Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

Part - A

I 1. Effective length - Length of Column of given length and section which has same buckling load capacity of an ideal Column of same section and material with both ends hinged. It is different for different end conditions or it is the length involved in buckling process — 2

2. It is the ratio of effective length of the column L_{eff} to the least radius of gyration — 2

$$= \frac{L_{eff}}{K_{min}}$$

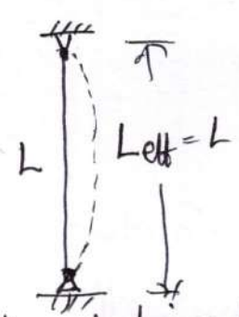
3. Core :- It is the area around C.G of c/s at which if load is applied no tension is developed any where on the column. — 2

4. Span, load, and flexural rigidity E.I. — 2

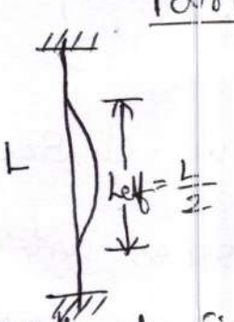
5. Stiffness - It is the moment required at one end of a member to produce a unit angle of rotation at that end — 2

Part - B

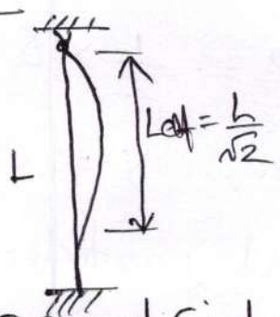
II 1.



① Both ends hinged

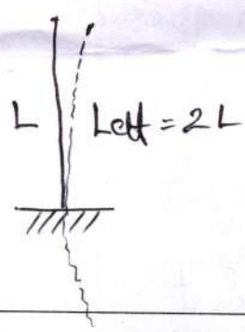


② Both ends fixed



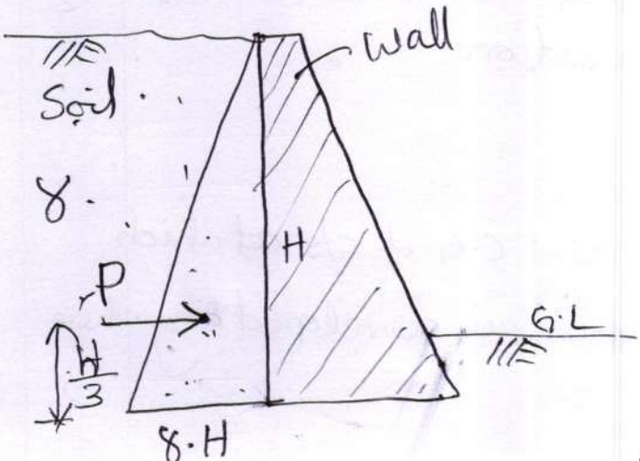
③ One end fixed and other hinged.

1½ × 4 — 6.



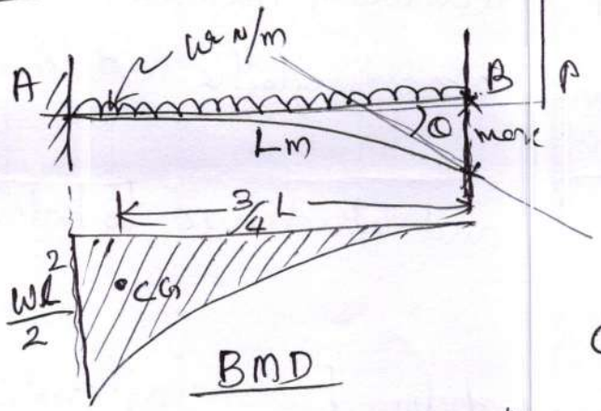
Scoring Indicators

Code : 4014 (Theory of structures II) **Version B**

Qn. No.	Scoring Indicators	Split score	Total score
3	Assumptions :- 1) Frame is a perfect structure (ie $n = 2j-3$) 2) The frame is loaded only at joints 3) The member are pin jointed at the ends. ④ Self wt. of members are neglected.	$4 \times 1\frac{1}{2}$	6
4.	 fig – 2 The soil pressure is calculated using the pressure diagram assuming it as a fluid Total pressure for one unit length = area of Pressure diagram. ie $P = \frac{1}{2} \times \gamma \cdot H \cdot H = \frac{1}{2} \gamma H^2$ — 2 where, γ = Unit wt. of soil. Since soil particles possess internal friction the total pressure available on retaining wall is reduced, which is called active earth pressure. According to Rankine the active earth pr is calculated by multiplying a constant known as Rankine's earth pr. coefficient. $K_a = \frac{1-\sin\phi}{1+\sin\phi}$; $P_a = K_a \cdot P$. — 2		6 marks

