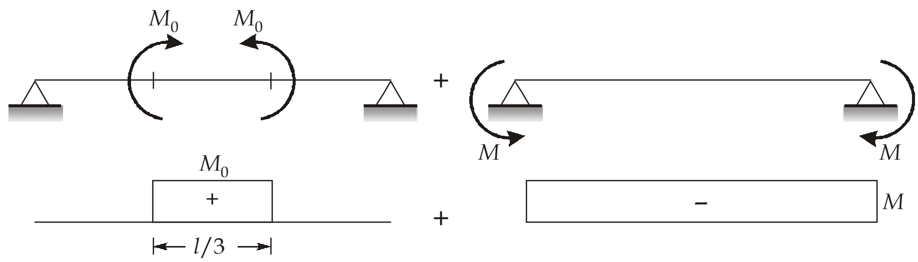
$$\therefore \quad \frac{\partial U}{\partial H} = \int_0^l \frac{(M_s - Hy)(-y)}{EI} dS = -\delta$$

$$\Rightarrow \quad \int_0^l -\frac{M_s y dS}{EI} + \int_0^l \frac{Hy^2}{EI} dS = -\delta$$

$$\Rightarrow \quad H = \frac{\int_0^l \frac{M_s y dS}{EI} - \delta}{\int_0^l \frac{y^2}{EI} dS}$$

23. (c)

The given beam is equivalent to the beams shown below.



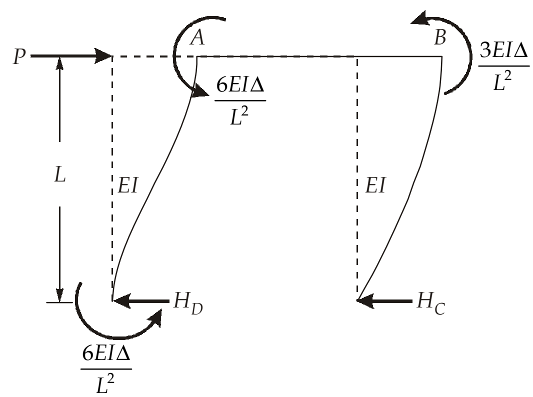
BMD

Slope is zero at ends and beam is symmetrical.

$$\therefore \quad M_o \times \frac{l}{3} - Ml = 0 \qquad \text{\{Area of BMD must add to zero\}}$$

$$\Rightarrow \quad M = \frac{M_o}{3}$$

24. (b)



$$\Sigma M_A = 0$$

$$H_D \times L - \frac{6EI\Delta}{L^2} - \frac{6EI\Delta}{L^2} = 0$$

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

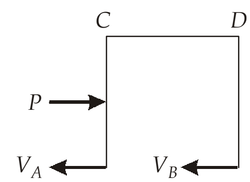
$$\Sigma M_B = 0$$

$$H_C L - \frac{3EI\Delta}{L^2} = 0$$

$$H_C = \frac{3EI\Delta}{L^3}$$

$$P = H_C + H_D = \frac{15EI\Delta}{L^3}$$

25. (d)



$$V_A + V_B = P \qquad \ldots(i)$$

$\Sigma M_C = 0;$
$$32 + V_A \times 4 = P \times 2 \qquad \ldots(ii)$$

$\Sigma M_D = 0;$
$$68 + 64 = V_B \times 4 \qquad \ldots(iii)$$

From equation (i), (ii) and (iii), we get

$$V_B = 33 \text{ kN}$$
$$P = 50 \text{ kN}$$

26. (d)

$$K_{BC} = \frac{4EI}{L}$$

$$K_{BA} = \frac{3EI}{L}$$

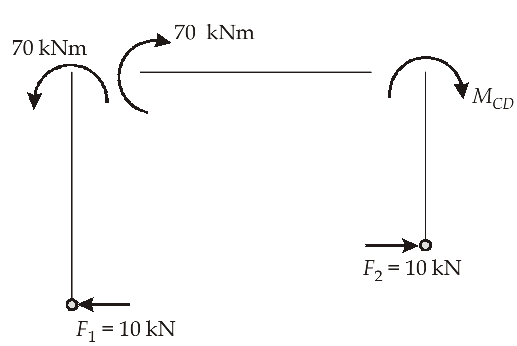
$$FEM_{BC} = M \text{ (say)}$$
$$FEM_{CB} = -M$$

