CBCS SCHEME

18CV42

USN

Fourth Semester B.E. Degree Examination, July/August 2022
Analysis of Determinate Structures

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Explain with examples statically determinate and indeterminate structures. (08 Marks)
b. Find the Static and Kinematic indeteminacies of the following structures.

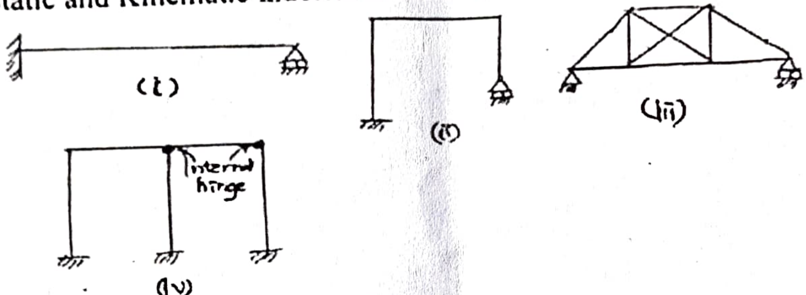


Fig.Q1(b) (12 Marks)

OR

2 a. What do you mean by influence line diagram and state its applications. (08 Marks)
b. Draw ILD for
(i) Reactions at supports of a simply supported beam.
(ii) Shear force of a simply supported beam carrying concentrated unit load. (12 Marks)

Module-2

3 a. Two point loads 4 kN and 6 kN spaced 6m apart cross a girder of 16m span, the 4 kN load, leading from left to right. Construct the maximum SF and BM diagrams stating the absolute maximum values. [Fig.Q3(a)].

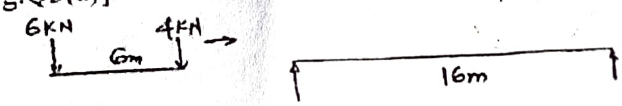


Fig.Q3(a) (10 Marks)

b. Draw the influence line for SF and BM at a section 5m from the left hand support of a simply supported beam 25m span. Hence calculate maximum shear force and BM at this section due to uniformly distributed load of 1 kN/m, 8m long. [Refer Fig.Q3(b)]

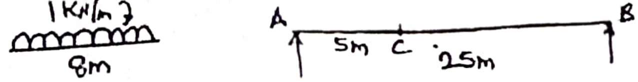


Fig.Q3(b) (10 Marks)

OR

4 A simply supported beam of span 20m is subjected to a set of loads of magnitude of 20 kN, 30 kN, 15 kN and 10 kN spaced as shown with 10 kN leading. Determine the maximum BM at a section 5m from the left end and also the absolute maximum BM developed in the beam. [Refer Fig.Q4] (20 Marks)

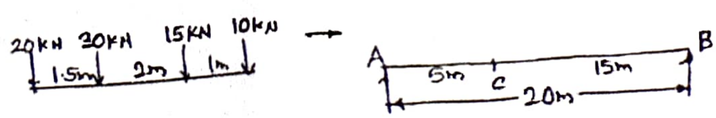


Fig.Q4

Module-3

5 a. Determine the slope and deflection at the free end of a cantilever beam loaded as shown in the Fig.Q5(a). Take $EI = 4\times10^5$ kNm^2. Use moment area method.

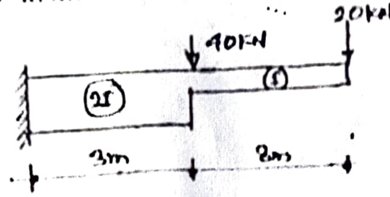


Fig.Q5(a)

10
(10 Marks)

b. Determine the slope at C and deflection at D of a simply supported beam shown in Fig.Q5(b). Take E = 200 GPa, $I = 2\times10^6$ mm^4. Use conjugate beam method. 10 (10 Marks)

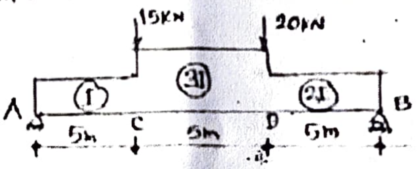


Fig.Q5(b)

OR

6 a. Determine the slope at the supports and deflection at the centre of a simply supported beam with a point load W at its mid span. Use moment area method. (10 Marks)

b. Determine the slope at the supports and deflection at the centre of a simply supported beam with uniformly distributed load of W/m over the entire span. Use moment area method. (10 Marks)

Module-4

7 a. Derive the expression for strain energy stored in an prismatic element subjected to pure bending moment. (08 Marks)

b. Determine the vertical deflection at C of a bent frame shown in the Fig.Q7(b). Use Castigliano's approach. Take E = 200 GPa, $I = 80\times10^7$ mm^4.