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score
5.	**Determinate str.** / **Indeterminate str.**		
	1) Can be analysed using conventional equilibrium eqns. / 1) Can not be analysed using equilibrium eqns.		
	2) Reduced Stability / 2) more stable.		
	3) Reduced stiffness / 3) Stiff		
	4) Bigger cross sections. / 4) Comparatively Smaller c/s		
	5) No temperature stresses / 5) Development of temperature stress	any four	
	6) No stress due to lack of fit / 6) chance for stress due to lack of fit.	$4 \times 1\frac{1}{2} = 6$	
	7) +ve B.M dominates / 7) mostly -ve B.M. dominates		
6.	 BMD		
	$[A = \frac{1}{3} \cdot L \cdot x]$		
	$\theta_{max} = \frac{\text{Area of BMD}}{EI}$		
	$= \frac{1}{3} \times L \times \frac{wL^2}{2}$		
	$\theta_{max} = \frac{wL^3}{6EI}$	3	
	$y_{max} = \frac{\text{moment of area about B}}{EI} = \frac{1}{3} L \frac{WL^2}{2} \times \frac{3}{4}\frac{L}{EI} = \frac{wL^4}{8EI}$	3	6 marks
	(Can be derived using double integration method also)		

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

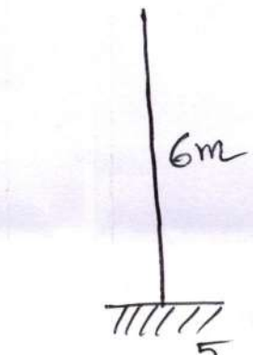
Qn. No.	Scoring Indicators	Split score	Total score
7.	① Assuming all members fixed, first find the fixing moment for all members at the ends. ② Find stiffness and distribution factors for all members w.r.t thier joints. ③ On a tabulation, arrange fixing moments using the sign Conventions. ④ Balance each joint for fixing moments Considering the distribution factor and distribute moments to various members w.r.t thier D.F values. ⑤ Carry over the applied balancing moments to far end with same sense according to the Condition of far end. ⑥ This will upset the joints and which are to balanced again ⑦ This process can be repeated by balancing and Carryover untill the balanced moments are negligibly small. ⑧ Add up all the end moments to get the final moments. ⑨ Net BMD can be made by combining free BMD and ~~fixed~~ Joint moments. 6 marks		

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

III a.



Part - C

Effective length = 2×6 = 12m. — 1

$I_{min} = \frac{\pi \times 160^4}{64} = 4,906,250$ — 1

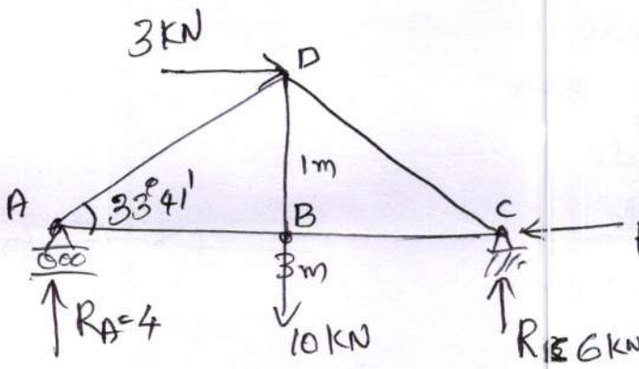
$P_b = \frac{\pi^2 \cdot E \cdot I}{(Leff)^2}$ — eqn: — 1

$= \frac{3.14^2 \times 2\times10^5 \times 4,906,250}{(12\times1000)^2}$

$= 67.185$ kN — 3

6 mark

b.



$\tan\theta = \frac{1}{1.5}$

$\theta = 33°41'$

[At Roller Support only Vertical Reaction]

$\Sigma H = 0 \Rightarrow 3KN = R_{CH}$

Taking moments about A

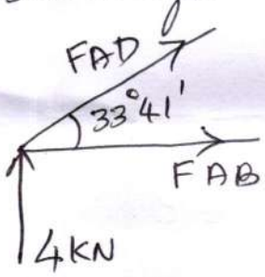
$3\times1 + 10\times1.5 = R_C \times 2$

$R_C = 6$ kN.