A	B	B	C
		M	$-M$
	$\frac{-3M}{7}$	$\frac{-4M}{7}$	
			$\frac{-2M}{7}$
	$\frac{-3M}{7}$	$\frac{+3M}{7}$	$\frac{-9M}{7}$

$$\frac{|M_{BC}|}{|M_{CB}|} = \frac{3M/7}{9M/7} = 1:3$$

27. (d)

Given negative moment is clockwise



$$\Sigma M_B = 0$$

$$\Rightarrow \quad 70 = F_1 \times 7$$

$$\Rightarrow \quad F_1 = 10 \text{ kN} \quad (\leftarrow)$$

$$\because \quad F_1 = F_2$$

$$\therefore \quad F_2 = 10 \text{ kN} \quad (\rightarrow)$$

$$\therefore \quad M_{CD} = F_2 \times 5$$

$$\Rightarrow \quad M_{CD} = 50 \text{ kNm} \qquad \text{(Clockwise)}$$

$$\Rightarrow \quad M_{CD} = -50 \text{ kNm}$$

28. (a)

We know that for fixed beam with central load W, central deflection,

$$\delta = \frac{WL^3}{192EI}$$

$$\therefore \quad \text{Stiffness, } k = \frac{W}{\delta} = \frac{192EI}{L^3}$$

$$\Rightarrow \quad \omega_n = \sqrt{\frac{k}{m}} = \sqrt{\frac{kg}{W}} = \sqrt{\frac{192EIg}{WL^3}}$$

29. (a)

$$\text{Stiffness, } k = \frac{F}{\Delta} = \frac{5000}{0.2} = 25000 \text{ N/cm}$$

$$= 25 \times 10^5 \text{ N/m}$$

$$\text{Undamped natural frequency, } w = \sqrt{\frac{k}{(W/g)}}$$

$$= \sqrt{\frac{25 \times 10^5}{(20000/9.81)}} = 35.02 \text{ radians/sec}$$

$$\text{Damped frequency} = w\sqrt{1-\xi^2}$$

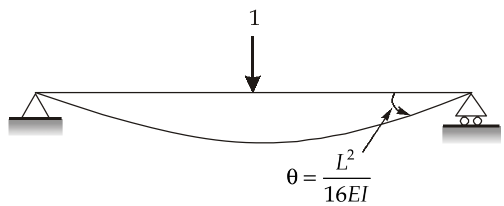
$$= 35.02\sqrt{1-(0.05)^2}$$

$$= 34.98 \text{ radians/sec}$$

30. (c)

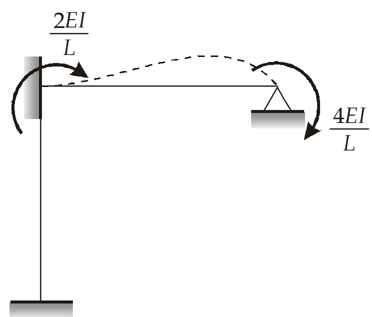
- The flexibility matrix will always be a square matrix in which diagonal elements will be non-negative and non zero.
- Order of flexibility matrix will be equal to degree of static indeterminacy.

31. (d)



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

32. (c)



$$k_{12} = \frac{2EI}{L}$$

33. (c)

Let $$A = \frac{3EI}{L}\begin{bmatrix} 4 & 1 \\ 1 & 4 \end{bmatrix}$$

$\therefore$ Determinant, $$A = |A| = \frac{3EI}{L}(16-1) = \frac{45EI}{L}$$

$\therefore$ $$A^{-1} = \frac{1}{|A|}\text{adjacent }(A) = \frac{L}{45EI}\begin{bmatrix} 4 & -1 \\ -1 & 4 \end{bmatrix}$$

34. (c)

