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Zeal Education Society's

ZEAL POLYTECHNIC, PUNE.

NARHE | PUNE -41 | INDIA

FIRST YEAR (FY)

DIPLOMA IN CIVIL ENGINEERING

SCHEME: I SEMESTER: IV

NAME OF SUBJECT: Theory of Structures

Subject Code: 22402

MSBTE QUESTION PAPERS & MODEL ANSWERS

1. MSBTE SUMMER-19 EXAMINATION
2. MSBTE WINTER-19 EXAMINATION

22402

21819

4 Hours / 70 Marks Seat No. | | | | | | | | |

Instructions – (1) All Questions are *Compulsory.*

(2) Answer each next main Question on a new page.

(3) Illustrate your answers with neat sketches wherever necessary.

(4) Figures to the right indicate full marks.

(5) Assume suitable data, if necessary.

(6) Use of Non-programmable Electronic Pocket Calculator is permissible.

(7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

Marks

1. Attempt any <u>FIVE</u> of the following: 10

a) Define core of section with sketch.

b) Give relationship between slope, deflection and radius of curvature.

c) State effect of continuity on continuous beam.

d) Define carry over factor and stiffness factor.

e) Draw neat sketch of symmetrical and unsymmetrical portal frame.

f) Draw stress distribution diagram for $6_0 = 6_b$, $6_0 > 6_b$

g) Define Redundant frame with sketch.

h) Define continuous beam and draw sketch of it.

Marks

2. Attempt any THREE of the following: 12

a) Explain with expression four conditions of stability of dam.

b) A hollow circular column having external diameter 500 mm and Internal diameter 300 mm carries an vertical load of 200 kN acting at an eccentricity of 60 mm from c.g Calculate maximum and minimum stresses developed.

c) Find maximum and minimum stress intensities induced on the base of a masonry wall 6 m high, 4 m wide and 1.5 m thick subjected to a horizontal wind pressure 1.5 kN/m^2 acting on 4 m side. The density of masonry material is 24 kN/m^3.

d) Calculate core of section for circular section having diameter 400 mm and draw sketch of it.

3. Attempt any THREE of the following: 12

a) A simply supported beam carries u.d.l of 4 kN/m over entire span of 4 m. Find the deflection at mid span in terms of EI.

b) Calculate fixed end moments and draw B.M.D as shown in Fig. No 1.

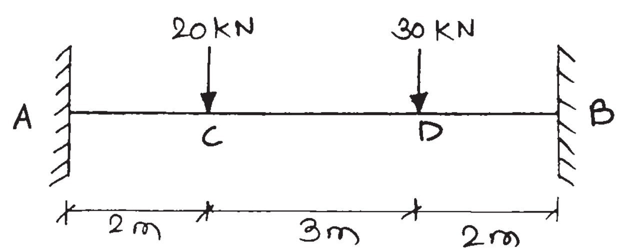


Fig. No. 1

c) Calculate value of load 'W' for a fixed beam as shown in Fig. No. 2

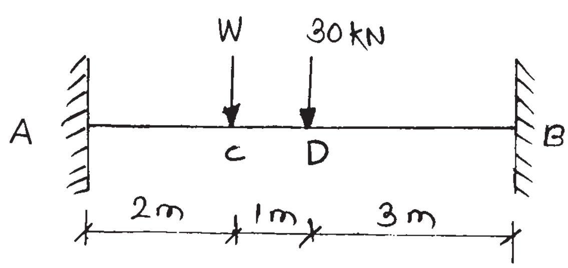


Fig. No. 2

d) Explain principle of super position with example.

Marks

4. Attempt any THREE of the following: **12**

a) State and explain Clapeyron's theorem of three moments.

b) Calculate distribution factors for the member OP, OQ and OR for the joint 'O' as shown in Fig. No. 3.

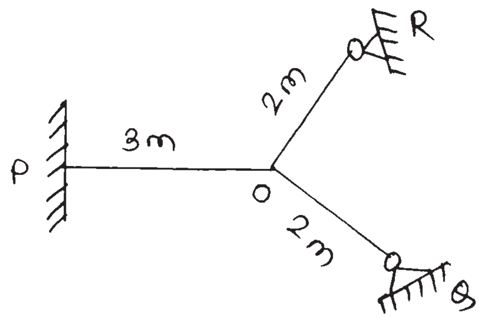


Fig. No. 3

c) Draw four types of trusses.

d) Draw SFD for a continuous beam as shown in Fig. No. 4 having negative B.M at support B as 66.14 kN/m.

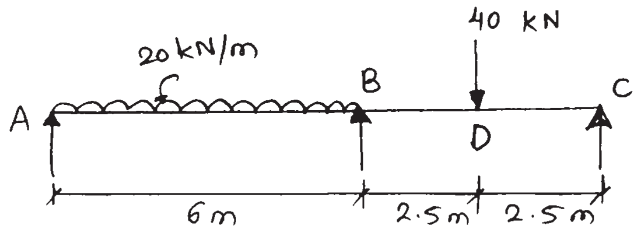


Fig. No. 4

e) Using moment distribution method determine the moments at fixed end of a proped cantilever of span 5 m carrying a u.d.l of 25 kN/m over entire.

5. Attempt any TWO of the following: **12**

a) A cantilever of span 3.5 m carries a point load at free end. If the maximum slope at the free end is 1°, determine the maximum deflection in mm.

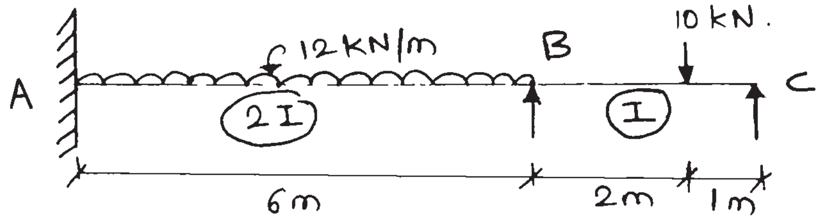
b) A continuous beam ABC of uniform M.I carries a central point load of 85 kN on span AB. A u.d.l of 30 kN/m is acting over the entire span BC. Plot BM diagram. Span AB and BC are 6 m and 4 m respectively. A and C are simple supports. Use three moment theorem.

Marks

c) A simply supported bean of span 6 m carrying 'W' kN at 4 m from left. Find the value of 'W':F deflection at centre is 20 mm. Take EI = 2000 $kN.m^2$. Use Macaulay's method.

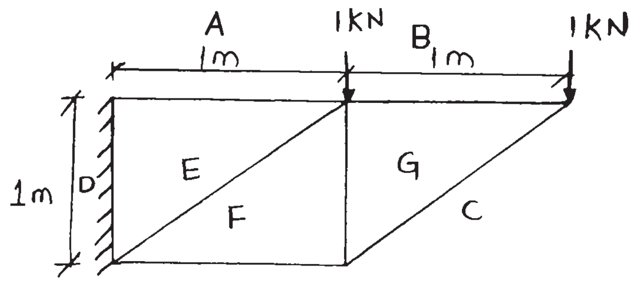
6. Attempt any <u>TWO</u> of the following: 12

a) Calculate the support moment using moment distribution method Refer Fig. No. 5.



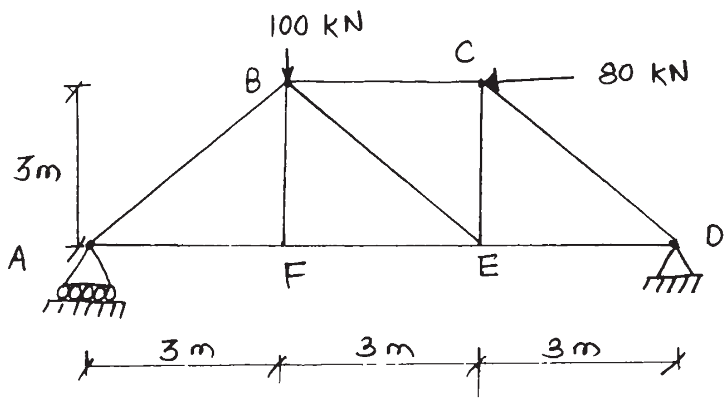
<u>Fig. No. 5</u>

b) A cantilever truss is loaded as shown in Fig. No. 6. Find the stresses in members by method of joint.



<u>Fig. No. 6</u>

c) Using method of section. Find the forces in the member BC, BE and FE of the frame as shown in Fig. No. 7



<u>Fig. No. 7</u>

MHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

(Autonomous)

(ISO/IEC - 27001 – 2015 Certified)

SUMMER- 2019 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.

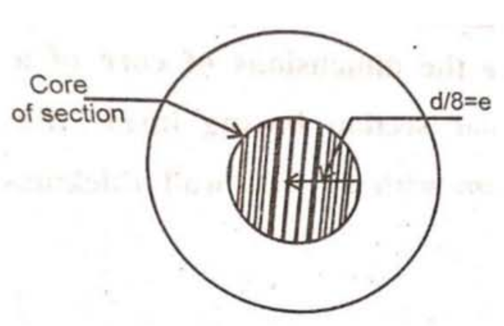
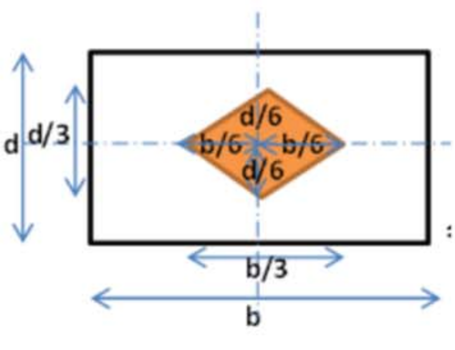
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.

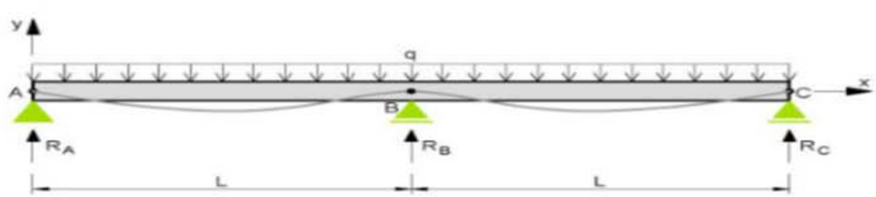
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

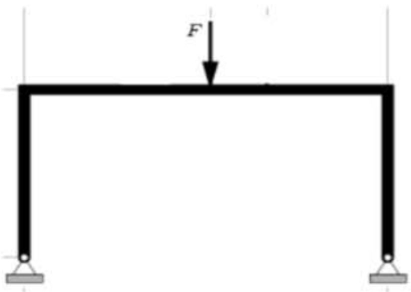
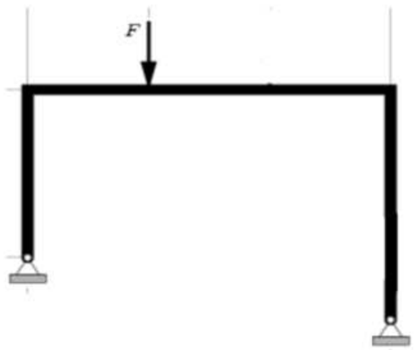
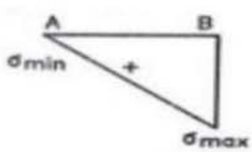
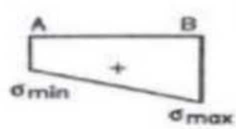
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values model answer.

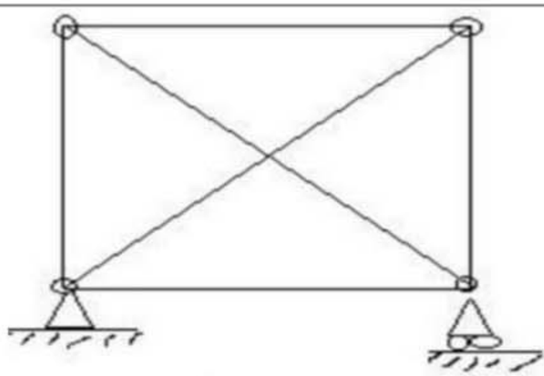
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer

7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. NO	ANSWERS	MARK SCHEME
Q.1	**Attempt any FIVE of the following:**	**(10)**
a)	**Define core of section with sketch**	
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. It is also defined as the region or area within which if load is applied, produces only compressive resultant stress. If Compressive load is applied, the there is no tension anywhere in the section. emax = d/8 e = Core of section	01 M
	 For Circular section  For rectangular section	01 M

b)	**Give relationship between slope, deflection and radius of curvature.**	
Ans :-	Slope of a beam at a point is defined as rate of change of deflection with respect to longitudinal distance i.e. slope = dy / dx , The point of slope is "radian" (dy /dx) = ∫ Mx / EI (Y) = deflection Where Y = ∫ (1/ EI) (dy /dx) $1/R = d^2y/dx^2$, R = radius of curvature 1/ R = M / EI from bending equation $d^2y/dx^2 = M/EI$ Where.M= BM at any section at xx	01 M 01 M
C)	**State effect of continuity on continuous beam.**	
Ans :	**Effect of continuity:-**If a beam is continuous, over the supports, 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 capacity of the beam is increased. Effects of continuity are as follows. 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 01 M
d)	**Define carry over factor and stiffness factor**	
Ans:	**Carry over factor** : It is the ratio of moment produced at a joint to the moment applied at the other end of the member It is (1/2) **Stiffness factor** : It is the moment required to obtain unit rotation at an end without translating it .	01 M 01 M

e)	**Draw neat sketch of symmetrical and unsymmetrical portal frame**	
Ans:	**i. Symmetrical portal frame (Non sway type)** **ii. Unsymmetrical portal frame (Sway type)**  **Symmetrical portal frame** **Unsymmetrical portal frame**	01 M each
f)	**Draw stress distribution diagram for $6_0 = 6_b$, $6_0 > 6_b$**	
Ans:	**Solution: stress distribution diagram for i) $6o = 6_b$ ii) $6o > 6_b$** Where, stresses 6o = Direct stress and 6_b = Bending stress 6o = P / A 6b = (M x y) / I $\mathbf{6_{max} = 6_0 + 6_b}$ $\mathbf{6_{min} = 6_0 - 6_b}$  **i) $6o = 6_b$** **ii) $6o > 6_b$**	01 M 01 M
g)	**Define Redundant frame with sketch**	
Ans	**Imperfect frame**: It is the simple frame in which number of joints (j) and number of members (m) does not satisfy the equation m = 2j – 3. Such frames are internally indeterminate/redundant or deficient. If m > 2j – 3; then frame is called as indeterminate or redundant frame and it cannot be analysed by using basic equations of equilibrium (ΣMA = 0, ΣFx = 0 and ΣFy = 0).	01 M



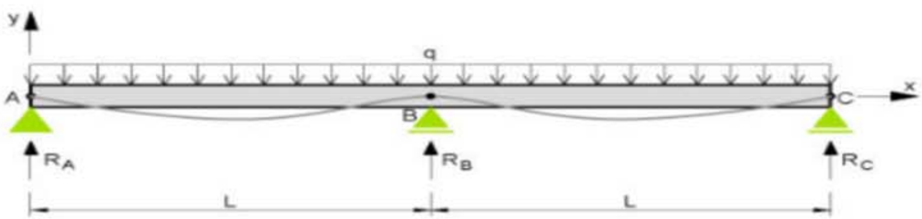
m = 6

01 M

h) **Define Continuous beam and draw sketch of it**

Ans: **Continuous beam :** A beam is said to be continuous if it has two or more spans and three or more supports as shown in figures. Here all three M_A , M_B and M_C are unknowns. Such beams are continuous over supports. 01 M

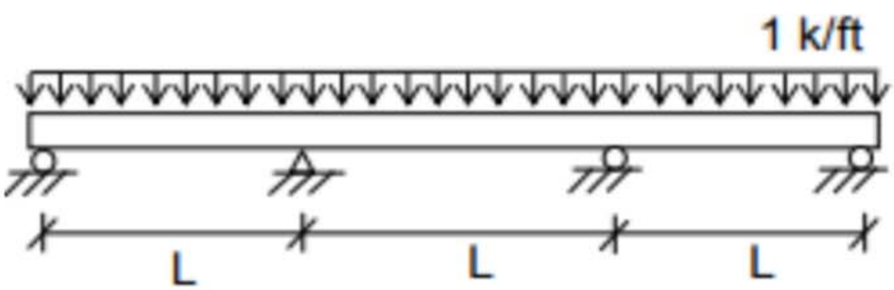
Here M_{A}, $M_{C} = 0$ and M_B is unknowns.



