CBCS SCHEME

USN | | | | | | | | | | |

18CV52

Fifth Semester B.E. Degree Examination, Feb./Mar. 2022
Analysis of Indeterminate Structures

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. Assume missing data suitably.

Module-1

1 Analyze the continuous beam shown in Fig.Q.1 by slope deflection method. Draw BMD and SFD. **(20 Marks)**

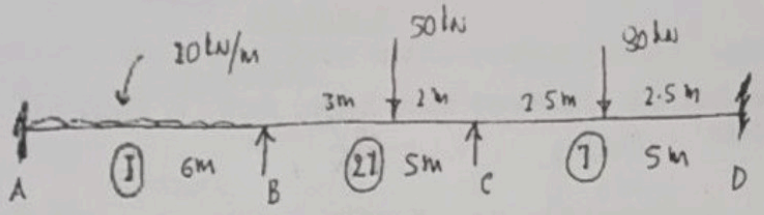

Fig.Q.1

OR

2 Analyze the portal frame shown in Fig.Q.2 by slope deflection method. Draw BMD. **(20 Marks)**

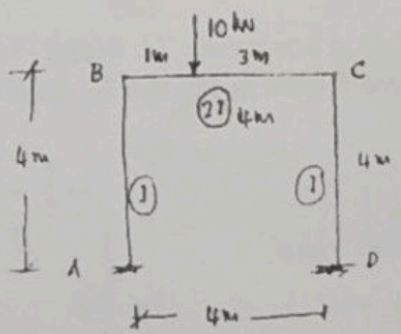

Fig.Q.2

Module-2

3 Analyze the beam shown in Fig.Q.3 by moment distribution method. Draw BMD EI is constant. **(20 Marks)**

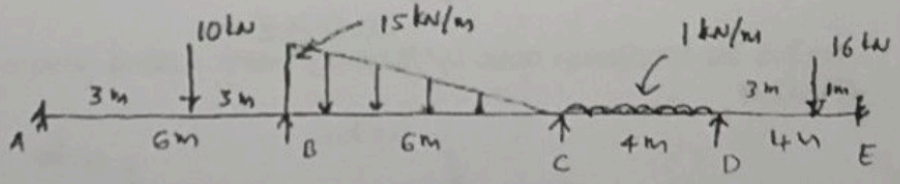

Fig.Q.3

OR

4 Analyze the portal frame by moment-distribution method draw BMD. **(20 Marks)**

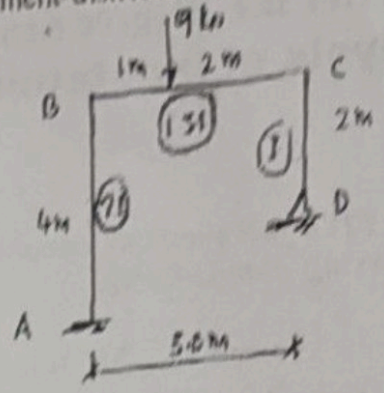

Fig.Q.4

Module-3

5 Analyze the continuous beam loaded shown in Fig.Q.5 by Kani's rotation method. Draw BMD. **(20 Marks)**

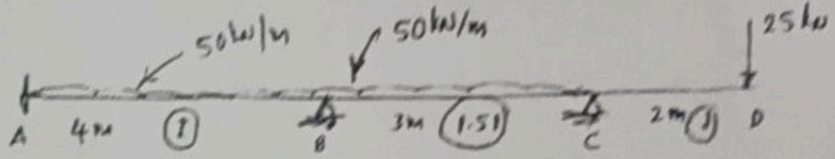

Fig.Q.5

OR

6 Analyze the frame shown in Fig.Q.6 by Kani's method. Take the advantage of symmetry. **(20 Marks)**

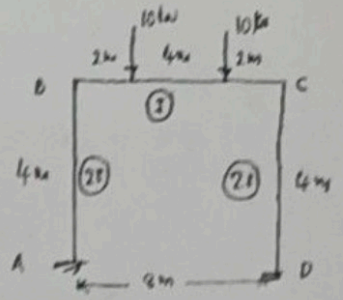

Fig.Q.6

Module-4

7 Analyze the continuous beam by flexibility matrix method (system approach). Draw BMD. (Fig.Q.7). **(20 Marks)**

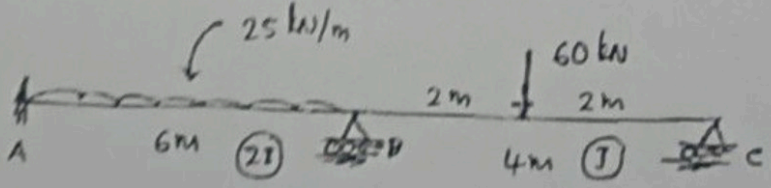

Fig.Q.7

OR

8 Analyze the L-frame shown in Fig.Q.8 by flexibility matrix method. Draw BMD (system approach). **(20 Marks)**

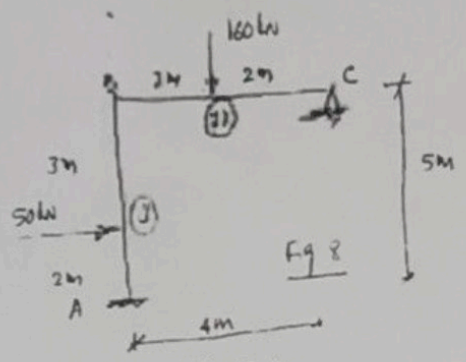

Fig.Q.8

Module-5

9 Analyze the continuous beam by stiffness matrix method (system approach) shown in Fig.Q.9. Draw BMD EI is constant. **(20 Marks)**

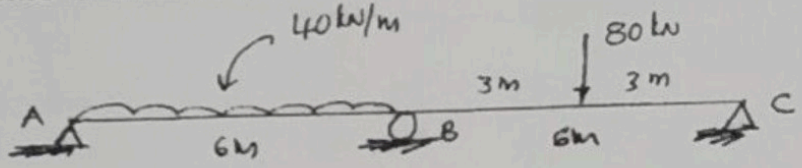

Fig.Q.9

OR

10 Find the forces in the members of a joint 'O' shown in Fig.Q.10 by stiffness matrix method. (system approach). **(20 Marks)**