Stiffness matrix, $$S = F^{-1} = \frac{3EI}{(8-2\times 2)}\begin{bmatrix} 8 & -2 \\ -2 & 1 \end{bmatrix}$$

$\Rightarrow$ $$S = \frac{3EI}{4}\begin{bmatrix} 8 & -2 \\ -2 & 1 \end{bmatrix}$$

Forces due to settlement of support 1 are given by,

$$\begin{bmatrix} V_B \\ V_C \end{bmatrix} = \frac{3EI}{4}\begin{bmatrix} 8 & -2 \\ -2 & 1 \end{bmatrix}\begin{bmatrix} \Delta/EI \\ 0 \end{bmatrix}$$

$$= \frac{3EI}{4}\begin{bmatrix} 8\Delta/EI \\ -2\Delta/EI \end{bmatrix} = \begin{bmatrix} 6\Delta \\ -1.5\Delta \end{bmatrix}$$

$$\therefore \quad V_B = 6\Delta$$

$$V_C = -1.5\Delta$$

35. (c)

Influence lines represent the effect of a moving load only at a specified point on a member, whereas shear and moment diagrams represent the effect of fixed load at all points along the axis of members.

36. (c)

The requirements for the principle of superposition to be applicable are:

- The material must behave in a linear-elastic manner, so that Hooke's law is valid and therefore the load will be proportional to displacement.
- The geometry of the structure must not undergo significant changes when the loads are applied, i.e., small displacement theory applies. Large displacements will significantly change the position of the loads. An example can be a cantilevered thin rod subjected to a load at its end.

37. (a)

Because of the assumptions mentioned in statement II, each truss member acts as an axial force member.

38. (a)

When deriving the necessary relations between the force in the cable and its slope, we make the assumption that the cable is perfectly flexible and inextensible. Due to its flexibility, the cable does not offer resistance to shear or bending and, therefore, the force acting in the cable is always tangent to the cable at points along its length.

Section B : CPM PERT-1 + Hydrology and Water Resource Engineering-1

39. (d)

Case I:

Case II:

After clubbing the activities

Std. deviation of individual activities

$$= \frac{9-3}{6} = 1 \text{ (before clubbing)}$$

$\therefore$ Std. deviation of whole project in case-I

$$X_1 = \sqrt{1^2+1^2+1^2+1^2+1^2+1^2+1^2+1^2} = \sqrt{8}$$

Std. deviation of individual activities after clubbing

$$= \sqrt{1^2+1^2} = \sqrt{2}$$

∴ Std. deviation of whole project in case-II

$$(X_2) = \sqrt{(\sqrt{2})^2 + (\sqrt{2})^2 + (\sqrt{2})^2 + (\sqrt{2})^2} = \sqrt{8}$$

$$\therefore \quad \frac{X_2}{X_1} = \frac{\sqrt{8}}{\sqrt{8}} = 1$$

40. (a)

In one cycle, volume of excavating material = 2.25 m^3

Loose swell = 25%

$$\therefore \text{ Bank measure volume of one cycle} = \frac{2.25}{1.25} = 1.8\ m^3$$

For 15 minutes idle time for every one hour,

Actual time per hour = 45 minutes

= 45 × 60 sec

$$\therefore \text{ Number of cycles being performed per hour} = \frac{45 \times 60}{27}$$

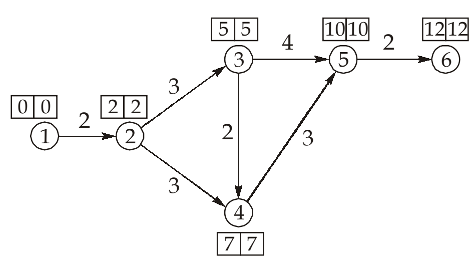
∴ Output of the shovel = Bank measure volume in one cycle in cum × Number of cycles/hr

$$= \frac{1.8 \times 45 \times 60}{27} = 180\ m^3/hr$$

42. (d)

The earliest finish time is the earliest possible time at which an activity can finish. The latest finish time is the latest possible time at which an activity can finish.