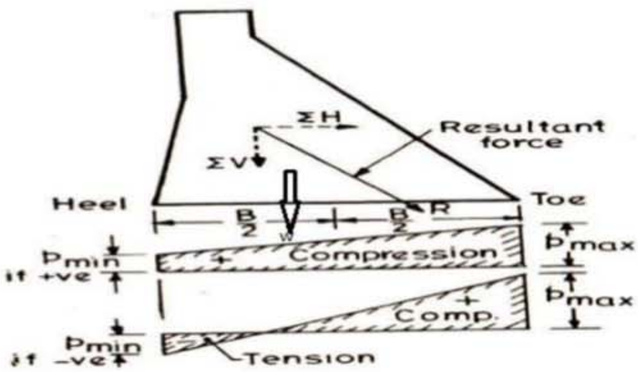
01 M

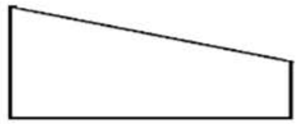
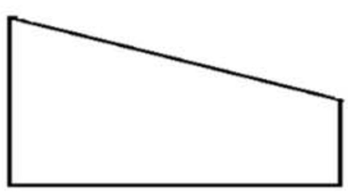
Continuous beam for three supports

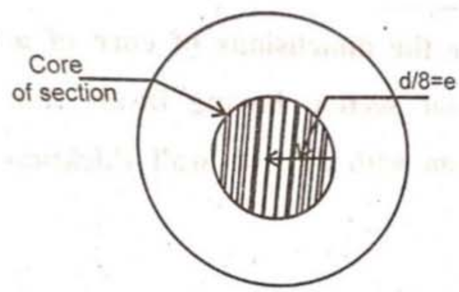
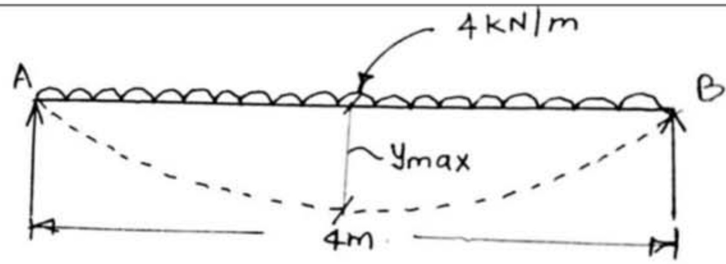
M_A M_B M_c

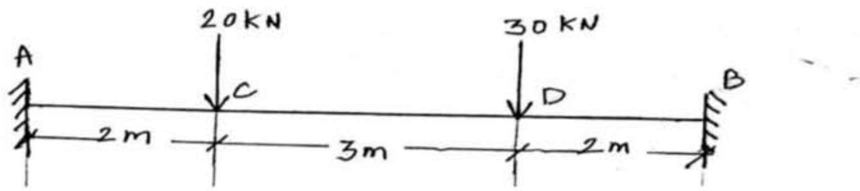


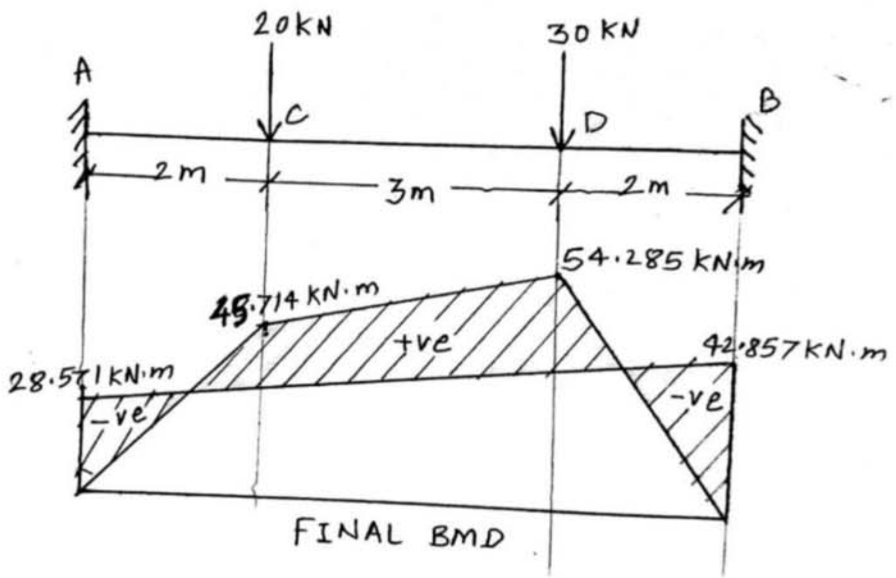
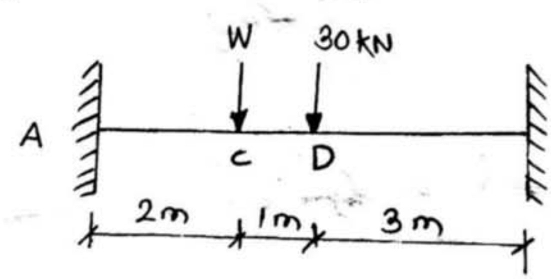
Continuous beam for more than three supports

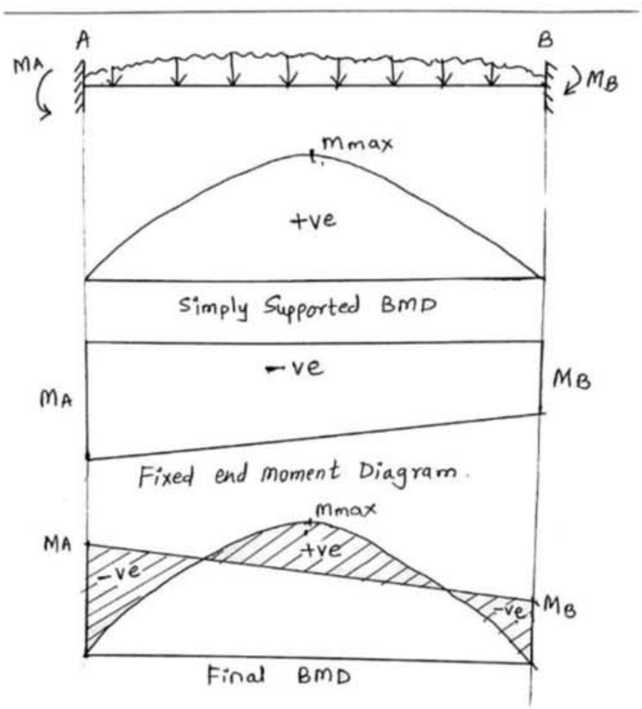
Q.2	**Attempt any THREE of the following:**	**(12)**
a)	**Explain with expression four conditions of stability of dam.**	
Ans:	1. Stability against Due to Overturning (P.h/3) < W(b-X) 2. Stability against Due to Sliding P < F 3. Compression or Crushing 4. Stability against No Tension e < (b/6) Where e = eccentricity P = Compressive Load h = Ht. of dam W =Wt of dam b = Base width of dam 	01 M 01 M 01 M 01 M
b)	**A hollow circular column having external diameter 500 mm and Internal diameter 300 mm carries an vertical load of 200 kN acting at an eccentricity of 60 mm from c.g Calculate maximum and minimum stresses developed.**	
Ans:	**Solution** :- A = Area of circular column P = 200 kN E = 60 mm D =500mm d= 300 mm $A = \pi /4 \ (500^2 - 300^2) = 125.66 \times 10^3 \ mm^2$ M = P x e = 200 x 60 =12000 kN mm $I = \pi /64 \ (500^4 - 300^4) = 2.67 \times 10^9 \ mm^4$ y = D / 2 = 500 / 2 = 250 mm. Where, Stresses $6_0 = P / A = (200 \times 1000)/ 125.66 \times 10^3 = 1.59 \ N/mm^2$ $6_b = (M \times y) / I = (12000 \times 1000 \times 250)/ 2.67 \times 10^9 \ N/mm^2$ **But,** $6_{max} = 6_0 + 6_b$, $6_{min} = 6_0 - 6_b$ $6_{max} = 6_0 + 6_b = 1.59 + 1.123 = 2.71$ N/mm^2 **Comp** $6_{min} = 6_0 - 6_b = 1.59 - 1.123 = 0.46$ N/mm^2 **Comp**	01 M 01 M 01 M 01 M

	 **2.71** N/mm^2 **0.46** N/mm^2 **Stress distribution diagram at base**	
c)	**Find maximum and minimum stress intensities induced on the base of a masonry wall 6 m high, 4, m wide and 1.5 m thick subjected to a horizontal wind pressure 1.5 kN/m^2 acting on 4 m side. The density of masonry material is 24 kN/m^3.**	
Ans	**Solution :**Area at base of wall = 4 x 1.5 = 6 m^2 Height of wall (h) = 6 m, Unit weight of material (σ) = 24 kN/m^3 Self-Weight of wall (W) = 24 x 6 x 6 = 864 kN. Stresses $6_0 = \sigma$ h OR 60 = W / A = 24 x 6 = 144 kN/m^2 OR 6_0 = W / A = 864 / 6 = 144 kN/m^2 I = 4 x 1.5^3 / 12 = 1.125 m4 y = 1.5 / 2 = 0.75 m Wind force (P) = Wind pressure x b x h = 1.5 x 4 x 6 = 36 kN Moment @ base (M) = P x h/2 = 36 x 6/ 2 = 108 kN-m **6_b = (M x y) / I = 108 x 0.75 / 1.125 = 72 kN/m^2** **$6_{max} = 6_0 + 6_b$ = 144 + 72 =216 kN/m^2 Comp** **$6_{min} = 6_0 - 6_b$ = 144 - 72 = 72 kN/m^2 Comp**  **216** N/mm^2 **72** N/mm^2 **Stress distribution diagram at base**	01 M 01 M 01 M 01 M

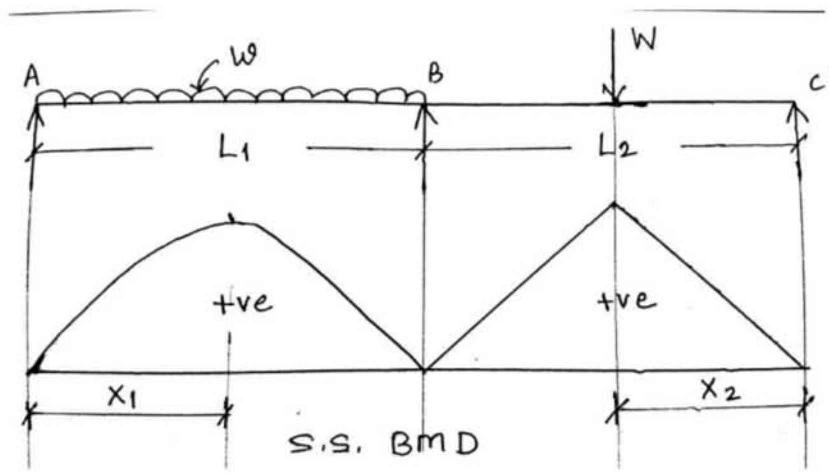
d)	**Calculate core of section for circular section having diameter 400 mm and draw sketch of it.**	
Ans:	Core of a section: It is defined as the region or area within which if load is applied,produces only compressive resultant stress. Solution : For No Tension ,$6_{min} = 0$ $6_{min} = 6_0 - 6_b$ $0 = P / A - (M x y) / I$ $0 = P / A - P * e * y / (\pi /64)d^4$ therefore $e < d/8$ d = 400 mm e max = d / 8 = 400 / 8 = 50 mm **Sketch of core section :**  	01 M 01 M 01 M 01 M
Q.3	**Attempt any THREE of the following:**	**(12)**
a)	**A simply supported beam carries UDL of 4 kN/m over entire span of 4m. Find the deflection at mid span in terms of EI.**	
	 Deflection at Centre $Ymax = \frac{5wL^4}{384EI}$ $Ymax = \frac{5x4x4^4}{384EI}$ $Ymax = \frac{13.333}{EI}$	**1M** **1M** **1M** **1M**

b)	**Calculate fixed end moments and draw BMD as shown in Fig. No. 1** 	
Ans.	Assume beam is simply supported beam and calculate support Reactions. $\sum M_A = 0$ Clockwise moment positive and Anti clockwise moment Negative $-R_B \times 7 + 20 \times 2 + 30 \times 5 = 0$ $R_B = 27.142$ kN $R_A + R_B =$ Total load $= 20+30 = 50$ $R_A + 27.142 = 50$ $R_A = 22.857$ kN Calculate BM at C and D for simply supported beam $M_c = 22.857 \times 2 = 45.714$ kN.m and moment at D $M_D = 22.857 \times 5 - 20 \times 3 = 54.285$ kN.m	1M
	Calculate Fixed End Moments $M_A = M_{A1} + M_{A2} = -\frac{W_1 a_1 b_1^2}{L^2} - \frac{W_2 a_2 b_2^2}{L^2}$ $= -\frac{20x2x5^2}{7^2} - \frac{30x5x2^2}{7^2} = -20.408 - 12.244$ $M_A = -32.652$ kN.m	1M
	$M_B = M_{B1} + M_{B2} = -\frac{W_1 a_1^2 b_1}{L^2} - \frac{W_2 a_2^2 b_2}{L^2}$ $= -\frac{20x2^2x5}{7^2} - \frac{30x5^2x2}{7^2} = -8.163 - 30.612$ $M_B = -38.775$ kN.m	1M

		1M for BMD
c)	**Calculate value of load 'W' for a fixed beam as shown in Fig. No.2** 	
Ans.	Assume $M_A = M_B$ if any other value of M_A and M_B is considered by students the weightage of marks are given accordingly and answer is checked. Calculate Support moments $M_A = -\frac{W_1 a_1 b_1^2}{L^2} - \frac{W_2 a_2 b_2^2}{L^2} = -\frac{Wx2x4^2}{6^2} - \frac{30x3x3^2}{6^2}$ $M_A = -0.888\ W - 22.5$ $M_B = -\frac{W_1 a_1 b_1^2}{L^2} - \frac{W_2 a_2 b_2^2}{L^2} = -\frac{Wx2^2x4}{6^2} - \frac{30x3^2x3}{6^2}$ $M_B = -0.444\ W - 22.5$ Equating $M_A = M_B$ $-0.888\ W - 22.5 = -0.444\ W - 22.5$ $-0.444W = 0$ $W = 0$	1M 1M 1M 1M

d)	**Explain Principle of superposition with Example.**	
	Statement- It states that if the number of forces/moments are acting simultaneously on a body, then their combined effect on the body is equal to the algebraic sum of the effects of the individual forces/ moments considered separately. This principle can be applied for analyzing a fixed beam as described below 1. The given fixed beam is converted into simply supported beam and simply supported bending moment diagram is plotted. 2. Fixed end bending moment diagram is plotted separately. 3. Simply supported BM diagram and fixed end BM diagram overlapped to get the final BM diagram for a fixed beam. 	2M 1M 1M
Q.4	**Attempt any THREE of the following:**	**(12)**
a)	**State and explain Clapeyron's theorem of three moments.**	
	The claperon's theorm of three moment is applicable to two span continuous beams. It state that " For any two consecutive spans of continuous beam subjected to an external loading and having uniform moment of inertia, the support moments M_A, M_B and M_C at supports A,B and C respectively are given by following equation	1M

$$M_A + 2M_B(L_1 + L_2) + M_C L_2 = -\left[\frac{6A_1X_1}{L_1}\right] - \left[\frac{6A_2X_2}{L_2}\right]$$ **1M**



1M

If the moment of inertia is not constant then claperon's theorem can be stated in the form of following equation.

$$M_A \frac{L_1}{I_1} + 2M_B\left(\frac{L_1}{I_1} + \frac{L_2}{I_2}\right) + M_C \frac{L_2}{I_2} + M_C \frac{L_2}{I_2} = -\left[\frac{6A_1X_1}{L_1I_1} + \frac{6A_2X_2}{L_2I_2}\right]$$ **1M**

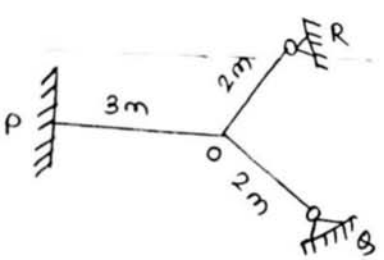
Where, L_1 and L_2 are length of span AB and BC respectively.