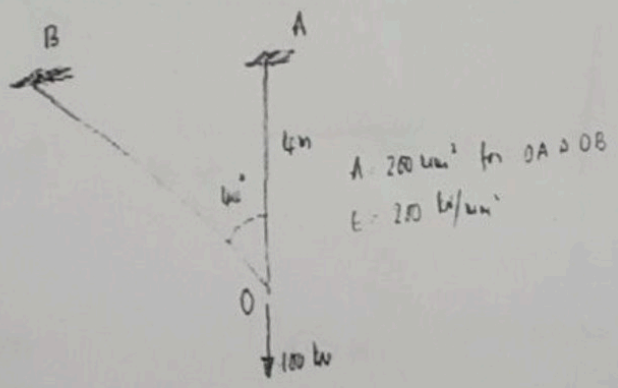

Fig.Q.10

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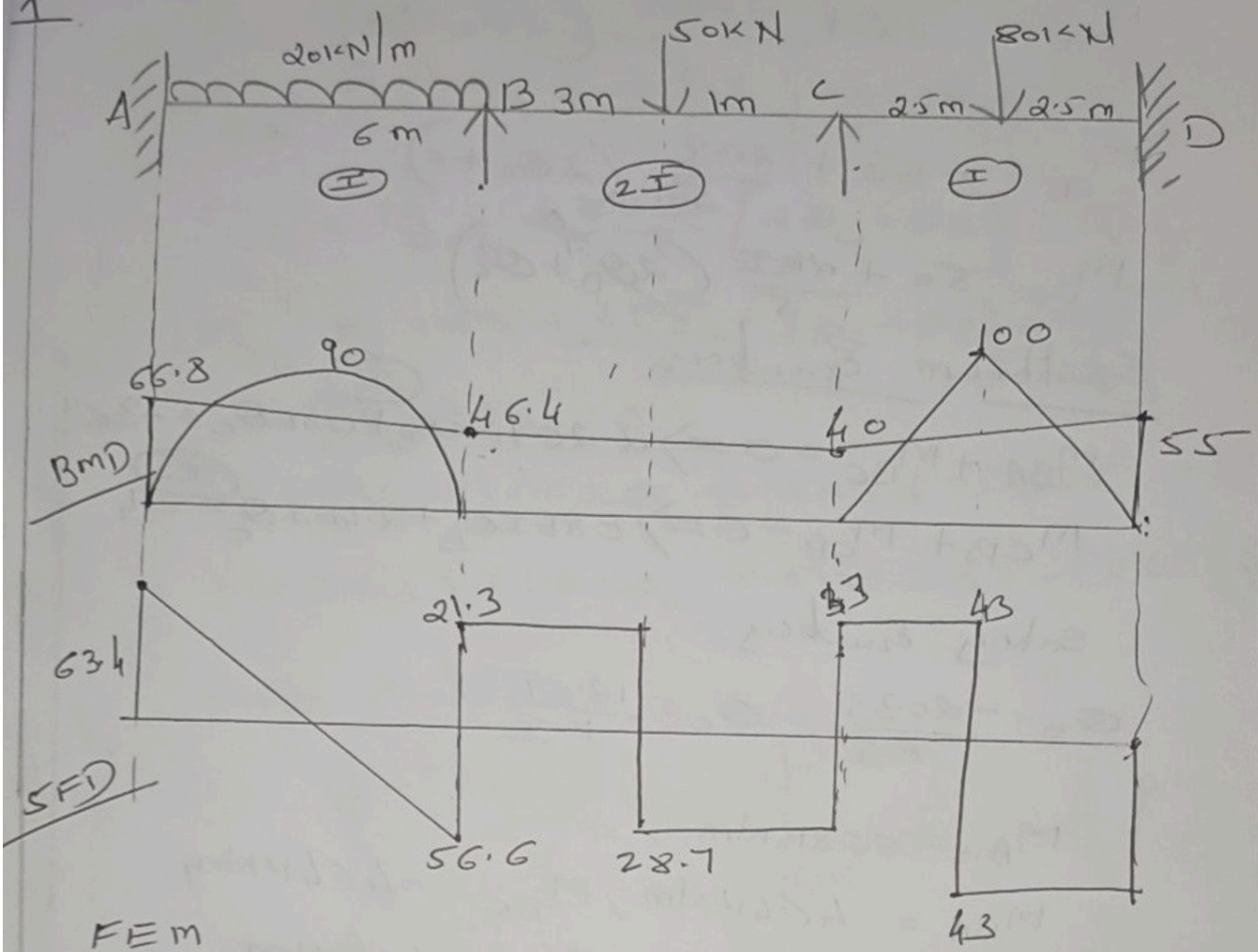
Module- 1

1



FEM

$M_{FAB} = -60kNm$ $\quad M_{FBA} = 60kNm$

$M_{FBC} = -24kNm$ $\quad M_{FCB} = 36kNm$

$M_{FCD} = -50kNm$ $\quad M_{FDC} = 50kNm$

Equations

$\theta_A = \theta_D = 0.$

Equilibrium Equations

$$M_{AB} = M_{FAB} + \frac{2EI}{L}\left[2\theta_A + \theta_B\right]$$

$$M_{AB} = -60 + \frac{2EI}{6}\left[0 + \theta_B\right]$$

$$M_{BA} = 60 + \frac{2EI}{6}\left[2\theta_B + 0\right]$$

$$M_{BC} = M_{FBC}^{(-24)} + \frac{2EI(2)}{5}(2\theta_B + \theta_C)$$

$$M_{CB} = 36 + \frac{2\times 2EI}{5}(2\theta_C + \theta_B)$$

$$M_{CD} = -50 + \frac{2EI}{5}(2\theta_C + 0)$$

$$M_{DC} = 50 + \frac{2EI}{5}(2\theta_D^{\,0} + \theta_C)$$

Equilibrium Equations

$$M_{BA} + M_{BC} = 0 \Rightarrow 2.267EI\theta_B + 0.8EI\theta_C = -36 \quad (I)$$

$$M_{CB} + M_{CD} = 0 \Rightarrow 0.8EI\theta_B + 2.4EI\theta_C = 14 \quad (II)$$