43. (a)



$$\text{Independent float for activity 3-5} = \left(T_{E_j} - T_{L_i}\right) - t_{ij}$$

$$= \left(T_{E_5} - T_{L_3}\right) - t_{3-5}$$

$$= (10 - 5) - 4 = 1 \text{ day}$$

44. (c)

Crew constraint can occur if specialist for certain activities are hard to obtain, and all such activities may have to be done in sequence with a small crew available at the disposal.

45. (d)

$$\text{For 95\% probability, } z = 1.647$$
$$\text{Variance, } \sigma^2 = 9 \text{ weeks}$$
$$\therefore \quad \text{Std. deviation, } \sigma = 3 \text{ weeks}$$
$$z = \frac{T_S - T_E}{\sigma}$$
$$\Rightarrow \quad 1.647 = \frac{T_S - 65}{3}$$
$$\Rightarrow \quad T_S = 65 + 3 \times 1.647$$
$$= 69.94 \text{ weeks}$$
$$\simeq 70 \text{ weeks}$$

46. (b)

$$\text{Gross weight of tractor} = 18000 \text{ kg} = 18t$$

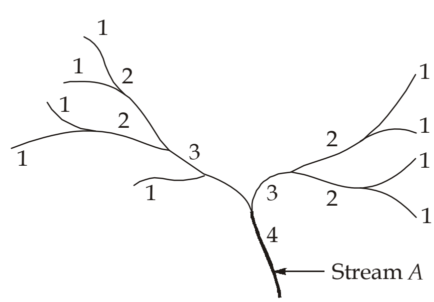
Hence rolling resistance offered by haul road = 18 × 45 = 810 kg

$$\text{Load on driving tyres} = \frac{60}{100} \times 18000$$
$$= 10800 \text{ kg}$$

Maximum possible rimpull prior to slippage of tyres = Coefficient of traction × Load on driving tyres

$$= 0.70 \times 10800$$
$$= 7560 \text{ kg}$$
$$\therefore \quad \text{Maximum effective rimpull} = 7560 - 810 = 6750 \text{ kg}$$

47. (c)



When two 1st order streams meet, the resultant stream is said to be of order 2. Similarly when two 2nd order streams meet, the resultant stream is of order 3 and so on.

48. (b)

Pyranometer (previously called pyrhelimeter) is used to measure the short wave solar radiation, both direct and diffused, reaching the Earth's surface.

50. (a)

The area of the hyetograph above the infiltration curve represents the runoff volume.

51. (a)

Albedo is the ratio of amount of solar radiation reflected by the surface to the amount of incident solar radiation on it.

52. (b)

Coalescence process occurs through electrostatic attraction amongst the oppositely charged cloud particles.

In the ice-crystal process, the water droplets may exist in clouds at subfreezing temperatures down to –40°C. In this range, solidification occurs in connection with certain particles which are called freezing nuclei.

55. (b)

Since k = 12 hr and 2 kx = z × 12 × 0.2 = 4.8 hr

Δt should be such that 12h > Δt > 4.8 hr

Taking Δt = 6 hr

$$C_0 = \frac{-kx + 0.5\Delta t}{k(1-x) + 0.5\Delta t}$$

$$= \frac{-12 \times 0.2 + 0.5 \times 6}{12 - 12 \times 0.2 + 0.5 \times 6} = 0.048$$

$$C_2 = \frac{k(1-x) - 0.5\Delta t}{k(1-x) + 0.5(\Delta t)}$$

$$= \frac{12 - 12 \times 0.2 - 0.5 \times 6}{12 - 12 + 0.5 \times 6} = 0.524$$

56. (d)

Pre-operations and post-operations of the activity under consideration are distinctly visible in AON networks.

57. (c)

Vegetation and forest cover increases the infiltration and storage capacities of the soil. Further they cause considerable retardance to the overland flow.