I_1 and I_2 are moment of inertia of span AB and BC respectively.

A_1 and A_2 are area of simply supported BMD of span AB and BC respectively.

X_1 and X_2 are distances of centroid of simply supported BMD from A and C respectively.

b) **Calculate the distribution factors for the member OP, OQ, and OR for the joint O as shown in fig 3.**



Ans.

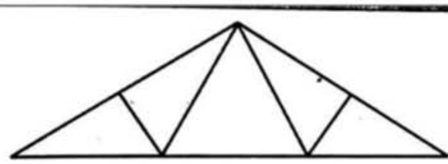
Joint	Member	Stiffness Factor	Total stiffness	Distribution Factor
O	OP	$K_{OP}=\frac{4EI}{L}=\frac{4EI}{3}$ $=1.333EI$	$\sum K_O = 1.333EI + 1.5EI + 1.5EI$ $= 4.333EI$	$DF_{OP}=\frac{1.333EI}{4.333EI}$ **DF_{OP}=0.3077**
	OQ	$K_{OQ}=\frac{3EI}{L}=\frac{3EI}{2}$ $=1.5EI$		$DF_{OQ}=\frac{1.5EI}{4.333EI}$ **DF_{OP}=0.3462**
	OR	$K_{OR}=\frac{3EI}{L}=\frac{3EI}{2}$ $=1.5EI$		$DF_{OR}=\frac{1.5EI}{4.333EI}$ **DF_{OR}=0.3462**

SF 2M

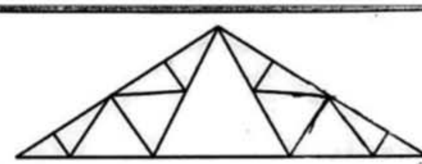
DF 2M

c) **Draw four types of trusses**

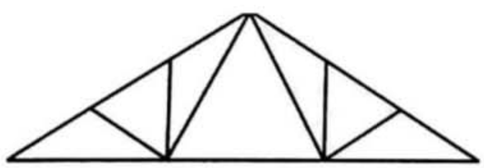
Ans.



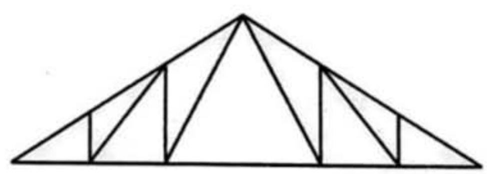
(a) Simple fink (span 6 - 9 m)



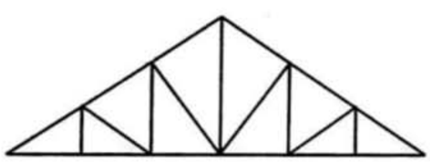
(b) Compound fink or french (span 12 - 18 m)



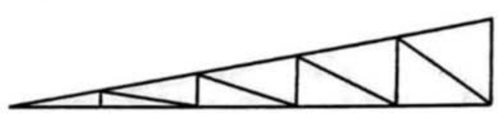
(c) Simple fan (span 7.5 - 12 m)



(d) Pratt (upto 30 m)

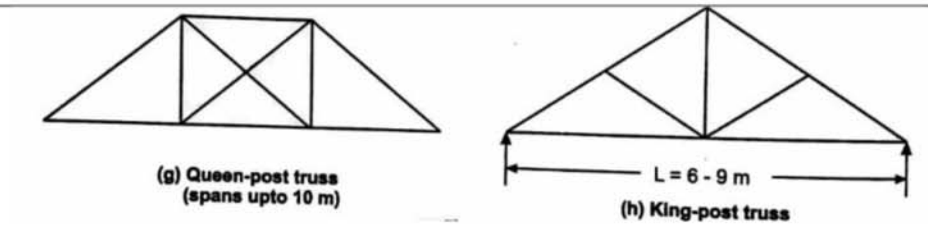


(e) Howe (span 6 - 24 m)

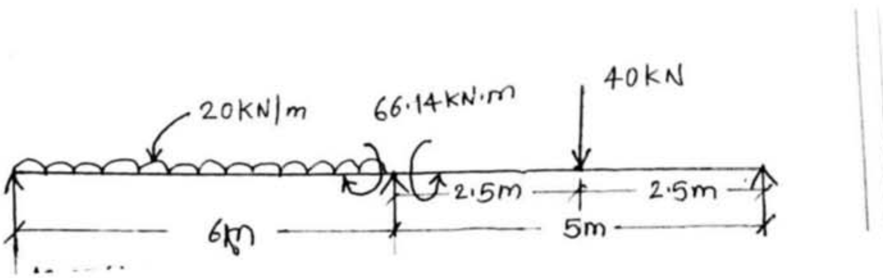


(f) North light root truss (Span 8 - 10 m)

1M Each



d) **Draw SFD for a continuous beam as shown in Fig. No. 4 having negative BM at support B as 66.14 kN.m**



Ans.

1. Calculate the support reactions

Consider Span AB Taking moment at B $\sum M_B = 0$

R_A x 6 – 20 x 6 x 3 + 66.14 = 0

R_A = 48.976 kN.

Consider Span BC Taking moment at B $\sum M_B = 0$

R_C x 5 – 40 x 2.5 - 66.14 = 0

R_C = 33.228 kN

$\sum F_y = 0$

R_A+R_B+R_C -20x6 – 40 = 0

48.976+R_B+33.228 = 160

R_B = 77.796 kN **1M**

2. **S.F. Calculations:**

SF at A, just left =0 and Just Right = +48.976 kN.

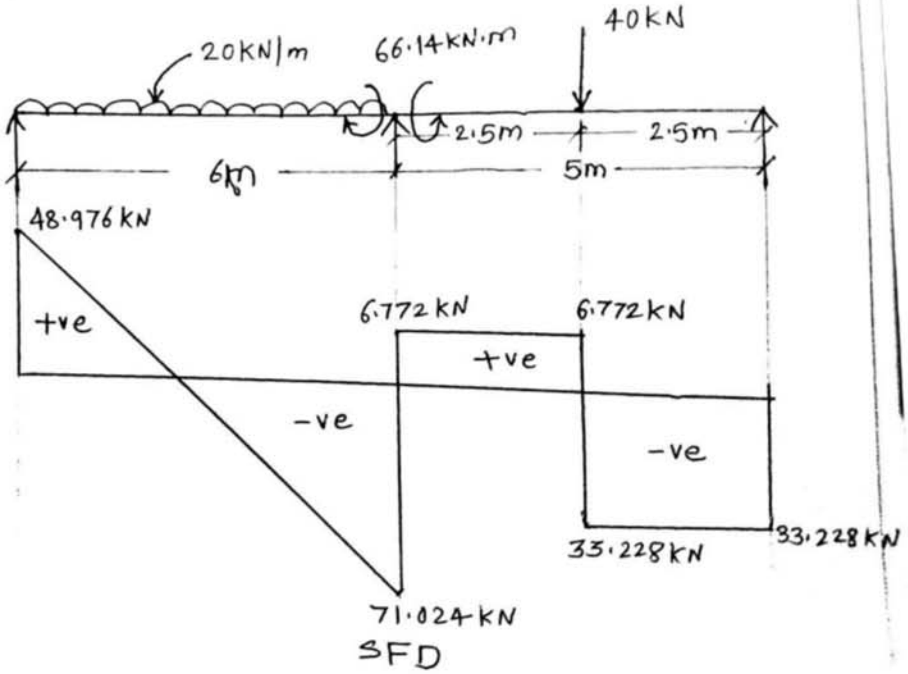
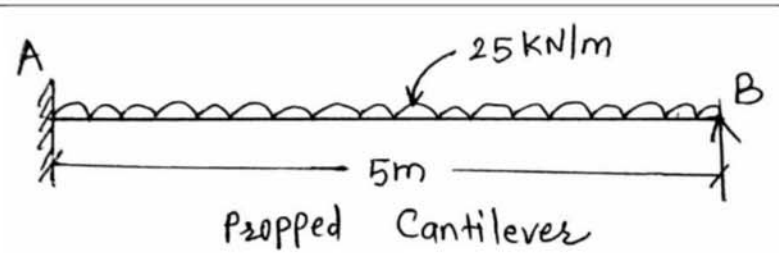
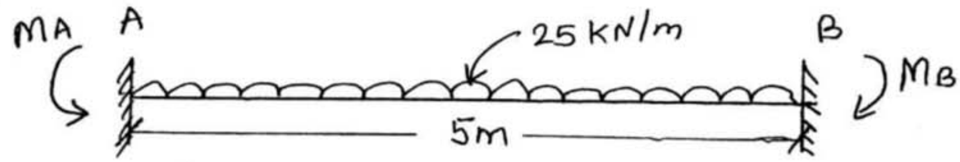
SF at B, just left = +48.976-20x6 = -71.024 kN.

Just Right = -71.024 + 77.796 = + 6.772 kN

SF at D, just left =+ 6.772 kN **1M**

Just Right = + 6.772 -40 = -33.228 kN

SF at C, just left = -33.228 kN

	Just Right = -33.228 kN + 33.228 kN = 0 	2M
e)	**Using moment distribution method determine the moments at fixed end of a proped cantilever of span 5m carrying a u.d.l. of 25 kN/m over entire.**	
Ans.	1. Calculate fixed end moments $M_{AB} = -\frac{wL^2}{12} = -\frac{25x5^2}{12} = -52.083kN.m$ $M_{BA} = -\frac{wL^2}{12} = -\frac{25x5^2}{12} = -52.083kN.m$	1M 1M

2. Distribution factors – as there is no continuation at Joint B and Joint A is fixed then there is no relative stiffness and there will not be any distribution factors.

Moment Distribution Table:

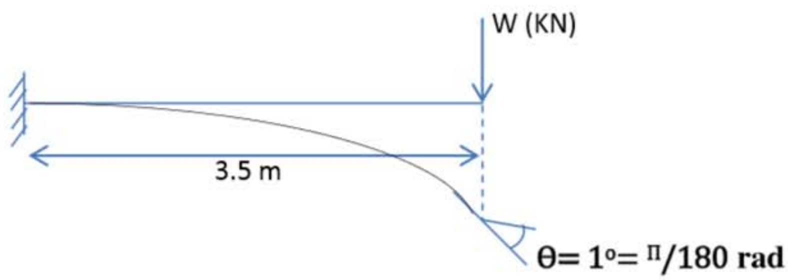
A	B	Joint
AB	BC	Member
-52.083	+52.083	Fixed end moments
	-52.083	Balancing at B
-26.041		Carryover to B
-78.124	0	Final Moments

Moment at fixed end M_A = -78.124 kN.m (-ve sign indicates Hogging moment)

2M

Q.5	**Attempt any TWO of the following:**	**(12)**
a)	**A cantilever of span 3.5 m carries a point load at free end, If the maximum slope at the free end is 1^o, Determine the maximum deflection in mm.**	

Ans.



1 M

As per standard formulae,

Max slope = $\theta_{max} = \left(\frac{dy}{dx}\right)_{max} = \frac{WL^2}{2EI}$

$$\frac{\pi}{180} = \frac{W(3.5)^2}{2\,EI}$$ 1 M

W = 0.00285 EI KN 1 M

& max deflection = $y_{max} = \frac{WL^3}{3\,EI}$ 1 M

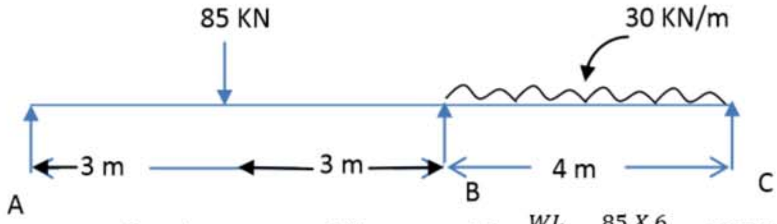
$$y_{max} = \frac{(0.00285\ X\ EI)(3.5)^3}{3\ X\ EI}$$ 1 M

y_{max} = 0.0407 m 1 M

y_{max} = 40.7 mm

b)	**A continuous beam ABC of uniform M.I carries a central point load of 85 KN on span AB. U.d.l. of 30 kN/m is acting over the entire span BC. Plot BM diagram. Span AB and BC are 6 m and 4 m respectively. A and C are simple supports. Use three moment theorem.**	

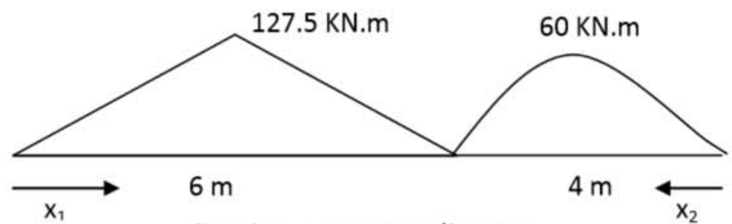
Ans.



I – Constant
BMD = ?

Sagging moment for span AB = $\frac{WL}{4} = \frac{85 \times 6}{4}$ = 127.5 KN.m — 1 M

Sagging moment for span AB = $\frac{WL^2}{8} = \frac{30 \times (4)^2}{8}$ = 60 KN.m



Sagging moment diagram — 1 M

$a_1x_1 = (\frac{1}{2} \times 6 \times 127.5)\left(\frac{6}{2}\right) = 1147.5$ — 1 M

& $a_2x_2 = (\frac{2}{3} \times 4 \times 60)\left(\frac{4}{2}\right) = 320$

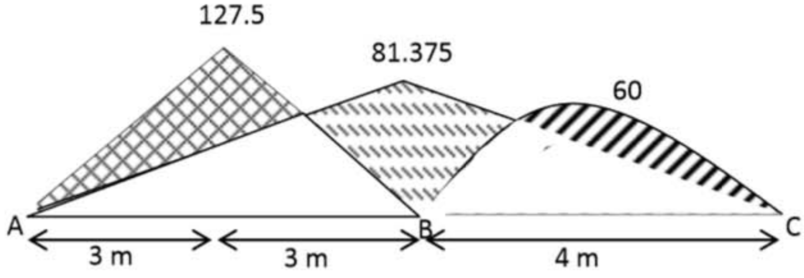
Using three moment theorem

$$M_AL_1 + 2M_B(L_1 + L_2) + M_CL_2 = \frac{-6a_1x_1}{L1} - \frac{6a_2x_2}{L2}$$ — 1 M

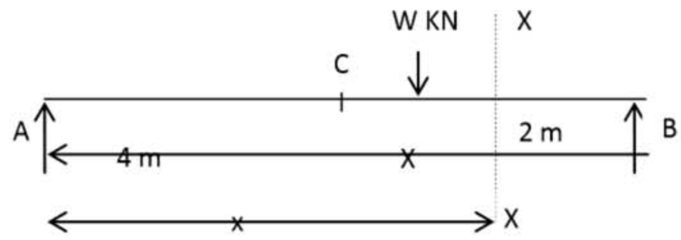
As $M_A = M_C = 0$ --- simply supported.

