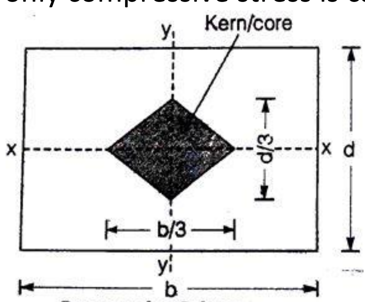
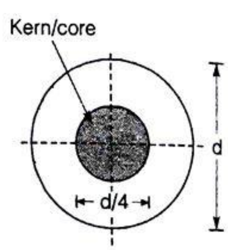
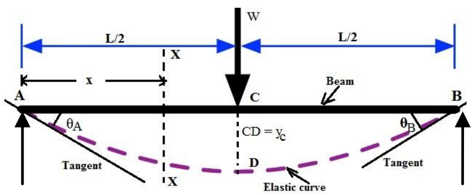
WINTER– 17 EXAMINATION

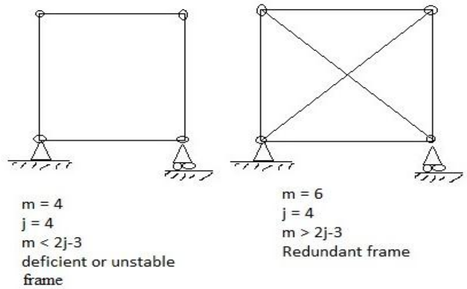
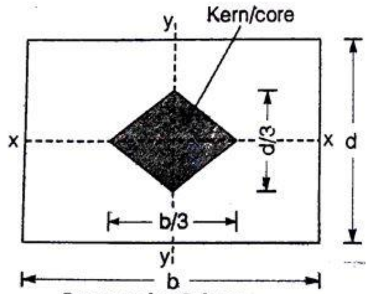
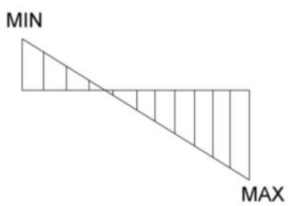
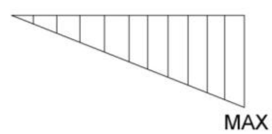
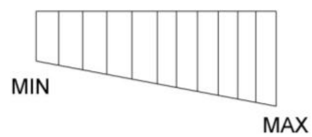
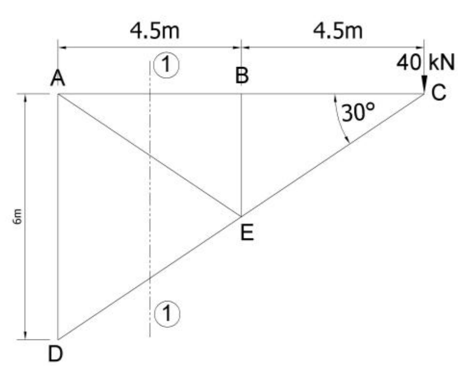
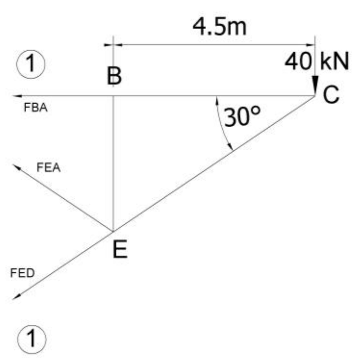
Subject Name: Theory of Structures **<u>Model Answer</u>** Subject Code: 17422

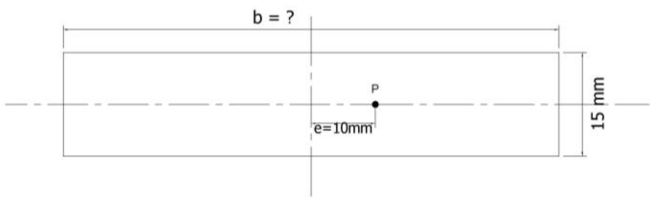
<u>Important Instructions to examiners:</u>

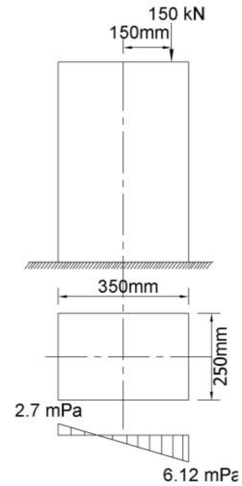
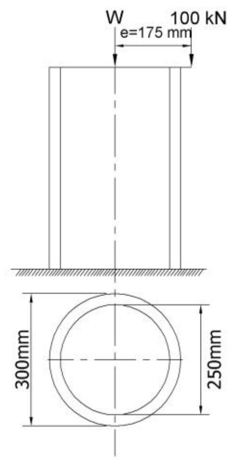
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

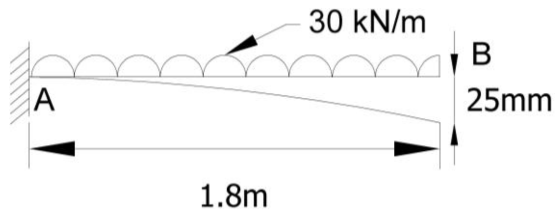
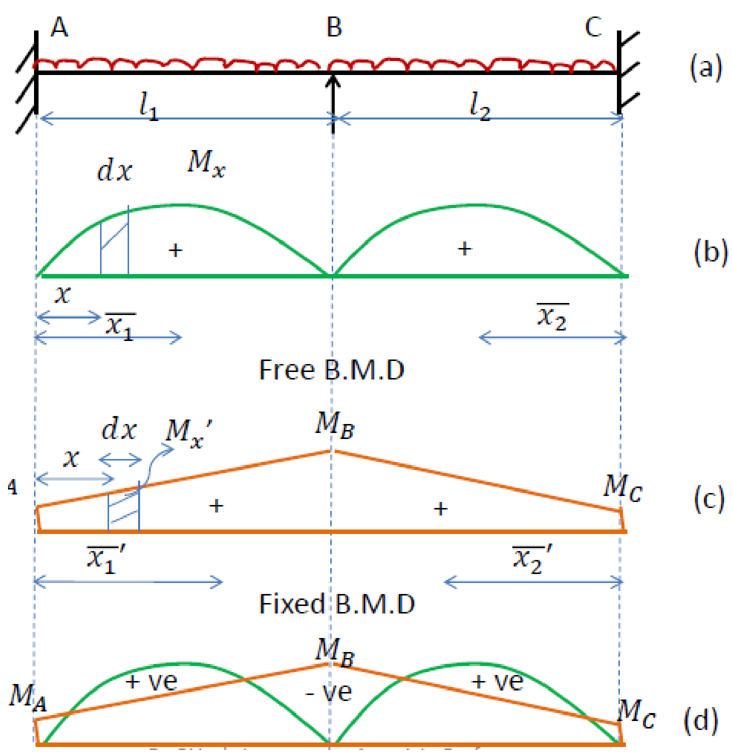
Q. No.	Sub Q. N.	Answer	Marking Scheme
Q.1	(A)	Attempt any SIX of the following.	(12)
Q.1	A)a) Ans	**Define core of the section.** It is the portion of a section around the center within which the line of action of load must act so as to produce only compressive stress is called as core of the section.  *Rectangular Column*  *Circular Column*	01 Mark 01 Mark
Q.1	A)b) Ans	**Define slope and deflection of a beam.** **Definition of Slope of beam:** The slope at any point on the elastic curve of the beam is defined as the angle in radians that the tangent at that point makes with the original axis of the beam. It is measured in radians **Definition of deflection of beam:** when a beam is loaded, the beam is deflected from its original position in the direction perpendicular to its longitudinal axis. Then displacement of beam measured from its neutral axis from unloaded condition of the beam to loaded condition is called deflection of beam. **OR** The deflection at any point on the axis of the beam is the distance between its positions before and after loading.	01 Mark 01 Mark
Q.1	A)c)	**Write the value of max. slope and deflection in case of simply supported beam loaded with udl over entire span.**	