Section C : Design of Steel Structure-2 + Surveying and Geology-2

58. (c)

- A heavy load or reaction concentrated on a short length produces a region of high compressive stresses in the vertical elements of the web either under the load or at the support. Away from the loading point, stresses are spread widely. But just under a load or above a reaction point, they may cause web failure such as web buckling and web crippling or web crushing. Web buckling or vertical buckling occurs when the intensity of vertical compressive stress near the centre of the section becomes greater than the critical buckling stress for the web acting as a column. Tests indicate that for rolled steel beams, initial failure is by web crippling rather than by buckling. But for built up beams having greater ratios of depth to thickness of web, failure by vertical buckling may be more probable than failure by web crippling.

- Maximum shear stress occurs at centre (i.e. at neutral axis of the section).
- Tests indicate that for rolled steel beams initial failure is by web crippling rather than by buckling.
- The effect of holes in the tension flange, on the design bending strength need not be considered if (**Clause 8.2.1.4** of **IS 800:2007**).

$$\frac{A_{nf}}{A_{gf}} \geq \frac{f_y}{f_u} \times \frac{\gamma_{m_1}}{\gamma_{m_0}} \times \frac{1}{0.9}$$

For Fe410

$$\frac{A_{nf}}{A_{gf}} \geq \frac{250}{410} \times \frac{1.25}{1.1} \times \frac{1}{0.9}$$

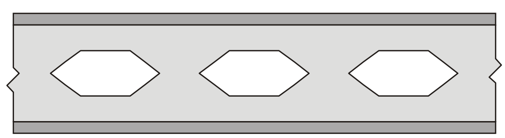
i.e. $$\frac{A_{nf}}{A_{gf}} \geq 0.77\ (\neq 0.85)$$

59. **(c)**

$\because$ Purlin is a continuous member (beam) and thus design moment is $\frac{PL}{10}$.

60. **(b)**

Latticed beams or open web steel joists are generally prefabricated trusses. Castellated beam is beam with a number of regular openings in the its web.



Castellated beam

61. **(a)**

For condition when transverse stiffeners are not provided and web is connected to flanges along both longitudinal edges, according to **Clause 8.6.1.1 of IS 800 : 2007**,

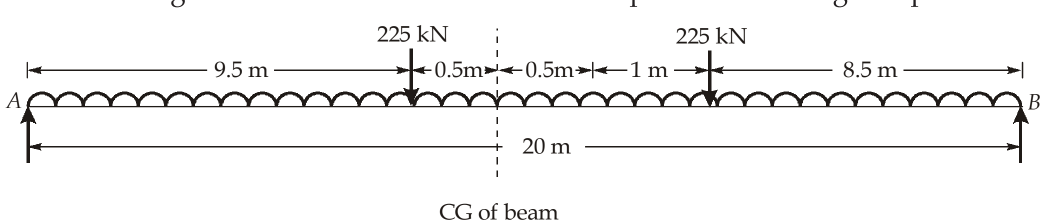
$$\frac{d}{t_w} \leq 200\,\varepsilon$$

62. **(b)**

Total factored UDL on girder = 1.5 × (20 + 10) = 45 kN/m

Factored moving load = 1.5 × 150 = 225 kN

The maximum bending moment due to UDL and point loads will occur at different points. The maximum bending moment in our case will be under point load with given positions of loading.



$$R_A \text{ and } R_B \text{ due to UDL} = \left(\frac{45 \times 20}{2}\right) = 450 \text{ kN}$$

$$R_A \text{ due to moving load} = \left(\frac{225 \times 10.5 + 225 \times 8.5}{20}\right) = 213.75 \text{ kN}$$

$$R_B \text{ due to moving load} = (2 \times 225) - 213.75 = 236.25 \text{ kN}$$

$$\text{Total } R_B = 450 + 236.25 = 686.25 \text{ kN}$$

$$\text{Total } R_A = 450 + 213.75 = 663.75 \text{ kN}$$

$$\therefore \quad \text{Maximum BM} = (663.75 \times 9.5) - \left(\frac{45 \times 9.5^2}{2}\right)$$

$$= 4275 \text{ kNm (under left point load)}$$

63. (a)