$2M_B(6 + 4) = -6\left[\frac{1147.5}{6} + \frac{320}{4}\right]$ — 1 M

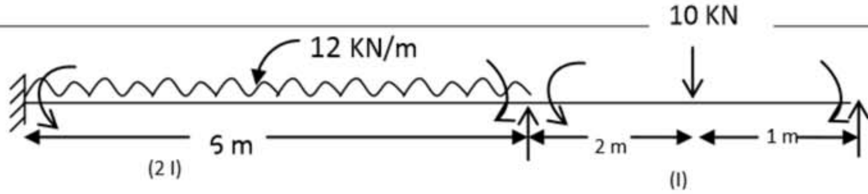
M_B = - 81.375 KN.m (Hogging)



BMD (KN.m) — 1 M

c)	**A simply supported bean of span 6 m carrying 'W' kN at 4 m from left. Find the value of 'W':F deflection at centre is 20 mm. Take EI = 2000 kN.m². Use Macaulay's method.**	
Ans.	 EI = 200 KN m^2 δ_{Centre} = 20 mm = 0.02 m Support reaction by using conditions of equilibrium $\sum M@A = 0 \quad R_A = \frac{W X 2}{6} = \frac{W}{3}$ KN $\sum F_y = 0 \quad R_B = \frac{2W}{3}$ KN	1 M
	Using Macaulay's Method – $EI \frac{d2y}{dx2} = Mx = \left(\frac{W}{3}\right) x \quad -W(x-4)$	1 M
	Integrating w.r.t x for slope $EI \frac{dy}{dx} = \left(\frac{W}{3}\right) \frac{x^2}{2} + C_1 \quad \frac{-W(x-4)^2}{2}$	1 M
	Integrating w.r.t x for deflection $EI\, y = \left(\frac{W}{18}\right) x^3 + C_1 x + C_2 \quad \frac{-W(x-4)^3}{6}$	1 M
	Applying boundary conditions at A & B for C_1 & C_2 At A, x = o …… y = 0 $\quad C2 = 0$ At B, x = 6m ……… y = 0 = $\left(\frac{W}{18}\right)(6)^3 + C_1(6) - \frac{W(6-4)^3}{6}$ $C_1 = -1.78\,W$ Deflection equation, $EI\, y = \left(\frac{W}{18}\right) x^3 - (1.78W)\, x \quad \frac{-W(x-4)^3}{6}$	1 M
	For deflection at centre x= 3 m, y = - 0.02 m (↓ $2000(-0.02) = \left(\frac{W}{18}\right)(3)^3 - (1.78W)(3)$ W = 10.42 KN.	1 M

Q. 6	**Attempt any TWO of the following:**	**12**
a)	**Calculate the support moment using moment distribution method Refer Fig. No. 5**	



Fixed end moments

$M_{AB} = \frac{-Wl^2}{12}$ = -36 KN m , $M_{BA} = \frac{+Wl^2}{12}$ = +36 KN m

$M_{Bc} = \frac{-Wab^2}{l^2}$ = -2.22 KN m , $M_{CB} = \frac{Wa^2b}{l^2}$ = +4.44 KN m 1 M

Joint	Member	Relative Stiffness	Total Stiffness	Distribution factor
B	BA	$\frac{4E(2I)}{6}$	14EI/6	$\frac{\frac{8EI}{6}}{\frac{14EI}{6}}$ = 0.57
B	BC	$\frac{3EI}{3}$		$\frac{\frac{6EI}{6}}{\frac{14EI}{6}}$ = 0.43

1 M

A	B	B	C	Joint
--	0.57	0.43	--	Distribution Factor
-36	+36	-2.22	+4.44	FEM
		-2.22	-4.44	Release 'C' carryover
-36	+36	-4.44	0	I.M.
-8.995	-17.99	-13.57		Distribute (Balance) C.O.
-44.995	+18.01	-18.01	0	Final Moments

1 M

1 M

1 M

Hence support moments are

MA = 44.995 KN.m (Hogging)

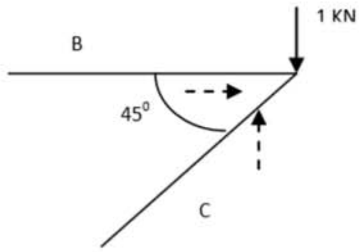
MB = 18.01 KN.m (Hogging) 1 M

MC = 0

b) **A cantilever truss is loaded as shown in Fig. No. 6. Find the stresses in members by method of joint.**

Ans.

1. At free end it B.C.



Using condition of equilibrium

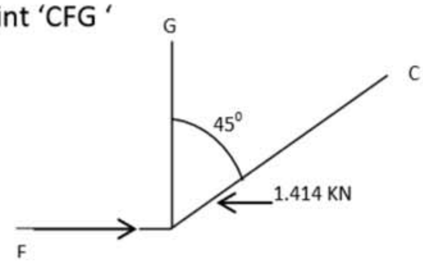
$\sum Fy = 0$, $Cy = 1$ KN

$F_C = \frac{1}{Sin\ 45}$ = 1.414 KN (comp) — 1M

$\sum Fx = 0$

F_B = 1.414 Cos 45 = 1 KN (tensile) — 1M

2. At Joint 'CFG '



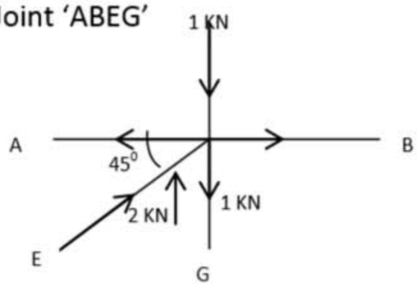
$\sum Fx = 0$

F_F = 1.414 Sin 45 = 1 KN (comp) — 1M

$\sum Fy = 0$

F_G = 1.414 Cos 45 = 1 KN (Tensile)

3. At Joint 'ABEG'



$\sum F_y = 0$

F_E = 2/Cos 45 = 2.83 KN (comp) — 1M

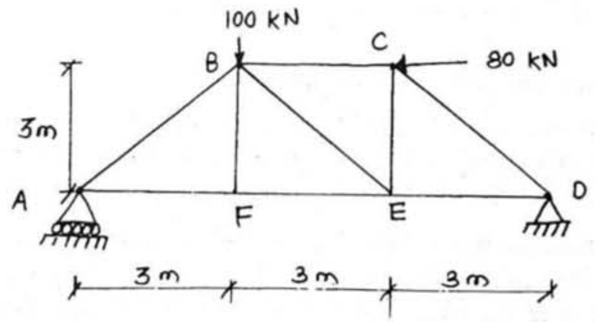
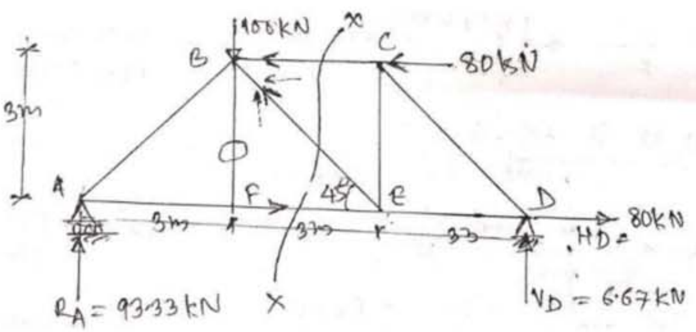
C $F_x = 0$

F_A = 1+2.83 Sin 45 = 3 KN (Tensile) — 1M

Sr. No.	Member	Force Stresses / Unit area (KN)	Nature
1	A	3	Tensile
2	B	1	Tensile
3	C	1.414	Compression
4	G	1	Tensile
5	E	2.83	Compression
6	F	1	Tensile

1 M

Note: If student attempts to determine the stresses by assuming suitable data of area of members, give credit accordingly.

c)	**Using method of section. Find the forces in the member BC, BE and FE of the frame as shown in Fig. No. 7**  **Fig. No. 7**	
Ans.	$\sum M@D = 0$ $(R_A \times 9) - (100 \times 6) - (80 \times 3) = 0$ $R_A = 93.33$ KN & $\sum Fy = 0$. YD = 100 – 93.33 = 6.67 KN & $\sum Fx = 0$. HD = 80 KN.	**1 M** **1 M**
		**1 M**
	Taking section x- x & applying conditions of equilibrium to the left part of truss $\sum M@B = 0$ $(R_A \times 3) = (F_{FE} \times 3)$ $F_{FE} = 93.33$ KN (Tensile) $\sum Fy = 0$. $93.33 + F_{BE} \sin 45 = 100$. $F_{BE} = 9.43$ KN (Compressive) $\sum Fx = 0$. $F_{FE} - F_{BE} \cos 45 = F_{BC}$ $93.33 - 9.43 \cos 45 = F_{BC}$ $F_{BC} = 86.67$ KN (Compressive)	**1 M** **1 M** **1 M**

22402

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4 Hours / 70 Marks Seat No. | | | | | | | | |

Instructions – (1) All Questions are *Compulsory.*

(2) Answer each next main Question on a new page.

(3) Illustrate your answers with neat sketches wherever necessary.

(4) Figures to the right indicate full marks.

(5) Assume suitable data, if necessary.

(6) Use of Non-programmable Electronic Pocket Calculator is permissible.

(7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

Marks

1. Attempt any FIVE of the following: 10

a) Define core of section.

b) State the condition for no tension in the column section.

c) State expressions for deflection of simply supported beam carrying point load at mid span.

d) State the values of maximum slope and maximum deflection for a cantilever beam of span 'L' carrying a point load 'W' at the free end. EI = constant.

e) Compare a simply supported beam and a continuous beam w.r.t. deflected shape of beam.

f) Write the values of stiffness factor for beams

(i) Simply supported at both ends

(ii) Fixed at one end simply supported at other end.

Marks

g) Make the following trusses perfect by adding or removing the members, if required as shown in Fig. No. 1.

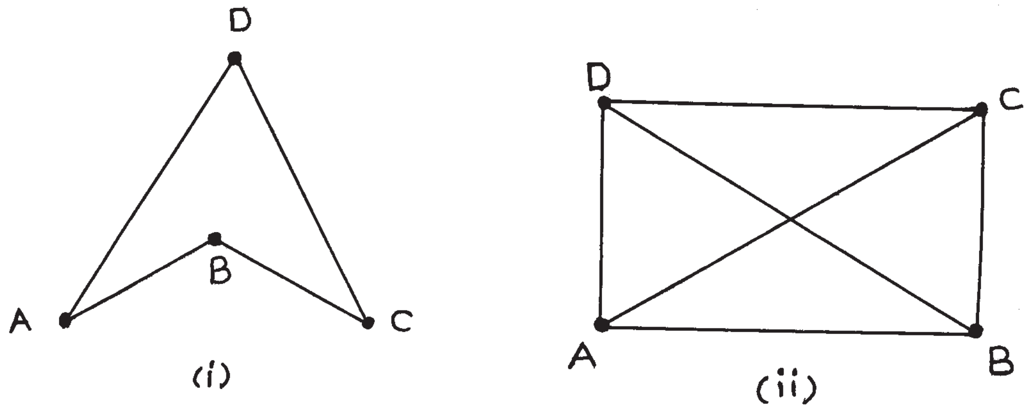


Fig. No. 1

2. Attempt any THREE of the following: 12

a) Explain the effect of eccentric load with sketch w.r.t. stresses developed.

b) Explain with expression four conditions of stability of dam.

c) Calculate maximum and minimum stresses at base of a rectangular column as shown in Fig. No. 2. It carries a load 200 kN at 'P' on the outer edge of a column. Draw stress distribution diagram.

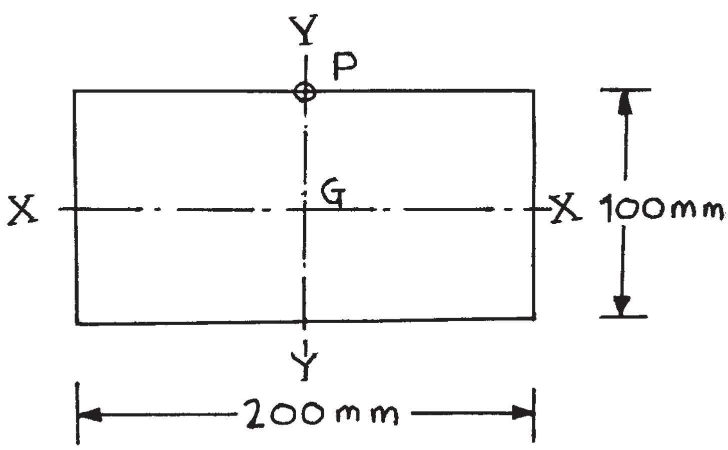


Fig. No. 2

Marks

d) Calculate the values of direct stress and bending stress at the base of chimney. Write interpretation of obtained values of stresses. Use following data.

(i) External diameter = 3m

(ii) Internal diameter = 2m

(iii) Height of chimney = 44m

(iv) Weight of masonry = 20 kN/m^3

(v) Co-efficient of wind resistance = 0.60

(vi) Wind pressure = 1kN/m^2

3. Attempt any THREE of the following: 12

a) Calculate deflection under point load of a simply supported beam as shown in Fig. No. 3. Take EI = constant. Use Macaulay's method.

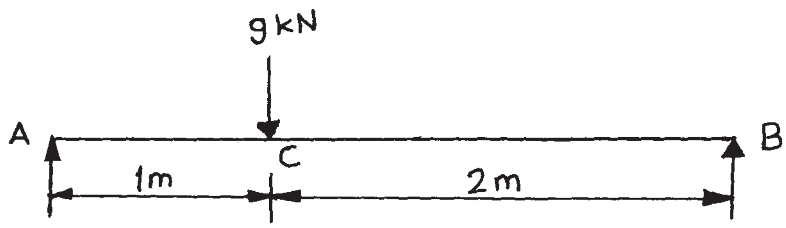


Fig. No. 3

b) Calculate fixed end moments and draw BMD for a fixed beam as shown in Fig. No. 4.

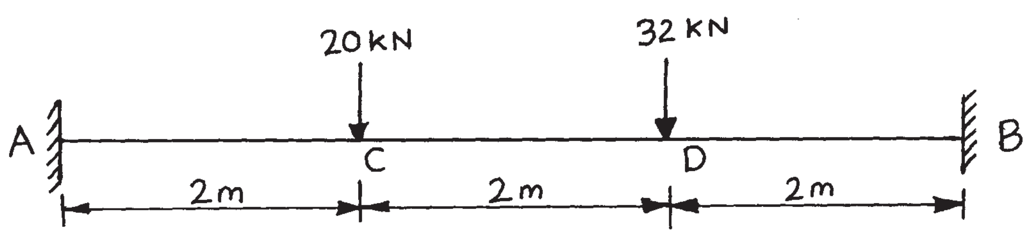


Fig. No. 4

Marks

c) Calculate fixed end moments and draw BMD for a beam as shown in Fig. No. 5. Use first principle method.