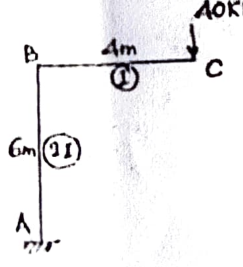


Fig.Q7(b)

6/12

(12 Marks)

OR

8 Determine the vertical and horizontal deflection of the point C, of the pin jointed frame shown in Fig.Q8. The cross sectional area of AB = 100 sqmm and BC and AC are 150 sqmm. Take $E = 2\times10^5$ N/mm^2.

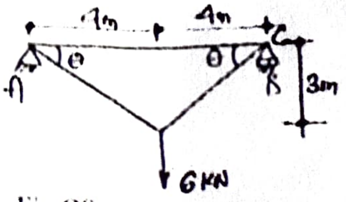


Fig.Q8

(20 Marks)

Module-5

9 A three hinged parabolic arch of 20m span with 4m central rise carries a point load of 4kN at 4m horizontally from the left hinge. Calculate the normal thrust and radial shear at a section just after the load. Also calculate the maximum positive and negative BM. Sketch BMD.
(20 Marks)

OR

10 A cable is of uniform section is suspended between two supports 100m apart. It carries a uniformly distributed load of 10 kN/m spread over the horizontal span. Find
(i) Maximum and minimum tension in the cable.
(ii) Minimum cross sectional area of the cable required if the allowable stress is 300 MPa.
(iii) Length of the cable.
(20 Marks)

*****

Sub: Analysis of Determinate Structures (18CV42)

July / August - 2022.

Q1 (a) Statically Determinate Structure :

A structure said to be statically determinate when the forces & bending moments are determined by static equilibrium equations. Ideally in this case if support is removed, the structure collapses.

Ex : ① Cantilever beam.

② Simply supported beam.

③ Three hinged arch.

(b) Indeterminate Structure :

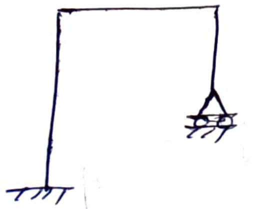
These structure contain some extra unknown forces and equilibrium conditions are not sufficient to determine forces. Thus equilibrium equations are to be supplemented by equation of compatibility of displacement.

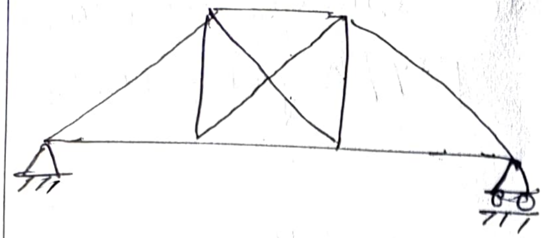
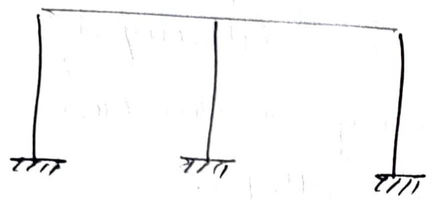
Ex : ① propped cantilever beam

② fixed beam

③ portal frames.

(B).

	Static	Kinematic.
	01.	02.
	01	08

	Static	Kinematic
	01.	09.
	06.	09.

2 (a). Influence line: Is a curve showing the variation of any resultant action, shear, bending moment, deflection or slope at a particular point in a structure under the influence of a unit load that rolls across span.

Its applications:

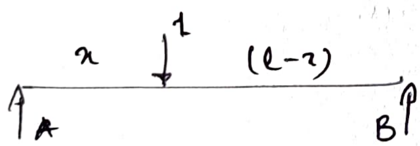
(i) Can be used all types of loads.

(ii) For designing can use max value of SF & BM

(iii) Suitable for both stationary & moving loads

(iv) Shear stress reversal in panels can be assessed in truss.

