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.

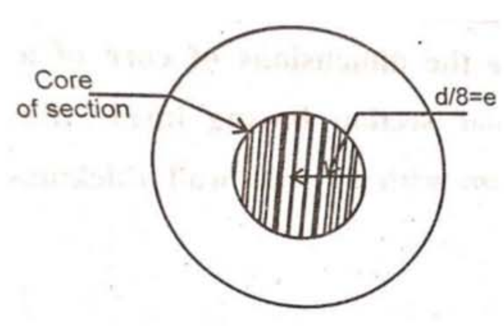
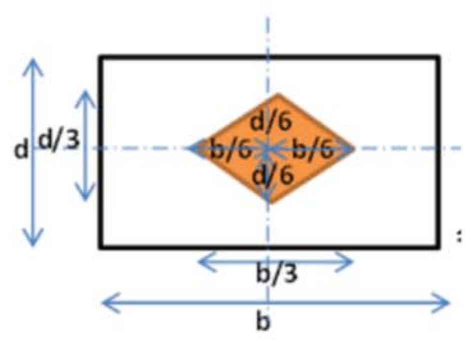
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.

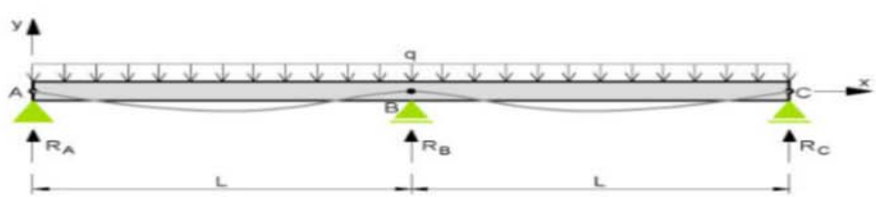
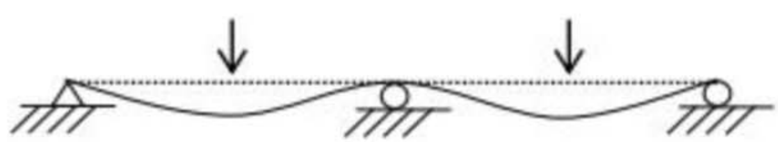
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

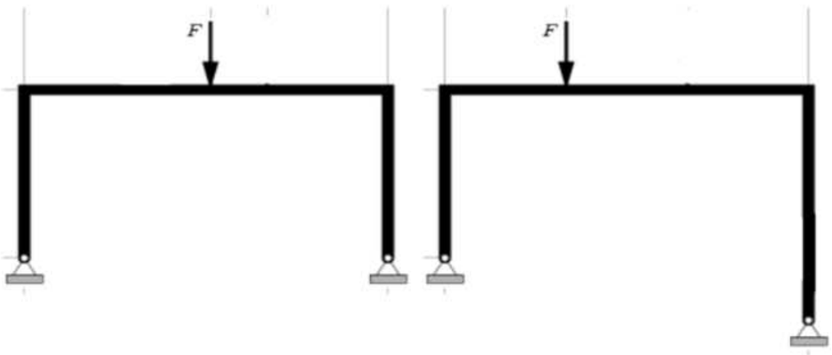
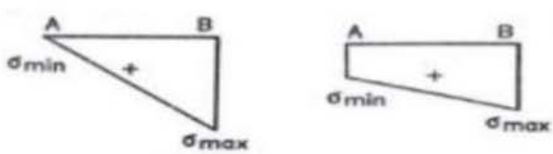
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values model answer.