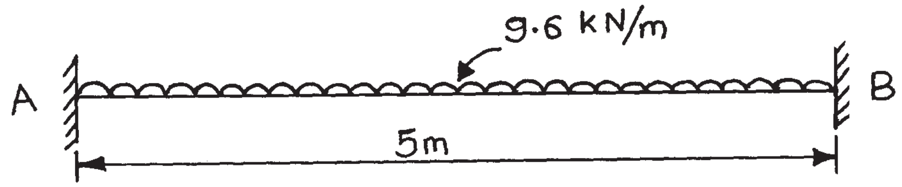


Fig. No. 5

d) (i) Explain with sketch the effect of fixity on bending moment of a beam and

(ii) State two advantages of fixed beam over simply supported beam.

4. Attempt any THREE of the following: 12

a) State Clapeyron's theorem of three moments for continuous beam with same and different EI.

b) Draw SFD for a continuous beam as shown in Fig. No. 6. having negative bending moment at support 'B' equal to 66.14 kN-m.

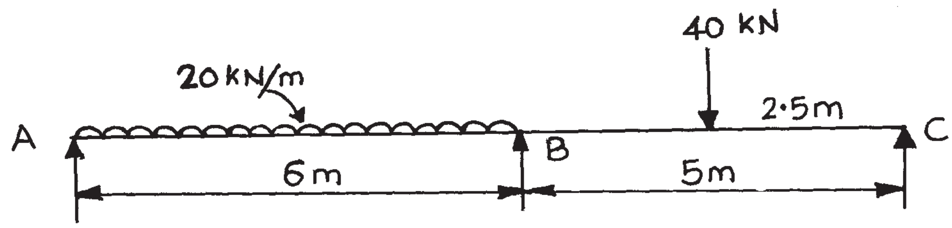


Fig. No. 6

Marks

c) Calculate distribution factors for the members OA, OB, OC, and OD for the joint 'O' as shown in Fig. No. 07.

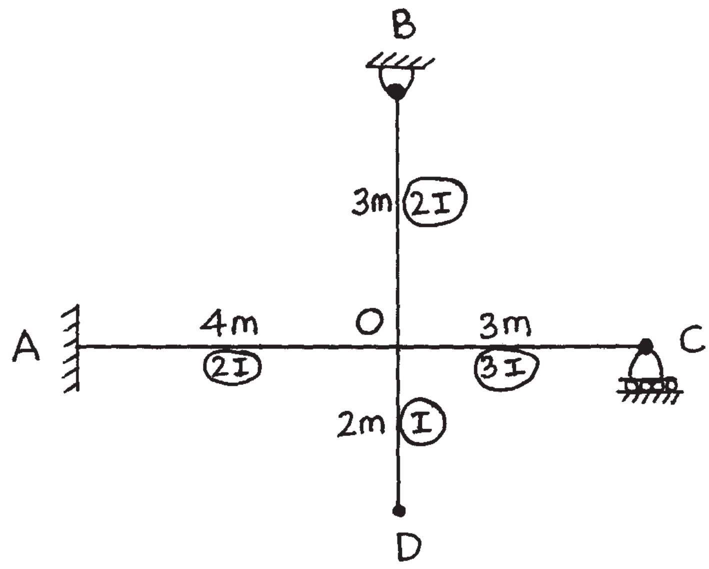


Fig. No. 7

d) Calculate support moments and draw BMD of a beam as shown in Fig. No. 8. Use moment distribution method.

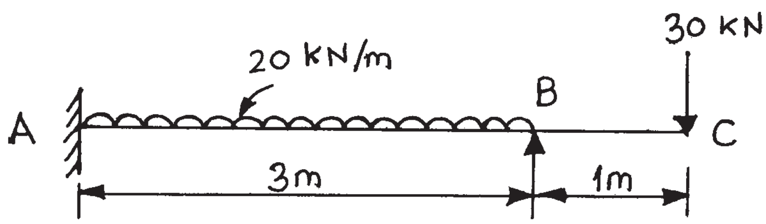


Fig. No. 8

e) Draw one sketch each of the following:

(i) Deficient frame

(ii) Redundant frame

(iii) Symmetrical portal frame

(iv) Unsymmetrical portal frame.

Marks

5. Attempt any TWO of the following: **12**

a) Calculate maximum deflection of a simply supported beam as shown Fig. No. 9. Take E=200GPa, I=2×10^8 mm^4.
Use Macaulay's method.

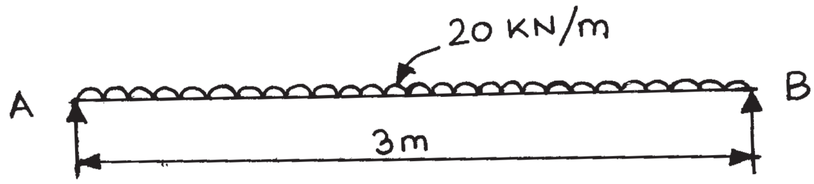


Fig. No. 9

b) Calculate maximum slope and maximum deflection of a cantilever beam as shown in Fig. No. 10.

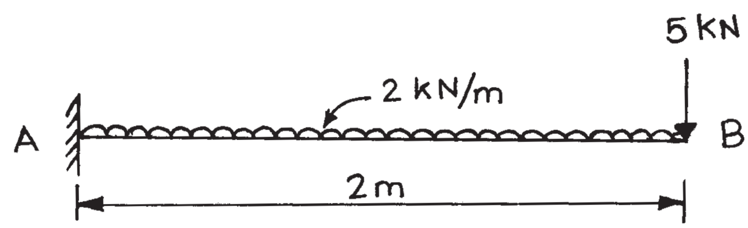


Fig. No. 10

Take E=100 GPa. Beam having width 100 mm and depth 200 mm in cross-section, Use standard formula.

c) Calculate support moments for a beam as shown in Fig. 08. on page no. 5 Q. 4(d).
Use three moment theorem.

6. Attempt any TWO of the following: **12**

a) Calculate support moments for a beam as shown in Fig. 11. Use Moment distribution method.

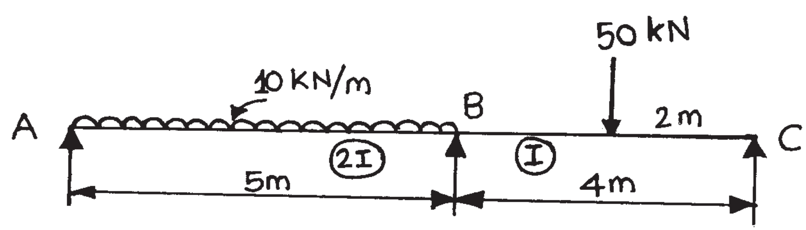


Fig. No. 11

Marks

b) Calculate magnitude and state the nature of forces in the members AB, BC, CD, DE, BD, and BE of a truss as shown in Fig. No. 12. Use method of section.

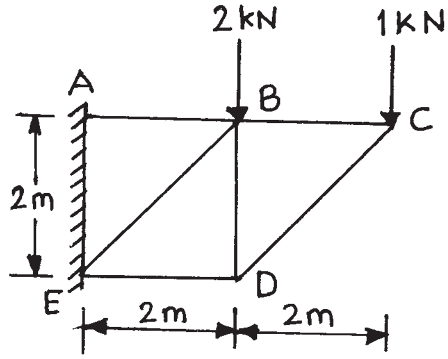


Fig. No. 12

c) Calculate magnitude and state the nature of forces in the members AB, BC, CD, AD and BD. of a truss as shown in Fig. No. 13. Use method of joints.

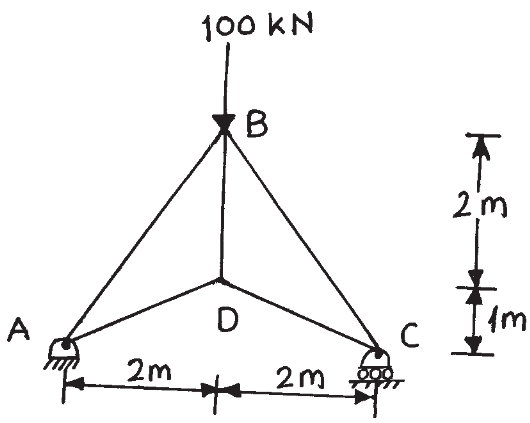


Fig. No. 13

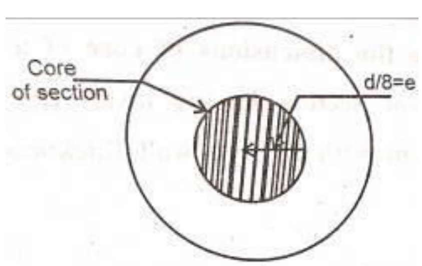
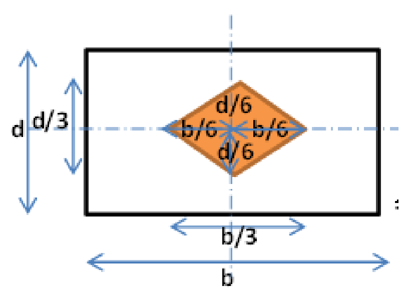
MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC -270001 – 2005 certified)

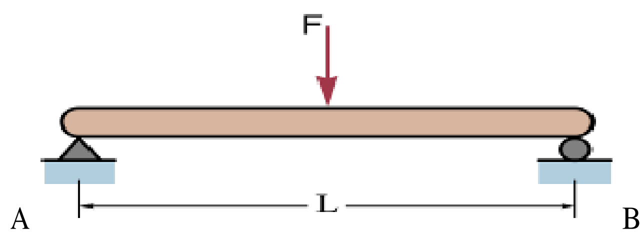
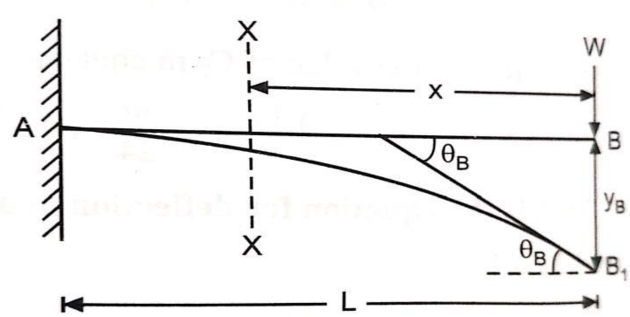
WINTER -2019 EXAMINATION **SUBJECT CODE: 22402**

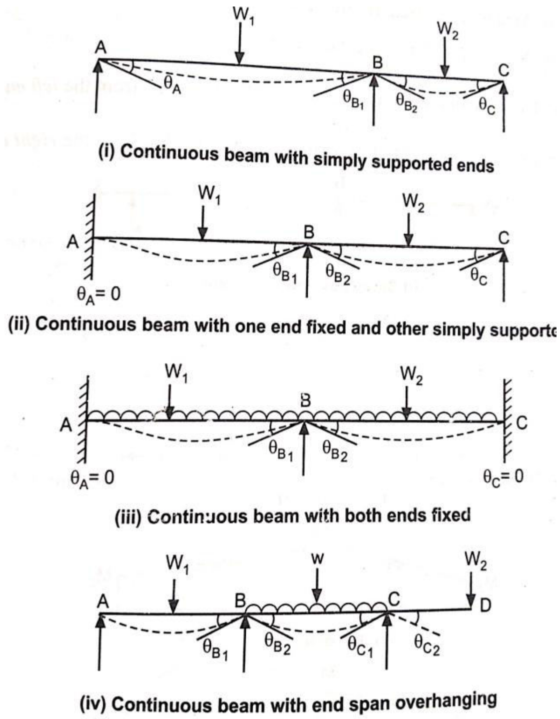
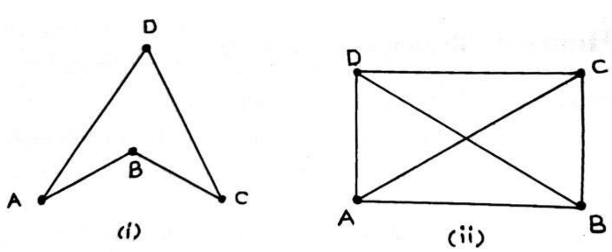
MODEL ANSWER

Important Instructions to examiners:

1) The answer should be examined by keywords 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 error such as grammatical, spelling errors should not be given more importance.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figure 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 the some cases, the assumed constants values may vary and there may be some difference in the candidate's answer and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidates understanding.

Que. NO	Answer with question	Mark
Q. 1	**Attempt any FIVE of the following**	**10 M**
a)	**Define core of section.**	
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. It is also defined as the region or area within which if load is applied, produces only compressive resultant stress**.** If Compressive load is applied, the there is no tension anywhere in the section. emax = d/8 e = Core of section	**01 M**
	 For Circular section  For rectangular section	**01 M**

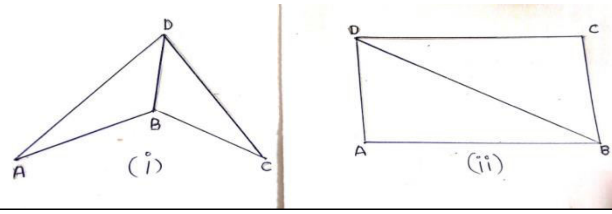
b)	**State the condition for no tension in the column section**	
Ans.	**Condition for no tension in the column section** σo = Direct stress and σ_b= Bending stress ,if $\sigma o > \sigma_b$ the resultant stress is compressive , If $\sigma o = \sigma_b$ the minimum stress is zero and the maximum stress is 2σo, the stress distribution is compressive . but $\sigma o < \sigma_b$ the stress is partly compressive and partly tensile. A small tensile stress at the base of a structure may develop tension cracks. Hence for no- tension condition, direct stress should be greater than or equal to bending stress. $\sigma o >= \sigma_b$ P / A = M/Z P / A = Pxe/Z , e = < Z/A Hence for no –tension condition, eccentricity should be less than Z/A	**01 M** **01 M**
c)	**State expression for deflection of simply supported beam carrying point load at midspan.**	
Ans.	**A simply supported beam of span L carrying a central point load F at midspan**  To find the maximum deflection at mid-span, we set x=L/2 in the equation and obtain ,maximum deflection = Yc Yc = Y max = $F L^3 / 48 EI$	**01 M** **01 M**
d)	**State the values of maximum slope and maximum deflection for a cantilever beam of span 'L' carrying a point load 'W' at the free end . EI = constant**	
Ans.	 Maximum slope = $\theta_B = dy/_{dx\ B} = WL^2/2EI$ Maximum deflection= $Y_B = - WL^3/ 3EI$	**01 M** **01 M**

e)	**Compare a simply supported beam and a continuous beam w.r.t deflected shape of a beam.**	
Ans.	The firm of a curve to which the longitudinal axis of the beam bends after loading is called elastic curve or deflected shape of the beam. In the figure shows the deflected shape for various types of continuous beam. The deflected shape is shown by a dotted curve. Deflected shape simply supported beam and continuous beam  	**01 M** **01 M** (Any one sketch)
f)	**Write the values of stiffness factor for beams.** **i) Simply supported at both ends** **ii)/fixed at one end simply supported at other end**	
Ans.	**i)** Stiffness factor for a beam Simply supported at both the ends = 3EI /L **ii)** Stiffness factor for a beam fixed at one end and simply supported at other end = 4EI/L	**01 M** **01 M**
g)	**Make the following truss perfect by adding or removing the members, if required as shown in fig. No.1**  **Fig. No. 1**	