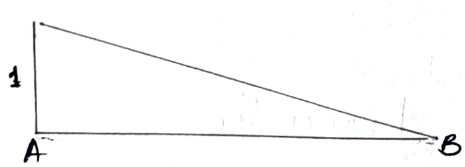
(b)



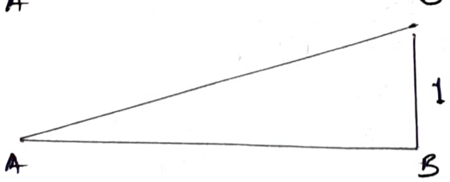
Reactions:

$\Sigma V = 0 \quad V_A + V_B = 1.$

$\Sigma M_A = 0 \quad V_B = x/L \quad V_A = 1 - x/L$

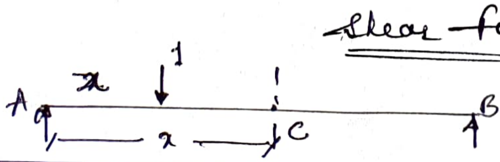


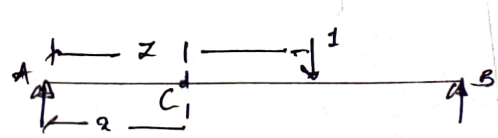
← ILD for V_A.



← ILD for V_B.

Shear force





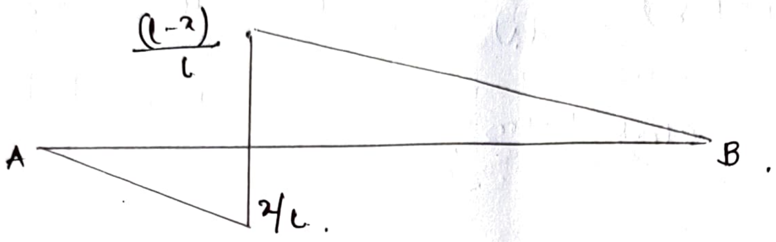
$V_B = -x/L$ $\quad z = 0 \quad SF = 0$ $\quad$ (i) $0 < z < x$

$z = x \quad SF = -x/L$

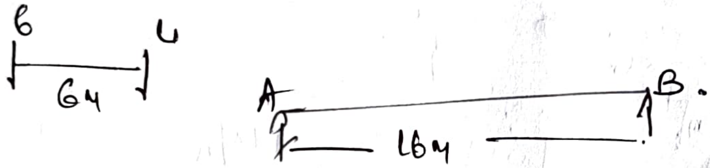
(ii) $x < z < L$

$V_A = \frac{1(l-x)}{L} \quad z = x \quad SF = (l-x)/L$

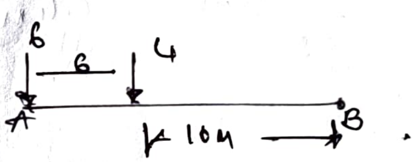
$z = L \quad SF = 0$



3(a)



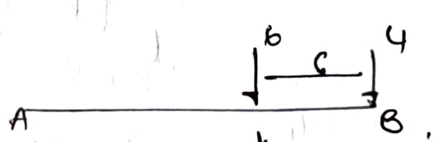
-ve shear force diagram



$R_B = \frac{4 \times 6}{16} = 1.5$

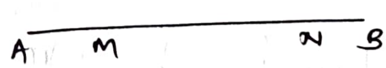
$R_B = \frac{6 \times 10 + 4 \times 16}{16} = 7.75$