$\therefore R_A = 4$ kN

Reactions. → 4

Consider equilibrium of Joint A



$\Sigma H = 0$

$F_{AB} + F_{AD}\cdot\cos 33°41' = 0$

$\Sigma V = 0$

$4 + F_{AD}\sin 33°41' = 0$

$\therefore F_{AD} = -7.21$ kN (Compressive)

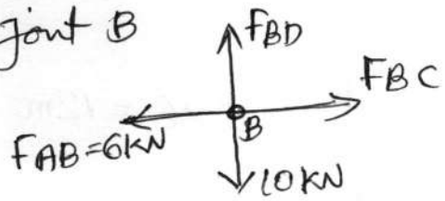
$F_{AB} = 6$ kN (Tensile)

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

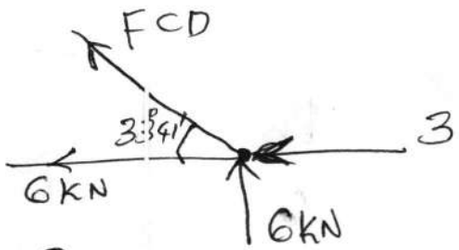
Consider joint B



$F_{BC} = 6\,KN$

$F_{BD} = 10\,KN$.

Joint C



$3 + 6 + F_{CD}\cos 33^\circ 41' = 0$

$9 = -F_{CD}\cos 33^\circ 41'$

$F_{CD} = \dfrac{-9}{\cos 33^\circ 41'} = \underline{\underline{-10.81\,KN}}$.

$F_{AB} = 6\,KN$ Tensile

$F_{AD} = 7.21\,KN$ Compressive

$F_{BC} = 6\,KN$ Tensile

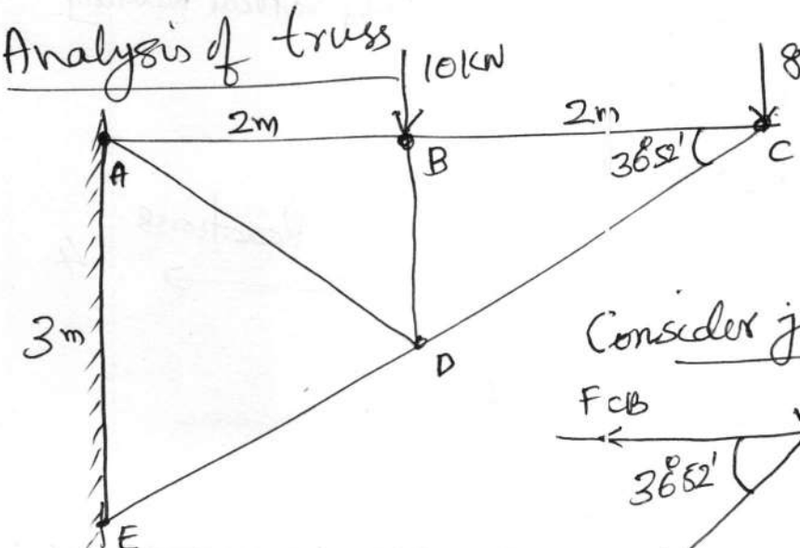
$F_{BD} = 10\,KN$ Tensile

$F_{CD} = 10.81$ Compressive

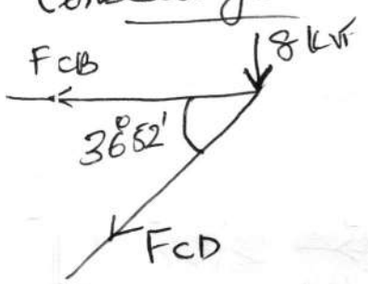
→ 5 marks 9 marks

IV

Analysis of truss



Consider joint C



$\Sigma H = 0 \Rightarrow$

$F_{CB} + F_{CD}\cdot\cos 36^\circ 52' = 0$

$\Sigma V = 0 \Rightarrow 8 + F_{CD}\sin 36^\circ 52' = 0$

$\therefore F_{CD} = -13.33\,KN$ (Compressi)

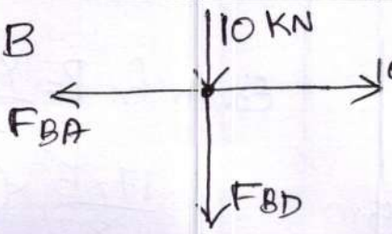
$F_{BC} = +10.66\,KN$ (Tensile)

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

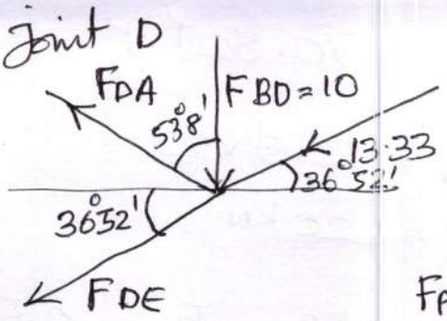
Consider Joint B



$F_{BA} = +10.66$ KN.

$F_{BD} = -10$ KN.