Solving Equtions

$$\theta_B = \frac{-20.33}{EI} \qquad \theta_C = \frac{12.61}{EI}$$

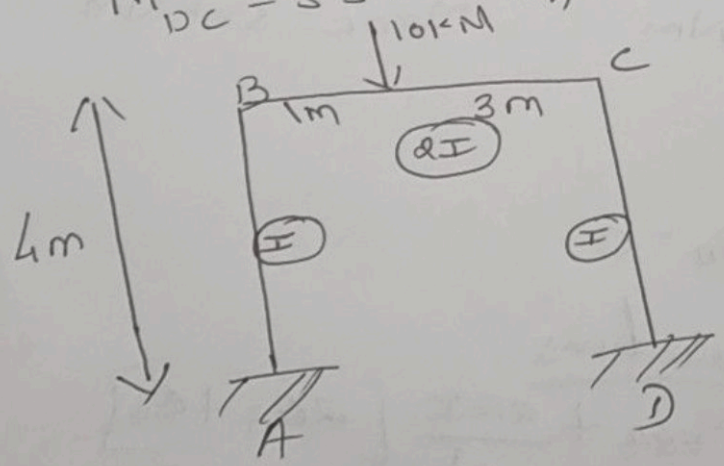
$M_{AB} = 66.81\,KNm$

$M_{BA} = 46.412\,KNm$, $M_{BC} = -46.412\,KNm$

$M_{CB} = -40.12\,KNm$, $M_{CD} = 40.12\,KNm$

$M_{DC} = 55.12\,KNm$

2.



$$M_{FAB} = M_{FBA} = M_{FCD} = M_{FDC} = 0.$$

$$M_{FBC} = -5.625\,KNm$$

$$M_{FCB} = 1.875\,KNm$$

S-D Equations $\theta_A = \theta_D = 0$

$$M_{BC} = M_{FBC} + \frac{2EI}{L}\left[2\theta_B + \theta_C - \frac{0.75 \times \Delta}{L}\right]$$

$$M_{BC} = -1.5625 + \frac{2EI \times 2}{4}\left[2\theta_B + \theta_C - \frac{0.75\Delta}{L}\right]$$

$$M_{CB} = M_{FCB} + \frac{2EI}{L}\left[2\theta_C + \theta_B - \frac{0.75\Delta}{L}\right]$$

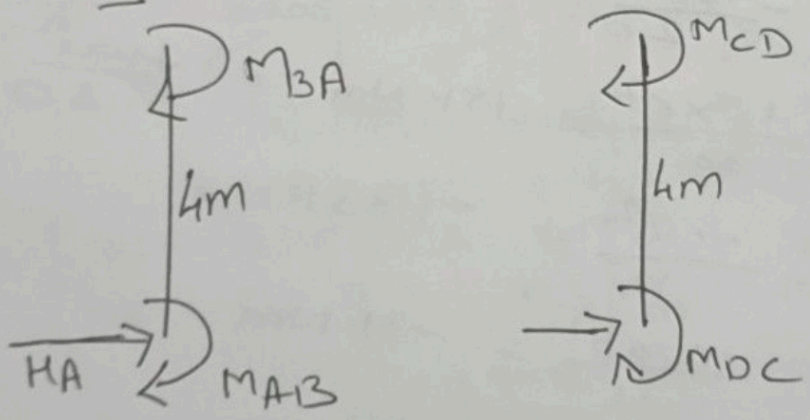
$$M_{CB} = 1.875 + \frac{4EI}{4}\left[2\theta_C + \theta_B - \frac{0.75\Delta}{L}\right]$$

$M_{BA} + M_{BC} = 0$

$$4EI\theta_B + 1.0EI\theta_C - 0.75EI\Delta = 5.625 \quad -(1)$$

$$1.0EI\theta_B + 3.0EI\theta_C - 0.375EI\Delta = -1.875 \quad -(2)$$

Sway Analysis.