Max +ve shear

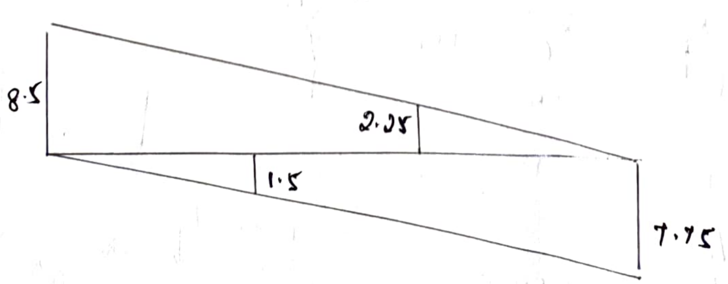


$R_A = \frac{6 \times 6}{16} = 2.25$

$R_A = \frac{4 \times 10 + 6 \times 16}{16} = 8.5$



For BM



$AM = \frac{6 \times 6}{6+4} = 3.6m$

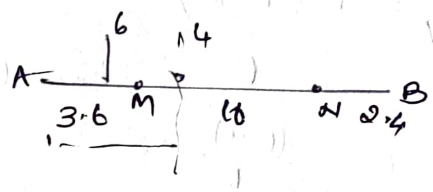
$NB = \frac{4 \times 6}{6+4} = 2.4m$

$MN = 16 - 3.6 - 2.4 = 10m.$

(i) case 1 $\frac{1}{2}(AB - AM) = x = 9.8m.$

$R_B = (4 \times 9.8 + 6 \times 3.8)/16 = 3.875$ kN, $M = 24$ kNm

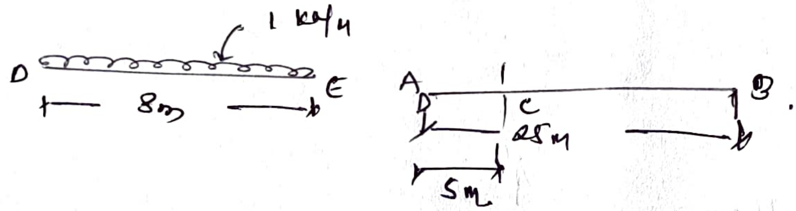
(ii) $x_1 = 6.8$ m from A.



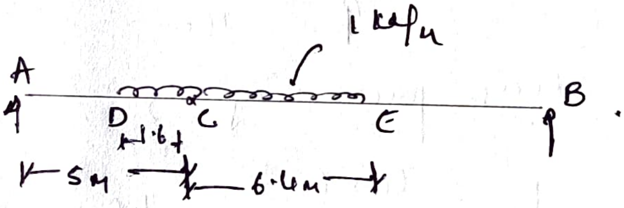
$R_B = \frac{(6 \times 0.6 + 4 \times 6.8)}{16} = 2kN$

$M_{max} = 2 \times 12.4 = 24.8$ kNm.

3 (b)



$CF = \frac{8 \times}{25} \times 20 = 6.4m$



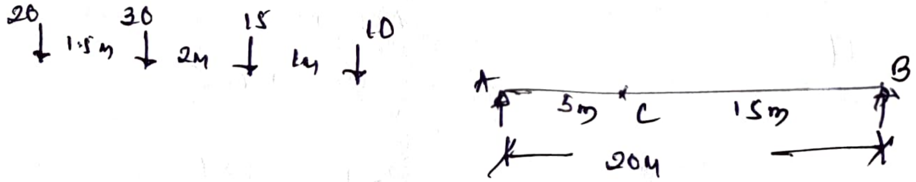
when $x = a$ $V_{max} = \frac{-wa^2}{2L} = -\frac{1 \times 8^2}{2 \times 25} = 1.28$ kN.

$x = L$ $V_{max} = \frac{-wa}{L}\left(L - \frac{a}{2}\right) = -\frac{1 \times 8}{25}\left(25 - \frac{8}{2}\right) = 6.72.$

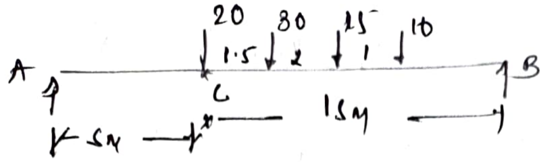
$R_B = \frac{1 \times 8 \times 7.4}{25} = 2.37$ kN.

$M_{max} = 2.37 \times 20 - 1 \times 6.4^2/2 = 26.92$ kNm

(A)



Load	(R_1)	(R_2)	Remark
10	65/5	10/15	
35	50/5 = 10	25/15	→ 1.67
30	20/5 = 4	55/15	→ 3.67



$V_A = (10 \times 10.5 + 15 \times 11.5 + 30 \times 13.5 + 20 \times 15)/20$

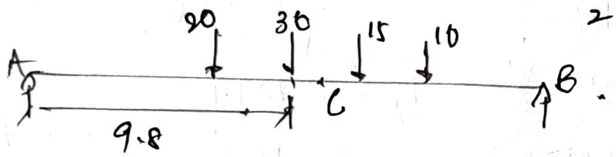
$\therefore V_A = 49.125$ kN.

$M_C = 245.62$ kNm

Absoulte BM

$\bar{x}$ from 20 $= \dfrac{30 \times 1.5 + 15 \times 3.5 + 10 \times 4.5}{20+30+15+10} = 1.9$

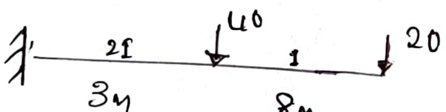
Distance of 30 kN from 'A' $= \dfrac{20}{2} - \tfrac{1}{2}(1.9 - 1.5) = 9.8$ m



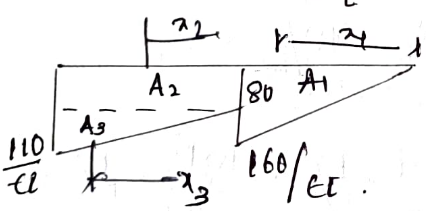
$V_A = \dfrac{10 \times 7.2 + 15 \times 8.2 + 30 \times 10.2 + 20 \times 11.7}{20} = 33.51$ kN.