Consider Joint D



$\Sigma H = 0$

$F_{AD} \times \sin 53°8' + F_{ED} \cos 36°52' + 13.33 \times \cos 36°52' = 0$

$F_{AD} \times \cos 53°8' = 10 + 13.33 \times \sin 36°52' + F_{DE} \times \sin 36°52'$

$\sigma_t = 50 N/mm^2$

$\sigma_c = 30 N/mm^2$

Solving the two equations

$F_{AD} = +8.34$ KN

$F_{DE} = -21.66$ KN.

	Force	Nature	Area required.
F_{BC}	+10.66 kN	Tension	$A = \frac{F}{\sigma} = 213.2\ mm^2$
F_{CD}	-13.33 kN	Compression	$444.3\ mm^2$
F_{BA}	+10.66 kN	Tension	$213.2\ mm^2$
F_{BD}	-10 kN	Compression	$333.33\ mm^2$
F_{AD}	+8.34 kN	Tension	$166.8\ mm^2$
F_{DE}	-21.66 kN	Compression	$722\ mm^2$

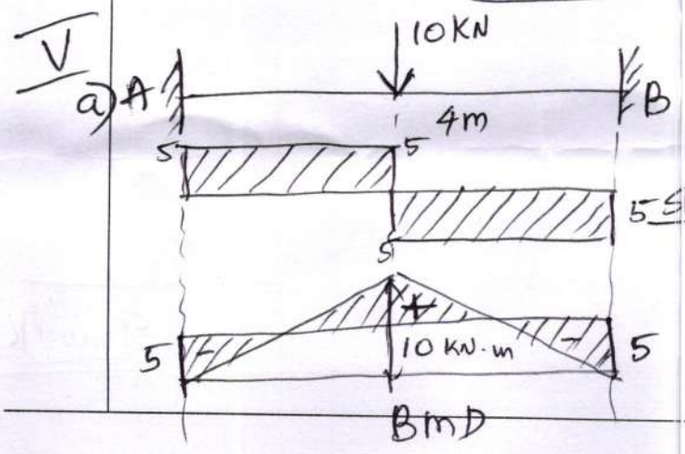
6 × 2 Analysis 12 marks

6 × ½ Area 3 marks

15 marks

V

a)



$M_A = M_B = \frac{WL}{8} = \frac{10 \times 4}{8} = 5$ KN.m — 2 mark

Free BM $= \frac{WL}{4} = 10$ KN.m — 2

SF at A, B $= \frac{10}{2} = 5$ kN — 2

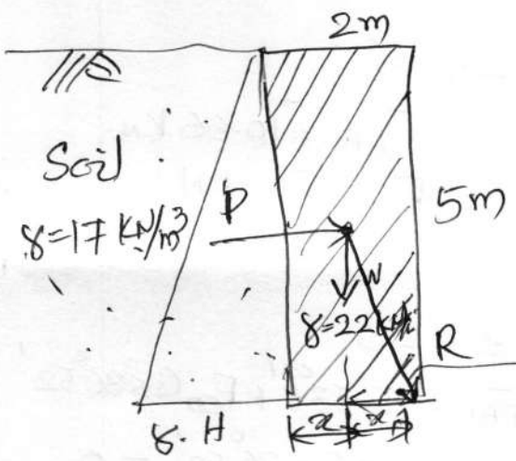
6 marks

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

V b)



Earth pr $P = \frac{\gamma h^2}{2} \times \left(\frac{1-\sin\phi}{1+\sin\phi}\right)$

$= \frac{17 \times 5^2}{2} \times \left(\frac{1-\sin 30}{1+\sin 30}\right)$

$P = 70.82\ kN$

$W = 2 \times 5 \times 22 =$

$= 220\ kN$

$x = 1m$

$x^1 = \frac{P}{W} \times \frac{b}{3} = \frac{70.82}{220} \times \frac{5}{3} = 0.536m$

$e = (x + x_1) - \frac{b}{2}$

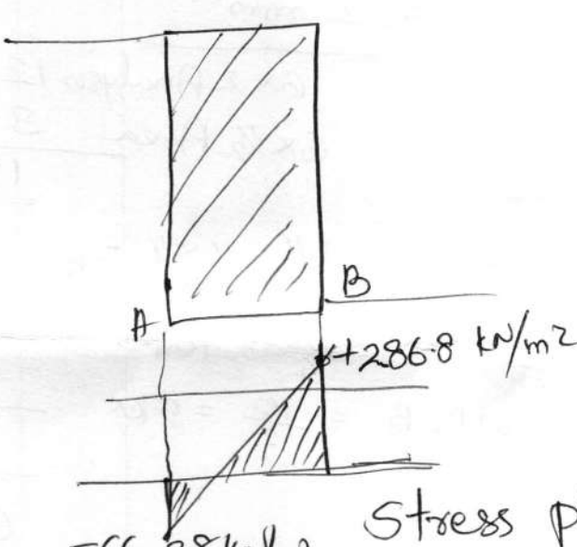
$(1 + 0.536) - 1 \quad = 0.536\ m$ — 2 mark.