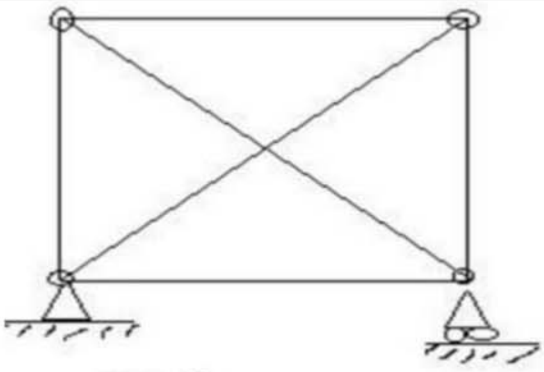
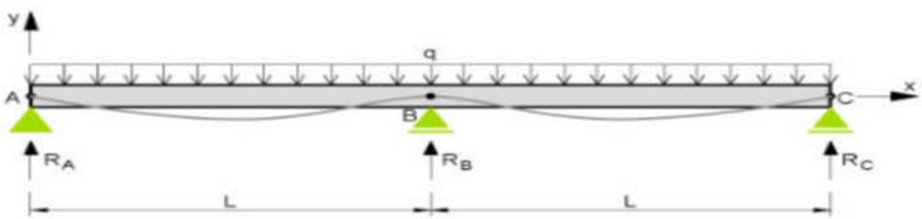
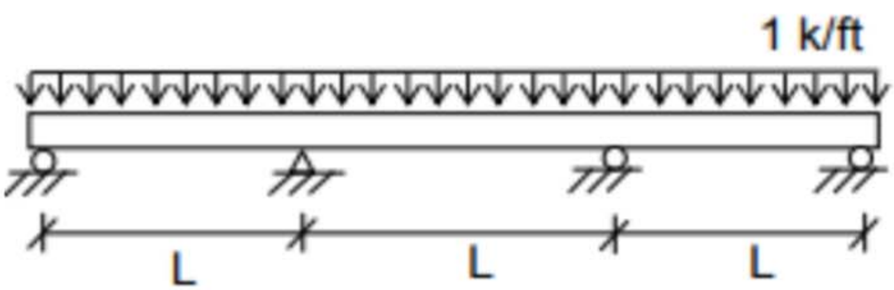
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer

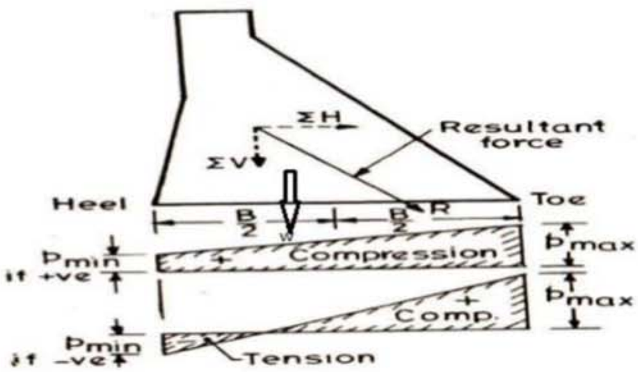
7) For programming language papers, credit may be given to any other program based on equivalent concept.

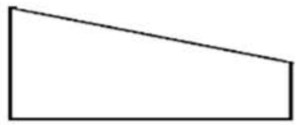
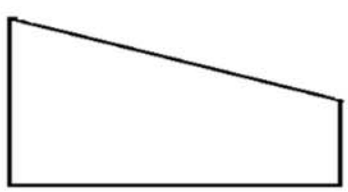
Q. NO	ANSWERS	MARK SCHEME
Q.1	**Attempt any FIVE of the following:**	**(10)**
a)	**Define core of section with sketch**	
Ans :-	Core of a section: Core of the section is that portion around the centroid in within which the line of action of load must act, so as to produce only compressive stress is called 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

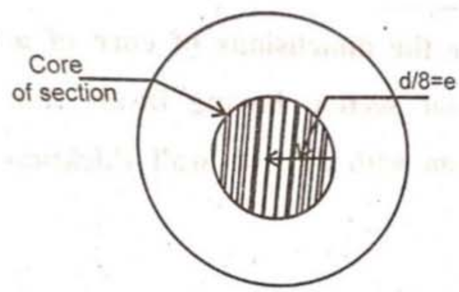
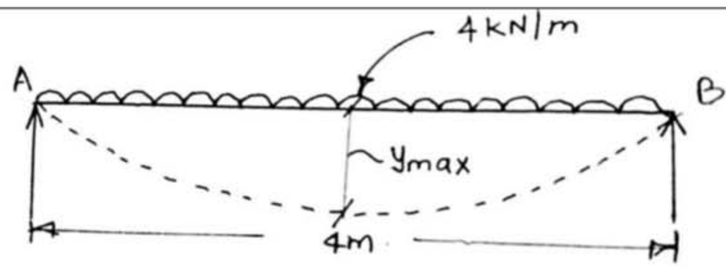
b)	**Give relationship between slope, deflection and radius of curvature.**	
Ans :-	Slope of a beam at a point is defined as rate of change of deflection with respect to longitudinal distance i.e. slope = dy / dx , The point of slope is "radian" $(dy/dx) = \int Mx / EI$ (Y) = deflection Where $Y = \int (1/EI)(dy/dx)$ $1/R = d^2y/dx^2$, R = radius of curvature $1/R = M/EI$ from bending equation $\boxed{d^2y/dx^2 = M/EI}$ 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