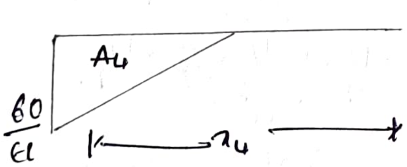
$M_C = 33.51 \times 10.8 - 20 \times 1.5 - 30 \times 0.2 = 295.1$ kNm

5 (a).



$EI = 4 \times 10^5$ kNm^2.



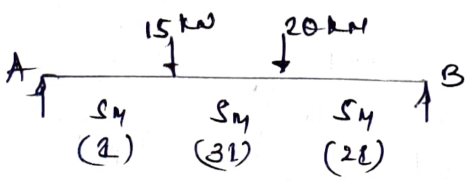


$A_1 = 640$	$x_1 = 5.33$	$= 3413$
$A_2 = 240$	$x_2 = 9.5$	$= 2280$
$A_3 = 45$	$x_3 = 10$	$= 450$
$A_4 = 90$	$x_4 = 10$	$= 900$
$1015/EI$		$7043/EI$

$\theta = \dfrac{1015}{4 \times 10^5} = 2.53$

$\Delta = \dfrac{7043}{4 \times 10^5} = 1.76$.

(b)

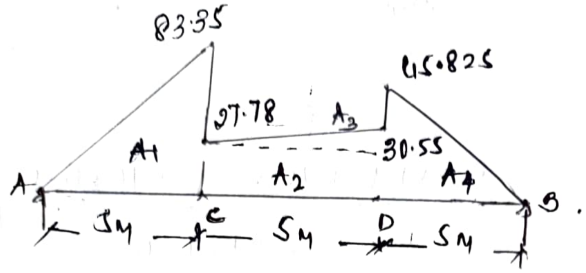


$E = 200$ GPa

$I = 2 \times 10^6$ mm^4

$R_B = \frac{15\times5 + 20\times10.}{15} = 18.33$, $R_A = 16.67$

$M_C = 16.67\times5 = 83.35$ & $M_D = 18.33\times5 = 91.65$



$A_1 = 208.37 \times 11.67 = 2431.7$

$A_2 = 138.90 \times 7.5 = 1041.75$

$A_3 = 6.925 \times 6.67 = 46.19$

$A_4 = \frac{114.56 \times 3.33}{488.76} = \frac{381.48}{3901.12}$

$\theta_C = 260.07 - 208.37 = \frac{51.63}{EI}$

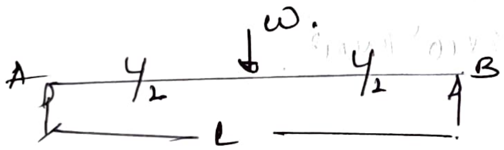
$R_A = \frac{3901.12}{15} = 260.07.$

$\Delta_D = 208.76\times5 - 381.48 = \frac{662.32}{EI}$

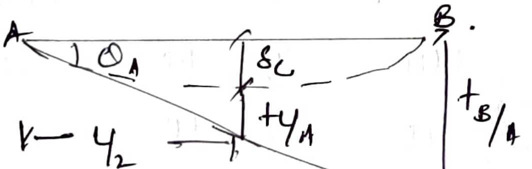
$R_B = 208.76.$

$\Delta_D = \frac{662.32\times10^9}{200\times2\times10^6} = 1.655.$

6 (a)

