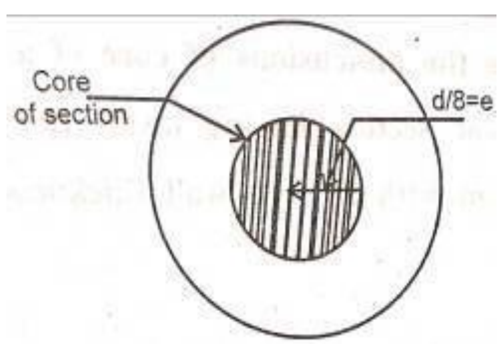
SUMMER – 2022 EXAMINATION

Subject Name: Theory of Structure **Model Answer** **Subject Code:** 22402

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

Q. No.	Sub Q. N.	Answer	Marking Scheme
Q-1		Attempt any **FIVE** of the following:	10 M
	a)	**Define core of the section.**	2 M
	Ans.	Core of a section: Core of the section is that portion around the centroid in within which the line of action of load must act, so as to produce only compressive stress is called as core of the section. **OR** It is also defined as the region or area within which if load is applied, produces only compressive resultant stress. **OR** If Compressive load is applied, the there is no tension anywhere in the section. $e_{max} = d/8$ e = Core of section	1 M
		 For Circular section	01 M

b) **Give relationship between bending moment, slope and deflection.**

Ans.

$$\frac{d_2y}{dx^2} = \frac{M}{EI}$$

01 M

Where,
θ= Slope at any section
Y= Deflection of Beam
M= Bending Moment
E=Modulus of Elasticity
I=Moment of Inertia

01 M

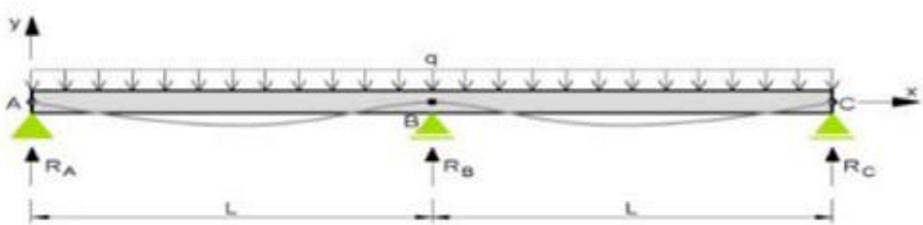
c) **State the effect of continuity in continuous beam.**

Ans. **Solution:**

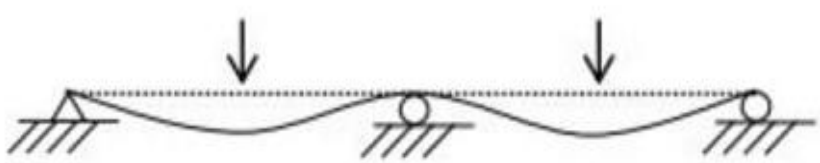
Effect of continuity: If a beam is continuous, over the support, a hogging moment is developed at that support which tries to bring the beam back to its equilibrium condition, as it was before loading. Thus the beam deflection and consequently the load carrying of the is increased. Effects of continuity are as follows.

01 M

i) Produces support moment of hogging nature.
ii) Reduces bending moment along the span.
iii) Reduces deflection and increases load carrying capacity.
iv) Sagging moment occurs at mid span.



01 M

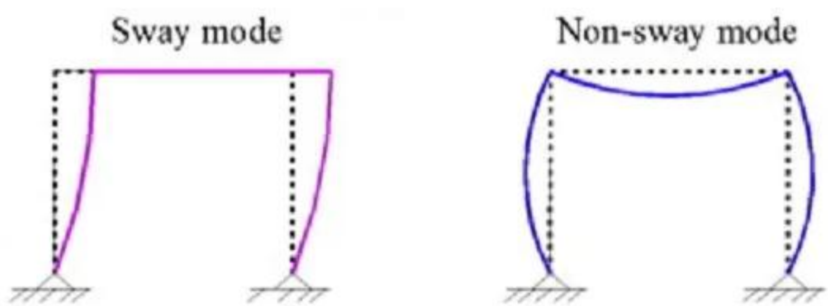
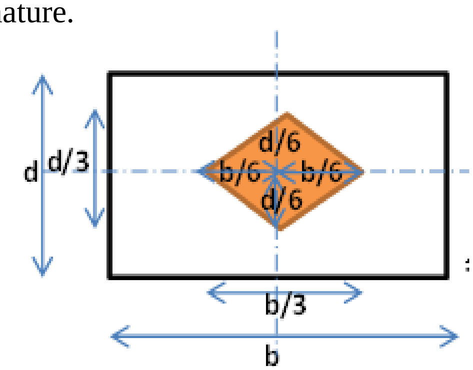


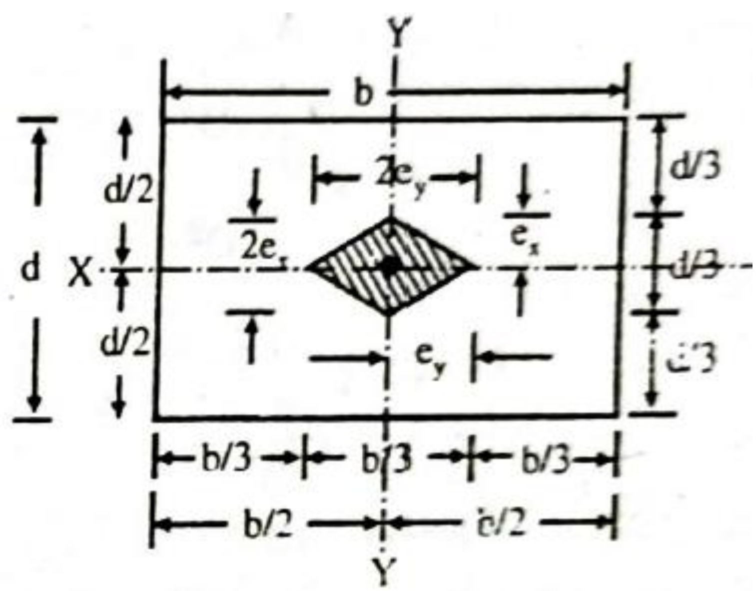
d) **Define**
i) Carry over factor
ii) Stiffness factor

Ans.

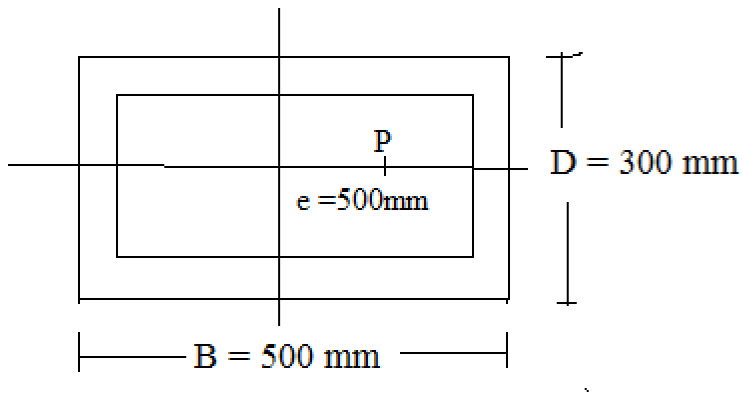
i) Carry over factor: It is the ratio of moment produced at a joint to apply at the other end of the member. it is (1/2). 01 M

ii) Stiffness factor: It is the moment required to obtain unit rotation at an end without translating it. 01 M