Ans. For i) n=5 ,j=4

2j-3 = 2 x 4 – 3 = 5 .since n = 2j-3 hence the frame is Perfect frame **01 M**

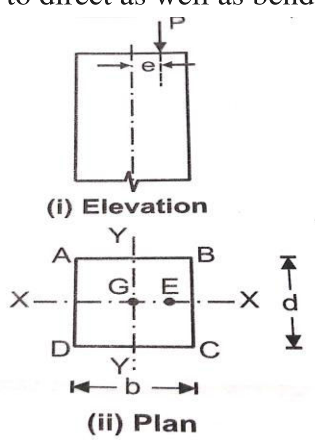
iii) n= 5 ,j=4 , 2j-3 = 2 x 4 – 3 = since n =2j-3 hence the frame is Perfect frame



01 M

Q. 2	**Attempt any THREE of the following:**	**12 M**
a)	**Explain the effect of eccentric load with sketch w.r.t stresses developed**	

Ans. Effect of eccentric load: A load whose line of action does not coincide with the axis of a member is called an eccentric load .The distance between the eccentric axis of the body and the point of loading is called an eccentric limit 'e'. Due to effect of eccentricity axial load causes only direct stress whereas an eccentric load causes direct as well as bending stresses. Direct load is that force which acts at centroidal longitudinal axis of the member. Eccentric load is that force which act away from centroidal longitudinal axis of the member. Thus the resultant stresses due to direct as well as bending stresses in the member **02 M**



01 M

Direct stress = σ0 , Bending stress = σb

σ0 = P / A ,σb = (M x y) / I therefor σb = M/Z But, Resultant stresses =

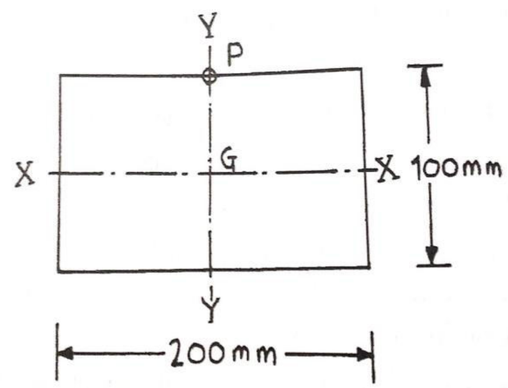
$\sigma_{direct} + \sigma_{bending}$ σmax = 60 + 6b ,

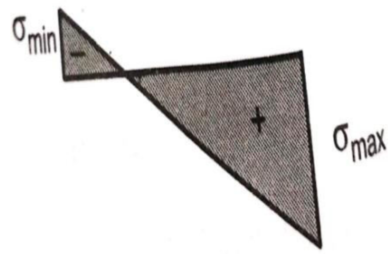
σmin = 60 - 6b **01 M**

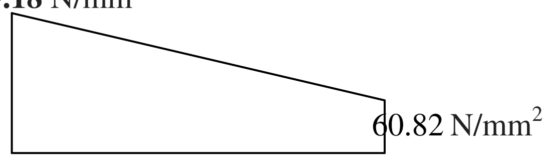
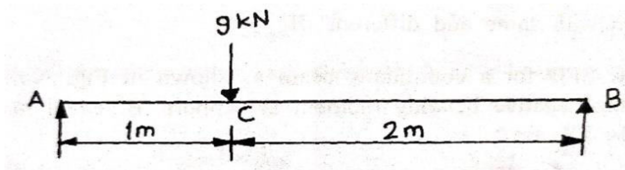
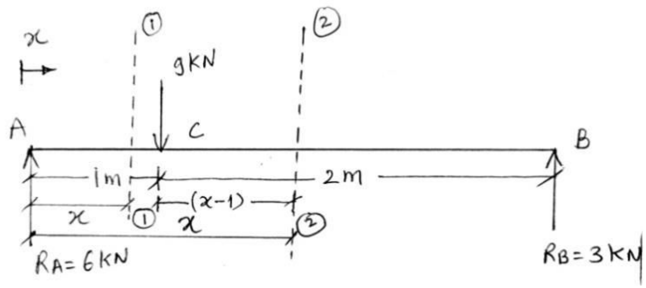
b)	**Explain with expression four conditions of stability of dam.**	

Ans.

1. Condition to prevent Overturning of a dam Stability against Due to Overturning (P.h/3) < W(b-X) **01 M**

	2. Condition to prevent sliding of a dam ,Stability against Due to Sliding P < F P < μ W factor of safety against sliding 3. Compression or Crushing of masonry 4. Condition to avoid tension in the masonry Stability against No Tension if e < (b/6) Where e = eccentricity P = Compressive Load h = Ht. of dam W =Wt of dam b = Base width of dam	**01 M** **01 M** **01 M**
c)	**Calculate maximum and minimum stresses at base of a rectangular column as shown in Fig No.2 . It carries a load 200 KN at 'P' on the outer edge of a column. Draw stress distribution diagram.** 	
Ans.	**Solution** :- Area =200 x 100 = 20000 mm^2 P = 200kN e = 50 mm M = P x e = 200 x 50 =10000 kN mm I =$bd^3/12 = 200x100^3/12 = 16.66x10^6 = mm^4$ y = 100/2 = 50 mm. Where, Stresses i) 6_0 = P / A = 200x 10^3/ 20000 = 10 N/ mm^2 ii) 6b = (M x y) / I (10000 x 10^3) x 50 / 16.66 x 10^6 = 30.012 N/ mm^2 But, 6max = 60 + 6b , 6min = 60 - 6b 6max = 6_0 + 6b = 10 + 30.012 = 40.012 N/mm^2 6min = 6_0 - 6b = 10 - 30.012 = -20.012 N/mm^2 (Tension)	**01 M** **01 M** **01 M**

	stress distribution diagram as below  Stress distribution diagram at base	**01 M**
d)	**Calculate the values of direct stress and bending stress at the base of chimney. Write interpretation of obtained values of stresses.** **Use following data** **i) External diameter = 3m** **ii) Internal diameter = 2m** **iii) Height of chimney = 44m** **iv) Weight of masonry = 20 kN/m2** **v) Co-efficient of wind resistance = 0.60** **vi) Wind pressure = 1 kN/m2**	
Ans.	**Solution :** Given = d1= 3m , d2=2m, height of chimney h =44 i) Area of the section = A = (π /4) x $(3^2 - 2^2)$ =3.926 m^2 I xx = I = π /64 $(3^4 - 2^4)$ = 51.05 mm^4 Wind pressure = Þ =1 kN/m^2 =1000 N/m^2 ii) Direct stress on the base σ_0 = W / A = A x h x ρ = (3.926 x 44 x 20) / A =880 kN/m^2 iii) section modulus Z = π /32 x $(3^4 - 2^4)/3$=2.127 m^3 iv) Total wind load P =C x Þ x projected area = 0.6 x Þ x D x h =0.6 x1 x 3 x 44 = 79.2 v) Moment on the base M= P x h/2 =79.2 x 44 /2 =1742.40 kNm vi) Bending stress on the base section , σb = (M x y) / I σb = ± M/Z =1742.40 /2.127 = ± 819.18 kN/m^2 σ max = σ0 + σb = 880 + 819.18 = 1699.18 kN/m^2 Comp σ min = σ0 - σb = 880 - 819.18 = 60.82 kN/m^2 Comp	**01 M** **01 M** **01 M**

	 **Stress distribution diagram at base**	**01 M**
3.	**Attempt any THREE of the following**	**12 M**
a)	**Calculate the deflection under point load of a simply supported beam as shown in figure No. 3 Take EI = constant. Use Macaulay's method.**  **Figure 3**	
Ans:	 1. Calculate support reactions: Taking moment at B $\sum M_B = 0$ R_A x 3 – 9 x 2 = 0 R_A = 6 kN. And R_B = 3 kN Macaulay's method EI $\frac{d^2y}{dx^2}$= M --- Differential Equation EI $\frac{d^2y}{dx^2}$= 6 x $\Big\|_{x=1}$ – 9 (x-1) Differentiating with respect to x EI $\frac{dy}{dx} = \frac{6x^2}{2} + C_1 \Big\| - \frac{9(x-1)^2}{2}$ ------------------- Slope Equation EIy = $\frac{3x^3}{3} + C_1x + C_2 \Big\| - \frac{9(x-1)^3}{6}$ ------------------- Deflection Equation Calculate Constants of Integration C_1 and C_2 Consider boundary condition	**01 M**

1) At x=0, y= 0 putting in deflection equation

EI (0) = 0 + C_1 x 0 + C_2

$C_2 = 0$

2) At x = 3m, y= 0 putting in deflection equation

EI (0) = 3^3 + 3 C_1 + 0 - $\frac{9}{6}(3-1)^3$ **01 M**

$C_1 = -5$

Putting values of C_1 and C_2 in Slope and Deflection Equation.

EI $\frac{dy}{dx} = \frac{6x^2}{2} - 5 - \frac{9(x-1)^2}{2}$ ------------------- Final Slope Equation **01 M**

EIy = $\frac{3x^3}{3} - 5x - \frac{9(x-1)^3}{6}$ ------------------- Final Deflection Equation

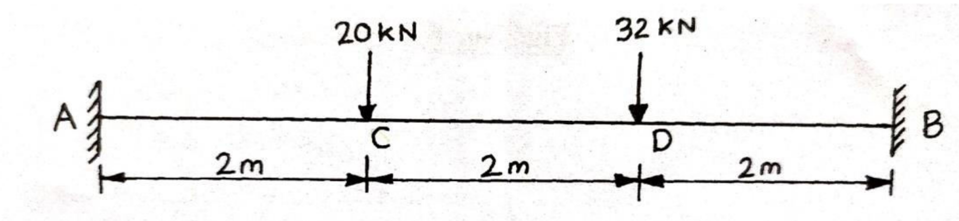
Calculate Deflection under point load

At x = 1m, y = y_c putting in deflection equation.

EI $y_c = \frac{3(1)^3}{3} - 5(1) - 9(0)$ **01 M**

$y_c = \frac{-4}{EI}$

b) **Calculate fixed end moments and draw BMD for a fixed beam as shown in Fig.**



Ans:

Assume beam is simply supported beam and calculate support Reactions.

$\sum M_A = 0$ Clockwise moment positive and Anti clockwise moment Negative

$-R_B$ x 6 + 20 x 2 + 32 x 4 = 0

R_B = 28 kN

$R_A + R_B$ = Total load = 20+32 = 52

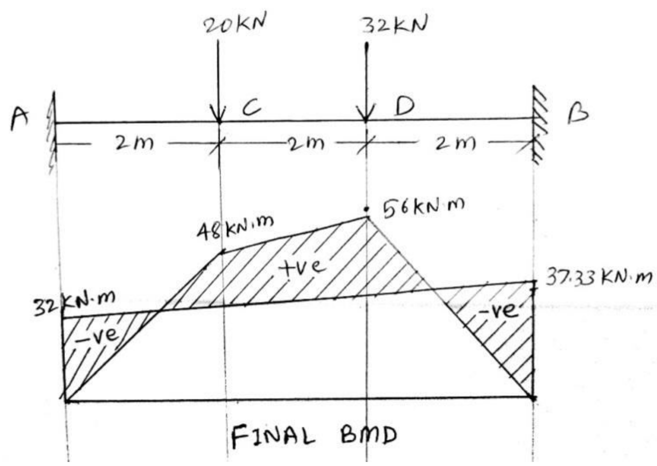
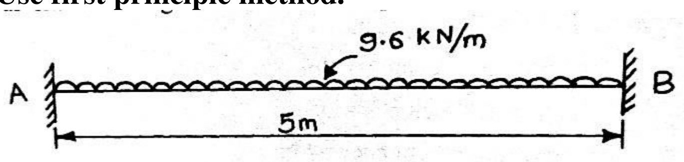
R_A + 28 = 52

R_A = 24 kN

Calculate BM at C and D for simply supported beam

M_c = 24 x 2 = 48 kN.m and moment at D M_D = 24 x 4- 20 x 2 = 56 kN.m **01 M**

Calculate Fixed End Moments

	$M_A = M_{A1} + M_{A2} = -\frac{W_1 a_1 b_1^2}{L^2} - \frac{W_2 a_2 b_2^2}{L^2}$ $= -\frac{20x2x4^2}{6^2} - \frac{32x4x2^2}{6^2} = -17.78-14.22$ M_A =- 32.0 kN.m	01 M
	$M_B = M_{B1} + M_{B2} = -\frac{W_1 a_1^2 b_1}{L^2} - \frac{W_2 a_2^2 b_2}{L^2}$ $= -\frac{20x2^2x4}{6^2} - \frac{32x4^2x2}{6^2} = -8.89-28.44$ M_B = -37.33 kN.m	01 M
	Draw final BMD for simply supported beam and fixed beam by overlapping each other  	01 M
c)	**Calculate fixed end moments and Draw BMD for a beam as shown in Fig. No. 5. Use first principle method.**  	
Ans:	1. Assume beam is simply supported beam and calculate simply supported BM. Mmax = $M_{AB} = \frac{wL^2}{8} = \frac{9.6x5^2}{8} = 30.0 kN.m$ 2. Calculate Fixed end Moments $M_A + M_B = \frac{-2a}{L}$ a = Area of SS BM dia. = area of Parabola = 2/3 bh a = 2/3 x 5 x 30 = 100 kN.m $M_A + M_B = \frac{-2x100}{5} = -40$ --------------- (I)	01 M

and $M_A + 2M_B = \frac{-6ax}{L^2}$

x = C.G. of SS BM = 5/2 = 2.5m

$M_A + 2M_B = \frac{-6x100x2.5}{5^2} = -60$ --------------- (II) **01 M**

Solving Two Simultaneous Equations I and II **01 M**

M_A = -20 kN.m M_B = -20 kN.m

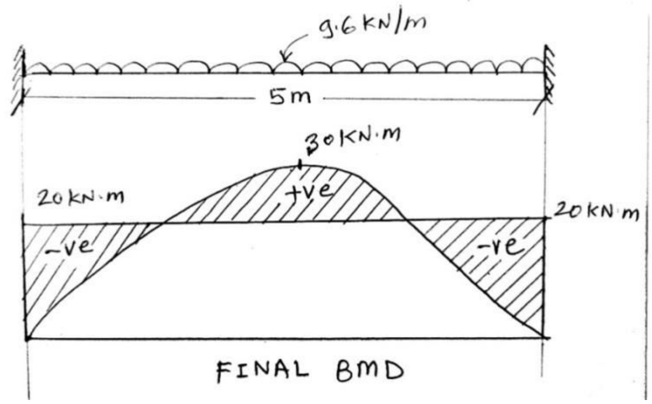
OR

Note: Fixed end moments can be calculated by using standard formula as formula is Derived using First Principle, hence if students solve problem using formula appropriate Marks shall be given

$$M_{AB} = -\frac{wL^2}{12} = -\frac{9.6x5^2}{12} = -20.0kN.m$$

$$M_{BA} = \frac{wL^2}{12} = +\frac{9.6x5^2}{12} = +20.0kN.m$$

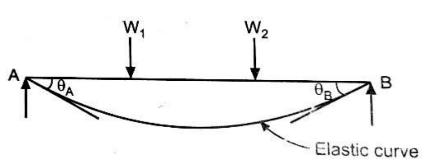
3. Draw Final BM diagram by overlapping simply supported BM and Fixed end BM.