$\sigma_{max} = \frac{W}{b}\left[1 + \frac{6e}{b}\right] = \frac{220}{2}\left[1 + \frac{6 \times 0.536}{2}\right]$ — 2 mark

$= 286.8\ kN/m^2$

$\sigma_{min} = \frac{W}{b}\left[1 - \frac{6e}{b}\right] = -66.88\ kN/m^2$

Tension. — 2 mark.



Stress plot.

Plot. — 3

9 mark.

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

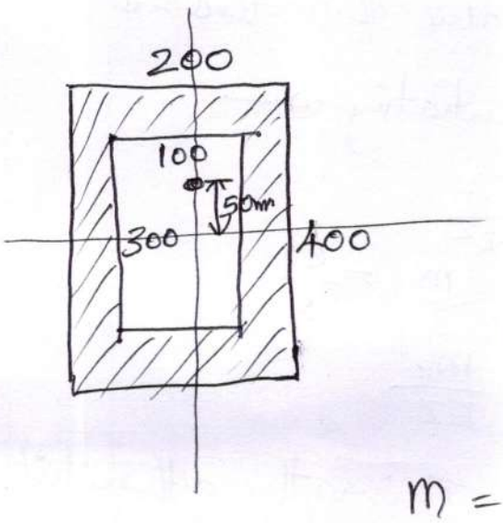
Qn. No.	Scoring Indicators	Split score	Total score

VI a) Stability Conditions of gravity dam.

1) Stability against over turning
2) " " sliding
3) " " Tension
4) " " Crushing.

Explanation of each point in few sentences $4 \times 1\frac{1}{2} = 6$ marks

b)



$$I = \frac{200 \times 400^3}{12} - \frac{100 \times 300^3}{12}$$

$$= 841.66 \times 10^6 \text{ mm}^4 \quad -1$$

$$A = (400 \times 200) - (300 \times 100)$$

$$= 50000 \text{ mm}^2$$

$$m = P \times e = 120 \times 1000 \times 50$$

$$= 6000000$$

$$= 6 \times 10^6 \text{ N.mm}.$$

$$\text{Direct stress} = \frac{P}{A} = \frac{120 \times 1000}{50000} = 2.4 \text{ N/mm}^2 \quad -1$$

$$\text{Bending stress} = \frac{m}{I} \times y_{max} = \frac{6 \times 10^6}{841.66 \times 10^6} \times 200 = 1.425 \text{ N/mm}^2 \quad -1$$

maximum stress $= 2.4 + 1.425 = 3.825 \text{ N/mm}^2 \quad -3$

minimum stress $= 2.4 - 1.425 = 0.975 \text{ N/mm}^2 \quad -3$

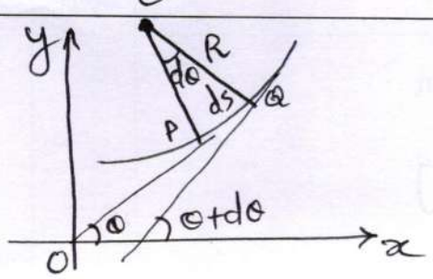
9 marks

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

VII a)



Consider a small portion PQ of elastic curve

Let C – centre of curvature.
R – Radius of curvature.
ds = arc length.
θ = Angle made by tangent at P.
θ+dθ = " " tangent at Q

$ds = R \cdot d\theta$; $\frac{1}{R} = \frac{d\theta}{ds} \approx \frac{d\theta}{dx}$

But $\frac{dy}{dx} = \tan\theta$ for small value of θ $\tan\theta = \theta$

$\theta = \frac{dy}{dx}$ differentiating

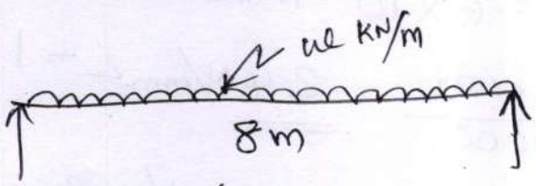
$\frac{d\theta}{dx} = \frac{d^2y}{dx^2}$; $\frac{1}{R} = \frac{d^2y}{dx^2}$

By pure Bending equation $\frac{m}{I} = \frac{E}{R}$

$\frac{1}{R} = \frac{mx}{EI}$; $\frac{d^2y}{dx^2} = \frac{mx}{EI}$

$EI\frac{d^2y}{dx^2} = mx$ — This is the differential equation — 6 marks.

b)



$E = 8 \times 10^4$ N/mm²

$I = \frac{200 \times 300^3}{12} = 450 \times 10^6$ mm⁴ — 1

deflection due to UDL $= \frac{5 \cdot wl^4}{384 E \cdot I}$ — 2

$3mm = \frac{5 \times w \times (8000)^4}{384 \times 8 \times 10^4 \times 450 \times 10^6}$

$w = 2.025$ N/mm — 6 mark.