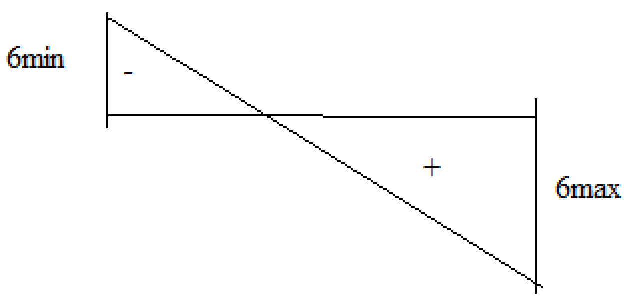
	e)	**With sketch, state the different types of portal frame.**	**02 M**
	Ans.	i. Symmetrical portal frame (Non sway type) ii. Unsymmetrical portal frame (Sway type)	01 M
			01 M (Fig.)
	f)	**State the middle third rule.**	02 M
	Ans.	**Middle third rule:** In case of rectangular cross section, if the load is applied at location along the middle third part of both mutually perpendicular axes then the stresses produced compressive nature.	01M
		 For Rectangular section	01M
	g)	**Identify nature of support if** **i) θ = 0, y = 0** **ii) θ = 0, y ≠ 0**	
	Ans.	i) θ = 0, y = 0 -------- Fixed Support ii) θ = 0, y ≠ 0 ------- Center of the Beam(Student May Right Propped Support)	01 M 01 M

Q-2		Attempt any **FIVE** of the following:	**12 M**
	a)	**Derive the expression for limit of eccentricity for rectangular section (b x d) dimensions.**	4 M
	Ans.	**Solution:** Let us consider a rectangular section of width b and thickness d as shown in fig. Area of section, A = b x d	
		$Zxx = \frac{I_{xx}}{Y_{max}} = \frac{\frac{bd^3}{12}}{\frac{d}{2}} = \frac{bd^2}{6}$	1/2 M
		$Zyy = \frac{I_{yy}}{Y_{max}} = \frac{\frac{db^3}{12}}{\frac{b}{2}} = \frac{db^2}{6}$	1/2 M
		For no tension condition, $e \leq \frac{Zxx}{A}$ and $e \leq \frac{Zyy}{A}$	1/2 M
		$e \leq \frac{\frac{bd^2}{6}}{bd}$ and $e \leq \frac{\frac{db^2}{6}}{bd}$	1/2 M
		$e \leq \frac{d}{6}$ and $e \leq \frac{b}{6}$	1/2 M
		ie $e_x = \frac{d}{6}$ and $e_y = \frac{b}{6}$ $2e_x = \frac{d}{3}$ and $2e_y = \frac{b}{3}$	1 M
			1/2 M

	b)	**Calculate intensity of stresses at base of hollow rectangular column 500mm x 300mm external dimension and 50mm thickness subjected to vertical load of l60kN with 200mm eccentricity parallel to 500mm side of column.**	4 M
	Ans.	Given: P= 160 KN = 160 x 10^3 N e = 500 mm Outer dimensions: B = 500 mm, D = 300 mm Inner dimensions: t = 50 mm b = 500 -100 = 400 mm d = 300 - 100 = 200 mm Area, A = BD – bd = (500 x 300) – (400 x 200) = 70000 mm^2	1/2 M
		Section modulus, $Zyy = \frac{I_{yy}}{Y_{max}} = \frac{\frac{DB^3}{12} - \frac{db^3}{12}}{\frac{B}{2}}$ $Zyy = \frac{DB^3 - db^3}{6B}$ $Zyy = \frac{300 \times 500^3 - 200 \times 400^3}{6 \times 500}$	1/2 M
		Zyy = 8.23 x 10^6 mm^3	1/2 M
		Direct stress, $6o = \frac{P}{A} = \frac{160 \times 10^3}{7000}$ **= 2.285 N/mm²**	1/2 M 1/2 M
		Bending stress, $6b = \frac{M}{Zyy} = \frac{P.e}{Zyy} = \frac{160 \times 10^3 \times 200}{8.23 \times 10^6}$ = **3.886 N/mm²**	
		6_{max} = 6o + 6b = 2.285 + 3.888 = 6.173 N/mm^2 (Compressive) 6_{min} = 6o - 6b = 2.285 - 3.888 = - 1.603 N/mm^2 (Tensile)	1/2 M



1/2 M



1/2 M

c. **Calculate the maximum and minimum stresses at the base of masonry chimney having outer dimension 4m x 4m and 1m thickness. Height of the chimney is 20 m subjected to wind pressure of 1.2 kN/m^2. use wt. of masonry as 22 kN/m^3.** 4 M

Ans.

Given:

B = 4m , t = 1m, b = 4-2x1 = 2 m , height of chimney h =20 m, p = 1.2 KN /m^2 = 1200 N /m^2 P = 22 KN /m^3 = 22 x 10^3 N /m^3

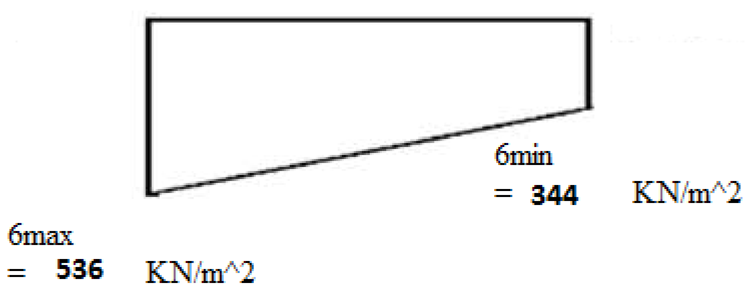
To find: σ max σ min

i) Area of the section = A = $B^2 - b^2 = 4^2 - 2^2 = 12\ m^2$

ii) Direct stress on the base $\sigma_0 = \frac{W}{A}$ or ρh

W = A x h x ρ = (7 x 20 x 22 x 10^3) = 3080 x 10^3 N

1/2 M

		$\sigma_0 = \frac{3080 \times 10^3}{7}$	1/2 M
		$= 440 \times 10^3$ N/m^2 = 440 KN/m^2 Or 20 x 22x 10^3 = 440 x 10^3 N/m^2 = 440 KN/m^2	
		iii) Total wind load P =C x Þ x projected area	1/2 M
		= C x Þ x D x h = 1 x 1200 x 4 x 20 = 96000 N = 96 kN	1/2 M
		iv) Moment on the base M= P x $\frac{h}{2}$ = 96000 x $\frac{20}{2}$ =960 x 10^3 Nm = 960 kNm	1/2 M
		v) Section modulus about Y-Y axis:	
		$Zyy = \frac{I_{yy}}{Y_{max}} = \frac{B^4 - b^4}{6 \times b} = \frac{4^4 - 2^4}{6 \times 4}$	
		Zyy = 10 m^3 = 10x 10^9 mm^3	
		vi) Bending stress on the base section,	
		$\sigma b = \pm \frac{M}{Z} = \frac{960 \times 10^3}{10}$ or $\frac{960}{10}$	
		= ± 96 x 10^3 N/m^2 = **± 96 kN/m^2**	1/2 M
		σ_{max} = $\sigma_0 + \sigma b$ = 440 + 96 = **536 kN/m^2 (Comp)**	1/2 M
		σ_{min} = $\sigma_0 - \sigma b$ = 440 – 96 = **344 kN/m^2 (Comp)**	
			1/2 M

	d.	**A short column of external diameter 250mm and internal diameter 200mm carries an eccentric load. Find the eccentricity which the load can have without producing section (Compression) in the section of column.** **Solution:**	4 M
	Ans.	D = 250 mm, d = 200 mm	
		$A = \frac{\pi}{4}(D^2 - d^2) = \frac{\pi}{4}(250^2 - 200^2) = 17671.458\ mm^2$	
		$I = \frac{\pi}{64}(250^4 - 200^4) = 113.207 \times 10^6\ mm^4$	1/2 M
		$Z = \frac{I}{Y} = \frac{I}{\frac{D}{2}} = \frac{113.207 \times 10^6}{\frac{250}{2}} = 905.656 \times 10^3\ mm^3$	1/2 M
		Direct stress $\sigma_o = \frac{P}{A} = \frac{P}{17671.458}$	1/2 M
		Bending stress, $\sigma_b = \frac{M}{Z} = \frac{P \times e}{Z} = \frac{P \times e}{905.656 \times 10^3}$	01 M
		For no tension condition, we know that $\sigma_o = \sigma_b$	
		$\frac{P}{17671.458} = \frac{P \times e}{905.656 \times 10^3}$	1/2 M
		e = 51.249 mm	01 M