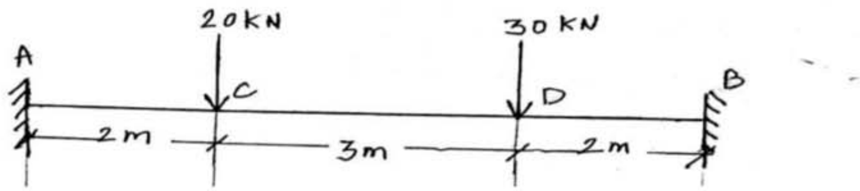
e)	**Draw neat sketch of symmetrical and unsymmetrical portal frame**	
Ans:	**i. Symmetrical portal frame (Non sway type)** **ii. Unsymmetrical portal frame (Sway type)**  **Symmetrical portal frame Unsymmetrical portal frame**	01 M each
f)	**Draw stress distribution diagram for $6_0 = 6_b$, $6_0 > 6_b$**	
Ans:	**Solution: stress distribution diagram for i) $6o = 6_b$ ii) $6o > 6_b$** Where, stresses $6o =$ Direct stress and $6_b =$ Bending stress $6o = P / A$ $6b = (M \times y) / I$ $6_{max} = 6_0 + 6_b$ $6_{min} = 6_0 - 6_b$  **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 ($\Sigma MA = 0$, $\Sigma Fx = 0$ and $\Sigma Fy = 0$).	01 M

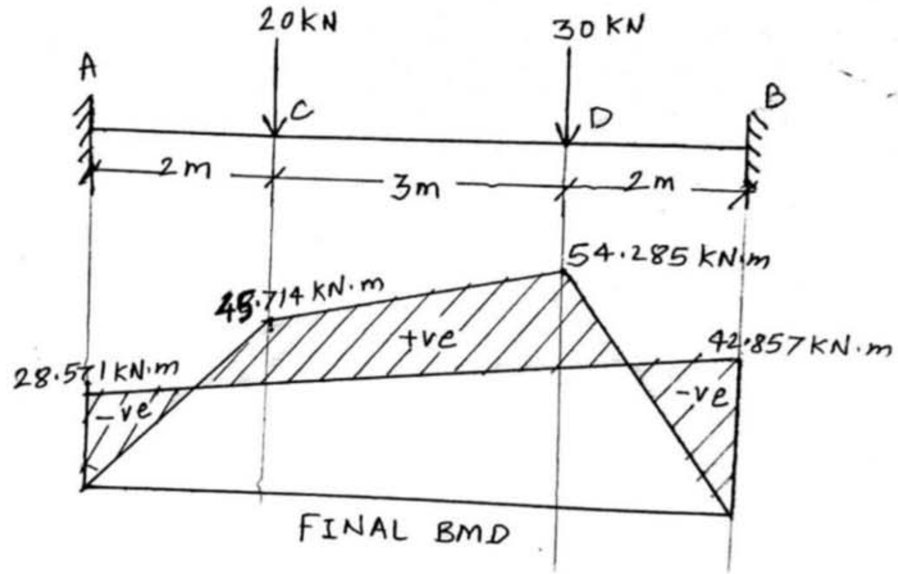
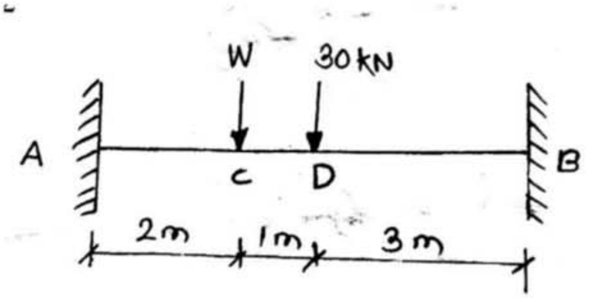
		01 M
h)	**Define Continuous beam and draw sketch of it**	
Ans:	**Continuous beam :** A beam is said to be continuous if it has two or more spans and three or more supports as shown in figures. Here all three M_A, M_B and M_C are unknowns. Such beams are continuous over supports. Here M_A, $M_C = 0$ and M_B is unknowns.  **Continuous beam for three supports** M_A M_B M_c  **Continuous beam for more than three supports**	01 M 01 M