$w = 2.025$ KN/m.

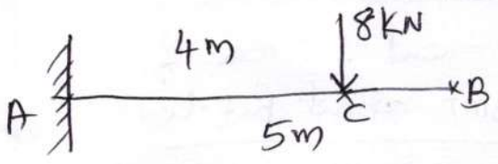
9 mal.

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

VIII a.



$$I = \frac{\pi}{64} \times 300^4$$

$$= 397.4 \times 10^6 \text{ mm}^4 \quad — 1$$

maximum deflection is developed at point B.

$$y_{max} = \text{defection at } C + \text{Slope} \times \bar{CB} \quad — 2$$

$$= \frac{Wa^3}{3EI} + \frac{Wa^2}{2EI}(l-a)$$

$$= \frac{8 \times 1000 \times 4000^3}{3 \times 8 \times 10^4 \times 397.4 \times 10^6} + \frac{8000 \times 4000^2 (5000-4000)}{2 \times 8 \times 10^4 \times 397.4 \times 10^6}$$

$$5.368 + 2.013 = \underline{\underline{7.38 \text{ m}}} \quad — 3$$

6 marks

b)

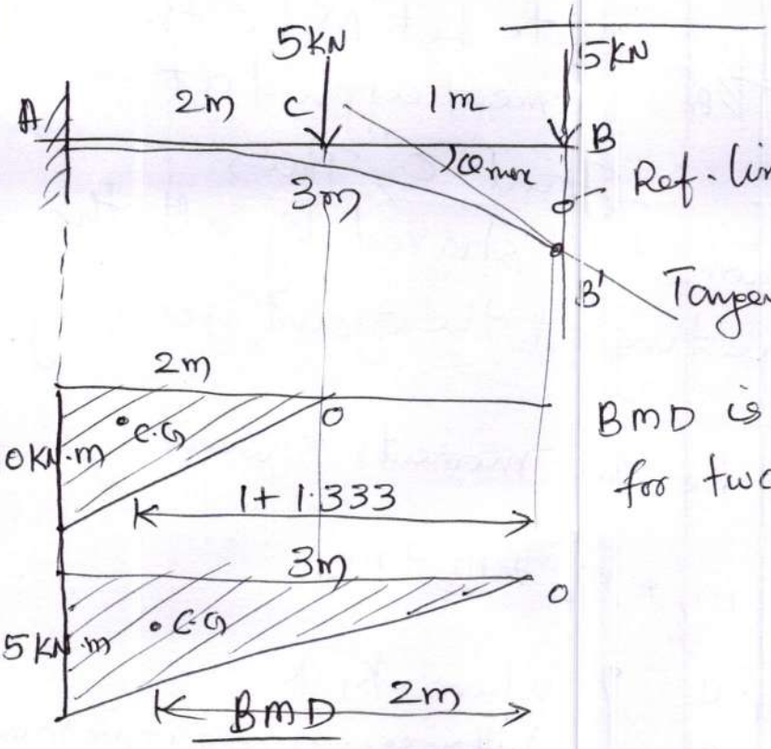


fig — 1 mark

BMD is drawn Separately for two loads.

BMD — 2 mark.

$$\text{max slope at } B' = \frac{\text{area of BMD}}{EI}$$

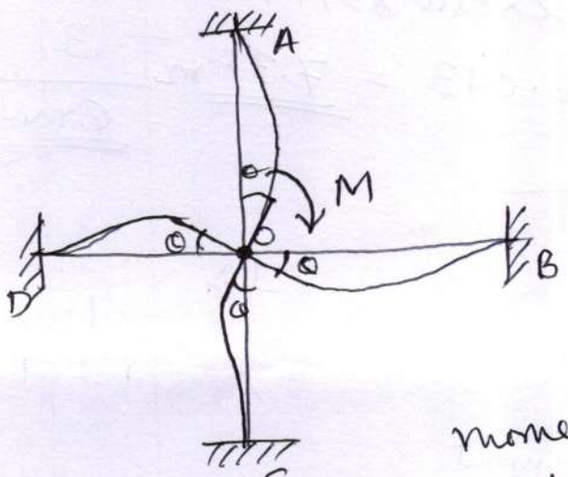
$$= \frac{\frac{1}{2} \times 2 \times 10 + \frac{1}{2} \times 3 \times 15}{EI}$$

