Model Answer: Winter-2018

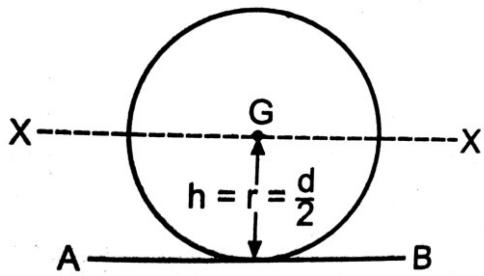
Subject: Mechanics of Structure **Sub. Code: 22303**

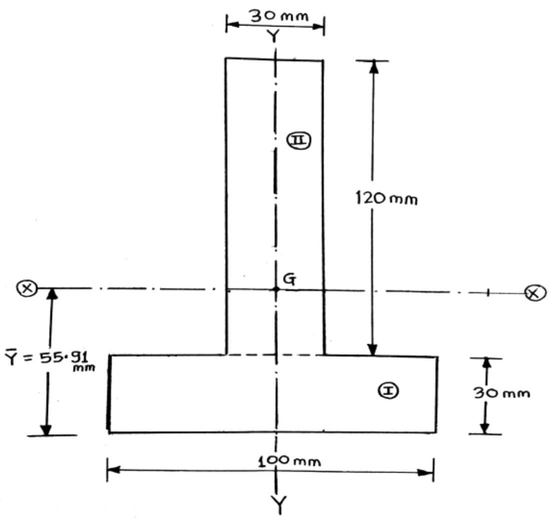
Important Instructions to examiners:

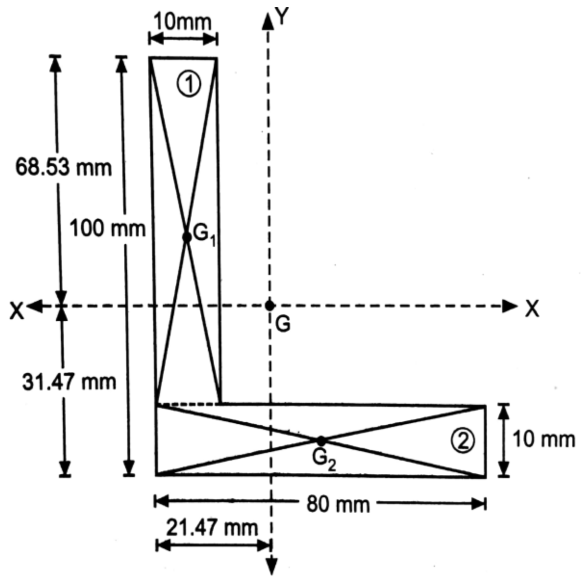
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 the candidate and those in the 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 the model answer.
6) In case of some questions credit may be given by judgment 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.