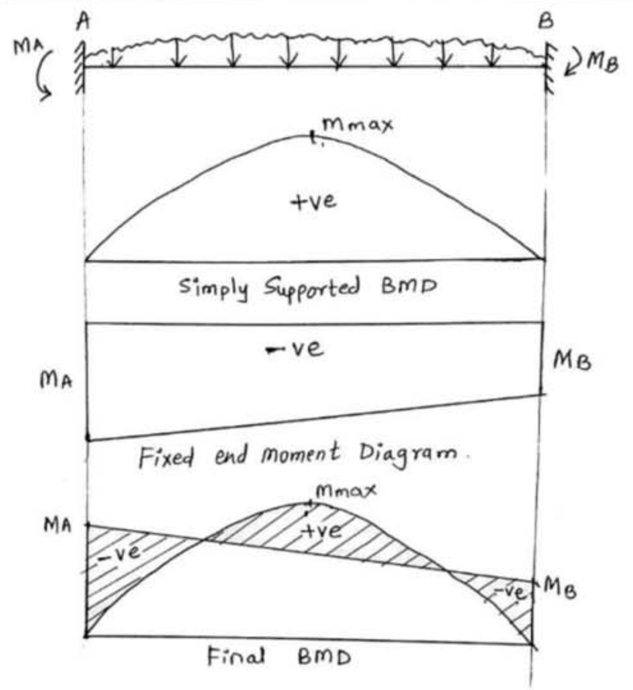
Q.2	**Attempt any THREE of the following:**	**(12)**
a)	**Explain with expression four conditions of stability of dam.**	
Ans:	1. Stability against Due to Overturning (P.h/3) < W(b-X) 2. Stability against Due to Sliding P < F 3. Compression or Crushing 4. Stability against No Tension e < (b/6) Where 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 = σ 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 / (π /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 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 $M_B = M_{B1} + M_{B2} = -\frac{W_1 a_1^2 b_1}{L^2} - \frac{W_2 a_2^2 b_2}{L^2}$ $= -\frac{20x2^2x5}{7^2} - \frac{30x5^2x2}{7^2} = -8.163 - 30.612$ $M_B = -38.775$ kN.m	**1M** **1M** **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 $M_A = -\frac{W_1a_1b_1^2}{L^2} - \frac{W_2a_2b_2^2}{L^2} = -\frac{Wx2x4^2}{6^2} - \frac{30x3x3^2}{6^2}$ $M_A = -0.888\ W - 22.5$ $M_B = -\frac{W_1a_1b_1^2}{L^2} - \frac{W_2a_2b_2^2}{L^2} = -\frac{Wx2^2x4}{6^2} - \frac{30x3^2x3}{6^2}$ $M_B = -0.444\ W - 22.5$ 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

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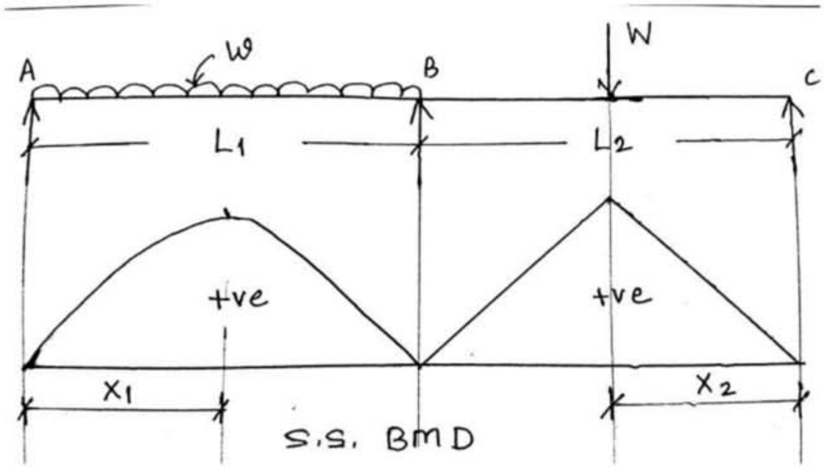
$$M_A + 2M_B(L_1 + L_2) + M_C L_2 = -\left[\frac{6A_1X_1 -}{L_1}\right] - \left[\frac{6A_2X_2}{L_2}\right]$$



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.

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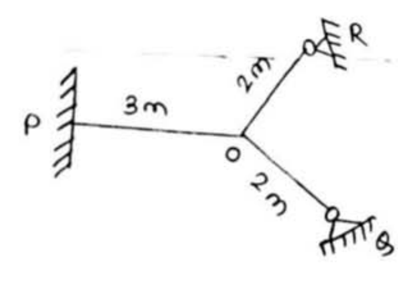
Calculate the distribution factors for the member OP, OQ, and OR for the joint O as shown in fig 3.