$$\theta_B = \frac{32.5}{EI} \text{ rad} \quad — 3 \text{ mark}$$

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score
	max. deflection is at B' = moment of area of BMD about Ref. line $= \frac{1}{2}\times 2\times 10\times 2.33 + \frac{1}{2}\times 3\times 15\times 2$ (EI) $y_{max} = \frac{68.33}{EI}$	3 mark	9 mark.
IX a	Distribution factor (D.F)		



Consider a rigid joint 'O' where four members meet. Let 'M' be the moment applied at joint 'O'. This moment is shared by all the four members meeting at the joint according to thier stiffness.

Let $m_1, m_2, m_3 \cdots$ be the moments shared by members,

then $M = m_1 + m_2 + m_3 + m_4 \cdots$

But $m_1 = k_1 \cdot \theta$
$m_2 = k_2 \theta$
$m_3 = k_3 \cdot \theta$
$m_4 = k_4 \cdot \theta$

where $k_1, k_2, \cdots$ stiffnesses of respective members

Due to rigidity at joint θ is same for all members.

$$M = m_1 + m_2 + m_3 + \cdots$$
$$= k_1\theta + k_2\theta + k_3\theta + \cdots$$
$$= \theta (k_1 + k_2 + k_3 + \cdots)$$

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

By definition of first member $D.F = \frac{m_1}{M}$

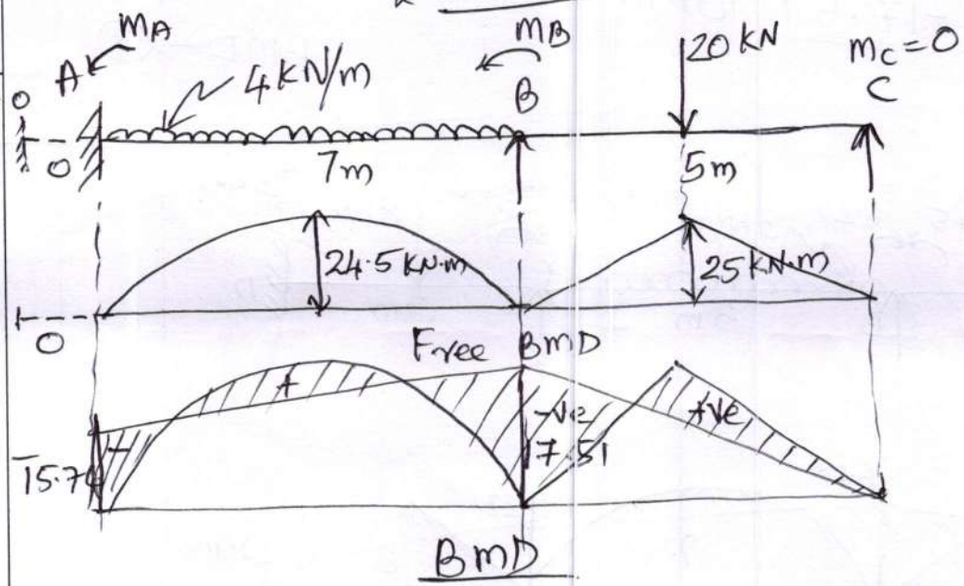
generally, $DF = \frac{M_i}{M}$

$= \frac{k_i \cdot \theta}{\theta(k_1+k_2+k_3+\cdots)}$

fig – 2
Derivation – 3
equation – 1
6 mark

$$DF = \frac{k_i}{\sum k_i}$$

IX a b



→ (2)

Applying theorem of three moments

$$m_A \cdot L_1 + 2m_B(L_1+L_2) + m_C L_2 = -\frac{6a_1x_1}{L_1} - \frac{6a_2x_2}{L_2} \quad (1)$$

Consider a zero span to the left of support A

Taking two consecutive spans in clapeyron's theorem.