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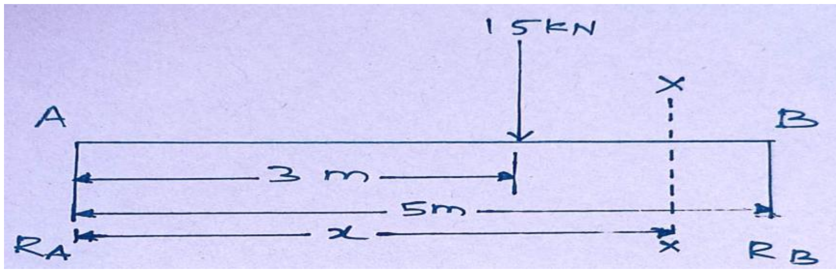
Subject Name: Theory of Structure **Model Answer** **Subject Code: 22402**

Q-3		Attempt any THREE of the following	12 M
	a.	Using Macaulay's method calculate slope under point load of 15 KN acting at 3 m from left hand support of simply supported beam of span 5 m in terms of EI.	4 M



Ans

ΣFy =0, $R_A + R_B = 15$

M@A = 0, RB X 5 =15 X 3,

RB = 9 KN, RA = 6 KN

Consider section at x-x distance from Support A

$Mx = R_A . x \ X - 15 (X-3)$

But $Mx = EI \dfrac{d^2y}{dx^2}$

$EI \dfrac{d^2y}{dx^2} = 9 X - 15 (X-3)$ ……….. Equation 1 — 1/2 M

1/2 M

Integrating Equation 1 , we get

$EI \dfrac{dy}{dx} = 9 X^2/2 - 15 (X-3)^2/2 + C_1$ slope equation 2 — 1/2 M

Integrating Equation 2, we get

$EI\ y = 9 X^3/6 - 15 (X-3)^3/6 + C_1 X + C_2$ equation 3

To calculate C_2 apply boundary condition put x = 0, y = 0 in equation 3 , we get — 1/2 M

$0 = 0 + 0 + C_2$

$C_2 = 0$

To calculate C_1, apply boundary condition, at x = 5, y = 0 in equation 3 — 01 M

$0 = 6 \times \dfrac{5^3}{6} - 15 \dfrac{(5-3)^3}{6} + C_1 \times 5 + 0$ — 1/2 M

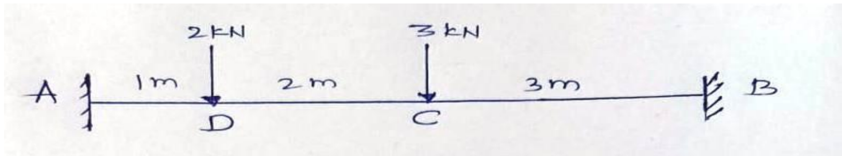
$C_1 = -21$

To calculate slope under point load, put x = 3m in slope equation 2, we get

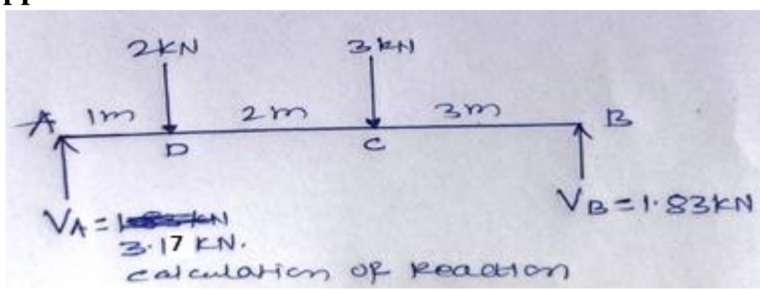
$EI \dfrac{dy}{dx} = 6 \times \dfrac{3^2}{2} - 15 \times \dfrac{(3-3)^2}{2} - 21 = 6$

$\dfrac{dy}{dx} = 6/EI$ Slope under point load. — 1/2 M

b. **Calculate fixed end moments and draw BMD for fixed beam shown in fig No.1** 4 M



Ans **Step 1) To find support reaction and free bending moment by assuming beam to be simply supported.**



Support reaction $\Sigma F_y = V_A - 2 - 3 + V_B$

$V_A + V_B = 5$

M @A =0 = 2X1+3X3-V_B X 6

V_B = 1.83 KN

V_A =3.17 KN

Free bending Moments

M_A =0, M_B = 0 Simply supported end 1/2 M

M_D =3.17 X1 = 3.17 kN.m (Sagging)

M_C = 1.83 X 3 =5.49 kN.m (Sagging)

Draw µ diagram using M_C and M_D 01 M

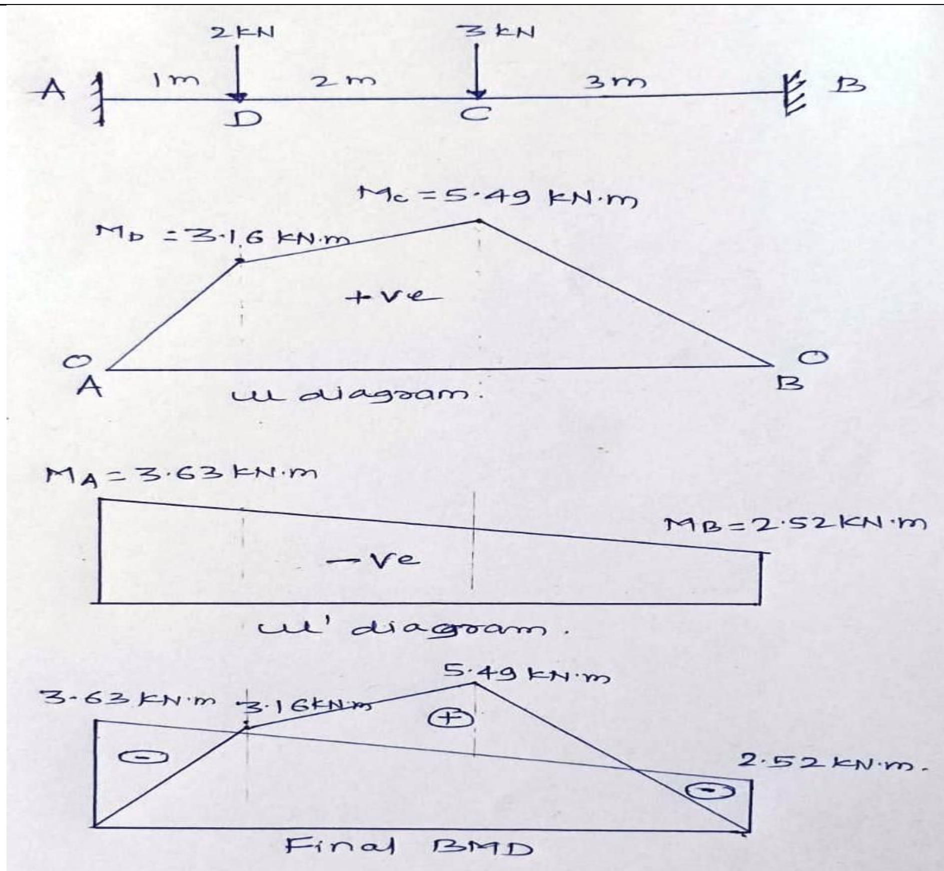
Step 2) To find fixed end moments M_A & M_B

$$M_A = \frac{-W_1.a_1.b_1^2}{L^2} - \frac{W_2.a_2.b_2^2}{L^2} = \frac{-2x1x5^2}{6^2} - \frac{3x3x3^2}{6^2} = -3.63 \text{ KN.m}$$

$$M_B = \frac{-W_1.b_1.a_1^2}{L^2} - \frac{W_2.b_2.a_2^2}{L^2} = \frac{-2x5x1^2}{6^2} - \frac{3x3x3^2}{6^2} = -2.52 \text{ KN.m}$$ 1/2 M