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1		**Attempt any FIVE of the following :**		(10)
	(a) Ans.	**Giving expression, define shear modulus.** Shear modulus is defined as when a body is loaded within elastic limit the ratio of shear stress to shear strain is constant.	1	
		$Shear\ Modulus\ (G) = \dfrac{Shear\ Stress}{Shear\ Strain}$ (N/mm^2)	1	2
	(b) Ans.	**Define resilience and Proof resilience.** **Resilience:** Resilience is the ability of material to absorb energy when it is deformed elastically and release that energy upon unloading.	1	2
		Proof Resilience: Proof resilience is defined as the maximum energy that can be absorbed within elastic limit without creating permanent deformation.	1	
	(c) Ans.	**Define volumetric strain. Also give the relation between lateral strain to and Poisson's ratio.** **Volumetric strain:** Volumetric strain is defined as the ratio of change in volume to original volume.	1	
		$e_v = \dfrac{\delta v}{V}$ Where: δv = Change in volume, V = Original volume		2
		Relation between lateral strain and linear strain: Lateral Strain = μ×LinerStrain Where, μ is Poission's ratio.	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1	(d)	**For a certain material, the modulus of elasticity is 200 N/mm^2. If Poisson's ratio is 0.35, calculate Bulk modulus.**		
	Ans.	**Data:** E=200 N/mm^2, Poisson's ratio=0.35 $E = 3K(1-2\mu)$	1	2
		$200 = 3K(1-2\times0.35)$ $K = 222.22 N/mm^2$	1	
	(e)	**Determine maximum shear force and maximum bending moment for a cantilever having 4 m span carrying udl of intensity 25 kN/m.**		
	Ans.	i) Maximum Shear Force = $w\times l = 25\times4 = 100kN$	1	2
		ii) Maximum bending Moment = $\frac{wl^2}{2} = \frac{25\times4^2}{2} = 200kN\text{-}m$	1	
	(f)	**Give the expression for maximum bending stress with meaning of each term.**		
	Ans.	Maximum bending stress(σ_b)= $\frac{M}{I}\times Y$	1	2
		Where, M= Maximum Bending Moment (kN.m) or (N.mm) I = Moment of Inertia (mm^4) Y= Distance of neutral axis from top or bottom (mm).	1	
	(g)	**Along with expression, define slenderness ration.**		
	Ans.	**Slenderness Ratio:** Slenderness ratio is defined as the ratio of effective length of column to its minimum radius of gyration.	1	2
		Slenderness Ratio (λ) = $\frac{\text{Effective Length}}{\text{Least radius of Gyration}} = \frac{Le}{K_{min}}$	1	

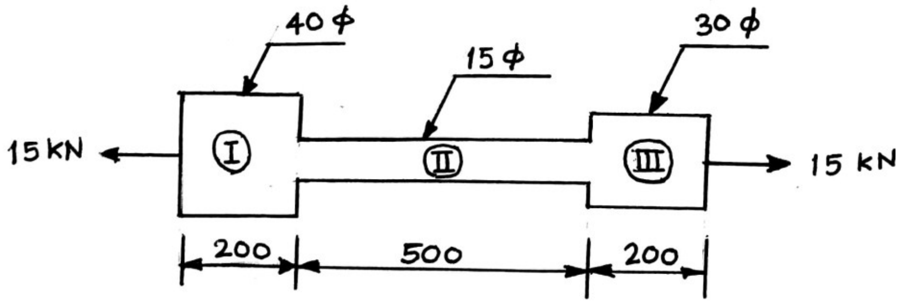
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2		**Attempt any <u>THREE</u> of the following :**		**(12)**
	(a)	**Along with the expression define radius of gyration and sectional modulus.**		
	Ans.	**Radius of gyration (K):** The radius of gyration of a given area about any axis is the distance from the given axis at which the area is assumed to be concentrated without changing the MI about the given axis.	**1**	
		$$K = \sqrt{\frac{I}{A}}$$	**1**	
		Where, I = Moment of Inertia (mm^4) A = Cross Sectional Area (mm^2) K = Radius of Gyration. (mm)		**4**
		Sectional Modulus (Z): It is the ratio of moment of inertia to the distance of extreme fiber from neutral axis.	**1**	
		$$Z = \frac{I}{Y}$$	**1**	
		Where, Z= Section Modulus (mm^3) I = Moment of Inertia (mm^4) Y= Distance of neutral axis from top or bottom (mm)		
	(b)	**For a circular lamina of diameter 100mm, calculate the moment of inertia and radius of gyration about any tangent.**		
	Ans.	**Data:** d = 100mm **Calculate: i) M.I. about tangent:**		
				
		$$I_{AB} = \frac{\pi}{64}d^4 + Ah^2$$	**1**	
		$$I_{AB} = \frac{\pi}{64}(100)^4 + \pi(50)^2 \times (50)^2$$		
		$$I_{AB} = 24543692.61\ mm^4$$	**1**	