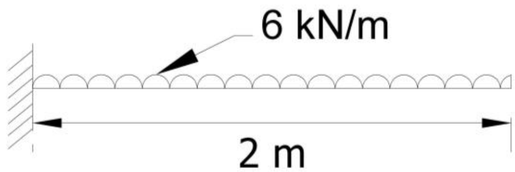
	Ans	Slope at the ends of S.S. beam = (Θ)=$wL^3/24EI$ Deflection at the centre= $y_{max}=y_{centre}$= $5/384\ wL^4/EI$ Where w= rate of loading.(KN/m) L= leangth of beam(m) E= modulus of elasticity(N/mm^2) I= moment of inertia of a beam mm^4	01 M 01 M
Q.1	A)d) Ans	**State the boundary conditions for simply supported beam using deflected shape.** Boundary conditions of simply supported beam (slope exists but deflection is zero) 1) slope (Θ)= dy/dx ≠ 0 2) deflection = y= 0  R_A = Reaction force at support A = W/2 R_B = Reaction force at support B = W/2 θ_A = Slope at support A θ_B = Slope at support B	01 Mark 01 Mark
Q.1	A)e) Ans	**Define fixing and fixed beam** **Fixing: -** When the ends of the beam are firmly built in the support so as the slopes at the support become zero i.e tangent to the deflected curve at support will be zero. **Fixed beam: -** A beam whose end supports are such that the end slopes remain zero is called a fixed beam**.**	01 M 01 M
Q.1	A)f) Ans	**Define distribution factor and carry over factor.** **Distribution factor:-** it is the ratio of relative stiffness of a member to the total stiffness of all the members meeting at a point**.** **Carry over factor:-** it is the ratio of moment produce at a joint to the moment applied at the other joint without displacing it.	01 M 01 M
Q.1	A)g) Ans	**Write the concept of carry over factor** **Carry over factor:-** it is the ratio of moment produce at a joint to the moment applied at the other joint without displacing it. 1) The beam fixed at one end and simply supported at other end , the carry over factor is ½. 2) The beam simply supported at both ends, the carry over factor is zero.	01 M 01 M
Q.1	A)h) Ans	**Define with sketch deficient frame and redundant frame** **Deficient frame** Assume, n = number of members, j= number of joints. If the number of members are less than the required number of members (n < 2j-3) then the corresponding frame is called as deficient frame. **Redundant frame** Assume, n = number of members, j= number of joints. If the number of members are less than the required number of members (n > 2j-3) then the corresponding frame is called as deficient frame.	01 M 01 M

		 	
Q.1	B)a) Ans	State middle third rule. Middle third rule: In case of rectangular cross section, if the load is applied at location along the middle third part of both mutually perpendicular axes then the stresses produced are wholly of compressive nature.  *Rectangular Column*	02 M 02 M
Q.1	B)b) Ans	Sketch resultant stress distribution diagram for $6_0 < 6_b$, $6_0 = 6_b$, $6_0 > 6_b$. i) $6_0 < 6_b$  ii) $6_0 = 6_b$  iii) $6_0 > 6_b$  Where, 6_0 = Direct stress and 6_b = Bending stress ---	01 Mark each for dia. 01 Mark
Q.1	B)c) Ans	**Using method of section only, determine nature and magnitude of axial forces in the members AB and AE only**   Consider section 1-1 which cuts AB, AE, and DE consider right part of section 1-1 Assume FAB, FAE and FDE are tensile and consider tensile as positive and compressive as negative Consider triangle ABE Tan (30)= (BE/AB) = BE/4.5	

		E= 2.596 ≈2.6m Consider the right part of section 1-1 in equilibrium taking moment at joint E We get ΣM_E = - F_{BA} x 2.6 + 40 x 4.5 **F_{AB} = 69.23KN (tensile)** To find F_{AE} and F_{DE} using condition of equilibrium Σfx =0 -F_{BA} – F_{EA}cos30 – F_{ED}cos30 =0 F_{EA}cos30 – F_{ED}cos30 = - 69.23-----------------------------------A Σfy = 0 - 40 + F_{EA}sin30 – F_{EDsin}cos30 = 0 F_{EA}sin30 – F_{ED}cos30 = 40-----------------------------------B Solving equations A and B We get **F_{EA} = 0.003KN≈ 0KN (tensile)** **F_{ED} = - 79.969KN≈ -80KN(compressive)**	 02 M 02 M
Q.2	a) Ans	**A tie rod of rectangular section having 15mm thickness it carries load of 200KN acts at an eccentricity of 10mm along a plane bisecting thickness. Calculate the width of section if maximum tensile stress shall not exceed 100MPa.**  Given:- D=15mm e= 10mm load line bisecting the thickness maximum tensile stress (σ_{max})= 100 MPa = 100 N/mm^2 Since the load is tensile on the right side of YY axis, the maximum tensile stress will occur on the right face of section face BC Let 'b' be the minimum width of the rod If the load is eccentric about YY axis σ_{max} = P/A + M/Zyy = (P/A) + [P.e/(db^2/6)] 100 = 200x10^3/bx15 + [(200x10^3 x 10)/(15 x(b^2/6)] 100 = 1.3333 x10^4 / b +8 x 10^5 /b^2 b^2 – 1.3333 x 10^{2}b - 8 x 10^3 =0 on solving we get b=178.23mm	 01M 01 M 01M 01 M