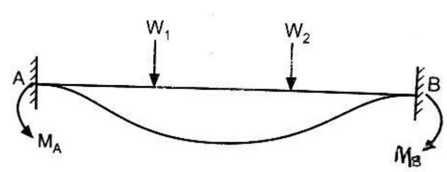
01 M

d) i) **Explain with sketch the effect of fixity on bending moment of a beam.**

Ans: If simply supported beam is considered subjected to any pattern of loading, beam bends and slopes will developed at the ends. If however, the ends of beam is 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. **01 M**

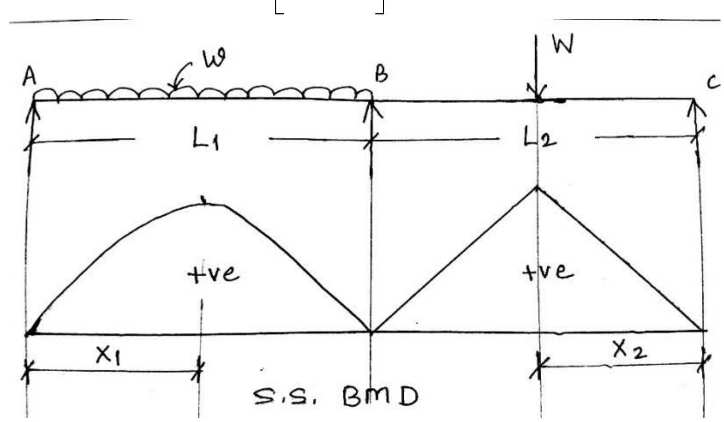


Simply supported beam

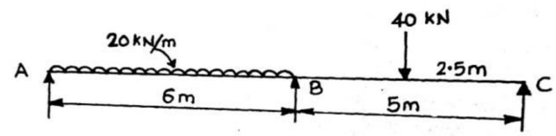


Fixed Beam

01 M

(ii)	**State two advantages of fixed beam over simply supported beam.**	
Ans:	1. End slopes of fixed beam are zero 2. A fixed beam is more stiff, strong and stable than a simply supported beam. 3. For the same span and loading, a fixed beam has lesser values of bending moments as compared to a simply supported beam. 4. For the same span and loading, a fixed beam has lesser values of deflections as compared to a simply supported beam.	**02 M for any 2**
Q.4.	**Attempt any THREE of the following**	**12**
a)	**State Clapeyron's theorem of three moments for continuous beam with same and different EI**	
Ans:	The claperon's theorm of three moment is applicable to two span continuous beams. It state that " For any two consecutive spans of continuous beam subjected to an external loading and having uniform moment of inertia, the support moments M_A, M_B and M_C at supports A,B and C respectively are given by following equation	**01 M**
	$$M_A + 2M_B(L_1 + L_2) + M_C L_2 = -\left[\frac{6A_1X_1 -}{L_1}\right] - \left[\frac{6A_2X_2}{L_2}\right]$$	**01 M**
		**01 M**
	If the moment of inertia is not constant then claperon's theorem can be stated in the form of following equation. $$M_A \frac{L_1}{I_1} + 2M_B\left(\frac{L_1}{I_1} + \frac{L_2}{I_2}\right) + M_C \frac{L_2}{I_2} + M_C \frac{L_2}{I_2} = -\left[\frac{6A_1X_1}{L_1I_1} + \frac{6A_2X_2}{L_2I_2}\right]$$ Where , L_1 and L_2 are length of span AB and BC respectively. I_1 and I_2 are moment of inertia of span AB and BC respectively. A_1 and A_2 are area of simply supported BMD of span AB and BC respectively. X_1 and X_2 are distances of centroid of simply supported BMD from A and C respectively.	**01 M**

b) **Draw SFD or a continuous beam as shown in Fig. No. 6 having negative bending moment at support 'B' equal to 66.14 kN.m Fig. No. 6**



Ans: Calculate the support reactions

Clockwise moment positive and Anti clockwise moment Negative

Consider Span AB Taking moment at B $\sum M_B = 0$

R_A x 6 – 20 x 6 x 3 + 66.14 = 0

R_A = 48.976 kN.

Consider Span BC Taking moment at B $\sum M_B = 0$

-R_C x 5 + 40 x 2.5 - 66.14 = 0

R_C = 6.772 kN

$\sum F_y = 0$

R_A+R_B+R_C -20x6 – 40 = 0

48.976+R_B+6.772 = 160

R_B = 104.252 kN **01 M**

1. **S.F. Calculations:**

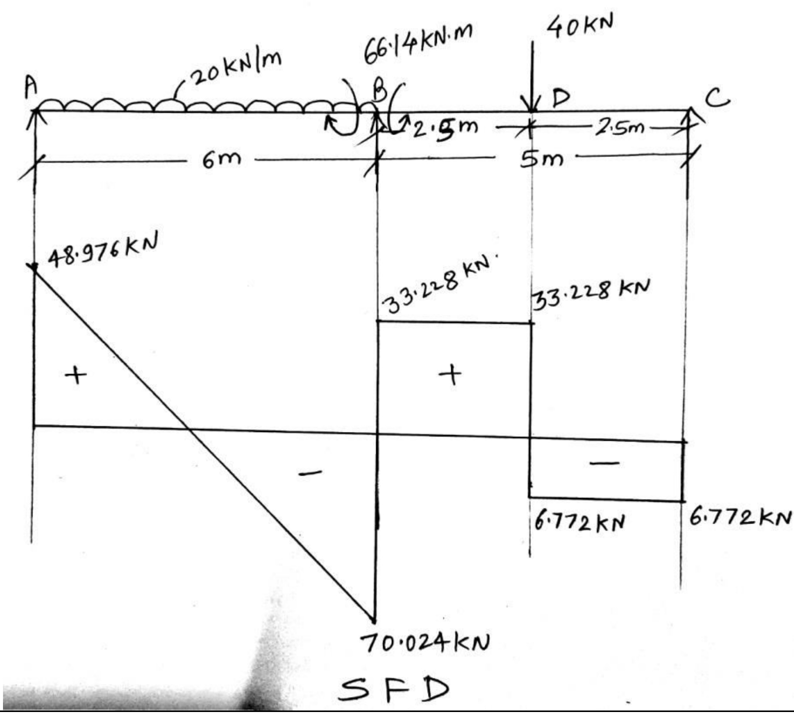
   SF at A, just left =0 and Just Right = +48.976 kN.

   SF at B, just left = +48.976-20x6 = -71.024 kN.

   Just Right = -71.024 + 104.252 = + 33.228 kN **02 M**

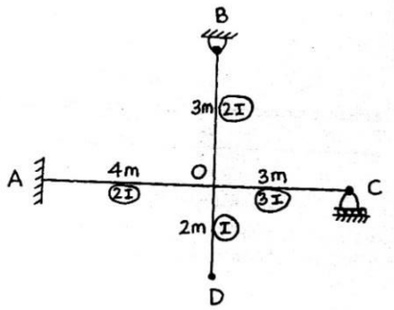
   SF at D, just left =+ 33.228 kN Just Right = + 33.228 -40 = -6.772 kN

   SF at C, just left = -6.772 kN Just Right = -6.772 kN + 6.772 kN = 0



01M

c) **Calculate distribution factors for the members OA, OB, OC and OD for the joint 'O' as shown in Fig. No. 7.**



Ans:

Joint	Member	Stiffness Factor	Total stiffness	Distribution Factor	
O	OA	$K_{OA} = \frac{4EI}{L} = \frac{4E(2I)}{4} = 2EI$	$\sum K_O = 2EI + 2EI + 3EI = 7EI$	$DF_{OA} = \frac{2EI}{7EI}$ **DF_{OA}=0.286**	**01 M for each D.F.**
	OB	$K_{OB} = \frac{3EI}{L} = \frac{3E(2I)}{3} = 2EI$		$DF_{OB} = \frac{2EI}{7EI}$ **DF_{OB} = 0.286**	
	OC	$K_{OC} = \frac{3EI}{L} = \frac{3E(3I)}{3} = 3EI$		$DF_{OC} = \frac{3EI}{7EI}$ **DF_{OC}=0.428**	
	OD	K_{OD}= 0		**DF_{OD}=0**	

d) **Calculate support moments and Draw BMD of a beam as shown in Fig. No. 8. Use moment distribution Method.**

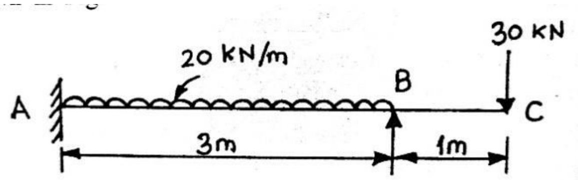


Fig. No. 8

Ans:

1. Calculate simply supported BM for span AB

$$m_{AB} = \frac{wL^2}{8} = \frac{20x3^2}{8} = 22.5kN.m$$

2. Calculate Fixed end Moment for span AB

$$M_{AB} = -\frac{wL^2}{12} = -\frac{20x3^2}{12} = -15kN.m$$

$$M_{BA} = \frac{wL^2}{12} = +\frac{20x3^2}{12} = +15kN.m$$

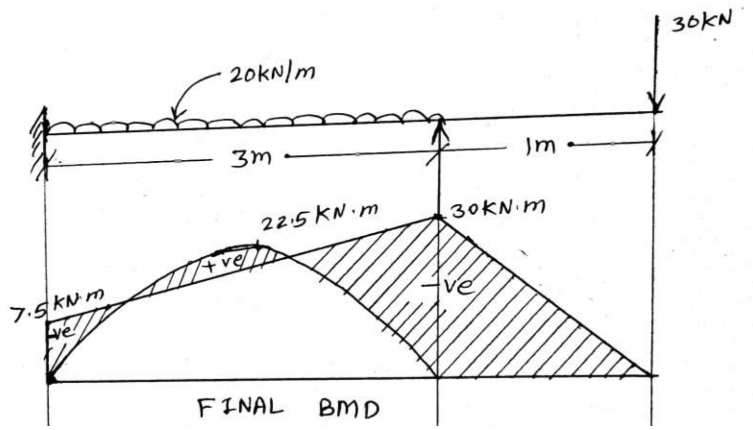
01 M

M_{BC} = - 30 x 1 = -30 kN.m

Distribution factor DF_{BA} = 1.0, DF_{BC} = 0 as it is overhang

A	B		C	Joint
AB	**BA**	**BC**	**CB**	Member
	1.0	**0**		Distribution factor
-15	+15	-30	0	Fixed end moments
	+15			Balancing at B
+7.5				Carryover to A
-7.5	**+30**	**-30**	**0**	Final Moments

Table 02 M

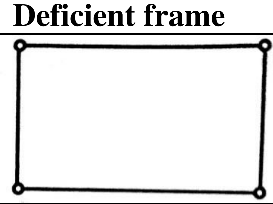


01 M

e) **Draw one Sketch of the following.**

(i) **Deficient frame**

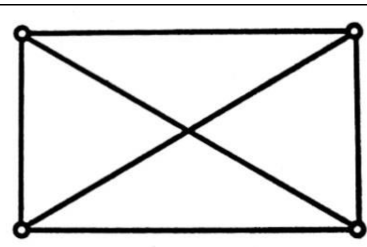
Ans:



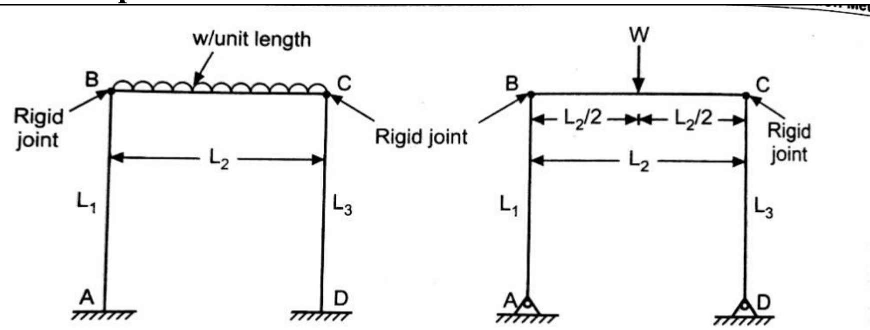
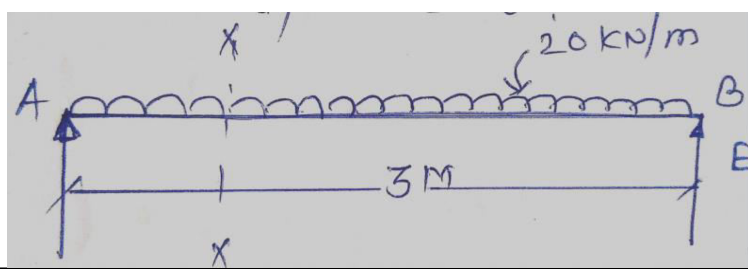
01M

(ii) **Redundant frame**

Ans:



01 M

(iii)	**Symmetrical portal frame**	
Ans:	 **(i) Symmetrical portal frame fixed at the base** **(ii) Symmetrical portal frame simply supported (hinged) at the base**	**Any 01 one mark**
(iv)	**Unsymmetrical portal frame**	
Ans:	 **(i) Unsymmetrical portal frame hinged at the base** **(ii) Unsymmetrical portal frame one end fixed, other hinged** **Note-** Other than these above sketches if any relevant sketch is drawn, the marks are given accordingly.	**Any 01 one mark**
Q.5.	**Attempt any TWO of the following**	**12 M**
a)	**Calculate Maximum Deflection of Simply Supported Beam as Shown In Fig no-9. take E=200gpa I=2x 10^8 Use Macaulay's Method.** 	
Ans:	Given :- E=200 GPA =200x10^3 =N/mm^2 E =200x10^3 =2x10^8 KN/m^2 I=2x10^8= mm^4 I=2x10^{-4} m^4 **1)Find support Reaction**	**01 M**

RA = RB=Wl/2 =20X3/2 =30KN

2)Find slope &deflection

EI d^2y/dx^2 = M -Differential equation

Taking moment at section X-X, and at distance x from A

$EI\, d^2y/dx^2 = 30x \;\Big|\; - 20x^2/2$

$EI\, d^2y/dx^2 = 30x \;\Big|\; -10x^2$

Integrating w. r to x

$EI\, dy/dx = 30x^2/2 + C1 \;\Big|\; -10x^3/3$

$EI\, dy/dx = 15x^2 + C1 \;\Big|\; -3.33x^3$ _______slope equation

01 M

Again integrating w.r to x

$EIy = 15x^3/3 + C1x + C2 - 3.33x^4/4$

$EIy = 5x^3 + C1x + C2 - 0.832x^4$ __________ Deflection equation

01 M

To find C2

Boundary condition

x=0 Y=0 put in **Deflection Equations**.

E1(0) =5(0) +c1(0)+c2- 0.83(0)4

C2=0

To find C1

Boundary condition

At x=3 y=0 put in deflection equation

$0 = 05(3)3 + c1x3 + 0 - 0.832 * 3^4$

3C1=67.608

C1= -22.53

01 M

Put this value in Deflection equation

$EIy = 5x^3 - 22.53x - 0.832x^4$

To find Maximum Deflection

Put x=L/2 = 3/2 = 1.5 m

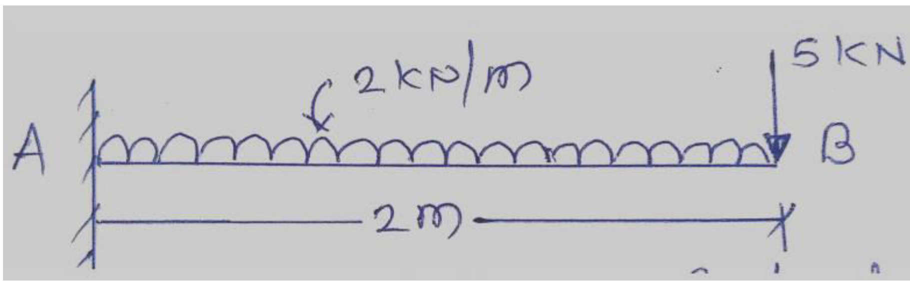
$EIY = 5(1.5)^3 - 22.53 * 1.5 - 0.832(1.5)^4$

EIY= -21.132

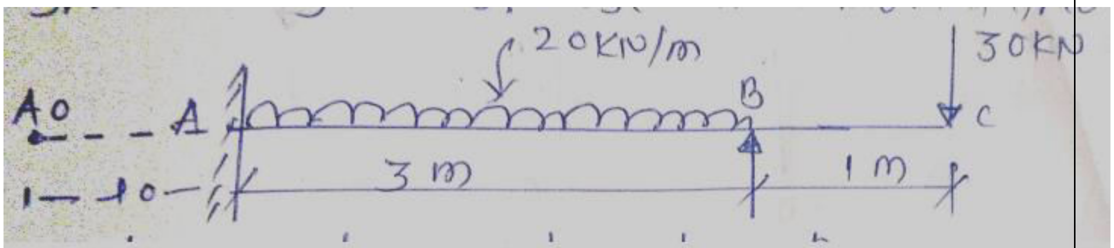
01 M

$E = 200$ GPA $= 200\times10^3 = N/mm^2$

$E = 200\times10^3 = 2\times10^8$ KN/m^2 (note:- W is in KN/m and L is in m.)