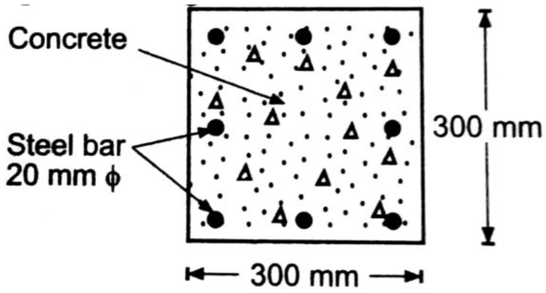
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2	(b)	**ii) Radius of gyration about tangent:** $K_{AB} = \sqrt{\frac{I_{AB}}{A}}$	1	4
		$K_{AB} = \sqrt{\frac{24543692.61}{7853.982}} = \sqrt{3125} = 55.90\text{mm}$	1	
	(c)	**Calculate the moment of inertia for an inverted T- Section about its horizontal centroidal axis. Take the size of flange 100 mm × 30 mm and vertical web 120mm X 30mm, overall depth =150mm**		
	Ans.	Find: I_{xx} =? 		
		$\bar{X} = \frac{\text{Flange Width}}{2} = \frac{100}{2} = 50\text{mm}$ $A_1 = 100 \times 30 = 3000\ \text{mm}^2$ $A_2 = 120 \times 30 = 3600\ \text{mm}^2$ $Y_1 = \frac{30}{2} = 15\text{mm}$ $Y_2 = 30 + \frac{120}{2} = 90\text{mm}$ $\bar{Y} = \frac{A_1Y_1 + A_2Y_2}{A_1 + A_2} = \frac{(3000\times15)+(3600\times90)}{3000+3600} = 55.91\text{mm}$	1	
		To find I_{xx}, $I_{xx} = I_{xx1} + I_{xx2}$ $I_{xx} = (IG + Ah^2)_1 + (IG + Ah^2)_2$		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 2	(c)	*Here*, $h_1 = \bar{Y} - Y_1 = 55.91 - 15 = 40.91mm$ $h_2 = Y_2 - \bar{Y} = 90 - 55.91 = 34.09mm$ $I_{xx} = \left(\frac{100 \times 30^3}{12} + 3000 \times 40.91^2\right)_1 + \left(\frac{30 \times 120^3}{12} + 3600 \times 34.09^2\right)_2$	2	4
		$I_{xx} = (5245884.3)_1 + (8503661.16)_2$ $I_{xx} = 13.75 \times 10^6 mm^4$	1	
	(d) Ans.	**Determine the moment of inertia of an angle section 100 mm× 80mm×10 mm about vertical centroidal axis. Longer leg is vertical.** **Find:** MI about vertical centroidal axis= I_{yy} =?  $A_1 = 10 \times 90 = 900mm^2$ $A_2 = 80 \times 10 = 800 mm^2$ $X_1 = 10/2 = 5mm$ $X_2 = 80/2 = 40mm$		
		$\bar{X} = \frac{A_1 X_1 + A_2 X_2}{A_1 + A_2} = \frac{(900 \times 5) + (800 \times 40)}{900 + 800} = 21.47mm$	1	
		To find $I_{YY} = (I_{YY})_1 + (I_{YY})_2$ $I_{YY} = (IG + Ah^2)_1 + (IG + Ah^2)_2$		

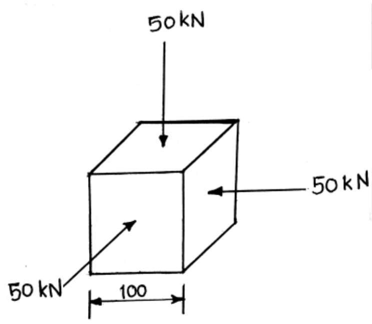
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.2	(d)	*Here*, $h_2 = X_1 - \bar{X} =$ 40 -21.47 = 18.53mm $h_1 = \bar{X} - X_2 =$ 21.47 - 5 = 16.47mm $I_{yy} = \left(\frac{90\times10^3}{12} + 900\times16.47^2\right)_1 + \left(\frac{10\times80^3}{12} + 800\times18.53^2\right)_2$ $I_{yy} = (251634.81)_1 + (701355.39)_2$ $I_{yy} = 9.53\times10^3 mm^4$	2 1	4