Draw µ’ diagram using M_A and M_B

By superimposing µ diagram and µ’ diagram, we get final BMD (As shown in fig) 1/2 M

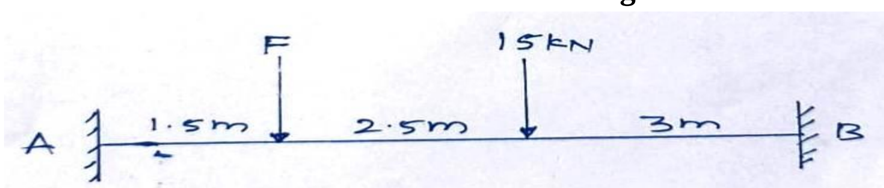


1/2 M

1/2 M

1/2 M

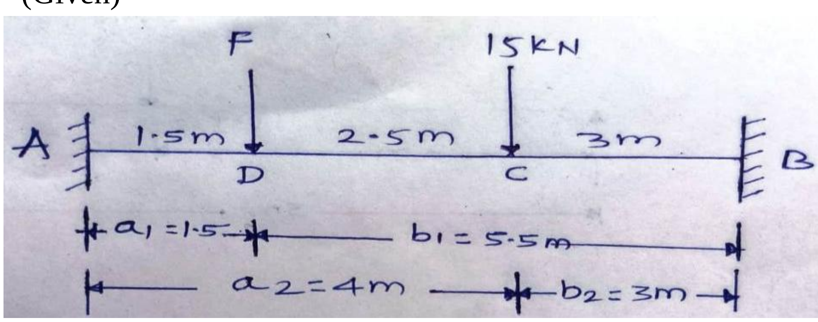
c. **Calculate the value of F for fixed beam as shown in fig No.2 if MA= MB.** 4 M



Ans

To find 'F'

MA = MB (Given)



1 M

$$M_A = \frac{-W_1.a_1.b_1^2}{L^2} - \frac{W_2.a_2.b_2^2}{L^2} = \frac{-Fx1.5x5.5^2}{7^2} - \frac{15x4x3^2}{7^2} = -0.92F-11.02 \quad (1)$$ 01 M

$$M_B = \frac{-W_1.b_1.a_1^2}{L^2} - \frac{W_2.b_2.a_2^2}{L^2} = \frac{-Fx5.5x1.5^2}{7^2} - \frac{15x3x4^2}{7^2} = -0.25\ F\ -14.93 \quad (2)$$ 01M

To get value of 'F', use $M_A = M_B$ (Given) 01 M

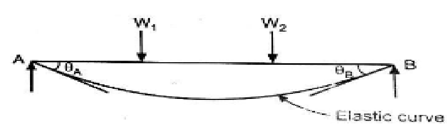
-0.92 F -11.02 = -0.25 F-14.93

0.67 F =3.91

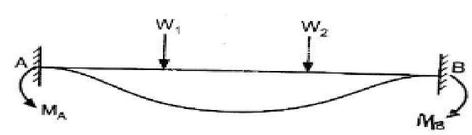
F= 5.835 KN.

d. **Explain the concept of fixity with effect in fixed beam** 4 M

Ans. If simply supported beam is considered subjected to any pattern of loading, beam bends and slopes will be developed at the ends. If however, the ends of beam are firmly built in supports i.e. ends are fixed, slopes at the supports are zero. Fixity at ends induces end moments. Due to fixity, deflection of beam at center of beam is also reduced as compared to simply supported beam. 2 M



Simply supported beam



Fixed Beam

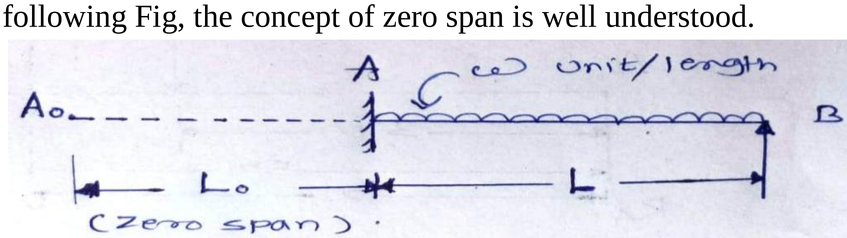
2 M

Q-4 **Attempt any THREE of the following** **12 M**

a. **Explain the concept of imaginary zero span in case of Clapeyron's theorem**. **4 M**

Ans. When the ends of the continuous beam are fixed, then an imaginary zero span is taken or considered to the left or right of the support as the case may be and the Clapeyron's theorem is applied to an imaginary span and its adjacent span. **2 M**

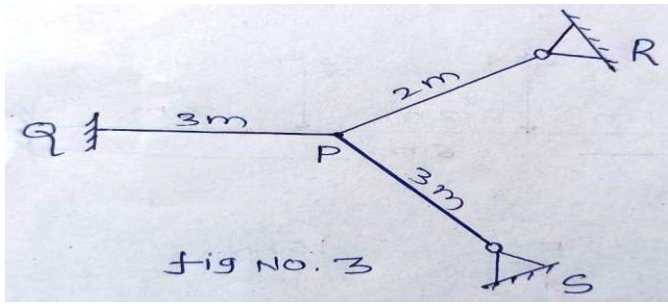
From the following Fig, the concept of zero span is well understood.



1 M

The end A is fixed, hence assume an imaginary span A0A, (called as zero span) to the left of A so as to apply Clapeyron's theorem for span A0A, and AB **1 M**

b. **Calculate the distribution factor for the members PQ, PR and PS as shown in fig 3 Take EI = constant.** 4 M



Ans.

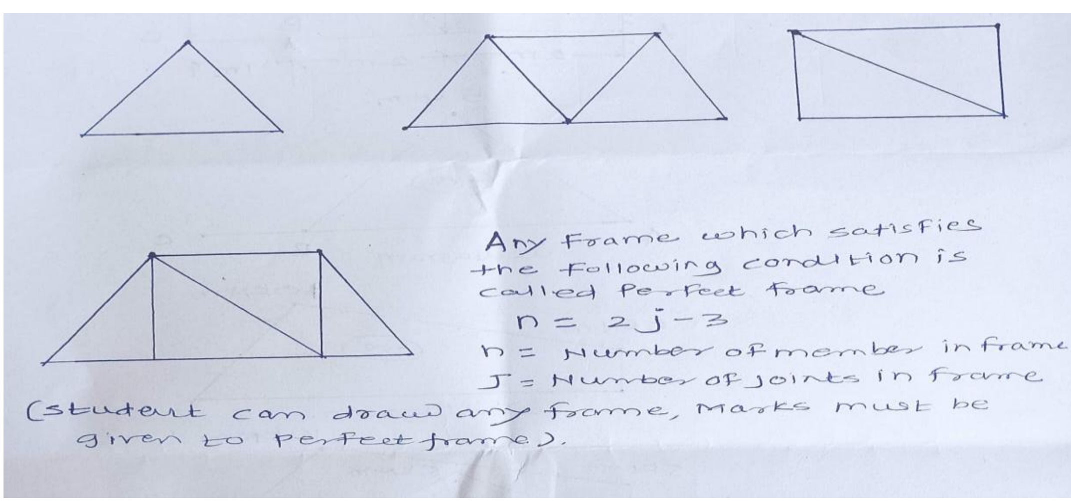
Joint	Member	Stiffness Factor	Total Stiffness	Distribution Factor
P	PQ	K_{PQ}= 4EI/L =4 EI/3 =1.333 EI	$K0= K_{PQ}+ K_{PR}+ K_{PS}$ = (1.333+1.5+1)EI =3.833 EI	$DF_{PQ} = \frac{1.333EI}{3.833EI}$ =0.348
	PR	K_{PR} = 3 EI/L =3 EI/2 =1.5 EI		$DF_{PR}= \frac{1.5EI}{3.833EI}$ =0.391
	PS	K_{PS} = 3EI/L =3 EI/3 = 1EI		$DF_{PS}= \frac{EI}{3.833EI}$ =0.261