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Ans.

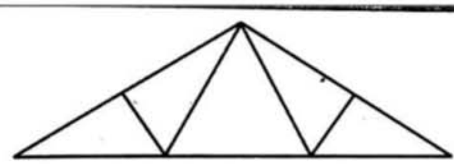
Joint	Member	Stiffness Factor	Total stiffness	Distribution Factor
O	OP	$K_{OP} = \frac{4EI}{L} = \frac{4EI}{3} = 1.333EI$	$\sum K_O = 1.333EI + 1.5EI + 1.5EI = 4.333EI$	$DF_{OP} = \frac{1.333EI}{4.333EI}$ **DF_{OP}=0.3077**
	OQ	$K_{OQ} = \frac{3EI}{L} = \frac{3EI}{2} = 1.5EI$		$DF_{OQ} = \frac{1.5EI}{4.333EI}$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

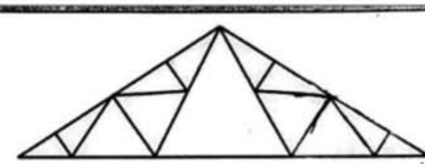
DF 2M

c) **Draw four types of trusses**

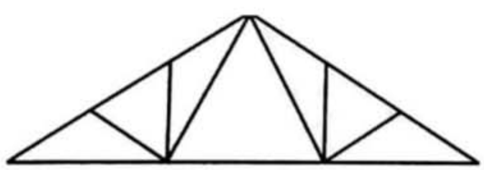
Ans.



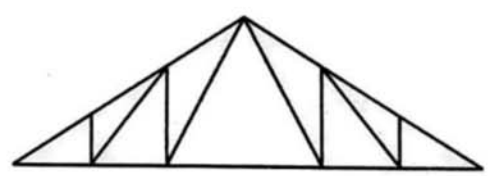
(a) Simple fink (span 6 - 9 m)



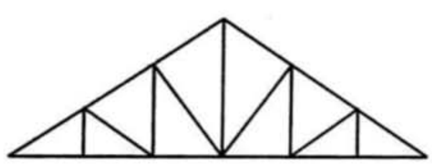
(b) Compound fink or french (span 12 - 18 m)



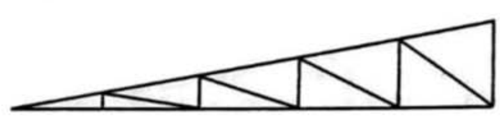
(c) Simple fan (span 7.5 - 12 m)



(d) Pratt (upto 30 m)

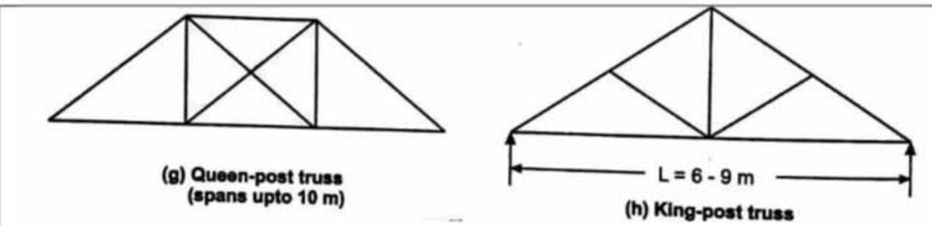


(e) Howe (span 6 - 24 m)

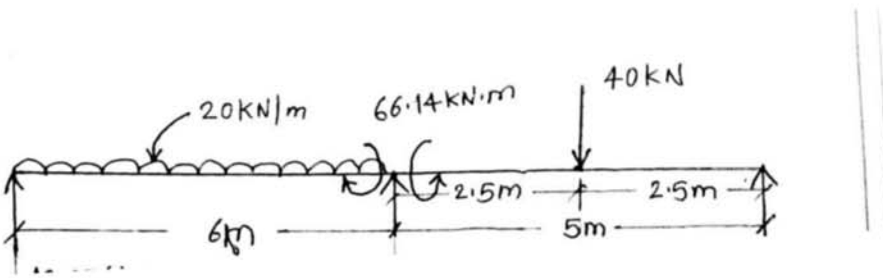


(f) North light roof truss (Span 8 - 10 m)

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.