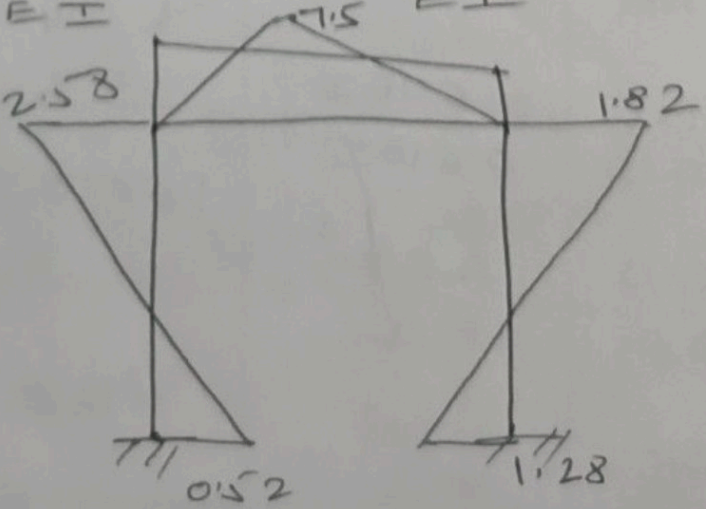
$H_A + H_D = 0$

$$3.0EI\theta_B + 1.54EI\theta_C - 2.25EI\Delta = 0 \quad -(3)$$

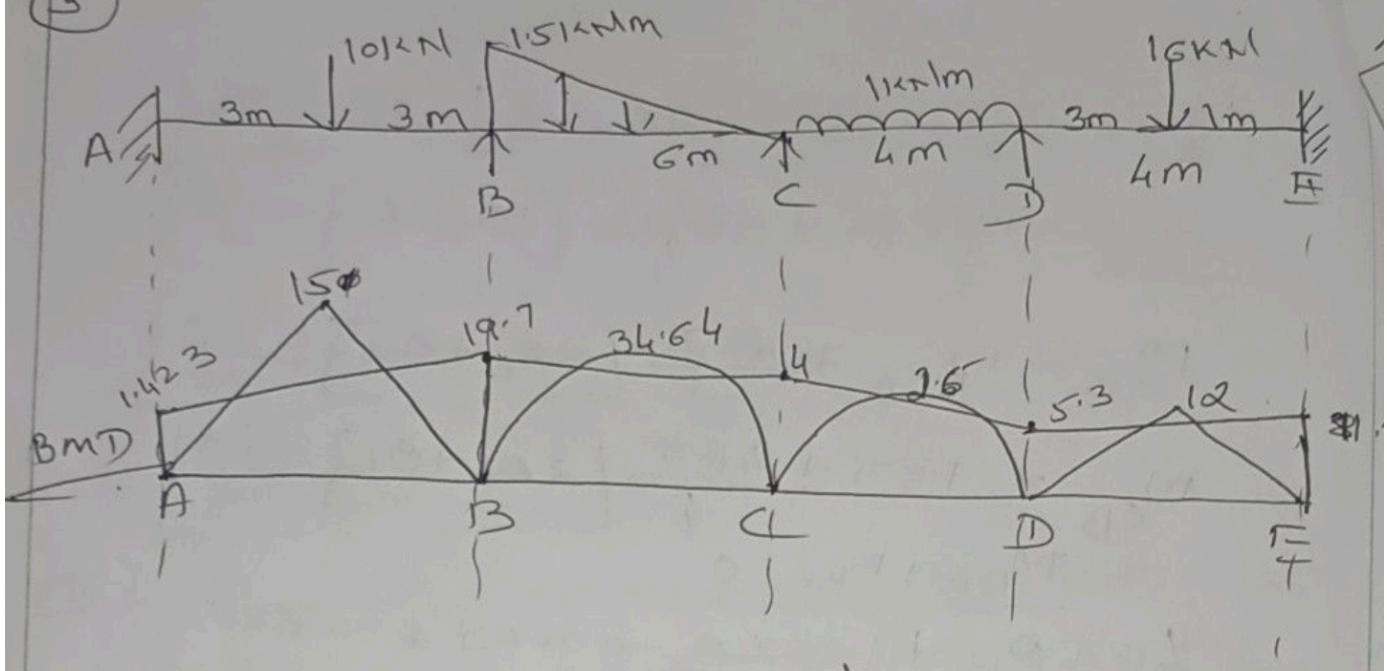
Solving Equations (1) (2) & (3)

$$\theta_B = \frac{2.05}{EI}, \quad \theta_C = \frac{-1.05}{EI}, \quad \Delta = \frac{2.03}{EI}$$

BMD



(3)



$M_{FAB} = -7.5\,kNm = \frac{-wl}{8}$

$M_{FBA} = +7.5\,kNm = \frac{+wl}{8}$

$M_{FBC} = -\frac{15\times6^2}{20} = -27\,kNm = \frac{-wl^2}{20}$

$M_{FCB} = \frac{15\times6^2}{30} = 18\,kNm = \frac{+wl^2}{30}$

$M_{FDC} = \frac{-wl^2}{12} = -1.33\,kNm$

$M_{FDE} = \frac{-wab^2}{l^2} = -3\,kNm$

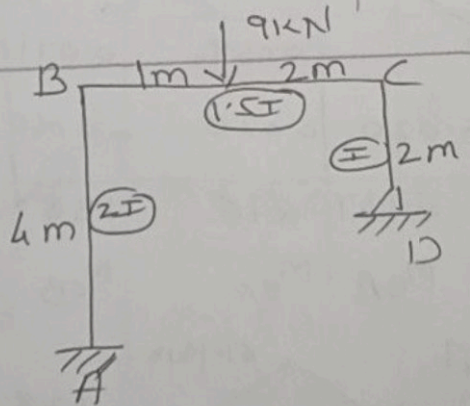
$M_{FED} = \frac{wa^2b}{l^2} = +9\,kNm$

Distribution factor

Joint	member	K	ΣK	DF
B	BA	0.67EI	1.334EI	0.5
	BC	0.67EI		0.5
C	CB	0.67EI	1.667EI	0.40
	CD	1EI		0.59
D	DC	EI	2EI	0.5
	DE	EI		0.5

Joint	A	B		C		D		E
member	AB	BA	BC	CB	CD	DC	DE	ED
DF	0	0.5	0.5	0.4	0.6	0.5	0.5	0
FEM	-7.5	7.5	-27	18	-1.33	-1.33	-3	
Balance		9.75	9.75	-6.66	-9.98	0.835	0.835	
CO	4.875		3.334	4.875	0.4175	-4.97		0.487
Balance		1.667	1.667	-2.117	-3.170	2.496	2.496	
CO	0.8335		-1.0585	0.835	1.248	-1.585		1.248
Balance		0.529	0.529	-0.832	1.248	+0.792		
CO	0.2045		-0.416	0.264	0.396	-0.623		0.396
Balance		0.208	0.208	-0.26	0.395	0.3115	0.3115	
CO	0.104		-0.1321	0.109	0.155	-0.09		0.1555
Balance		0.066	0.066	0.103	-0.141	0.09	0.09	
Final	-1.426	19.72	-19.72	14.19	-14.19	-1.53	+1.53	11.216
	M_{AB}	M_{BA}	M_{BC}	M_{CB}	M_{CD}	M_{DC}	M_{DE}	$M_{E=D}$

4]