	$I=2x10^{8}= mm^{4}$ **$I=2x10^{-4} m^{4}$** Y= -21.132/EI $= 21.132/ (200x10^{-4} * 200x10^{8})$ **Y max = 0.0005288 m=0.000528m** **Y max=0.528 mm (- ve indicate downward deflection)**	**01 M**
b)	**Calculate Maximum Slope & Maximum Deflection Of A Cantilever Beam As Shown In Fig** 	
Ans:	Given :- $E=100$ GPA$=100X10^{3}$ N/mm^{2} Width =100 mm ,depth=200mm $I=bd^{3}/12 =100*(200)^{3}/12 =66.66X10^{6}$ Maximum deflection =Deflection due to UDL+ deflection due to point load YB=yB1+yB2 $Yb1=-WL^{4} / 8EI = (-2X(2000)^{4}) / (8X100 * 10^{3} * 66.66X10^{6})$ **=-0.600 mm** $Yb2 = - WL^{4}/ 3EI = (-5000X(2000)^{3})/ (3*100*66.66*10^{6}*10^{3})$ **= -2.01 mm** YB = YB1+YB2 = -(0.6+2.01) = **-2.6 mm** maximum slope = slope due to UDL + slope due to point load $\theta = \theta 1+ \theta 2$ $\theta1 = W L^{3} /6 EI = (2*2000^{3}/6*100*10^{3}* 66.66X10^{6})$ **=0.0004 Radian** $\theta2 = W L^{2} /2 EI = (5000*2000^{2}/2*100X10^{3} * 66.66*10^{6})$ **=0.0015 Radian** θ = 0.0004+0.0015=**0.0019 Radian** **deflection Maximum =2.6mm (-ve indicates the downward deflection)** **Maximum slope =0.0019 Radian**	 **1M** **1M** **1 M** **1M** **1M** **1 M**

c) **Calculate Support Moments For A Beam As Shown In Fig No-08** .
Use Three Moment Theorem.



Ans: TO find support moments and reactions

B.M at mid span AB = $WL^2 / 8 = 20(3)^2 /8$

= **22.5 KN.M**

Consider the cantilever action point BC

MB = -30X1 **= -30KNm**

Since the end A is fixed assume as imaginary span A-AO at left of A **01 M**

For span AO - A

6 ao* o / L0 = 0

Span AO A B

A1 = Area Of A Diagram =(2/3) * 3 * 22.5 **= 45**

X1= centroidal distance of a diagram =3/2 = **1.5m**

A1 X1 = 45*1.5 **= 67.5** **01 M**

Applying clapeymn's theorem of three moment for span A Ao & AB we get

Mo L0+2MA (Lo+L1) +MBL1 =-[6a0X0/ Lo + 6a1x1 /L1] **01 M**

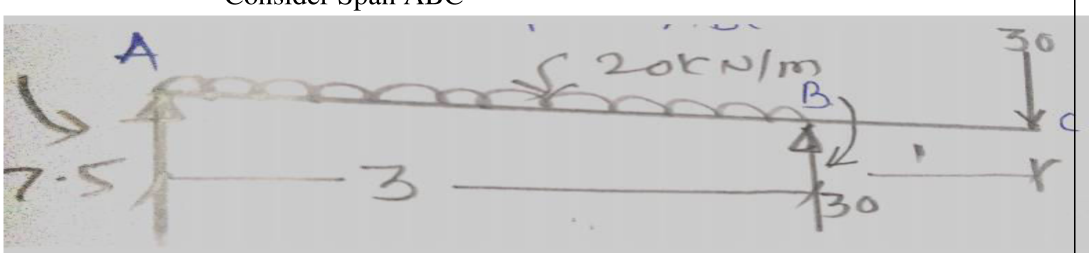
0+2MA (0+3) +(-30) (3) = [0+6X67.5/3]

6 MA -90 =-135

6 MA = -135+90=-45 **01 M**

MA=-7.5 KN-m

Consider Span ABC



Take moment @ a

O=20*3*1.5+30+30*4 -RB*3 **01 M**

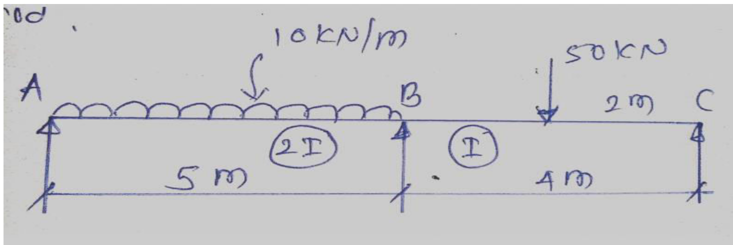
RB*3 = 240 **RB=80KN**.

∑ fy = 0

0 =RA+RB-20X3-30

0=RA+80-60-30 **01 M**

RA= 10KN

Q.6.	**Attempt Any Two of the following**	**12 M**
a)	**calculate support moment for a spam as shown in fig no.11 Use moment distribution method** 	

Ans:

Solution :- Assume span AB & BC as a fixed beam and find fixed end moment

$M\ AB = -WL^2/12 = -10(5)^2/12 = -20.83$ KN-m

$M\ BA = WL^2/12 = 10(5)^2/12 = 20.83$ KN-m

$M\ BC = -Wab^2/L^2 = 50(2)(2)^2/4^2 = -25$ KN-m

$M\ CB = +Wab^2/L^2 = 5*2*2^2/4^2 = 25$ KN-m **01 M**

To find the Stiffness factor at joint B

K BA = 3EI/L AB = 3E(2I)/5=6EI/5=**1.2 EI**

K BC = 3EI/LBC = 3EI/4 = **0.75 EI**

∑K=1.2EI+0.75EI=**1.95 EI**

Distribution Factor

DFBA=KBA/∑K =1.2EI/1.95EI=**0.62** **01 M**

DFBC = KBC/∑K =0.75EI/1.95EI =**0.38**

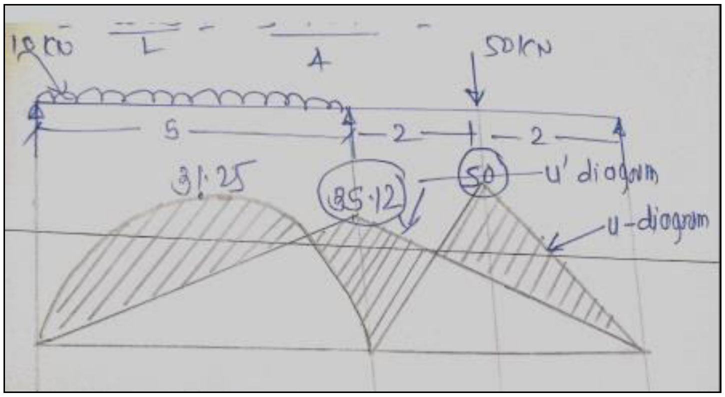
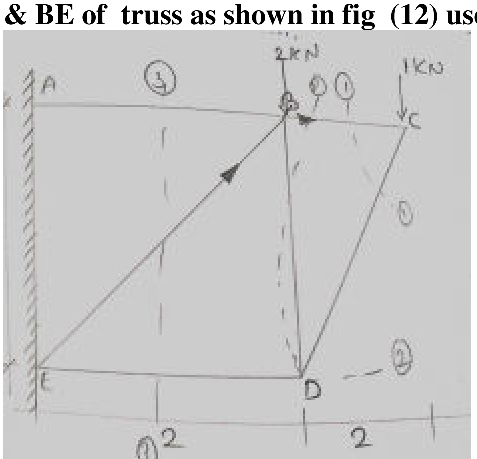
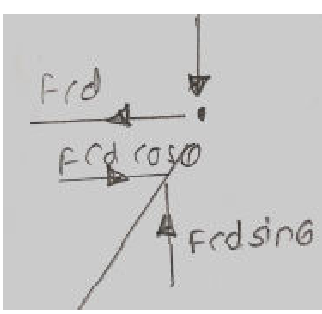
Point	A B	C
Member	AB BA	BC CB
Distribution factor	0.62	0.38
Fixed end moment	-20.83 20.83	-25 25
Release support A& C and then carry over from A to B from C to B	+20.83 → 10.415	-25 ↙ -12.5
Initial moment	0 31.245	-37.5 0
Ist distribution C balance B	+3.87	+2.37
Final moment	+35.12	-35.12

02 M

Assume span AB and BC to be simply supported beam and find free BM.

For span AB L=5m W=10KN/m

$M\ max = wl^2/8 = 10*(5)^2/8 =$ **31.25 KN.m**

	For span BC SPAN BC =4m ,a=2m b=2m w =50 kn = wab/L =50*2*2 /4 =**50kn-m**  	**02 M**
b)	**Calculate magnitude& state the nature of forces in the member AB,BC,CD,DE,BD & BE of truss as shown in fig (12) use method of section**  	
Ans:	Consider △ CBD tan θ =2/2 =45 θ **=45** Consider section (1)-(1) cut at BC & CD (joint C) + ↑ - ↓  ∑FY=0 0 =-1+Fcd sin θ Fcd sin θ =1	

Fcd=1.41 KN (C)

∑FX=0

0= Fcd cos θ - Fcb

Fcb = Fcd cos θ

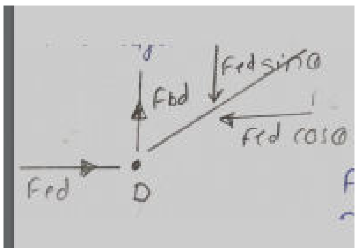
= 1.41 cos 45

=0.997

= *1KN(T)* **02 M**

Consider section (2)-(2) cut at CD,BC,ED

Consider right hand side



∑ fy=0

0=-1-Fcd sin θ +Fbd **02 M**

Fbd=1+Fcd sin 45

Fbd=2(T)

∑fx=o

0= - Fcd cos θ +Fed

1.41 cos 45 =Fed

Fed =1.41 cos 45

Fed= 1 kN(c)

Consider section (3)-(3), take moment at @ A

0=Fbe cos 45 +Fed *2 +2*2+1*4

10 = 1.41 Fbe

F be =7.092 (-ve indicate compressive) **01 M**

∑fx=o

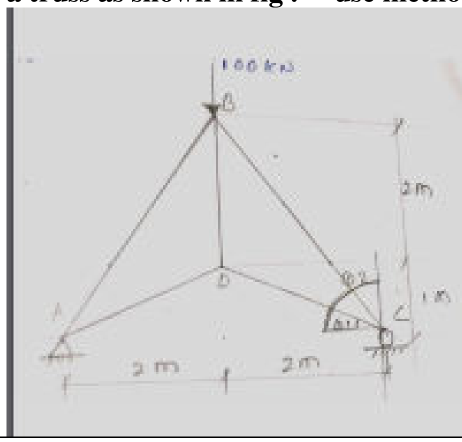
0= -fab+feb cos45 +fed

Fab =7.092X COS 45 +1

Fab =6.014 (T) **01 M**

MEMBER	FORCE (KN)	NATURE
AB	6.014	TENSION
BC	1	TENSION
CD	1.41	COMPRESSION
DE	1	COMPRESSION
BD	2	TENSION
BE	7.092	COMPRESSION

c) **calculate magnitude &state the nature of forces in member AB,BC,CD,AD&BD Of a truss as shown in fig . use method of joints.**



Ans:

∑ fy =0

RA+RC =100, due to symmitricity

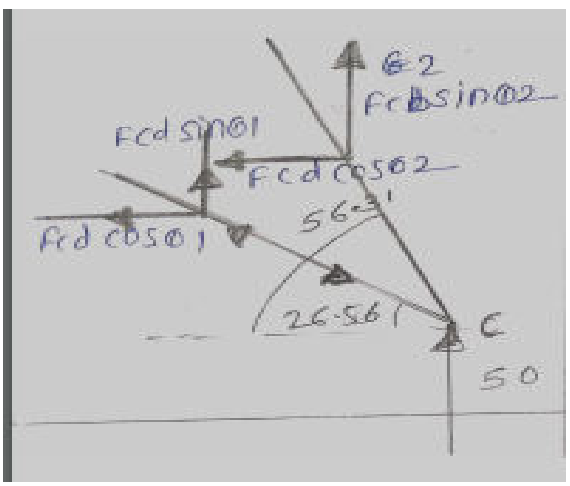
RA=RC=W/2=100/2 = 50KN

Consider joint C

θ 1 = tan θ 1 =1/2 θ2=tan θ 2 =3/2

θ 1 =26. 56 θ2=56.31 **01 M**

Consider Joint C



∑Fx= 0 fcd cos θ 1 +fcb cos θ 2= 0

0.8944 fcd +0.55fcb= 0 ____________________1

∑ fy =0

0= 50+fcd sin θ1 + fcb sin θ2

-50= fcd sin θ1 + fcb sin θ2

-50=0.4471fcd+0.832 fcb ______________________2

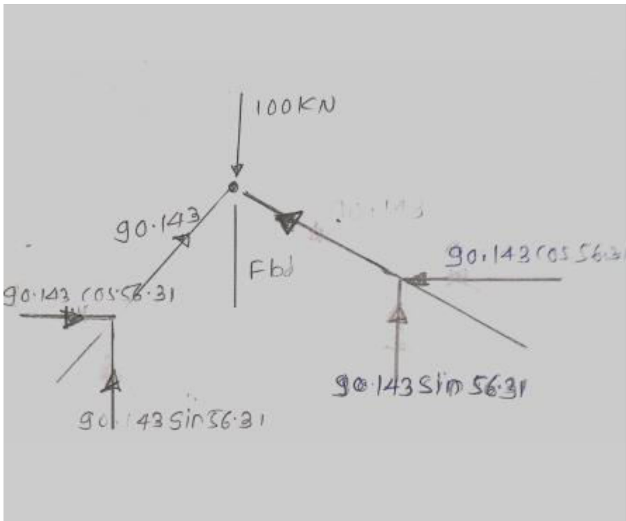
Solving both equation 1& 2, We get

Fcd=   55.91 KN   (T)

Fcb = -90.143 KN   (C)

02 M

Consider Joint B



02 M

$\sum FY = 0$

0= Fbd -100+90.143 sin 56.31+90.143sin56.31

Fbd= 50 KN

01 M

MEMBER	FORCE in KN	NATURE
AB	90.143	COMPRESSION
BC	90.143	COMPRESSION
CD	55.91	TENSION
AD	55.91	TENSION
BD	50.00	COMPRESSION