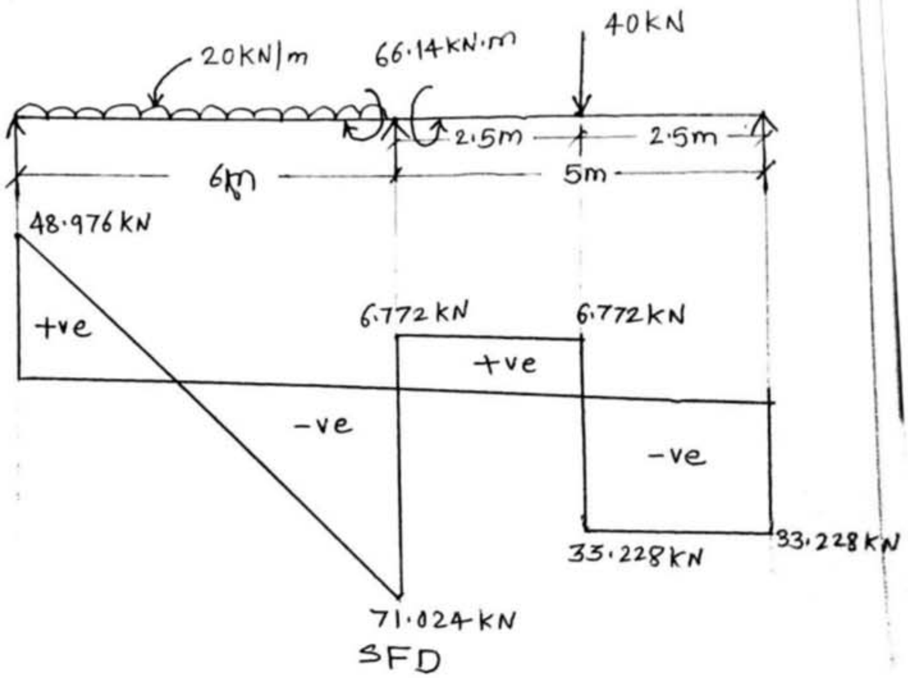
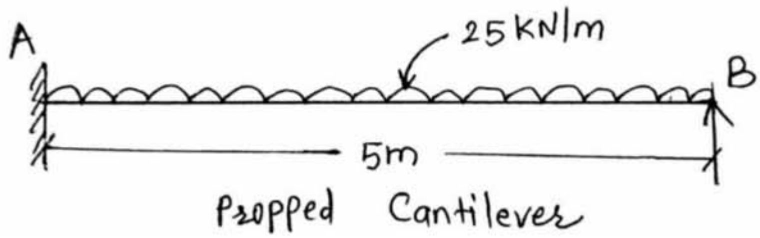
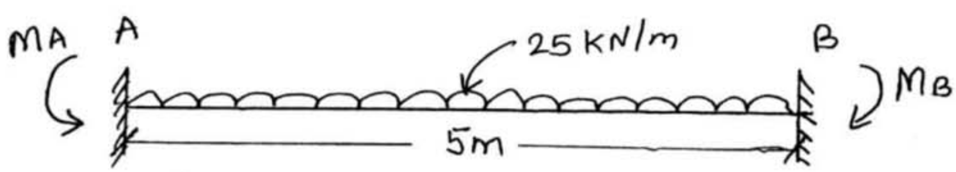
SF at B, just left = +48.976-20x6 = -71.024 kN.

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:

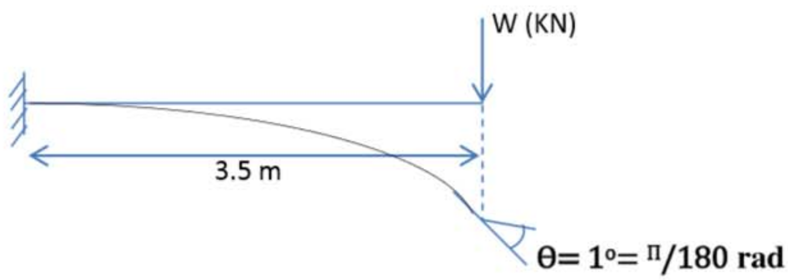
A	B	Joint
AB	BC	Member
-52.083	+52.083	Fixed end moments
	-52.083	Balancing at B
-26.041		Carryover to B
-78.124	0	Final Moments