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3		**Attempt any <u>THREE</u> of the following :**		(12)
	(a)	**A load of 6 kN is to be raised with the help of steel cable. Determine the minimum diameter of steel cable if stress is not to exceed 110 N/mm^2.**		
	Ans.	Data : P = 6kN $\sigma = 110 N/mm^2$		
		Find: d_{min} =?		
		$\sigma_{max} = \frac{p_{max}}{A_{min}}$	1	
		$A_{min} = \frac{p_{max}}{\sigma_{max}}$		
		$A_{min} = \frac{6 \times 10^3}{110} = 54.54 mm^2$	1	4
		$\frac{\pi}{4} \times d^2{}_{min} = 54.54 mm^2$	1	
		$d^2{}_{min} = 54.54 \times \frac{4}{\pi} = 69.442$	1	
		$d_{min} = 8.33 mm$		
	(b)	**A Steel rod 15 m long is at a temperature of 15^{0}C. Find the free expansion of the length when the temperature is raised to 65^{0}C. Find the temperature stresses when the expansion of the rod is fully prevented.** **Take, α = 12×10^{-6} per ^{0}C. E = 2×10^5 N/mm^2**		
	Ans.	**Data:** $L = 15m \;\; t_1 = 15°C \;\; t_2 = 65°C \;\; \alpha = 12 \times 10^{-6} / °C$ $E = 2 \times 10^5 N/mm^2$		
		Find: $\delta L_t = ? \;\; \sigma_t = ?$		
		t=$t_1 - t_2 = 50°C$		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(b)	$\delta L_t = \alpha \times t \times L$	1	
		$\delta L_t = 12\times10^{-6}\times50\times15\times10^3$		
		$\delta L_t = 9mm$	1	4
		$\sigma_t = \alpha\times t\times E$	1	
		$\sigma_t = 12\times10^{-6}\times(65-15)\times2\times10^5$		
		$\sigma_t = 120N/mm^2$	1	
	(c)	**A Steel bar is 900mm long; its two ends are 40mm and 30mm in diameter and the length of each part of rod is 200mm. The middle portion of the bar is 15 mm in diameter and 500 mm long. If the bar is subjected to an axial tensile load of 15 kN, find its total extension.**		
	Ans.	Assume: $E_{steel} = 2\times10^5\ N/mm^2$ Find: $\delta_L = ?$		
				
		$\delta L = \delta L_1 + \delta L_2 + \delta L_3$		
		$\delta L = \left(\frac{PL}{AE}\right)_1 + \left(\frac{PL}{AE}\right)_2 + \left(\frac{PL}{AE}\right)_3$	1	
		$\delta L = \frac{P}{E}\left(\frac{L_1}{A_1}+\frac{L_2}{A_2}+\frac{L_3}{A_3}\right)$		
		$\delta L = \frac{P}{E\left(\frac{\pi}{4}\right)}\left(\frac{L_1}{d_1^2}+\frac{L_2}{d_2^2}+\frac{L_3}{d_3^2}\right)$	1	4
		$\delta L = \frac{15\times10^3}{2\times10^5\left(\frac{\pi}{4}\right)}\left(\frac{200}{40^2}+\frac{500}{15^2}+\frac{200}{30^2}\right)$	1	
		$\delta L = 0.245$mm	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(d)	**A R.C.C. column is 300 mm X 300 mm in section. It is provided with 8 bars of 20 mm diameter. Determine the stresses induced in concrete and steel bars, if it carries a load of 180 kN. Take $E_{s=}$ 210GPa, E_c= 14 GPa**		
	Ans.	Data: P= 180kN $E_s = 210Gpa = 210\times10^3 N/mm^2$ $E_c = 14GPa = 14\times10^3 N/mm^2$ Find: $\sigma_s = ?$ $\sigma_c = ?$		
				