Q.2	b) Ans	**A rectangular column of size 0-35m x0.25 m carries an eccentric load of 150 KN. The load acts at 0.15m from c.g. of the section on axis bisecting the shorter side. Determine resultant stress at the base and draw stress distribution diagram.** Given:- b= 0.35m = 350mm d= 0.25m= 250mm P = 150 KN e= 150mm load line bisecting shorter face i.e. thickness area (A)= b xd = 350 x250 =87500 mm^2 direct stress (σo) = P/A =150 $x10^3$/ 87500 =1.71 N/mm^2(comp) bending stress (σb) = M/Z=P.e/Zyy =150 $x10^3$ x 150/ ((250 $x350^2$)/6) = 4.41 N/mm^2 (Comp. at right face and Tensile at left face) $\sigma_{max}= \sigma_o+\sigma_b$ = 1.71 +4.41 = 6.12 N/mm^2 (comp) $\sigma_{min}= \sigma_o-\sigma_b$ = 1.71-0.44 = - 2.7 N/mm^2 i.e. 2.7 N/mm^2 (Tensile)  	1/2M 1/2M 1/2M 1 M 1 M for diagram
Q.2	c) Ans	**A hollow C.I. column of external diameter 300mm and internal diameter 250mm carries an axial load of 'W' KN and load of 100KN at an eccentricity of 175mm. calculate minimum value of W so as to avoid tensile stresses.** Given External diameter D= 300mm Internal diameter d= 250mm Axial load = W KN Eccentric load (P)= 100 KN Eccentricity e= 175mm Avoid tensile stress i.e. assume no tension condition i.e direct stress (σo)= bending stress (σb) To find Axial load W Area (A) = $\pi/4(D^2-d^2)$ = $\pi/4(300^2-250^2)$ = 21.6 $x10^3mm^2$ Direct stress (σo) = (W+P)/A =[W + 100 $x10^3$/ 21.6$x10^3mm^2$] ----- (1) Bending stress (σb) = M/Z=P.e/Zyy ={100 $x10^3$ x 175/ [$\pi/32((300^4-250^4)/300)$]} bending stress (σb) = 12.75 N/mm^2 ---- (2) to avoid tensile stress we have to assume no tension condition i.e Direct stress (σo)= Bending stress (σb) equating (1)and (2) [(W + 100) $x10^3$/ 21.6$x10^3$] = 12.75 We will get W= 175.4 kN  	1M 1M 1M 1M
Q.2	d) Ans	**A cantilever beam of span 1.8m carries 30 KN/m udl over entire span. if deflection at free end is limited to 25mm, determine the elastic modulus of material I=1.3$x10^8$ mm^4.** Given L= 1.8m W= 30 KN/m	

		y = 25mm I = 1.3×10^8 mm^4 For a cantilever beam carrying UDL over entire span The deflection is given by the formula $y = wL^4/8EI$ $25 = (30 \times (1.8 \times 10^3)^4)/(8 \times E \times 1.3 \times 10^8)$ On solving we get $E = 12.112 \times 10^3$ N/mm^2  	2M 1M 1M
Q.2	e) Ans	**A beam of span 3m is simply supported and carries udl of 'W' N/m if slope at the ends is not to exceed 1^0, find the maximum deflection.** ϴ= slope at the end $=1^o = (1 \times \pi/180)$ radians = 0.017 rad ϴ= slope at the end simply supported and carries udl on entire span is given by $=wL^3/24\ EI$ $0.017 = (w/EI) \times (L^3/24)$ $(w/EI) = 0.0151$ To find maximum deflection for simply supported and carries udl (for downward deflection) $Y_{max} = [5/384(wL^4/EI)]$ $Y_{max} = 5L^4/384 \times (w/EI)$ $Y_{max} = -5L^4/384 \times 0.0151$ $Y_{max} = 15.9$ mm ≈ 16mm	1/2M 1M 02M
Q.2	f) Ans	**Clapeyron's theorem of three moments with neat sketch and give meaning of each term** For a two span continuous beam having uniform moment of inertia, supported at ends A, B and C subjected to any external loading , the support moments MA, MB and MC at the supports A,B and C respectively are given by the relation $M_AL_1 + 2MB(L_1+L_2) + MCL_2 = -(6a_1x_1/L_1 + 6a_2x_2/L_2)$ Where L_1= length of span AB L_2= length of span BC a_1 = area of free BMD for the span AB (figure b) a_2 = area of free BMD for the span BC (figure b) x_1= distance of C.G. of free BMD over the span AB from Left end A x_2= distance of C.G. of free BMD over the span BC from right end C  	1M 1M 2M for dia.
Q.3	a) Ans	A cantilever beam 2 m long carrying udl of intensity 6 kN/m over full length. Calculate the depth of the beam if max. deflection is limited to 5 mm and depth to width ratio is 2. $E = 2 \times 10^5$ mPa.	



$Y_{max} = (wl^4) / (8EI)$ — 01 M

$5 = (6 \times 2000^4) / (8 \times 2 \times 10^5 \times I)$ — 01 M

$I = 12 \times 10^6\ mm^4$

$I = bd^3 / 12$

$12 \times 10^6 = b \times (2b)^3 / 12$ (d = 2b) — 01 M

b = 65.136 mm — 01 M

d = 2 x 65.136 = 130.27 mm

Q.3 b) A simply supported beam carries udl of 4KN/m over entire span of 4m find deflection at mid span in terms of EI.

Ans

W= 4KN/m

L= 4m

EI= flexural Rigidity ($kN\text{-}m^2$)

The formula for the deflection of simply supported beam carrying udl over entire span is given by

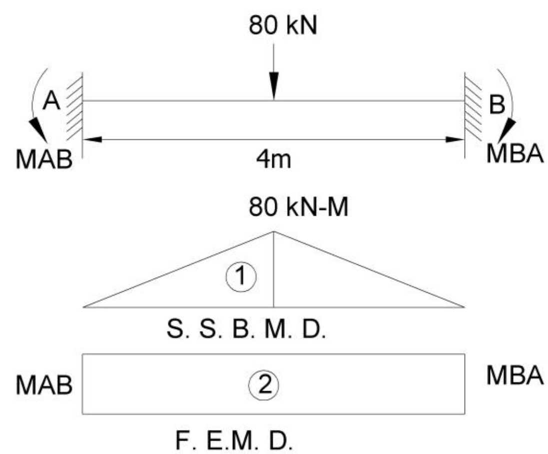
$Y_{max} = (5 \times w \times L^4)/ 384EI$ — 2M

$Y_{max} = (5 \times 4 \times 4^4)/ 384EI$

$Y_{max} = 13.33/EI$ m. — 2M

Q.3 c) A fixed beam AB of span 4m carries a point load of 80 KN at its centre. Find fixed end moments by using the first principle and draw SF and BM diagrams

Ans



Simply supported bending moment at mid-span = WL/4 = 80 x 4 / 4 = 80 kN-m.

Due to symmetry, $M_{AB} = M_{BA}$ — 1M

Area of S. S. B. M. Dia. = a_1 = 0.5 x 4 x 80 = 160 — 1M

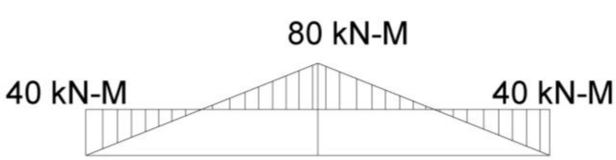
Area of F. E. M. Dia. = M_{AB} x 4

Area of simply supported bending moment diagram = Area of fixed end moment diagram

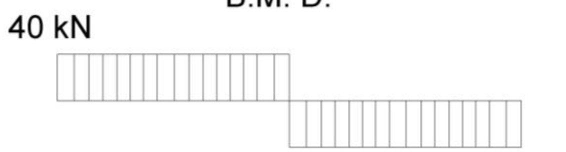
$a_1 = a_2$

$160 = M_{AB} \times 4$ — 1M for diagram

Hence M_{AB} = 40 kN-m And M_{BA} = 40 kN-m

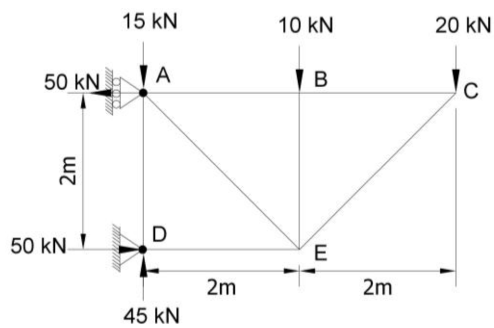
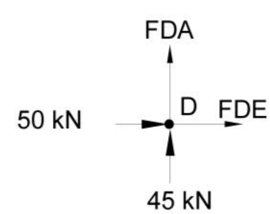
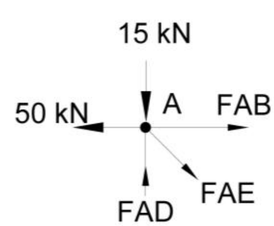


B.M. D.