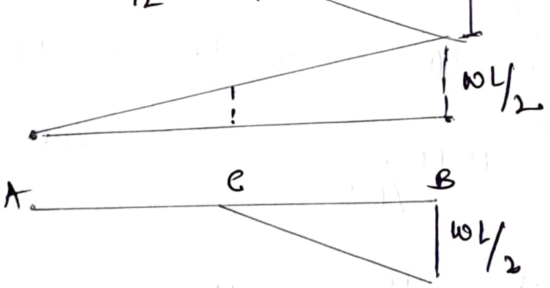


$R_A = R_B = W/2$



$t_{B/A} = \frac{WL}{2}\times L/3 = \frac{Wl^2}{6EI}\times l/2$

$- \frac{1}{2}\times l/2 \times Wl/2 \cdot l/3 \times l/2$



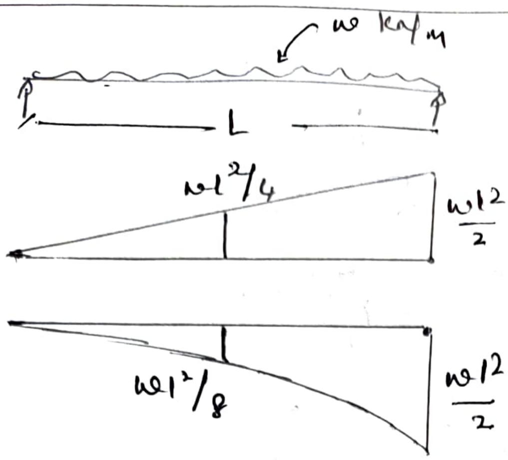
$t_{B/A} = \frac{Wl^3}{12} - \frac{Wl^3}{48} = \frac{Wl^3}{16EI}$

$\theta_A = \frac{Wl^3/16}{L} = \frac{Wl^2}{16EI}$

$t_{C/A} = \frac{1}{2}\times l/2 \times \frac{Wl}{4} = \frac{Wl^2}{16EI}\times l/3 \times l/2 = \frac{Wl^3}{96}$

$\delta_C = \left(\frac{Wl^2}{16}\times l/2 - Wl^3/96\right) = 2Wl^3/96EI = \frac{Wl^3}{48EI}$

6(B)



$R_A = R_B = wl/2$.

$t_{B/A} = \frac{1}{2} \times l \times \frac{wl^2}{2} - \frac{1}{3} \cdot l \times wl^2/2$

$= \left(\frac{wl^3}{4}\right) l/3 - \frac{wl^3}{6} \cdot (l/4)$

$t_{B/A} = \frac{wl^4}{24EI}$ //

$\theta_A = \frac{wl^4/24EI}{L} = \frac{wl^3}{24EI}$

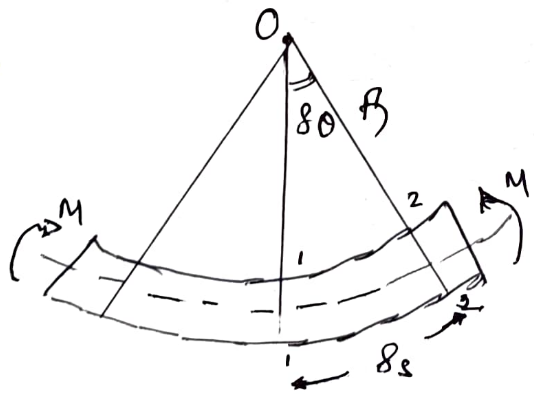
$t_{C/A} = \left(\frac{1}{2} \times \frac{l}{2} \times \frac{wl^2}{4}\right) \cdot \frac{l}{3 \times 2} - \left(\frac{l}{3} \times \frac{l}{2} \times \frac{wl^2}{8}\right) \cdot \left(\frac{l}{4} \times \frac{l}{2}\right)$

$= \frac{wl^4}{96EI} - \frac{wl^4}{384EI} = \frac{3wl^4}{384EI}$.

$\delta_c = \theta_A \cdot l/2 - t_{C/A} \Rightarrow \frac{wl^3}{24EI} \times l/2 - \frac{3wl^4}{384EI} = \frac{5wl^4}{384EI}$ //

Module - 4.

7a.



$\delta U_b = \frac{1}{2} M \cdot \delta\theta$.

from fig $R\delta\theta = \delta s$.

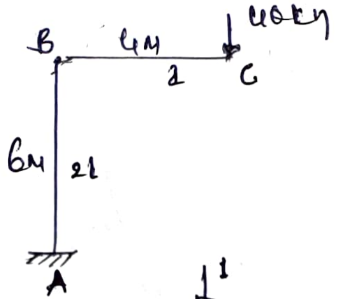
$\therefore \delta U_b = \frac{1}{2} M \cdot \frac{\delta s}{R}$.

from theory of bending

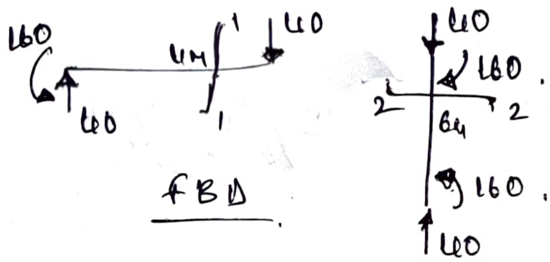
$\frac{M}{I} = \frac{E}{R} = \frac{f}{y} \Rightarrow \frac{1}{R} = \frac{M}{EI}$ //

$\delta U_b = \frac{1}{2} M \cdot \frac{M}{EI} \delta s \Rightarrow U_b = \int \frac{M^2}{2EI} \delta s$.