		$\frac{\sigma_s}{E_s} = \frac{\sigma_c}{E_c}$ $\sigma_s = \frac{E_s}{E_c}\times\sigma_c$ $\sigma_s = \frac{210\times10^3}{14\times10^3}\times\sigma_c$ $\sigma_s = 15\times\sigma_c$	1	
		$P = \sigma_s\times A_s + \sigma_c\times A_c$ $A = 300\times300 = 90000mm^2$ $A_s = \frac{\pi}{4}\times20^2 = 2513.27mm^2$	1	
		$A_c = A - A_s = 87486.73mm^2$ $180\times10^3 = (15\times\sigma_c\times2513.27)+(\sigma_c\times87486.73)$ $180\times10^3 = (37699.05\times\sigma_c)+(\sigma_c\times87486.73)$ $180\times10^3 = (125185.78\times\sigma_c)$		4
		$\sigma_c = \frac{180\times10^3}{125185.78}$ $\sigma_c = 1.437N/mm^2$	1	
		$\sigma_s = 15\times\sigma_c$ $\sigma_s = 15\times1.437$ $\sigma_s = 21.555N/mm^2$	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(a)	**Attempt any <u>THREE</u> of the following :** **For a given material, Young's modulus is 110GN/m^2 and shear modulus is 42 GN/m^2. Find the Bulk modulus and lateral contraction of a round bar of 37.5 mm diameter and 2.4 m length when stretched by 2.5 mm. when subjected to an axial load.**		(12)
	Ans.	Data- E= 110GN/m^2= 110×10^{3}N/mm^2 G= 42GN/m^2= 42×10^{3}N/mm^2 d= 37.5mm, L=2.4m=2400mm, δl=2.5mm Find- K=? , δb=? **To Calculate Possion's ratio (μ):** E= 2G(1+μ) 110 ×10^3= 2 ×42 ×10^3 (1+ μ) μ = 0.309	1	
		To Calculate Bulk Modulus (K): E= 3K(1-2μ) 110×10^3= 3K(1-2×0.309) K=95.986×10^3 N/mm^2	1	4
		To Calculate change in diameter(δd): $\mu = \frac{Lateral\ Strain}{Linear\ Strain} = \left(\frac{e_L}{e}\right) = \frac{(\delta d / d)}{(\delta_L / L)}$	1	
		$0.309 = \frac{(\delta d / 37.5)}{(2.4 / 2400)}$ $\delta d = 0.012 mm$	1	
	(b)	**A cube of 100 mm size is subjected to a direct load of 50kN (compressive) on all its faces. Find the change in volume if K= 1.3GPa and μ=0.30.**		
	Ans.	Given, K= 1.3 GPa =1.3 X 10^3 N/mm^2, μ=0.30 Find- δv=?		



Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(b)	**To find E:** E= 3K(1-2μ) $E = 3\times1.3\times10^3(1-2\times0.30)$ $E = 1.56\times10^3\ N/mm^2$	1	
		To find δv: $\sigma_x = \sigma_y = \sigma_z = -\frac{P_x}{A}$ $\sigma_x = \sigma_y = \sigma_z = -\frac{(50\times10^3)}{100\times100} = -5N/mm^2$	½	
		$e_v = \frac{\sigma_x+\sigma_y+\sigma_z}{E}(1-2\mu)$	½	4
		$e_v = \frac{-5-5-5}{1.56\times10^3}\times(1-2\times0.30)$ $e_v = -3.846\times10^{-3}$ $\frac{\delta_v}{V} = -3.846\times10^{-3}$	1	
		$\delta_v = -3.846\times10^{-3}\times V$ $\delta_v = -3.846\times10^{-3}\times100^3$ $\delta_v = -3846\ mm^3$ $\delta_v = 3846\ mm^3\ (Decrease))$	1	
	(c)	**A beam ABCD is supported at 'A' and 'D'. AB=BC=CD=2m. It is subjected to udl of 10 kN/m over AB and a point load of 20kN at 'C' Draw shear force and bending moment diagrams.**		
	Ans.	**I) Reaction Calculation:** ∑Fy = 0 $R_A + R_D - (10\times2) - 20 = 0$ $R_A + R_D - 40 = 0$ $R_A + R_D = 40$………(i) ∑ MA=0 $(10\times2\times1) + (20\times4) - (R_D\times6) = 0$ $R_D = 16.66kN$ From (i), $R_A + 16.66 = 40$ $R_A = 23.34kN$		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(c)	**II) SF Calculation:**		