S.F. D.

01 M for BMD & SFD

Q.3	d) Ans	**State any two advantages and dis advantages of fixed beam over simply supported beam** **Advantages of fixed beam over simply supported beam:** (1) Due to end fixity ,end slope of a fixed beam is zero. (2)A fixed beam is more stronger,stiffer and stable. (3) For same span and loading,fixed beam has lesser value of Bending moment. (4) Smaller moment permits smaller sections and there is saving in beam material. (5) Fixed beam has lesser deflection for same span and loading as compared to S.S. beam **Disadvantages of fixed beam over simply supported beam:** 1) A little sinking or settlement of support induces additional moment at each support. 2) secondary stresses are develop due to temperature 3) dynamic loading may disturb the fixity	1M each for any two 1M each for any two
Q.3	e) Ans	**Using method of joints, find nature and magnitude of forces in AE and DE in frame as shown**  Step 1 Calculation of support reaction at support A(roller)I.e. RA_H and at support D (hinged) RD_H and RD_V as shown in diagram Using conditions of equilibrium $\Sigma M_D=0$ $RA_H \times 2 + 10 \times 2 + 20 \times 4 = 0$ $RA_H = -50KN$ i.e 50 kN towards left $\Sigma fx=0$ $RD_H - RA_H = 0$ $RD_H = 50$ kN towards right $\Sigma fy=0 = -15 -10 -20 + RD_V = 0$ **$RD_V = 45$ KN (upward)** **Joint D**  JOINT D Assuming forces tensile in nature. Using condition of equilibrium $\Sigma fy=0$ $45 + F_{DA} = 0$ **I.e. $F_{DA} = -45KN$ i.e 45 kN (Compressive)** $\Sigma fx=0$ $F_{DE} + 50 = 0$ **i.e. $F_{DE} = -50KN$ i.e. 50 kN (Compressive)** **joint A**  Assuming forces tensile in nature. Using condition of equilibrium	02 M 02 M

$\Sigma f_y = 0 = -15 + 45 - F_{AE} \sin 45 = 0$

F_{AE} = 30KN (Tensile)

Member	Force	Nature
AE	30 kN	Tensile
DE	50 kN	Compressive

Q.3 f) What is meant by analysis of frame? Write the assumptions used for analysis

Ans

Analysis of frame-

To calculate the magnitude and nature of forces of the members of the frame (perfect frames) using equilibrium conditions is called analysis of frames. — 02 Marks

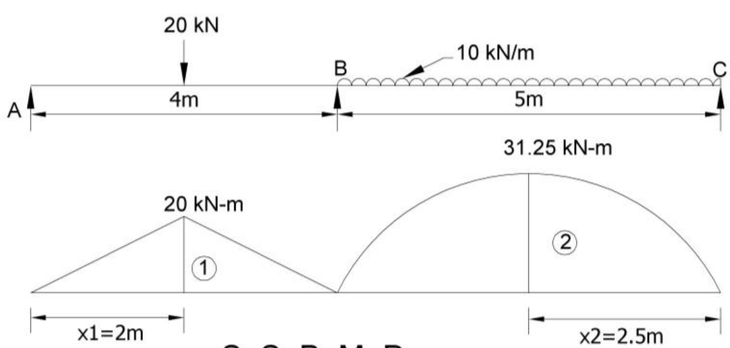
Assumptions made for analysis of frame:-

1) the frame is perfect frame
2) All members are hinged or pinned connected at the ends.
3)the loads are acting only at the joints — 02 M
4)self-weight of the member is neglected

Q.4 Attempt any FOUR of the following. (16)

Q.4 a) A beam ABC is simply supported at A, B and C. Span AB and BC are of length 4 m and 5 m respectively. AB carries a point load of 20 kN at center. BC carries a udl of 10 kN/m over entire span. Calculate support moment at B using theorem of three moments.

Ans.



S. S. B. M. D. — 01 M

$M_1 = 20 \times 4/4 = 20.0$ kN-m $\quad a_1 = 0.5 \times 4 \times 20 = 40 \quad x_1 = 4/2 = 2.0$ m — 01 M

$M_2 = 10 \times 5^2/8 = 31.25$ kN-m $\quad a_2 = 2 \times 5 \times 31.25/3 = 104.17 \quad x_2 = 5/2 = 2.5$ m

Using three moment theorem;

$$M_A \times L_1 + 2M_B(L_1 + L_2) + M_C \times L_2 = -[(6 \times a_1 \times x_1/L_1) + (6 \times a_2 \times x_2/L_2)]$$

$M_A = M_C = 0$ (End simple supports) — 01 M

$$0 + 2M_B(4 + 5) + 0 = -[(6 \times 40 \times 2/4) + (6 \times 104.17 \times 2.5/5)]$$

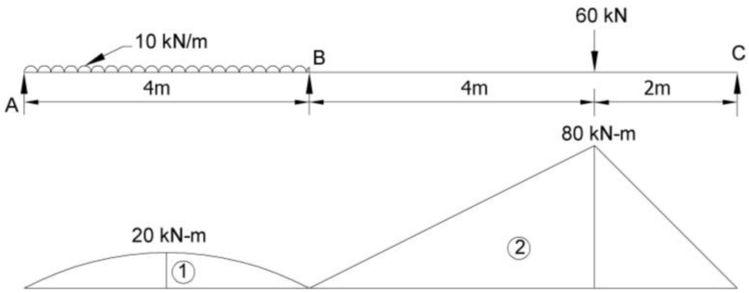
$$18M_B = -(120 + 312.51)$$

$$M_B = -432.51 / 18$$

$$= -24.03 \text{ kN-m}$$ — 01 M

Q.4 b) Using three moments method, find support moments for continuous beam shown in fig. Draw B. M. D.