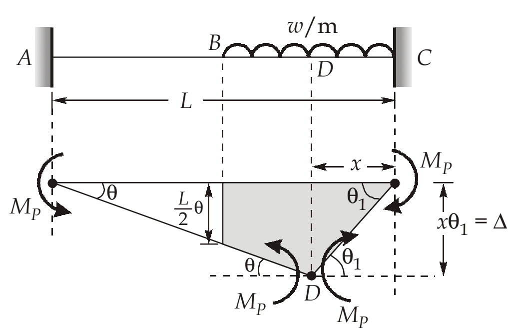
The weights of the purlins are known in advance as they are designed prior to the trusses. Since the weight of the truss is small compared to the total dead and live loads, considerable error in the assumed weight of the truss will not have a great impact on the stresses in the various members. For live load upto 2 kN/m^2, the following formula may be used to get an approximate estimate of the weight of the trusses : w = 20 + 6.6L where w is the weight of truss in N/m^2 and L is the span of the truss in m.

For welded trusses, the self weight of the truss is given by,

$$w = 53.7 + 0.53\text{A} \qquad \text{where A is the area of 1 bay}$$

64. (c)

The beam may develop plastic hinges at points A, C and D (at a distance x from support C)



$$\Delta = x\theta_1 = (L - x)\theta$$

$$\Rightarrow \quad \theta_1 = \left(\frac{L - x}{x}\right)\theta$$

External work done = Load × Area of mechanism diagram under the load.

$$W_e = w \times \left[\frac{x\theta_1 + \frac{\theta L}{2}}{2} \times \left(\frac{L}{2} - x\right) + \frac{x\theta_1}{2} \times x\right] \qquad \text{...(i)}$$

$$\text{Substitute } \theta_1 = \left(\frac{L-x}{x}\right)\theta \text{ in equation (i)}$$

$$W_e = \frac{w\theta}{8}\left(3L^2 - 4Lx\right)$$

$$\text{Internal work done} = M_P\theta + M_P(\theta+\theta_1) + M_P\theta_1$$

$$W_i = 2M_P(\theta+\theta_1) = 2M_P\left(1+\frac{L-x}{x}\right)\theta$$

$$= 2M_P\frac{L}{x}\theta$$

By the principle of virtual work

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

$$\frac{w\theta}{8}\left(3L^2 - 4Lx\right) = 2M_P\left(\frac{L}{x}\right)\theta$$

$$M_p = \frac{wx}{16}\left(3L^2 - 4Lx\right)$$

For maximum value of M_p, $\dfrac{dM_P}{dx} = 0$

$$\left(\frac{3wL^2}{16L} - \frac{8Lwx}{16L}\right) = 0$$

$$x = \frac{3}{8}L$$

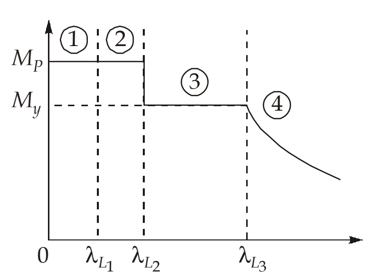
Hence,

$$M_p = \frac{w\times\frac{3L}{8}}{16L}\left(3L^2 - 4L\times\frac{3L}{8}\right)$$

$$= \frac{9}{256}wL^2$$

$$w = \frac{256}{9}\frac{M_P}{L^2} = \frac{28.44M_P}{L^2}$$

65. (c)



(1) - Plastic section

(2) - Compact section

(3) - Semi-compact section

(4) - Slender section

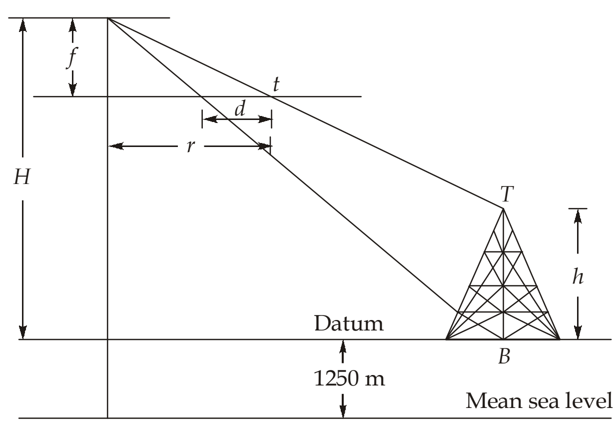
66. (d)

Both remote sensing and communication of earth is restricted only to four wave bands, namely, visible light, infrared waves, microwaves and radio waves. But radio waves are usually not used for remote sensing because their resolution is very poor due to their very long wavelengths.