$M_{FAB} = M_{FBA} = 0$

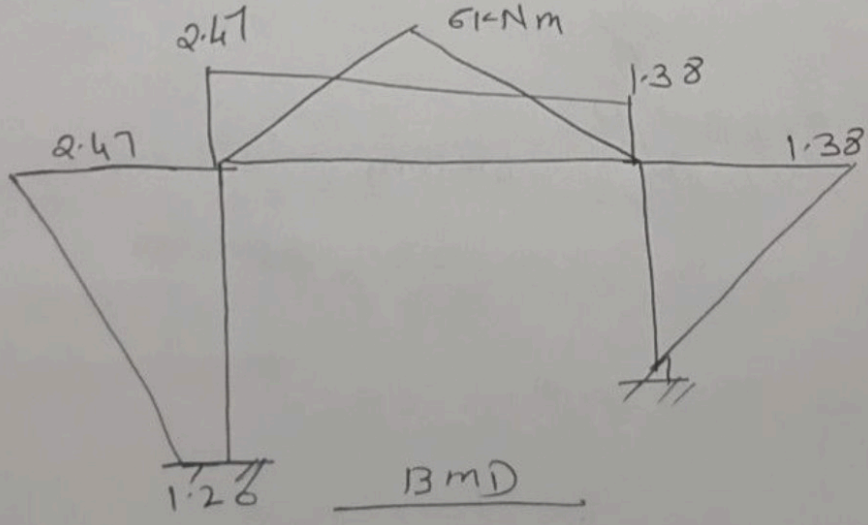
$M_{FBC} = \frac{-\omega ab^2}{L^2} = -4kNm$

$M_{FCB} = \frac{+\omega a^2 b}{L^2} = \frac{9 \times 1^2 \times 2}{3^2} = 2.0kNm$

$M_{FCD} = M_{FDC} = 0$

Joint	member	K	ΣK	DF
B	BA	2EI	4EI	0.5
	BC	2EI		0.5
C	CB	2EI	3.5EI	0.57
	CD	1.5EI		0.43

Joint	A	B		C		D
member	AB	BA	BC	CB	CD	DC
DF	0	0.5	0.5	0.57	0.43	1
FEM	0	0	-4	2	0	0
Total Balan	0	2	2	-1.14	-0.86	
				1		
CO	1		-0.57			
Balance		0.285	0.285	-0.57	-0.43	
CO	0.1425		-0.285	0.1425		
Balance		0.1425	0.1425	-0.081	-0.0612	
CO	0.071		-0.049	0.071		
Balance		0.020	0.020	-0.049	-0.0305	
Final Moment	1.2133 M_{AB}	2.447 M_{BA}	-2.16 M_{BC}	1.38 M_{CB}	-1.38 M_{CD}	



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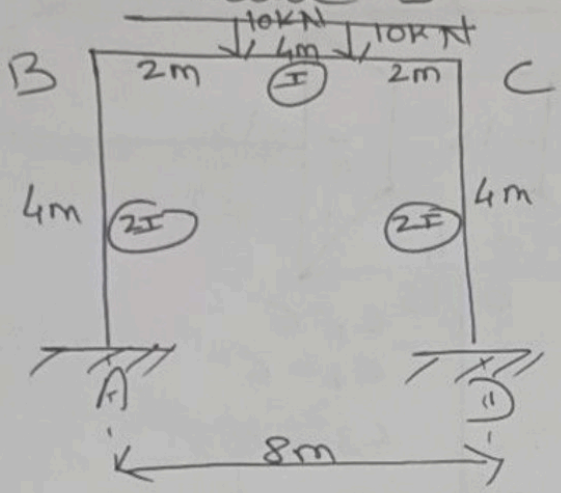
Module - 3



FEM

$$M_{FAB} = M_{FBA} = M_{FCD} = F_{FDC} = 0$$

$$M_{FBC} = \frac{-wab^2}{l^2} - \frac{wab^2}{l^2}$$

$$= \frac{-10\times2\times6^2}{8^2} - \frac{10\times6\times2^2}{8^2}$$

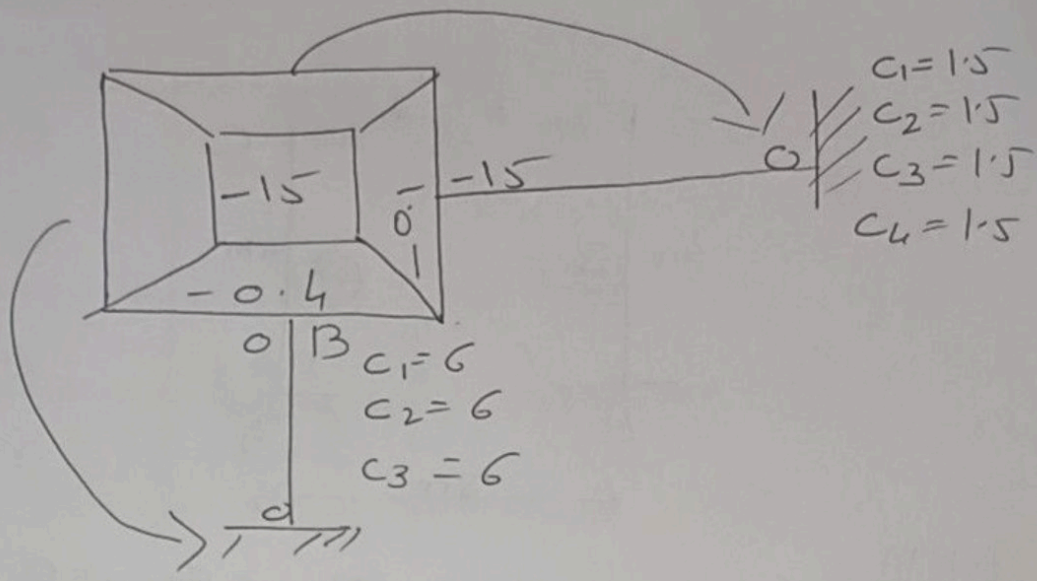
$$M_{FBC} = -15 KNm$$

$$M_{FCB} = \frac{wa^2b}{l^2} + \frac{wa^2b}{l^2} = \frac{10\times2^2\times6}{8^2} + \frac{10\times6^2\times2}{8^2}$$

$$= 15 KNm$$

Rotational factor

Joint	member	K	ΣK	DF	RF
B	BA	2EI	2.5EI	0.8	-0.4
	BC	0.5EI		0.2	-0.1
C	CB	0.5EI	2.5EI	0.2	-0.1
	CD	2EI		0.8	-0.4