Ans



S. S. B. M. D.

01 M

$M_1 = 10 \times 4^2/8 = 20.0$ kN-m — 01 M

$a_1 = 2 \times 4 \times 20/3 = 53.33$

$x_1 = 4/2 = 2.0$ m

$M_2 = 60 \times 4 \times 2/6 = 80.0$ kN-m — 01 M

$a_2 = 0.5 \times 6 \times 80 = 240$ $\quad x_2 = (6+2)/3 = 2.67$ m

Using three moment theorem;

$M_A \times L_1 + 2M_B(L_1 + L_2) + M_C \times L_2 = -[(6 \times a_1 \times x_1/L_1) + (6 \times a_2 \times x_2/L_2)]$

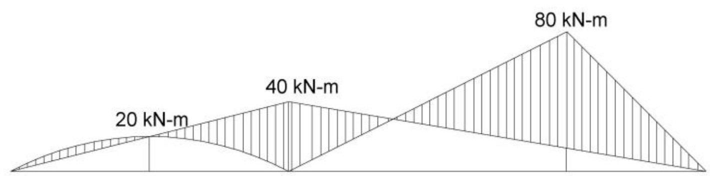
$M_A = M_C = 0$ (End simple supports)

$0 + 2M_B(4 + 6) + 0 = -[(6 \times 53.33 \times 2/4) + (6 \times 240 \times 2.67/6)]$

$20M_B = -(160 + 640)$

$M_B = -800 / 20$

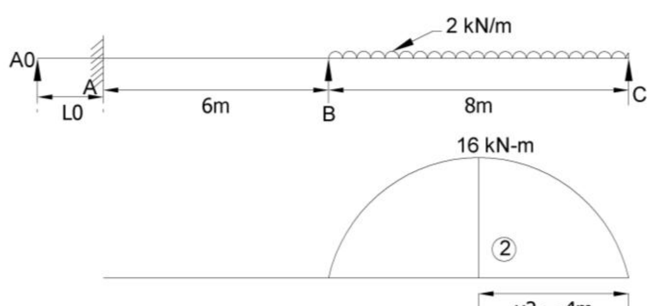
$= -40.0$ kN-m — 01 M



B. M. D.

Q.4 c) A continuous beam ABC is fixed at A and simply supported at B and C. Only span BC is loaded with udl 2 kN/m, span AB = 6 m, span BC = 8 m. Draw B. M. D. for beam. Use three moments theorem only.

Ans



S. S. B. M. D.

01 M

Consider zero span at A (span A_0- A)

$M_2 = 2 \times 8^2/8 = 16.0$ kN-m $\quad a_2 = 2 \times 8 \times 16.0 / 3 = 85.33 \quad x_2 = 8/2 = 4$ m

Using three moment theorem;

Span A_0-A and A-B

$M_0 \times l_0 + 2M_A (l_0 + l_1) + M_B \times l_1 = -[(6 \times a_0 X x_0/l_0) + 6 \times a_1 X x_1/l_1)]$

$M_0 = 0$ (Imaginary support) — 01 M

$0 + 2M_A(0 + 6) + M_B \times 6 = 0 + 0$

$12M_A + 6M_B = 0$

$M_B = -2M_A$

Span A-B and B-C

$M_A \times L_1 + 2M_B(L_1 + L_2) + M_C \times L_2 = -[(6 \times a_1 \times x_1/L_1) + (6 \times a_2 \times x_2/L_2)]$

$M_C = 0$ (End simple support)

$6M_A + 2M_B(6 + 8) + 0 = -[(0) + (6 \times 85.33 \times 4/8)]$

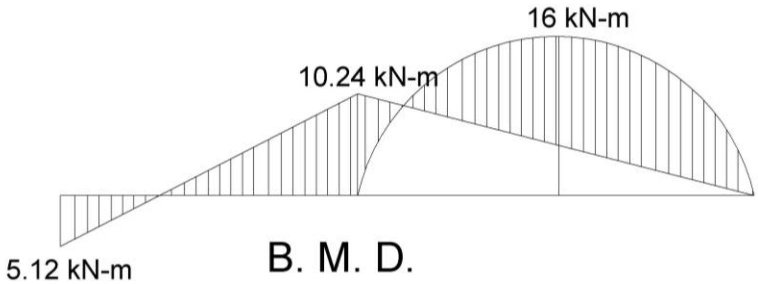
$6M_A + 28M_B = -(256)$ — 01 M

$-3M_B + 28M_B = -256$

$M_B = -256 / 25$

$= -10.24$ kN-m

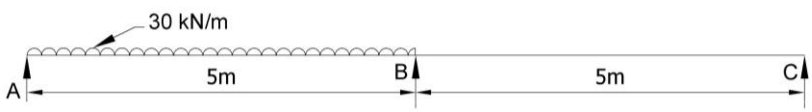
$M_A = -(-10.24/2) = 5.12$ kN-m.



01 Mark

Q.4 d) A continuous beam ABC is simply supported at A, B and C. Span AB and span BC are of length 5 m. AB carries a udl of 30 kN/m over entire span. Calculate support moments by using moment distribution method.

Ans



$M_{AB} = -30 \times 5^2/12 = -62.5$ kN-m $M_{BA} = 30 \times 5^2/12 = 62.5$ kN-m — 01 M

$M_{BC} = M_{BC} = 0$

Joint	Member	Stiffness (k)	Σk	D.F. = k/Σk
B	BA	3 x EI/5 = 0.6EI	1.2EI	0.6EI/1.2EI = 0.5
	BC	3 x EI/5 = 0.6EI		0.6EI/1.2EI = 0.5

01 M

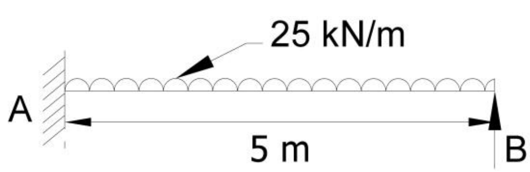
Joint	A	B		C
Members	AB	BA	BC	CB
Dist^n. factor	1.0	0.5	0.5	1.0
F.E.M.	–6 2.5	62.5	0	0
Balancing	62.5	-31.25	-31.25	0
Carry over		31.25		
Balancing		-15.625	-15.625	
Final moments	0.0	46.875	- 46.875	0.0

02 M

$M_A = 0$, $M_B = 46.875$ kN-m (Hogging) $M_C = 0$

Q.4 e) Using moment distribution method, determine the moment at fixed end of propped cantilever of span 5 m carrying udl 25 kN/m over entire span.

Ans



$M_{AB} = -25 \times 5^2/12 = -52.083$ kN-m $M_{BA} = 25 \times 5^2/12 = 52.083$ kN-m — 01 M

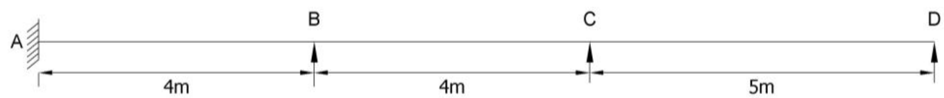
Joint	A	B

Members	AB	BA
Dist^n. factor	1.0	1.0
F.E.M.	– 52.083	52.083
Balancing Carry over	 – 26.0417	– 52.083
Final moments	– 78.125	0.0

03 M

M_A = 78.125 kN-m (Hogging)

Q.4 f) Determine distribution factors at continuity for a continuous beam ABCD which is fixed at A and supported at B, C and D. Take AB = BC =4 m and CD = 5 m. Assume same M.I. for all spans.