(Stiffness calculation 1M, Total stiffness =1 M, D.F Calculation = 2M)

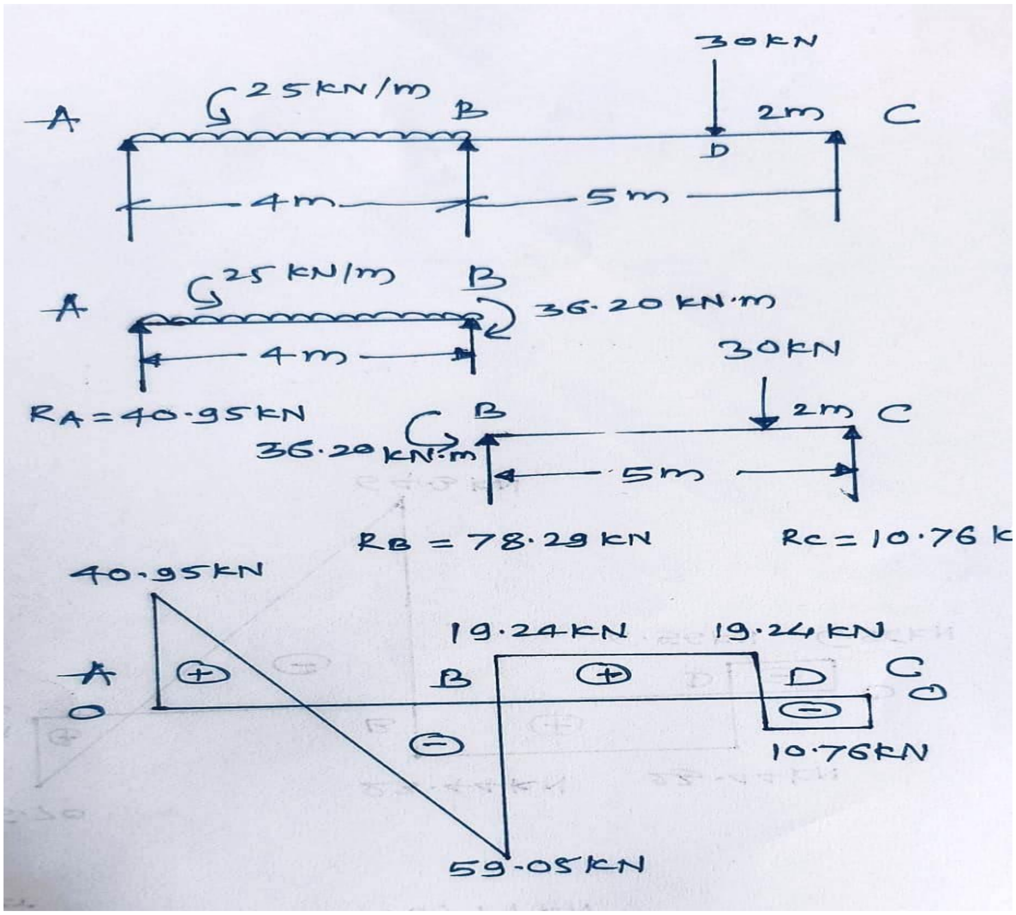
Stiffness calculation 1M, Total stiffness =1 M, D.F Calculation = 2M)

c. **Draw the sketches of any four perfect trusses** 4 M

Ans.



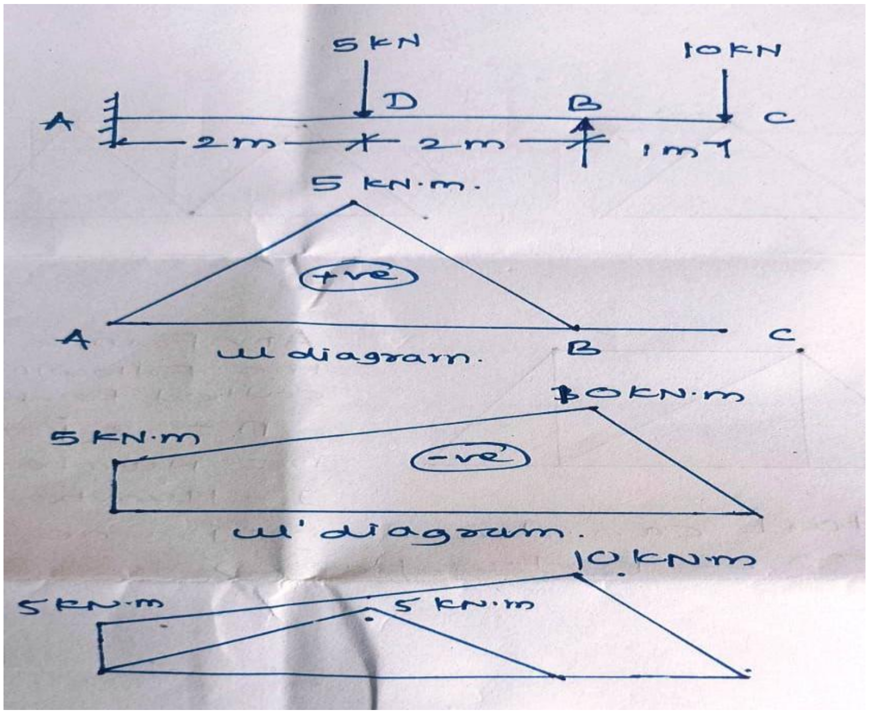
1 M for Each Fig.

	d.	Draw SFD for continuous beam as shown in fig No. 4. Also calculate B.M at support B.	4 M
	Ans.		1 M
		Step 1) To find the support moments at A, B & C support $M_A = M_C = 0$ (Due to simply supported end) For span AB & BC a_1 =Area of μ diagram of span AB = ($\frac{2}{3}$ x 4x50) =133.33 $\bar{x}_1$ =Centroidal distance of μ diagram from end A =4/2 = 2m. a_2 = Area of μ diagram of span BC = (1/2 x 5 x 36) = 90 $\bar{x}_2$ =Centroidal distance of μ diagram from end C = $\frac{(L+b)}{3} = \frac{(5+2)}{3}$ =2.33 **Apply Clapeyron's theorem of three moments for span AB & BC.** $M_A.L_1 + 2M_B(L_1+L_2) + M_C L_2 = -\left(\frac{6xa_1xX_1}{L_1} + \frac{6xa_2xX_2}{L_2}\right)$	1 M

		$0 \times 4 + 2 \times M_B (4 + 5) + 0 \times 5 = -\left(\frac{6x133.33x2}{4} + \frac{6x90x2.33}{5}\right) = -651.64$	
		$M_B = -36.20$ KN.m	
		Step 3) To find support reaction	1 M
		For span AB,	
		M @ B = R_A X 4 – (25X4X2)+36.20 =0	
		R_A =40.95 KN.	
		For span BC,	
		M @ B =-36.20 + 30 x 3 - Rc x 5	
		Rc = 10.76 KN	
		Σ Fy = 0 = R_A +R_B+R_C-25 X 4 -30	
		40.95 + R_B +10.76 =130	
		R_B= 78.29 KN	
		Step 4) Shear force calculation,	1 M
		S.F A_{Left} =0	
		S.F A_{Right} =40.95 KN	
		S.F B_{Left} = 40.95-25 x4 =-59.05 KN.	
		S.F B_{Right} = -59.05 +78.29 =19.24 KN.	
		S.F D_{Left} = 19.24 KN	
		S.F D_{Right} =19.24-30 =-10.76 KN	
		S.F. C_{Left}=-10.76 KN.	
		S.F @ C = -10.76 +10.76 =0 KN.	

e. **Calculate support moments and draw BMD of beam shown in Fig. No 5 by moment distribution method** — 4 M

Ans.