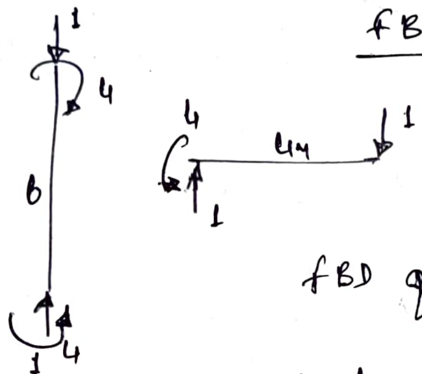
7(b)



$E = 200$ GPa $I = 80 \times 10^7$ mm^4.



FBD



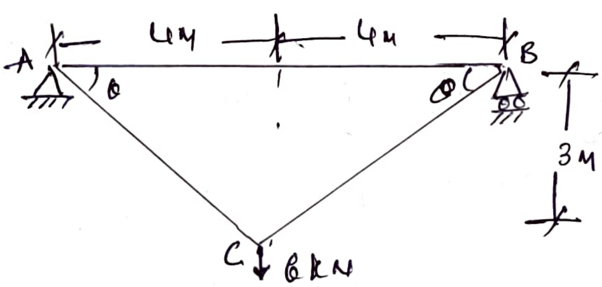
FBD of vertical unit load.

Member	Origin	Limit	M	m	I
BC	C	0–4	−40x	−x	I
AB	B	0–6	−160	−4	2I

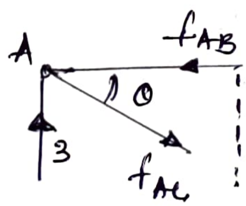
$$\Delta = \int \frac{M \cdot m \cdot dx}{EI} = \int_0^4 \frac{(-40x)\,(-x)}{EI} + \int_0^6 \frac{-160 \times -4}{2EI}.$$

$$\Delta = \frac{40}{EI}\frac{x^3}{3}\Big|_0^4 + 320\,[x]_0^6 \rightarrow \frac{2773.3}{EI} = 1.733 \text{ mm}$$

8



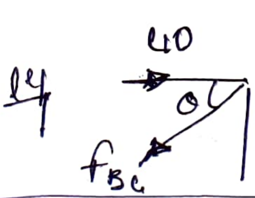
$V_A = V_B = 6/2 = 3$ kN.



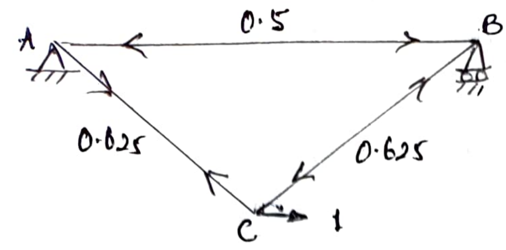
$\tan\theta = 3/4$ ∴ $\theta = 36.86$. $\sin\theta = 0.6$ $\cos\theta = 0.8$

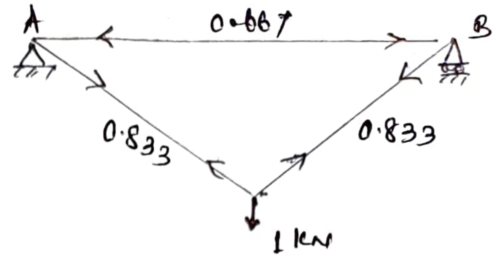
$\Sigma V = 0$ $f_{AC} \sin\theta = 3$ ∴ $f_{AC} = 5$ kN.

$\Sigma H = 0$ $f_{AB} = 5.0 \cos\theta = 4$ kN.



∴ $f_{BC} = \dfrac{4.0}{\cos\theta} = 5$ kN.