Ans

Joint	Member	Stiffness (k)	Σk	D.F. = k/Σk
B	BA	4 x EI/4 = EI	2EI	EI/2EI = 0.5
	BC	4 x EI/4 = EI		EI/2EI = 0.5
C	CB	4 x EI/4 =EI	1.6EI	EI/1.6EI = 0.625
	CD	3EI/5 =0.6EI		0.6EI/1.6EI = 0.375

01 M for each factor

Q.5 Attempt any TWO of the following. (16)

a) A masonry chimney of uniform hollow rectangular section has size 2 m x 1.4 m and has thickness 0.3 m. It is subjected to horizontal wind pressure of 1.5 KPa. Find maximum height of chimney if max. compressive stress at the base is limited to 280 kN/m^2. Also sate nature of minimum stress. Take density of masonry = 22 kN/m^3.

Ans Data: External dimensions = 2.0 m x 1.4 m

Internal dimensions = 1.4 m x 0.8 m

Horizontal wind pressure (p) = 1.5 kN/m^2

Unit weight of material (σ) = 22 kN/m^3

$б_d$ = σh = 22 x h = 22h kN/m^2 — 01 M

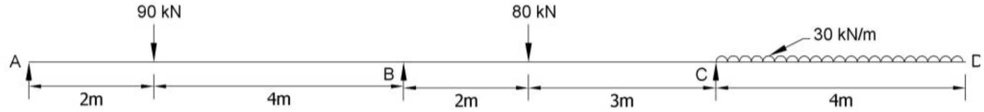
Case 01:- Longer face subjected to wind pressure:	Case 02:- Shorter face subjected to wind pressure:
Horizontal wind force (P) = p x h x B = 1.5 x h x 2 = 3h Moment about base (M) = P x h/2 = 3h x h/2 = 1.5h^2 I = [(2 x 1.4^3) - (1.4 x 0.8^3)]/12 = 0.3976 m^4 y_{max} = 0.7 $б_b$ = M x y_{max}/I = 1.5h^2 x 0.7 / 0.3976 = 2.64h^2	Horizontal wind force (P) = p x h x B = 1.5 x h x 1.4 = 2.1h Moment about base (M) = P x h/2 = 2.1h x h/2 = 1.05h^2 I = [(1.4 x 2.0^3) - (0.8 x 1.4^3)]/12 = 0.7504 m^4 y_{max} = 1.0 $б_b$ = M x y_{max}/I = 1.05h^2 x 1.0 / 0.7504 = 1.4h^2

01 M
01 M
01 M
01 M

		$б_{max} = б_d + б_b$ $280 = 22h + 2.64h^2$ h = 6.943 m. $б_d$ = 22 x 6.943 = 152.746 kN/m^2 $б_b$ = 2.64 x 6.943^2 = 127.26 kN/m^2 $б_{min}$ = 152.746 – 127.26 = 25.48 kN/m^2 (Compressive)	$б_{max} = б_d + б_b$ $280 = 22h + 1.4h^2$ h = 8.32 m. $б_d$ = 22 x 8.32 = 183.04 kN/m^2 $б_b$ = 1.4 x 8.32^2 = 96.91 kN/m^2 $б_{min}$ = 183.04 – 96.91 = 86.13 kN/m^2 kN/m^2 (Compressive)	01 M 01 M 01 M

Q.5 b) A continuous beam ABCD is 15 m long rests on supports A, B and C all at same level. AB = 6 m, BC = 5 m, CD = 4 m. It carries two concentrated loads 90 kN and 80 kN at 2 m and 8 m from A respectively and a udl of 30 kN/m over CD. Find support moment by using moment distribution method and draw BMD.

Ans



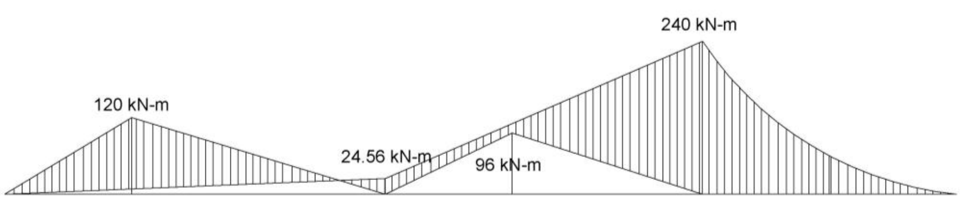
$M_{AB} = -90 \times 2 \times 4^2/6^2 = -80.0$ kN-m $M_{BA} = 90 \times 4 \times 2^2/6^2 = 40.0$ kN-m   02 M
$M_{BC} = -80 \times 2 \times 3^2/5^2 = -57.6$ kN-m $M_{BC} = 80 \times 2^2 \times 3/5^2 = 38.4$ kN-m
MCD = $-30 \times 4^2/2 = -240.0$ kN-m

Joint	Member	Stiffness (k)	Σk	D.F. = k/Σk
B	BA	3 x EI/6 = 0.5EI	1.1EI	0.5EI/1.1EI = 0.45
	BC	3 x EI/5 =0.6EI		0.6EI/1.1EI = 0.5

02 M

Joint	A	B		C	
Members	AB	BA	BC	CB	CD
Dist^n. factor	1.0	0.45	0.55	1.0	0.0
F.E.M.	– 80.0	40.0	– 57.6	38.4	– 240.0
Balancing Carry over	80.0	7.92 40.0	9.68 100.8	201.6	0.0
Balancing		–63.36	–77.44		
Final moments	0.0	24.56	– 24.56	240.0	–240.0

02 M

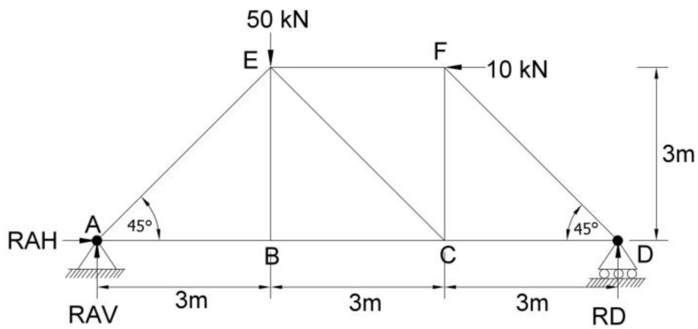


B. M. D.

02 M

Q.5 c) Using method of section find forces in members BC, BE and EF and EC for truss shown in Fig.State nature of forces tabulate results.