Cycle 1 @ B

$M'_{BA} = -0.4\,[-15 + (0+0)] = 6\,kNm$

$M'_{BC} = -0.1\,(-15 + (0+0)) = 1.5\,kNm$

Cycle-2 @ B

$M'_{BA} = -0.4\,(-1.5 + 0) = 6\,kNm$

$M'_{BC} = 1.5\,kNm$

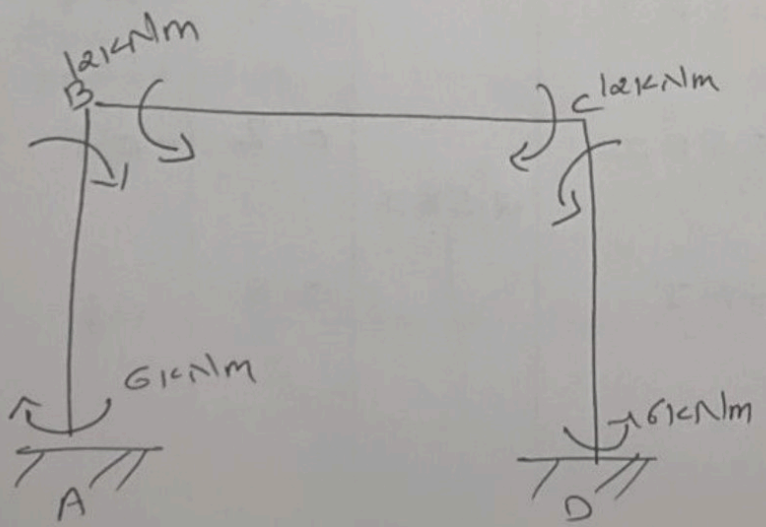
Final moments

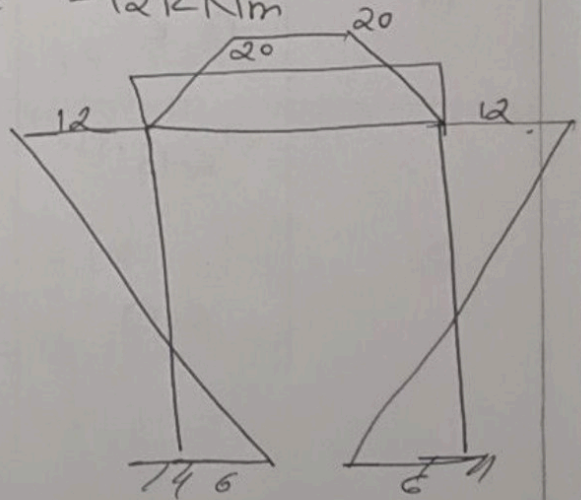
$M_{AB} = M_{FAB} + 2M'_{AB} + M''_{BA} = 0 + 2(0) + 6 = 6\,kNm$

$M_{BA} = M_{FBA} + 2M'_{BA} + M''_{AB} = 0 + 2(6) + 0 = 12\,kNm$

$M_{BC} = M_{FBC'} + 2M'_{BC} + M''_{CB} = -15 + 2(1.5) + 0$

$= -12\,kNm$

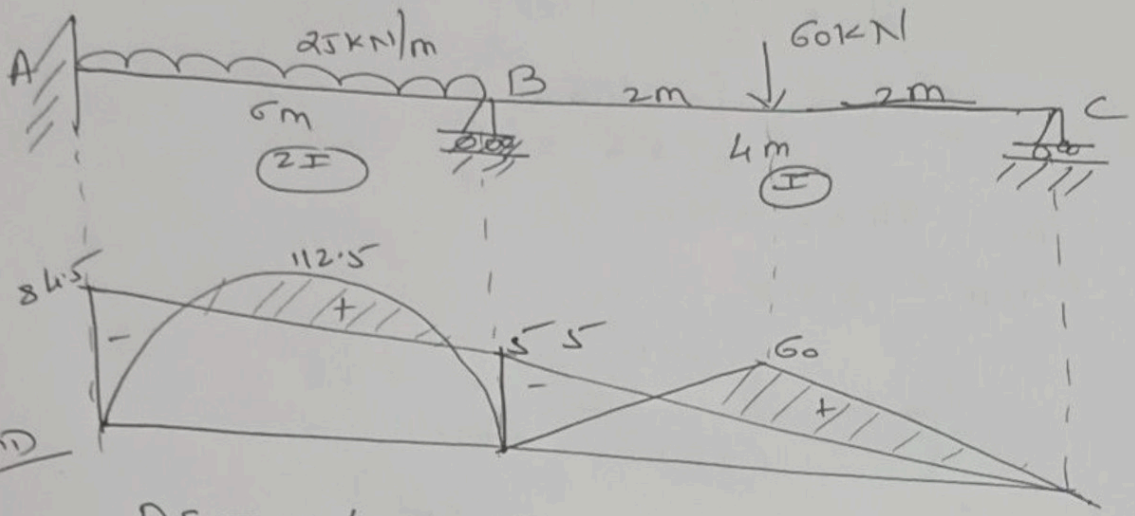




BMD

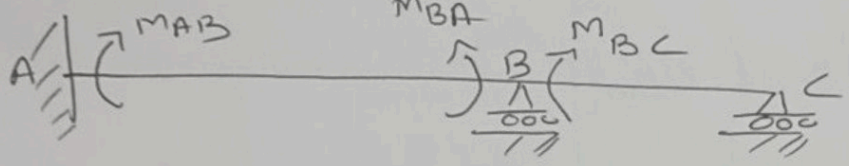
Module-4

7)