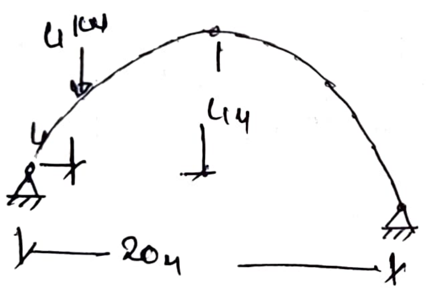
Applying horz load 1 kN

Applying vertical load 1 kN.

member	length	Area	P(kN)	k	PkL/A	k'	Pk'L/A
AB.	8000.	100.	-4	-0.667	213.44	-0.5	160
BC.	5000	150	5	0.833	138.83	-0.625	-104.1
AC	5000	150.	5	0.833	138.83.	0.625	104.1
					491.10		160

$$\Delta_{VC} = \frac{491.10}{200} = 2.45\,mm \qquad \Delta_{VH} = \frac{160}{200} = 0.8\,mm.$$

(9)



$\Sigma V = V_A + V_B = 4$ kN.

$\therefore V_B = \frac{4 \times 4}{20} = 0.8$ kN.

$V_A = 4 - 0.8 = 3.2$ kN.

$\Sigma M_C = 0.\quad 3.2 \times 10 - 4 \times 6 - H_A \cdot 4 = 0 \quad \therefore H_A = 2$ kN.

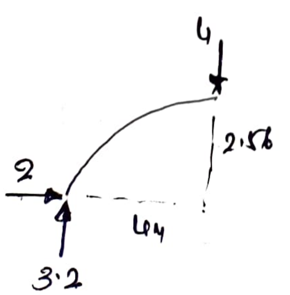
$$y = \frac{4h\,x(l-x)}{l^2} = \frac{4 \times 4}{20^2}(20-x)\,x = 0.8x - 0.04x^2.$$

$\therefore y_D = 2.56$ m. $\quad \frac{\partial y}{\partial x} = 0.8 - 0.08x$

$\tan\theta = 0.48$

$\sin\theta = 0.432$

$\cos\theta = 0.901.$



$NT = V \cdot \sin\theta + H \cdot \cos\theta,$

$= 0.8 \times 0.432 + 2.0 \times 0.901 = 2.14$

$RS = V\cos\theta - H \cdot \sin\theta$

$= 0.8 \times 0.901 - 2.0 \times 0.432 = 0.14:$

Max +ve BM $\quad 3.2 \times 4 - 2 \times 2.56 = 7.68$.

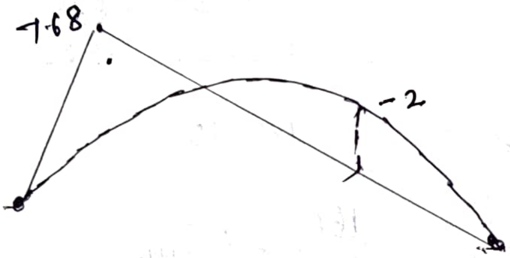
Max −ve BM $\quad 0.8x(20-x) - 2(0.8x - 0.04x^2)$

$= 16 - 0.8x - 1.6x + 0.08x^2$

$\frac{\partial M}{\partial x} = 0.16x - 2.4 \quad \& \quad x = 15\,m$

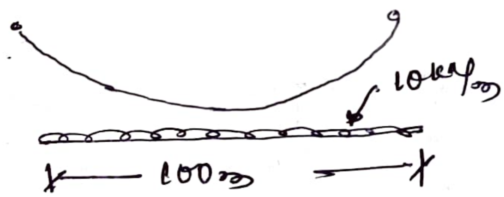
−ve BM $\quad M = 0.8(20-15) - 2(0.8 \times 15 - 0.04(15)^2]$

$= -2$ kN-m



(10). Assume depth as 10 m.

$V_A = V_B = 10 \times 100 / 2 = 500$ kN.



$H = \frac{wl^2}{8h} = \frac{10 \times 100^2}{8 \times 10} = 1250$ kN.

$T_{max} = \frac{wl}{2}\sqrt{1 + \frac{l^2}{16h^2}} = \sqrt{V^2 + H^2} = 1346.3$ kN.

$T_{min} = H = 1250$ kN.

$\tan\theta = V/H$

$\theta = 21^\circ 48'$

min C/s area $= \frac{1346.3}{300} = 4.48 \times 10^3\ mm^2$.

length of Cable $= 100 + \frac{8}{3} \times \frac{10^2}{100} = 102.67\,m$ $\left[l + \frac{8}{3}\frac{d^2}{L} \right.$

(G.V. Chalapati)

24-09-2022

HEAD
Dept. of Civil Engg.
KLS V.D.I.T., Haliyal