Ans



Reactions:

$\Sigma M_A = 0 = 50 \times 3 - 10 \times 3 - R_D \times 9$

$R_D = 13.33$ kN

$R_{AV} = 50 - 13.33 = 36.67$ kN

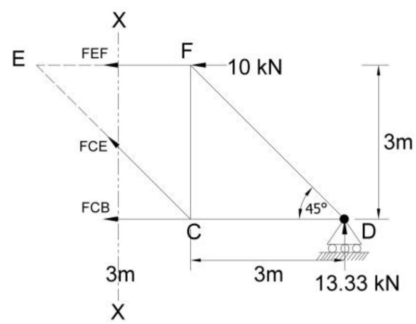
$\Sigma F_V = 0$ — 01 M

$R_{AH} - 10 = 0$

$R_{AH} = 10$ kN

Taking section along EF, EC and BC

Assuming all forces Tensile



01 M

Taking moment @ C;

$- 13.33 \times 3 - 10 \times 10 - F_{EF} \times 3 = 0$

$F_{EF} = -23.33$ i.e. 23.33 kN (Compressive)

Taking moment @ E; — 02 M

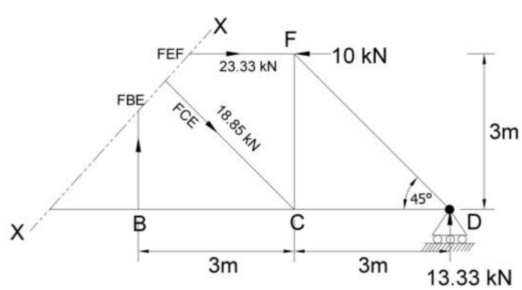
$F_{CB} \times 3 - 13.33 \times 6 = 0$

$F_{CB} = 26.67$ kN (Tensile)

$\Sigma F_V = 0 = 13.33 + F_{CE} \sin 45$

$F_{CE} = - 18.85$ i.e. 18.85 kN (Compressive)

Taking section along EF, EC, EB and BA



01 M

$\Sigma F_V = 0 = 13.33 - 18.85 \sin 45 + F_{BE}$ — 01 M

$F_{BE} = 0$

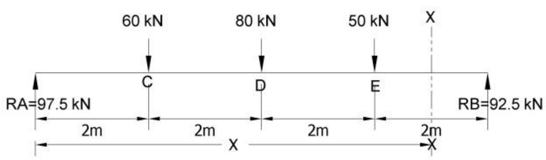
Member	Force	Nature
BC	26.67 kN	Tensile

BE	0	--	
EF	23.33 kN	Compressive	
EC	18.85 kN	Compressive	02 M

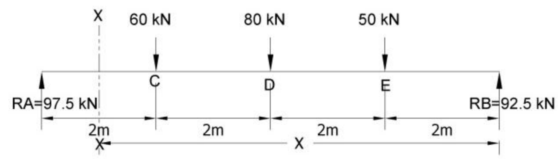
Q.6 Attempt any TWO of the following: **(16)**

Q.6 a) A simply supported beam of span 8 m is subjected to point loads of 60 kN, 80 kN and 50 kN at 2 m, 4 m and 6 m from left support respectively. Determine slope at left support and deflection under 60 kN and 80 kN loads. $EI = 2.668 \times 10^9$ kNm^2.

Ans



OR



Reactions:

$\Sigma M_A = 0$

$60 \times 2 + 80 \times 4 + 50 \times 6 - R_B \times 8 = 0$

$R_B = (120 + 320 + 300) / 8$ — 01 M

$= 92.5$ kN.

$R_A = 60 + 80 + 50 - 92.5 = 97.5$ kN.

Taking section X-X at distance 'X' from A

$M_x = 97.5 \times X - 60 \times (X-2) - 80 \times (X-4) - 50 \times (X-6)$ — 01 M

$EId^2y/dx^2 = -Mx$

$= -97.5 \times X + 60 \times (X-2) + 80 \times (X-4) + 50 \times (X-6)$

Integrating

$EIdy/dx = -97.5 \times X^2/2 + 60 \times (X-2)^2/2 + 80 \times (X-4)^2/2 + 50 \times (X-6)^2/2 + C_1$ — 01 M

Integrating

$EIy = -97.5 \times X^3/6 + 60 \times (X-2)^3/6 + 80 \times (X-4)^3/6 + 50 \times (X-6)^3/6 + C_1 \times X + C_2$ — 01 M

At X = 0; y = 0 in EIy eq^n.

$0 = 0 + C_2$

$C_2 = 0$

At X = 8; y = 0 in EIy eq^n.

$0 = -97.5 \times 8^3/6 + 60 \times (8-2)^3/6 + 80 \times (8-4)^3/6 + 50 \times (8-6)^3/6 + C_1 \times 8 + 0$

$C_1 = 655$ — 01 M

Hence $C_1 = 655$ and $C_2 = 0$

Slope equation-

$dy/dx = (1/EI)[-97.5 \times X^2/2 + 60 \times (X-2)^2/2 + 80 \times (X-4)^2/2 + 50 \times (X-6)^2/2 + 655]$ -----(01)

Deflection equation- — 01 M

$y = (1/EI)[-97.5 \times X^3/6 + 60 \times (X-2)^3/6 + 80 \times (X-4)^3/6 + 50 \times (X-6)^3/6 + 655 \times X]$ -------(02)

For slope at support A

Put X = 0 in eq^n.01

Taking section X-X at distance 'X' from B

$M_x = 92.5 \times X - 50 \times (X-2) - 80 \times (X-4) - 60 \times (X-6)$

$EId^2y/dx^2 = -Mx$

$= -92.5 \times X + 50 \times (X-2) + 80 \times (X-4) + 60 \times (X-6)$

Integrating

$EIdy/dx = -92.5 \times X^2/2 + 50 \times (X-2)^2/2 + 80 \times (X-4)^2/2 + 60 \times (X-6)^2/2 + C_1$

Integrating

$EIy = -92.5 \times X^3/6 + 50 \times (X-2)^3/6 + 80 \times (X-4)^3/6 + 60 \times (X-6)^3/6 + C_1 \times X + C_2$

At X = 0; y = 0 in EIy eq^n.

$0 = 0 + C_2$

$C_2 = 0$

At X = 8; y = 0 in EIy eq^n.

$0 = -92.5 \times 8^3/6 + 50 \times (8-2)^3/6 + 80 \times (8-4)^3/6 + 60 \times (8-6)^3/6 + C_1 \times 8 + 0$

$C_1 = 645$

Hence $C_1 = 645$ and $C_2 = 0$

Slope equation-

$dy/dx = (1/EI)[-92.5 \times X^2/2 + 50 \times (X-2)^2/2 + 80 \times (X-4)^2/2 + 60 \times (X-6)^2/2 + 645]$ -----(01)

Deflection equation-

$y = (1/EI)[-92.5 \times X^3/6 + 50 \times (X-2)^3/6 + 80 \times (X-4)^3/6 + 60 \times (X-6)^3/6 + 645 \times X]$ -------(02)

For slope at support A

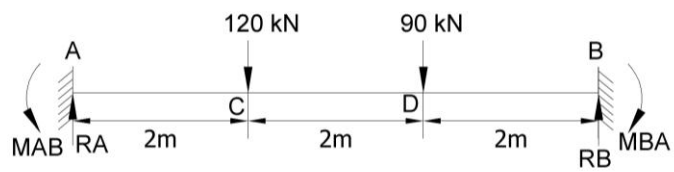
Put X = 8 in eq^n.01

$(dy/dx)_A$ = (1/EI) x (655) = 655 / EI
= 655 / 2.668 x 10^9 = **2.455 x 10^{-7} rad.**
For deflection at B
Put X = 2 in eq^n.02
y_B =(1/EI)[-97.5 x 2^3/6 + 655 x 2]
= 1180 / 2.668 x 10^9 = **4.423 x 10^{-7} m.**
= 4.423 x 10^{-4} mm.
For deflection at C
Put X = 4 in eq^n.02
Y_C =(1/EI)[-97.5 x 4^3/6 + 60 x $(4-2)^3$/6 + 655 x 4]
= 1660 / 2.668 x 10^9 = **6.222 x 10^{-7} m.**
= 6.222 x 10^{-4} mm.