67. (b)

$$\begin{aligned} M &= R\left[1-\cos\left(\frac{\Delta}{2}\right)\right] \\ &= 500\left[1-\cos\left(\frac{60^\circ}{2}\right)\right] \\ &= 500\left[1-\frac{\sqrt{3}}{2}\right] = 500(1-0.866) \\ &= 500 \times 0.134 \text{ m} \\ &= 67 \text{ m} \end{aligned}$$

68. (b)



Let H = Height of camera lens above the bottom of tower

The displacement d of the image of the top with respect to the image of the bottom is given by

$$d = \frac{hr}{H}$$

where h = height of the tower above its base = 50 m

$$H = 2500 - 1250 = 1250 \text{ m}$$

$$\therefore \quad d = \frac{50 \times 6.35}{1250} \text{ cm} = 0.254 \text{ cm} \simeq 0.25 \text{ cm}$$

69. (b)

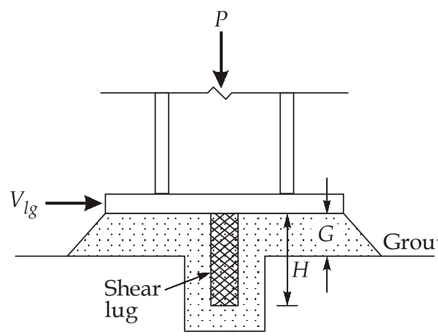
Geographic Interface System (GIS) deals with mostly two types of data i.e.

(i) Spatial data - Space and position values

(ii) Non spatial data - Graphic values and images

- Spatial databases are also known as geodata bases.

70. (b)



- When the shear force to be transmitted to the foundation from the column is high, a shear lug (a short length of a rolled I-section or a plate) is welded perpendicular to the bottom of the plate as shown in figure above. Failure occurs when a wedge of concrete shears off.

71. (d)

All the statements are correct.

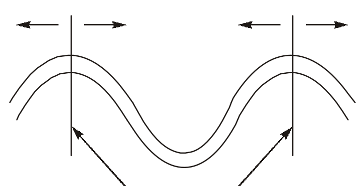
- $$1 \text{ nautical mile} = \frac{\text{Circumference of the great circle}}{360° \times 60}$$
$$= \frac{2\pi \times 6370}{360 \times 60} \text{ km} = 1.852 \text{ km}$$
- The azimuth and altitude of a star are not constant but are continuously changing due to diurnal variation.
- Spherical excess, $E = (A + B + C - 180°)$

72. (b)

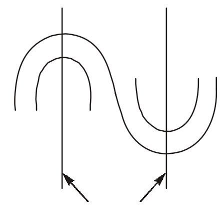
$$S = \frac{L^2}{24R}$$
$$= \frac{80 \times 80}{24 \times 120} = 2.22 \text{ m}$$

73. (c)

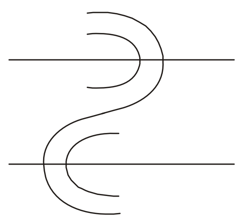
Usually, the folds have inclined limbs i.e. the limbs will be mutually diverging or converging with reference to axial planes, but in some folds, the limbs will be mutually parallel to a great extent. Such folds are called isoclinal folds. These folds may be vertical, inclined or horizontal. The horizontal isoclinal folds are called recumbent folds.



Axial planes
Normal type of fold



Axial planes
Isoclinal folds



Recumbent folds

74. (c)

The effective length of column depends on the end condition.

75. (a)

Tunneling through folded rocks results in release of stress of the rocks which causes the tunnel to cave in or bulging of sides.