$DSI = 4 - 2 = 2$

General co-ordinates



$$[D] - [DL] = [F]_{2\times2}[P]_{2\times1}$$

$$DL_1 = \frac{\omega L^3}{24EI} = \frac{25\times6^3}{24\times2EI} = \frac{112.5}{EI}$$

$$DL_2 = \frac{\omega L^2}{16EI} = \frac{60\times4^2}{16EI} = \frac{60}{EI}$$

$$DL_2 = \frac{60 + 112.5}{EI} = \frac{172.5}{EI}$$

$$D_L = \frac{1}{EI}\begin{bmatrix} 112.5 \\ 172.5 \end{bmatrix}$$

$$[F] = \begin{bmatrix} f_{11} & f_{12} \\ f_{21} & f_{22} \end{bmatrix}_{2\times2} = \begin{bmatrix} 1 & 0.5 \\ 0.5 & 2.33 \end{bmatrix}\frac{1}{EI}$$

$$f_{11} = \frac{ML}{3EI} = \frac{1}{EI}$$

$$f_{21} = \frac{ML}{6EI} = \frac{0.5}{EI}$$

$$f_{12} = \frac{ML}{6EI} = \frac{0.5}{EI}$$

$$f_{22} = \left(\frac{ML}{3EI}\right)_{BA} + \left(\frac{ML}{3EI}\right)_{BC} = \frac{2.33}{EI}$$

$$[D] - [D_L] = [F][P]$$

$$[P] = [F]^{-1}[D_L]$$

$$[P] = \begin{bmatrix} -84.55 \\ -55.88 \end{bmatrix}$$

$M_{AB} = 84.55$ kNm

$M_{BA} = 55.81$ kNm

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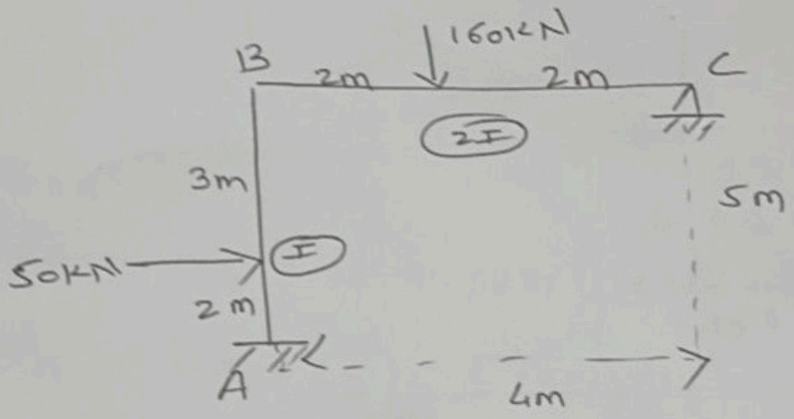


DSI = 5 − 3 = 2

$[D_L]$ $\theta_A = \frac{wb}{6EI}\left[\frac{L^2-b^2}{L}\right] = \frac{50\times3}{6EI}\left(\frac{5^2-3^2}{5}\right) = \frac{80}{EI}$

@ AB $\theta_B = \frac{-wa}{6EI}\left[\frac{b^2-a^2}{L}\right] = \frac{70}{EI} = \frac{50\times2}{6EI}\left[\frac{5^2-2^2}{5}\right]$

@ BC $\theta_B = \frac{wL^2}{16EI} = \frac{160\times4^2}{16EI} = \frac{80}{EI}$

$DL_1 = \theta_A = \frac{80}{EI}$

$DL_2 = (\theta_B)_{AB} + (\theta_B)_{BC}$

$= \frac{80}{EI} + \frac{70}{EI} = \frac{150}{EI}$

$$DL = \begin{Bmatrix} DL_1 \\ DL_2 \end{Bmatrix} = \begin{bmatrix} 80 \\ 150 \end{bmatrix}\frac{1}{EI}$$

$$[F] = \begin{bmatrix} 1.67 & 0.83 \\ 0.83 & 2.33 \end{bmatrix} \frac{1}{EI}$$

$$f_{11} = \frac{ML}{3EI} = \frac{1.67}{EI}$$

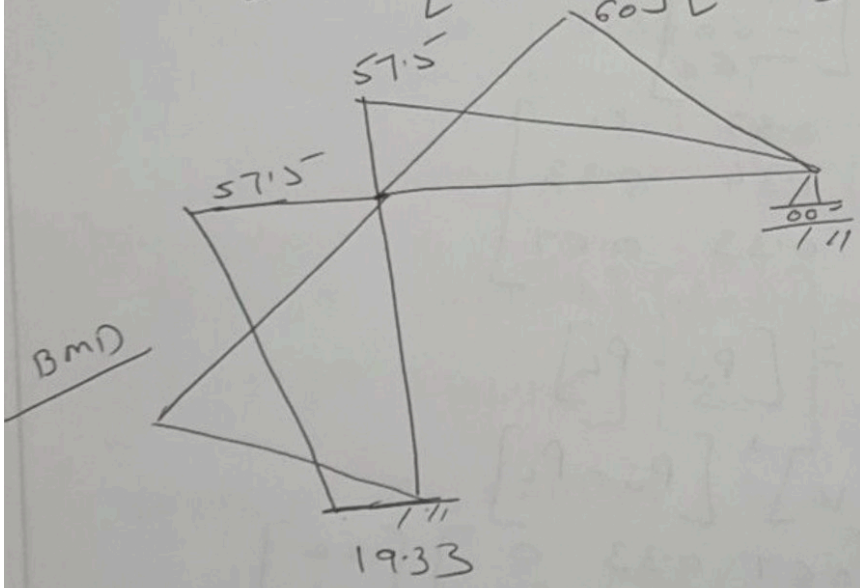
$$f_{21} = \frac{ML}{6EI} = \frac{0.83}{EI}$$

$$f_{12} = \frac{ML}{6EI} = \frac{0.83}{EI}$$

$$f_{22} = \left(\frac{ML}{3EI}\right)_{BA} + \left(\frac{ML}{3EI}\right)_{BC} = \frac{2.33}{EI}$$

$$[P] = [F]^{-1}[D_L] = EI \begin{bmatrix} 1.67 & 0.83 \\ 0.83 & 2.33 \end{bmatrix}^{-1} \begin{bmatrix} -80 \\ -150 \end{bmatrix} \frac{1}{EI}$$

$$[P] = \begin{bmatrix} -19.33 \\ -57.51 \end{bmatrix} = \begin{bmatrix} M_{AB} \\ M_{BA} \end{bmatrix}$$