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

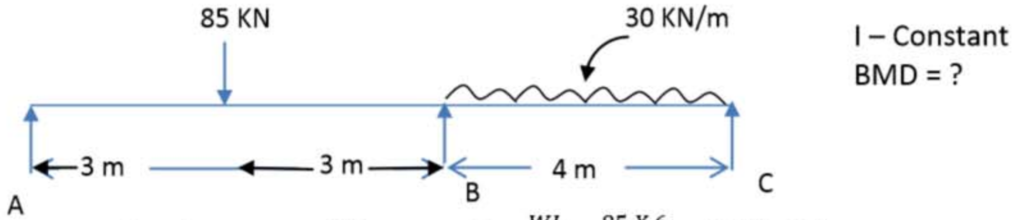
$$y_{max} = \frac{(0.00285\ X\ EI)(3.5)^3}{3\ X\ EI}$$ 1 M

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.**

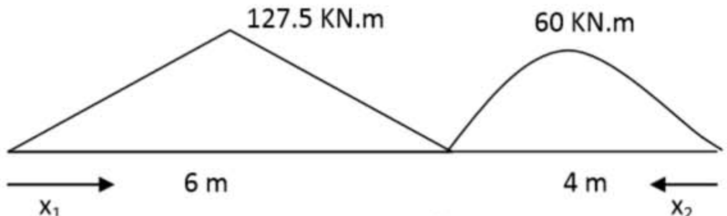
Ans.



Sagging moment for span AB = $\frac{WL}{4} = \frac{85 \, X \, 6}{4}$ = 127.5 KN.m

1 M

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



1 M

Sagging moment diagram

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

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

Using three moment theorem

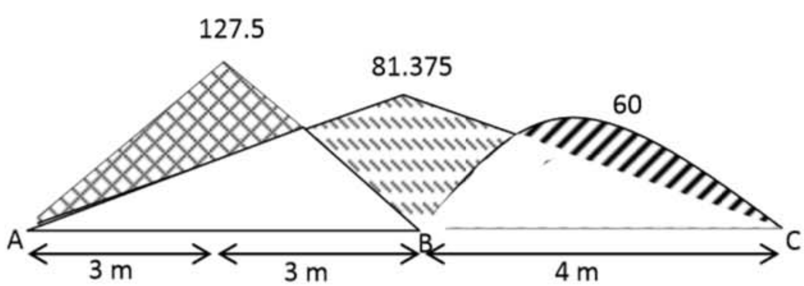
$$M_AL_1 + 2M_B\,(L_1 + L_2) + M_CL_2 = \frac{-6a_1x_1}{L1} - \frac{6a_2x_2}{L2}$$ 1 M

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)

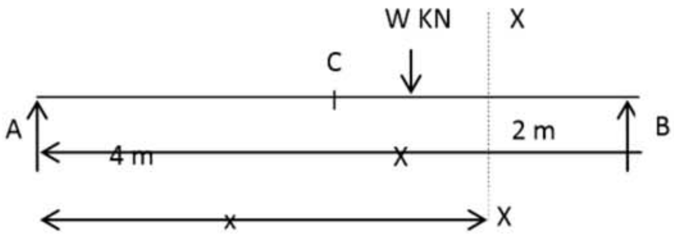


1 M

BMD (KN.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.m^2. 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 – $EI \frac{d2y}{dx2} = Mx = \left(\frac{W}{3}\right) x \; | \; -W(x-4)$ — 1 M

Integrating w.r.t x for slope — 1 M

$$EI \frac{dy}{dx} = \left(\frac{W}{3}\right) \frac{x^2}{2} + C_1 \; | \; \frac{-W(x-4)^2}{2}$$

Integrating w.r.t x for deflection $EI\, y = \left(\frac{W}{18}\right) x^3 + C_1 x + C_2 \; | \; \frac{-W(x-4)^3}{6}$ — 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

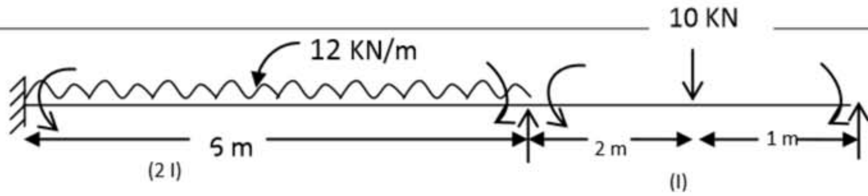
Deflection equation, $EI\, y = \left(\frac{W}{18}\right) x^3 - (1.78W)\, x \; | \; \frac{-W(x-4)^3}{6}$ — 1 M

For deflection at centre x= 3 m, y = - 0.02 m (↓

$$2000(-0.02) = \left(\frac{W}{18}\right)(3)^3 - (1.78W)(3)$$ — 1 M

W = 10.42 KN.