$$m_0 L_0 + 2m_A(0+7) + m_B \times 7 = -\frac{6 \times \frac{2}{3} \times 7 \times 24.5 \times 3.5}{7}$$

$$= 0 - 6 \times \frac{2}{3} \times 7 \times 24.5 \times 3.5$$

$$14m_A + 7m_B = -343$$

$$14m_A + 7m_B = -4343 \quad (I)$$

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

Now Consider Spans AB and BC

$$m_A \times 7 + 2m_B(7+5) + 0 = -6 \times \frac{2}{3} \times \frac{7 \times 24.5}{7} \times 3.5 - 6 \times \frac{1}{2} \times \frac{5 \times 25}{5} \times 2.5$$

$$7 \cdot m_A + 24\, m_B = -343 - 187.5$$

$$7m_A + 24m_B = -530.5 \quad \text{— (II)}$$

$$14\, m_A + 7\, m_B = -343 \quad \text{— (I)}$$

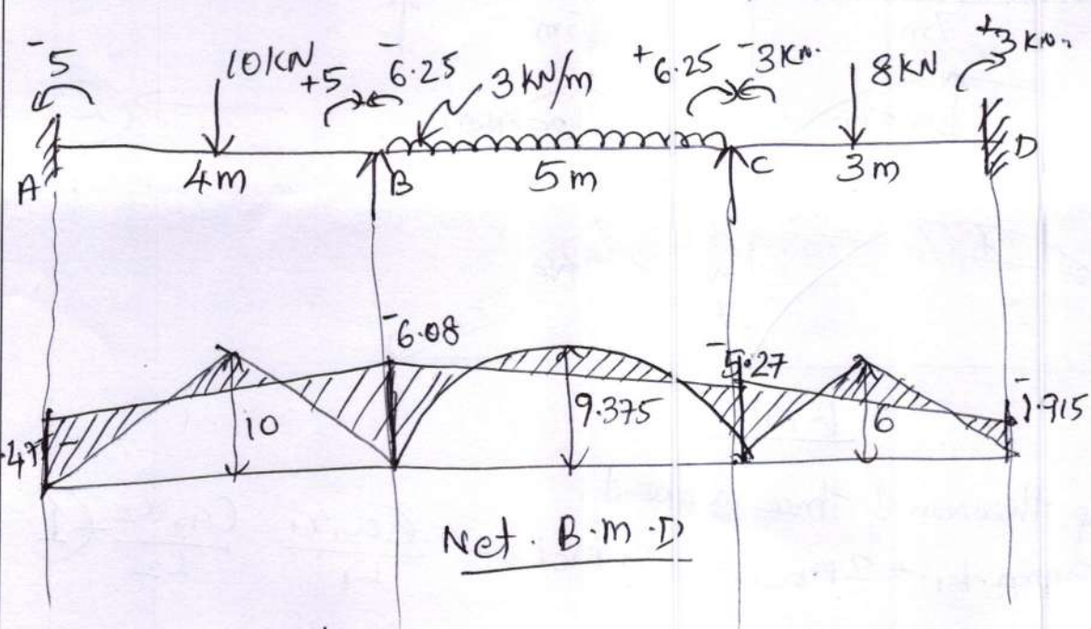
$m_A = -15.74$ kN·m → (3)

$m_B = -17.51$ kN·m

BMD → (3)

9 marks

X a)



Net B.M.D

Fixing moments

$$Fm_{AB} = \frac{10 \times 4}{8} = 5 \text{ kN·m}$$

$$Fm_{BC} = \frac{3 \times 5^2}{12} = 6.25 \text{ kN·m}$$

$$Fm_{CD} = \frac{8 \times 3}{8} = 3 \text{ kN·m}$$

Stiffness k for AB

$$K_{BA} = \frac{4 \cdot EI}{4} = EI$$

$$K_{BC} = \frac{4\, EI}{5} = \frac{4}{5} EI$$

Scoring Indicators

Code : 4014 (Theory of structures II) **Version:B**

Qn. No.	Scoring Indicators	Split score	Total score

Distribution factor for BA $= \frac{EI}{EI(1+\frac{4}{5})} = \frac{5}{9} = 0.56$

for BC $= \frac{\frac{4}{5}EI}{EI(1+\frac{4}{5})} = \frac{4}{9} = 0.44$

$K_{CB} = \frac{4EI}{5}$ $K_{CD} = \frac{4EI}{3}$

D.F for CB $= \frac{\frac{4}{5}EI}{EI(\frac{4}{5}+\frac{4}{3})} = 0.375 \approx 0.38$

DF for CD $= \frac{4}{3}EI / EI(\frac{4}{5}+\frac{4}{3}) = 0.625 \approx 0.62$

	0.56	0.44	0.38	0.62	
−5	+5	−6.25	+6.25	−3	+3
	+0.7	+0.55	−1.235	2.015	
+0.35	0	−0.62	+0.275		−1.0
	+0.35	+0.27	−0.105	−0.17	
+0.175	0	−0.05	+0.135	0	−0.085
	+0.028	+0.022	−0.051	−0.084	
−4.475	+6.08	−6.08	+5.269	−5.269	+1.915

Final end moments.

DF → 4

Tabulation → 6

BMD → 5

15 marks.