½ M

½ M

½ M

Step 1) Fixed end moments

M_{AB} = $-\frac{WL}{8} = -\frac{5X4}{8} = -2.5KN/m$

M_{BA} = $\frac{WL}{8} = \frac{5X4}{8} = 2.5KN/m$

M_{CB} = 30x1= 30 KN/m. — ½ M

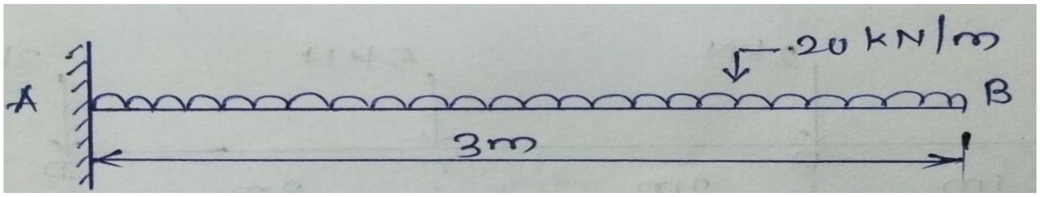
Step 2) Distribution factor — ½ M

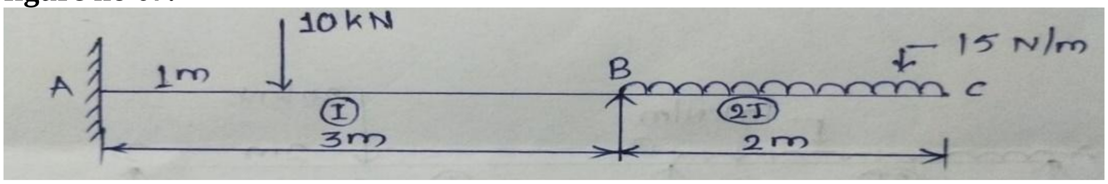
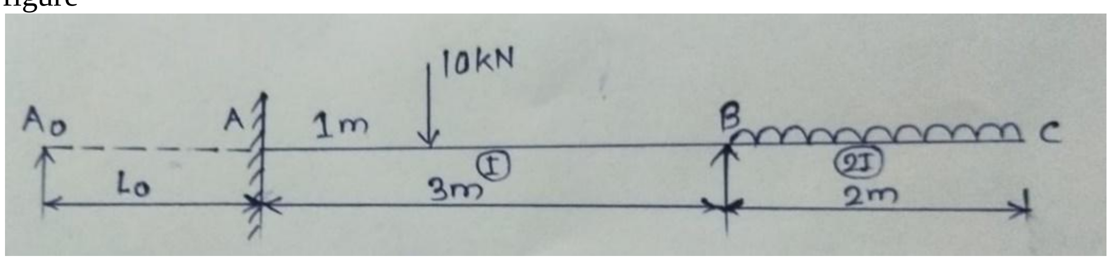
As there is no continuation at joint B and joint A is fixed there in no relative stiffness and there will not be any distribution factor. — ½ M

Moment distribution table:

Joint	A	B
Member	AB	BA
Fixed End Moments	-2.5	2.5
Balancing at B		-2.5
Carry over to A	-2.5	
Final Moments	-5	0

2 M

		Fixed end moment at End A is = - 5 KN/m (- ve sign indicates hogging moments) Draw μ' diagram for above value. Steps 2) Calculate free end moments considering beam to be simply supported. For span AB $M_{max} = \frac{WL}{4} = \frac{5x4}{4} = 5kN/m$ Draw μ diagram for above value.	1 M
Q-5		Attempt any **Two** of the following:	**12 M**
	a	**Calculate slope and deflection at free end of cantilever beam as shown in figure no.06 having cross section 160 mm width and 220 mm depth. Using standard formulae and take E=201 GPa**  	6 M
	Ans.	**Step 01:** Moment of Inertia about X-X Axis $= \frac{bd^3}{12} = \frac{160\ X\ 220^3}{12}$ $Ixx = 141.97 \times 10^6\ mm^4$ **Step 02:** To find the slope at free end i.e. point B $\boldsymbol{\theta B} = \boldsymbol{\theta max} = \frac{Wl^3}{6\ EI} = \frac{20\ X\ 3000^3}{6\ X\ 201\ X 10^3\ X 141.97 X\ 10^6}$ $\boldsymbol{\theta B} = \boldsymbol{\theta max} = 3.15\ X\ 10^{-3}$ radian **Step 03:** To find the deflection at free end i.e. point B. Let, Y_B = Deflection at free end $Y_B = \frac{-Wl^4}{8\ EI} = -\frac{20\ X\ 3000^4}{8\ X\ 201\ X 10^3\ X 141.97 X\ 10^6}$ = - 7.09 mm (Downward)	2 M 1 M 1 M 1 M 1 M

	b	**Using three moment theorem, Calculate support moments for beam as shown in figure no 07.** 	6 M
	Ans.	**Step 01:** Assuming each span of a continuous beam to be simply supported and calculating the Fixed End Moments (FEM). Free Bending Moment for span AB $M_A = 0, M_B = 0$ M_{max} = Bending Moment at mid span of AB $= \frac{W.a.b}{L} = \frac{10 \ X\ 1\ X\ 2}{3}$ = 6.67 kN-m **Step 02:** Calculating the support moments at A,B,C Since end A is Fixed, Assuming an imaginary AA_0 to the left of support A as shown in figure 	1 M
		M_0 = Support moments at A_0 = 0 ………………………(due to zero span) M_A= Support moments at A M_B= Support moments at B due to the UDL **= -(15 x 2 x 2/2) = -30 N-m** M_C= Support moments at C = 0 …………………(due to simply supported at C)	1 M
		For Span A_0A and AB $a_0 x_0 = 0$ a_1 = area of μ diagram of span AB =(1/2 x b x h) = (½ x 3 x6.67) $x_1 = \frac{L1+b}{3} = \frac{3+2}{3}$ = 1.67 …………………(from end B) $a_1 x_1$ = (1/2 x 3 x 6.67 x x 1.67) = 16.67	1 M

Applying Clapeyron's Theorem for span AA_0 & AB we get,

$$M_0\frac{L0}{I0} + 2M_A\left(\frac{L_0}{I_0}+\frac{L_1}{I_1}\right)+M_B\left(\frac{L_1}{I_1}\right) = -\left(\frac{6\,a_0x_0}{l_0I_0} + \frac{6\,a_1x_1}{l_1I_1}\right)$$

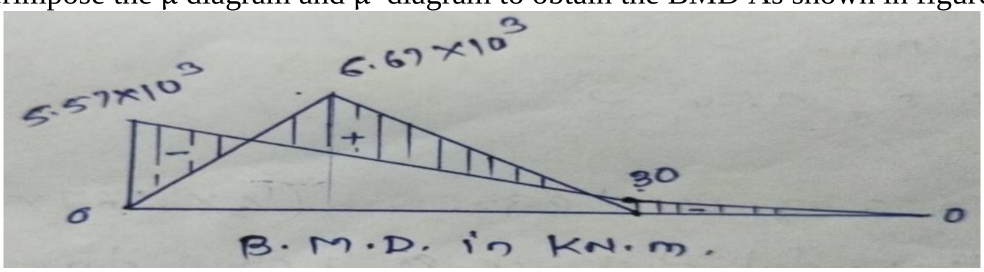
$$0 + 2M_A\left(0+\frac{3}{I_1}\right) - 30\text{ X }\left(\frac{3}{I_1}\right) = -\left(0 + \frac{6\text{ X }16.70}{3\text{ X }I_1}\right)$$