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)

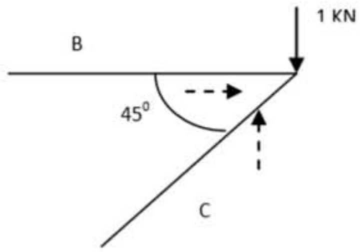
MB = 18.01 KN.m (Hogging) 1 M

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

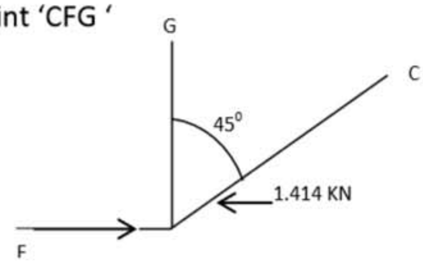
$\sum Fy = 0$, $Cy = 1$ KN

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

$\sum Fx = 0$

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

2. At Joint 'CFG '



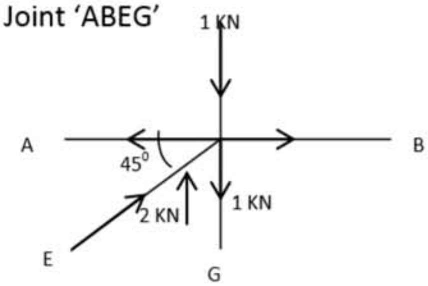
$\sum Fx = 0$

$F_F = 1.414$ Sin 45 = 1 KN (comp) — 1M

$\sum Fy = 0$

$F_G = 1.414$ Cos 45 = 1 KN (Tensile)

3. At Joint 'ABEG'



$\sum F_y = 0$ — 1M

$F_E = 2/Cos\ 45 = 2.83$ KN (comp)

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**

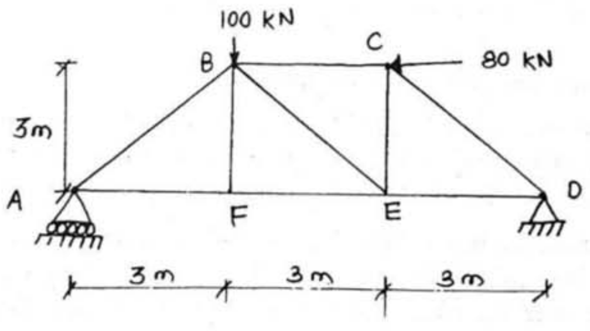


Fig. No. 7

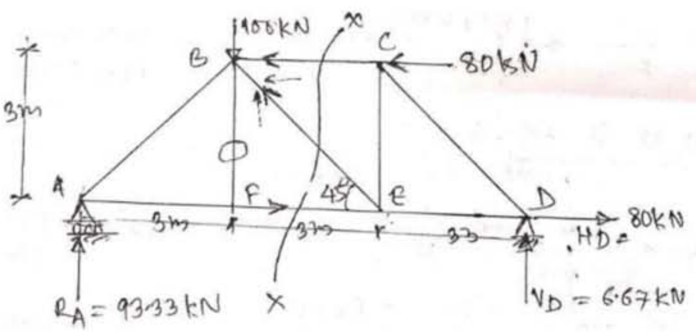
Ans.

$\sum M@D = 0 \ (R_A \times 9) - (100 \times 6) - (80 \times 3) = 0$ **1 M**

$R_A = 93.33$ KN **1 M**

& $\sum Fy = 0$. YD = 100 – 93.33 = 6.67 KN

& $\sum Fx = 0$. HD = 80 KN.



1 M

Taking section x- x & applying conditions of equilibrium to the left part of truss

$\sum M@B = 0 \quad (R_A \times 3) = (F_{FE} \times 3)$ **1 M**

$F_{FE} = 93.33$ KN (Tensile)

$\sum Fy = 0. \quad 93.33 + F_{BE} \sin 45 = 100.$ **1 M**

$F_{BE} = 9.43$ KN (Compressive)

$\sum Fx = 0. \quad F_{FE} - F_{BE} \cos 45 = F_{BC}$

$93.33 - 9.43 \cos 45 = F_{BC}$ **1 M**

$F_{BC} = 86.67$ KN (Compressive)