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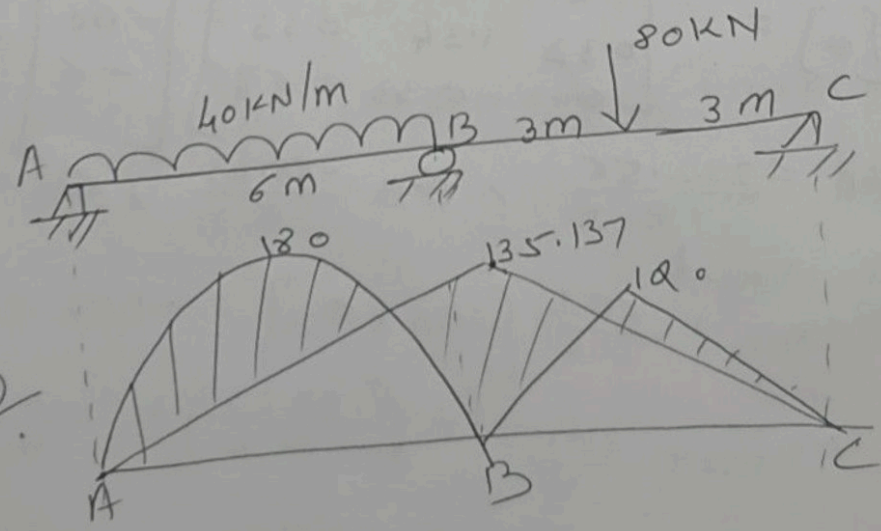


$$M_{FAB} = \frac{-wL^2}{12} = -120\,KNm$$

$$M_{FBA} = \frac{wL^2}{12} = \frac{40\times 36}{12} = 120\,KNm$$

$$M_{FBC} = \frac{-wL^2}{8} = -60\,KNm, \quad M_{FCB} = 60\,KNm$$

DoF = 3

$$P_U = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$P_L = \begin{bmatrix} P_{L1} \\ P_{L2} \\ P_{L3} \end{bmatrix} = \begin{bmatrix} -120 \\ +60 \\ 60 \end{bmatrix}$$

$$[P_U - P_L] = \begin{bmatrix} 120 \\ -60 \\ -60 \end{bmatrix}$$

$$K = \begin{bmatrix} 0.67 & 0.33 & 0 \\ 0.33 & 1.34 & 0.33 \\ 0 & 0.33 & 0.67 \end{bmatrix}$$

$$[K][\theta] = [P_U - P_L]$$

$$[\theta] = [K]^{-1}[P_U - P_L]$$

$$[\theta] = \begin{bmatrix} 0.67 & 0.33 & 0 \\ 0.33 & 1.34 & 0.33 \\ 0 & 0.33 & 0.67 \end{bmatrix} \begin{bmatrix} 120 \\ -60 \\ -6 \end{bmatrix}$$

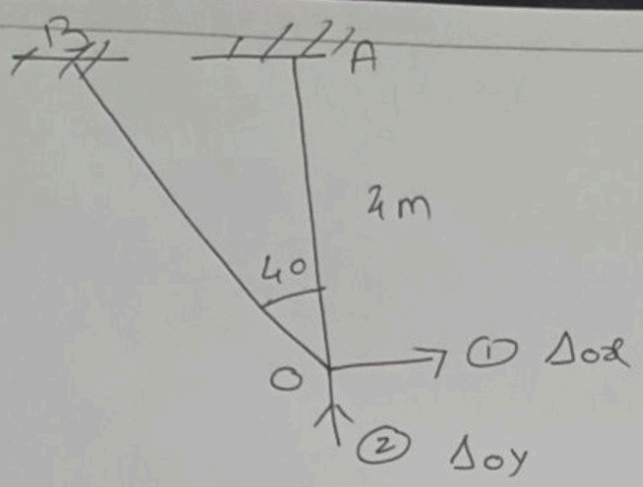
$$\theta_A = \frac{222.56}{EI}, \quad \theta_B = \frac{-88.23}{EI}, \quad \theta_C = \frac{-46.1}{EI}$$

Final Moment

$$M_{AB} = M_{FAB} + \frac{2EI}{L}[2\theta_A + \theta_B] = -1.03 \approx 0$$

$$M_{BA} = M_{FBA} + \frac{2EI}{L}\left[2\left(\frac{-88.23}{EI}\right) + \left(\frac{222.56}{EI}\right)\right]$$

$$= 135.37\,KNm //$$



$$[K][\Delta] = [P_S]$$

$$[P_S] = \begin{bmatrix} 0 \\ -100 \end{bmatrix}$$

	$\frac{AE}{L}$	θ	$\frac{AE}{L}\cos^2\theta$	$\frac{AE}{L}\sin^2\theta$	$\frac{AE}{L}\cos\theta\sin\theta$
OA	100	90	0	100	0
OB	76.73	130	31.39	44.96	-37.57
			31.39	144.96	-137.57
			K_{11}	K_{22}	K_{33}

$$\begin{bmatrix} 31.39 & -37.57 \\ -37.57 & 144.16 \end{bmatrix} \begin{bmatrix} \Delta ox \\ \Delta oy \end{bmatrix} = \begin{bmatrix} 0 \\ -100 \end{bmatrix}$$

Solving $\Delta ox = -1.197$ $\Delta oy = -1.0$

$$F_{OA} = -100\left[-(1.197 \times 0) + (-1 \times 1)\right] = -100\,kN/m$$

$$F_{OB} = -76.63\left[(-1.19 \times -0.64) + (-1.0 \times 0.766)\right] = 0\,kN/m$$

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