$6M_A - 90 = -33.34$

M_A = 9.43 kN-m …….(-ve sign indicates hogging bending moment) 1 M

Step 04:

Superimpose the μ diagram and μ′ diagram to obtain the BMD As shown in figure. 2 M



c. **Calculate slope at B and deflection at C of cantilever beam in terms of EI as shown in figure no.8 by using Macaulay's method.** 6 M

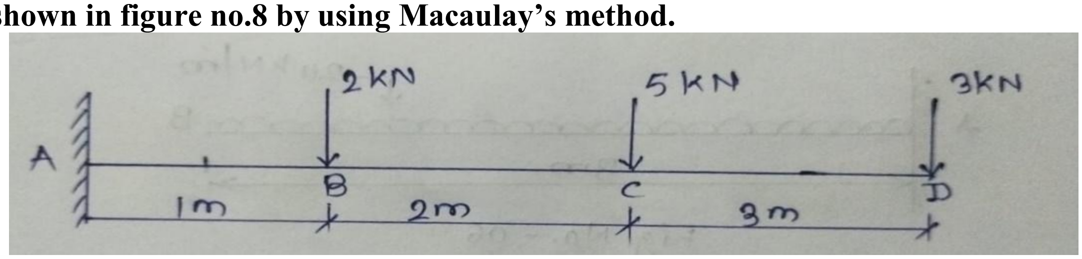
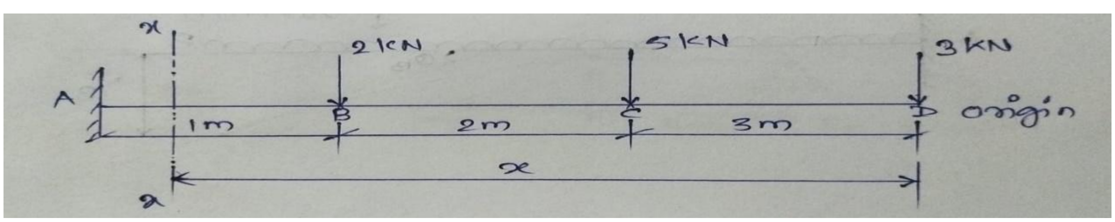


figure no.8

Ans. Step 01:

Consider the free end D as origin and consider the section X-X at a distance X from origin D in portion AB as shown in figure



		The general bending moment equation at a distance X from D. (Considering, Clockwise moment +Ve & Antilock wise moment –ve) (EI x $\frac{d^2y}{dx^2}$) = Mx-x = (3.x) + 5 (x-3) + 2 (x-5) ……………….(i)	½ M
		Integrating above eq.(i) w. r. to x (EI x $\frac{dy}{dx}$) =3 $\frac{x^2}{2}$ + 5 $\frac{(x-3)^2}{2}$ + 2 $\frac{(x-5)^2}{2}$ + C_1 …………(ii) (Slope Equation)	½ M
		Integrating above eq.(ii) w. r. to x (EI x y) = $\frac{3}{2}$ x $\frac{x^3}{3}$ + $\frac{5}{2}$ X $\frac{(x-3)^3}{3}$ + $\frac{2}{2}$ x $\frac{(x-5)^3}{3}$ + C_1.x + C_2 (EI x y) = $\frac{x^3}{2}$ + 2.50 X $\frac{(x-3)^3}{3}$ + $\frac{(x-5)^3}{3}$ + C_1.x + C_2 …….(iii) (Deflection Equation)	1 M
		Step 02: Apply boundary condition for calculating the value of constant of integration C_1 and C_2 <u>Condition 01:</u> At point A, where x= 6 m and $\frac{dy}{dx}$ = 0 Put these value in eq.(i) i.e. slope equation 0 = (3 x$\frac{6^2}{2}$) +(5 x $\frac{(6-3)^2}{2}$) +(2 x $\frac{(6-5)^2}{2}$) + C_1 0 = 54 + 22.50+ 1 + C_1 **C_1 = - 77.50 kN**	1 M
		At point A, where x= 6 m and y = 0 Put these value in eq.(ii) i.e. deflection equation 0 = ($\frac{6^3}{2}$) +(2.50 x $\frac{(6-3)^3}{3}$) +($\frac{(6-5)^3}{3}$) – (77.50 x 6) + C_2 = 108+ 22.50 +0.33 -465 + C_2 **C_2 = 334.17**	1 M

Step 03:

Calculating Slope at point B in terms of EI, where x= 5 m from origin D.

$(EI \times \frac{dy}{dx})_B = 3\frac{5^2}{2} + 5\frac{(5-3)^2}{2} + 2\frac{(5-5)^2}{2} - 77.50$

$(EI \times \frac{dy}{dx})_B = 37.50 + 10 + 0 - 77.50$

$(\frac{dy}{dx})_B = \theta B = -\frac{30}{EI}$ — 1 M

Step 04:

Calculating deflection at point C in terms of EI, where x= 3 m from origin D.

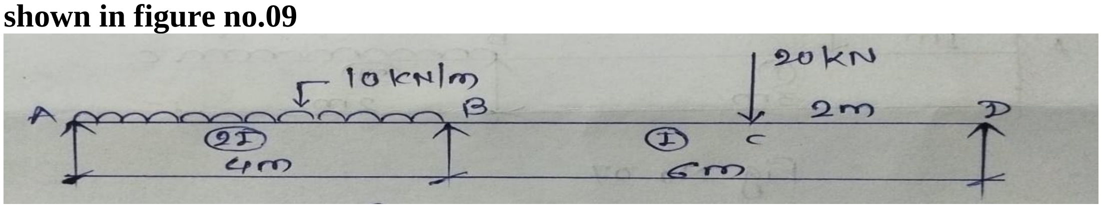
$(EI \times y_C) = \frac{3^3}{2} + 2.50 \times \frac{(3-3)^3}{3} + \frac{(3-5)^3}{3} - (77.50 \times 3) + 334.17$

$(EI \times y_C) = 13.50 + 0 + 0 - 232.50 + 334.17$

$y_C = \frac{115.17}{EI}$ — 1 M

Q-6 Attempt any **Two** of the following: **12 M**

a. **Using moment distribution method, calculate the support moments of beam as shown in figure no.09** — 6 M



Ans.

L1= 4 m , L2=6 m, W=10 kN/m W=20kN

For span AB= 2I

For span BC = I

Step 01:

Assuming each span of given beam to be fixed and calculating Fixed End Moments (FEM)

For Span AB:

$M_{AB} = -\frac{WL_1^{\,2}}{12} = -\frac{10x4^2}{12} = -13.33$ kN-m — ½ M

$M_{BA} = +\frac{WL_1^{\,2}}{12} = -\frac{10x4^2}{12} = +13.33$ kN-m — ½ M

For Span BD:

$M_{BD} = -\frac{Wab^2}{L^2} = -\frac{20x\ 4x2^2}{6^2}$ = -8.89 kN-m ½ M

$M_{DB} = +\frac{Wba^2}{L^2} = +\frac{20x\ 2x4^2}{6^2}$ = +17.78 kN-m ½ M

Step 02:

To find stiffness factor (K) for Joint B

$K_{BA} = \frac{3EI_1}{L_1} = \frac{3E.2I}{4}$ = 1.50 EI ½ M

$K_{BC} = \frac{3EI_2}{L_2} = \frac{3EI}{6}$ = 0.50 EI ½ M

$\sum K$= (1.50 EI +0.50 EI) = 2.00 EI

Step 03:

Calculating Distribution Factor:

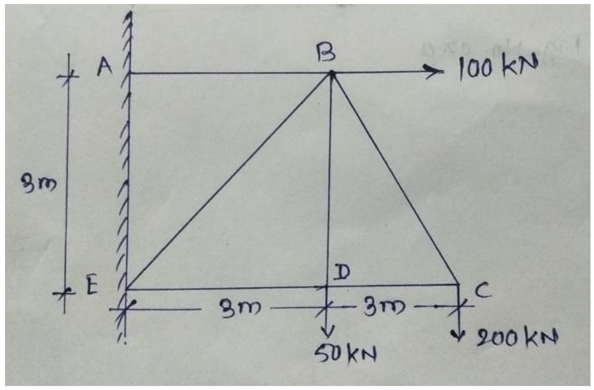
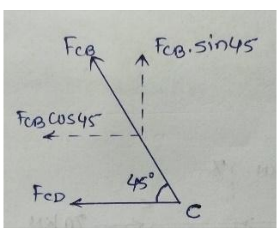
$(DF)_{BA} = \frac{K_{BA}}{\sum K} = \frac{1.50\ EI}{2\ EI}$ = 0.75 ½ M

$(DF)_{BC} = \frac{K_{BC}}{\sum K} = \frac{0.50\ EI}{2\ EI}$ = 0.25 ½ M

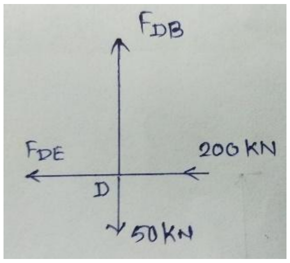
Check: (0.75 + 0.25)= 1.00

Step 04: Moment Distribution Table 02 M

Joint	A	B		D
Member	AB	BA	BD	DB
Distribution Factor	--	0.75	0.25	--
FEM	-13.33	+13.33	-8.89	+17.78
Release Support A&C C.O. from A to B & From D to B	+13.33			-17.78
		+6.665	-8.890	
Initial Moments First Distribution	0	+19.995	-17.780	0
Balance at B		-1.661	-0.554	
Final Moments	0	+18.334	-18.334	0

	b	**Using Method of Joints Calculate magnitude and state the nature of forces in the members AB,BD and DC of the truss shown in Fig.No.10** 	6 M
	Ans.	In ΔBCD ,Angle BCD = $\tan^{-1}\left(\frac{3}{3}\right) = 45$ In ΔDBE ,Angle DBE = $\tan^{-1}\left(\frac{3}{3}\right) = 45$ Consider, Tensile force as +ve And Compressive force as –ve. Calculating the member forces by using Joint method: **1)Take FBD of Joint C:**  $\sum Fy=0$ $F_{CB} \sin 45 – 200 = 0$ $F_{CB} = \left(\frac{200}{\sin 45}\right) = 282.84$ kN (Tensile) $\sum Fx=0$ $F_{CD} + 282.84 \cos 45= 0$ $F_{CD} = - 200$ kN $F_{CD} = 200$ kN (Compressive)	1 M 1 M

2) Take FBD of joint D:



$\sum Fy=0$

$F_{DB} - 50 = 0$

$F_{DB} = 50$ kN (Tensile) — 1 M

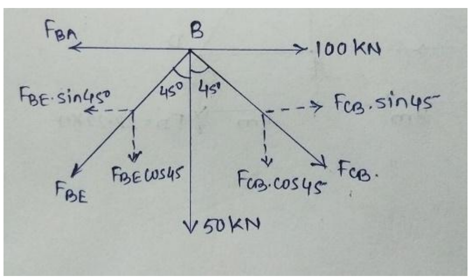
$\sum Fx=0$

$F_{DE} + 200 = 0$

$F_{DE} = -200$ kN

$F_{DE} = 200$ kN (Compressive) — 1 M

3) Take FBD of Joint B:



$\sum Fy=0$

$-50 - 282.84 \cos 45 - F_{BE} \cos 45 = 0$

$-250 - F_{BE} \cos 45 = 0$

$- F_{BE} = \frac{250}{\cos 45} = 353.55$ kN — 1 M

$F_{BE} = 353.55$ kN (Compressive)

$\sum Fy=0$ — 1 M

$F_{BA} + 353.55 \sin 45 - 100 - 282.84 \sin 45 = 0$

$F_{BA} = 50$ kN (Tensile)

Sr.	Member	Force	Nature
1	AB	50 kN	Tensile
2	BD	50 kN	Tensile
3	DC	200 kN	Compressive

c **Calculate the magnitude and state the nature of forces in the members BC and FE of truss As shown in fig.no 11 by using method of joints.** 6 M

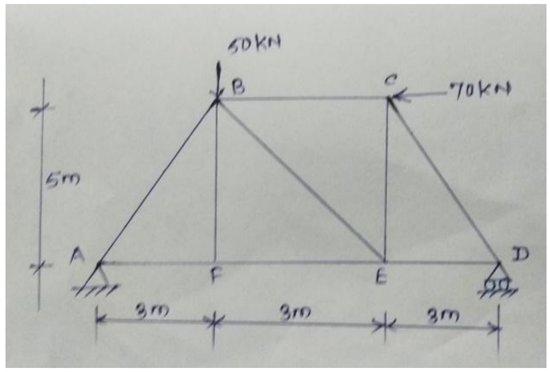
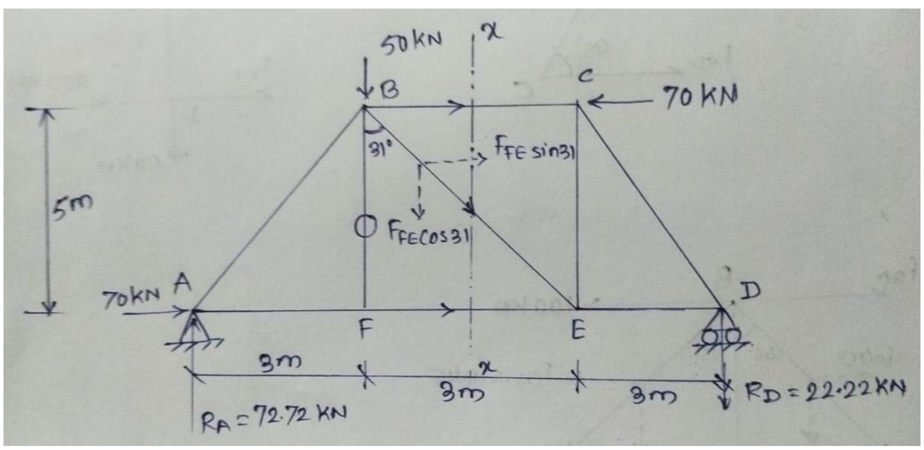


Fig no 11

Ans. In ΔBFE Angle FBE= tan-1 (3/5) = 30.96 = 31 1 M



Step 01:

Calculating Support reactions of truss:

$\sum M@A$=0

-(R_D x 9) +(50 x 6) –(70 x 5) = 0

R_D=22.22 kN (down ward) 1 M

$\sum Fy$=0

R_A – R_D =50

R_A=50+ 22.22 = 72.22 kN (upward) 1 M

$\sum Fx$=0

H_A= 70 kN (right side)

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		Considering the sectin X-X and applying conditions of equilibrium to the left part of truss. $\sum M@B$=0 -(F_{FE} x 5) + (72.22 x 3) –(70 x 5) = 0 F_{FE} = 26.68 kN (Tensile)	1 M
		$\sum Fy$=0 -50 +72.22 –(F_{BE} cos31) = 0 F_{BE} = 25.92 (Tensile)	1 M
		$\sum Fx$=0 70 + 26.68 + (25.92 sin31)+ F_{BC} = 0 F_{BC} = -110.02 kN F_{BC} = 110.02 kN(Compressive)	1 M

Sr	Member	Force	Nature
1	BC	110.02 kN	Compressive
2	FE	26.68 kN	Tensile