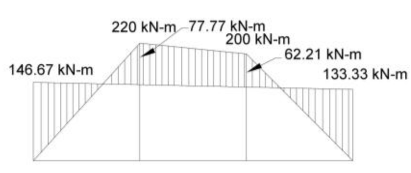
$(dy/dx)_A$ =(1/EI)[-92.5 x 8^2/2 + 50 x $(8-2)^2$/2 + 80 x $(8-4)^2$/2 + 60 x $(8-6)^2$/2 + 645]
= 655 / 2.668 x 10^9 = **2.455 x 10^{-7} rad.** 01 M
For deflection at B
Put X = 6 in eq^n.02
y_B =(1/EI)[-92.5 x 6^3/6 + 50 x $(6-2)^3$/6 + 80 x $(6-4)^3$/6 + 645 x 6]
= 1180 / 2.668 x 10^9 = **4.423 x 10^{-7} m.**
= 4.423 x 10^{-4} mm.
For deflection at C 01 M
Put X = 4 in eq^n.02
Y_C =(1/EI)[-92.5 x 4^3/6 + 50 x $(4-2)^3$/6 + 645 x 4]
= 1660 / 2.668 x 10^9 = **6.222 x 10^{-7} m.**
= 6.222 x 10^{-4} mm.

Q.6 b) A fixed beam AB of span 6 m carries point loads of 120 kN and 90 kN at 2 m and 4 m from left hand support. Find fixed end moments and support reactions. Draw S.F.D and B.M.D.

Ans

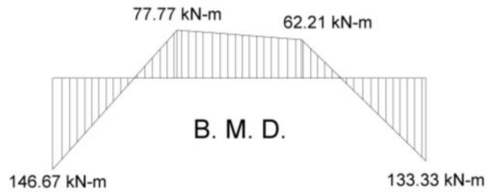


M_{AB} = (120 x 2 x 4^2 / 6^2) + (90 x 4 x 2^2 / 6^2) 01 M
= 146.67 kN-m
M_{BA} = (120 x 2^2 x 4 / 6^2) + (90 x 4^2 x 2/ 6^2) 01 M
= 133.33 kN-m
Reactions:
$\Sigma M_A = 0$
120 x 2 + 90 x 4 + 133.33 – 146.67 – R_B x 6 = 0
R_B = (240 + 360 – 13.33) / 6
= 97.78 kN. 01 M
R_A = 120 + 90 – 97.78 = 112.22 kN.
Bending moment at point load
M_C = – 146.67 + 112.22 x 2
= 77.77 kN-m 02 M
M_D = – 146.67 + 112.22 x 4 – 120 x 2
= 62.21 kN-m
Shear force calculations:
At B = – 97.78 kN
At D, just right = –97.78 kN
At D, just left = –97.78 + 90 = -7.78 kN 01 M
At C, just right = –7.78 kN
At C, just left = –7.78 + 120 = 112.22 kN
At A = 112.22 kN

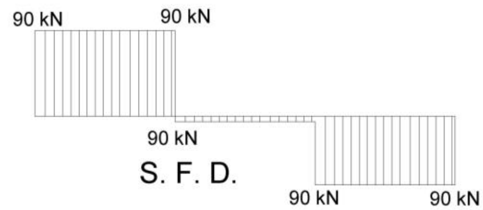


B. M. D.

OR



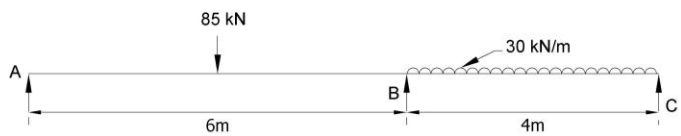
01 M

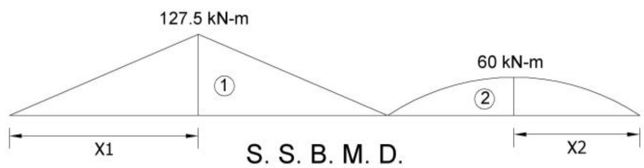


01 M

c) A continuous beam of uniform flexural rigidity is simply supported at A, B, and C. AB = 6 m, BC = 4 m. The beam carries a central point load of 85 kN on span AB and a udl of 30 kN/m over entire span BC. Calculate support moments by using theorem of three moments. Draw S.F.D and B.M.D.

Ans





01 M

M_1 = 85 x 6/4 = 127.5 kN-m a_1 = 0.5 x 6 x 127.5 = 382.5 x_1 = 6/2 = 3.0 m 01 M

M_2 = 30 x 4^2/8 = 60.0 kN-m a_2 = 2 x 4 x 60/3 = 160.0 x_2 = 4/2 = 2.0 m

Using three moment theorem;

M_A x l_1 + 2M_B (l_1 + l_2) + M_C x l_2 = – [(6 x a_1 X x_1/l_1) + 6 x a_2 X x_2/l_2)] 02 M

M_A = M_C = 0 (End simple supports)

2M_B(6 + 4) = – [(6 X 382.5 X 3.0/6) + 6 X 160 X 2.0/4)]

20.0M_B = –1147.5 – 480

M_B = –1627.5/20 = – 81.375 i.e. 81.375 kN-m Hogging

Reactions:

R_A = (85 x 3 – 81.375) / 6 = 28.94 kN. 01 M

R_C = (30 x 4.0 x 2.0 – 81.375) / 4 = 39.66 kN.

R_B = 85 + 30 x 4 – 28.94 – 39.66 = 136.4 kN.

Net bending moments:

Under 85 kN load = 127.5 – (81.375/2) = 86.81 kN-m 01 M

At mid-span of BC = 60 – [(81.375)/2] = 20.31 kN-m.

Shear force calculations:

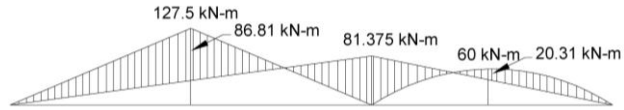
At C = -39.66 kN

At B, right = -39.66 + 30 x 4 = 80.34 kN

At C, left = 80.34 - 136.4 = - 56.06 kN 01 M

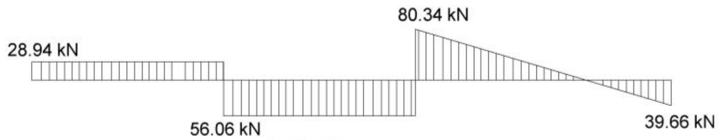
At 85 kN load, right = - 56.06 kN

At 85 kN load, left = - 56.06 + 85 = 28.94 kN
At A, right = 28.94 kN



B. M. D.

01 M



S. F. D.

01 M