SF at $A_L = 0$

A_R= +23.34kN

B_L = +23-(10 × 2) = +3.34 kN

B_R = +3.34 kN

C_L= +3.34 kN

C_R = +3.34-20=-16.66 kN

D_L= -16.66 kN

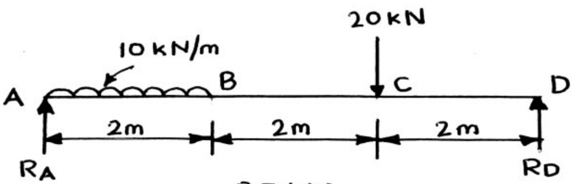
D_R= -16.66+16.66=0 kN **1**

III) BM Calculation:

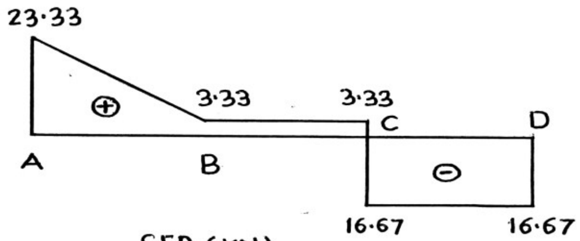
BM at A= 0 and D= 0

B=+(23.34×2)- (10×2×1)=26.68 kN.m **1**

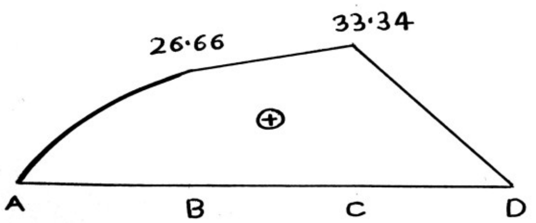
C= +(23.34×2)- (10×2× 3)=33.36 kN.m



BEAM



SFD (KN) **1**

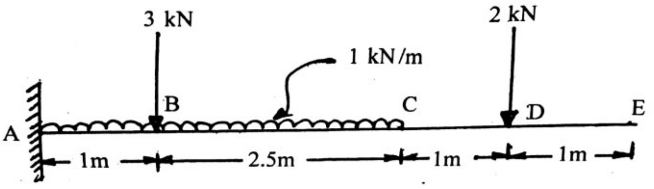
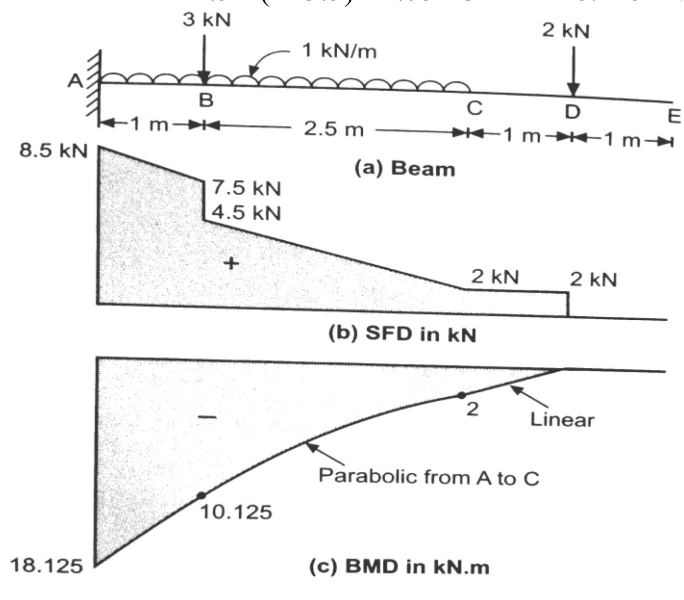


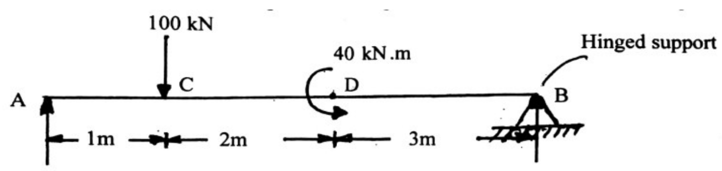
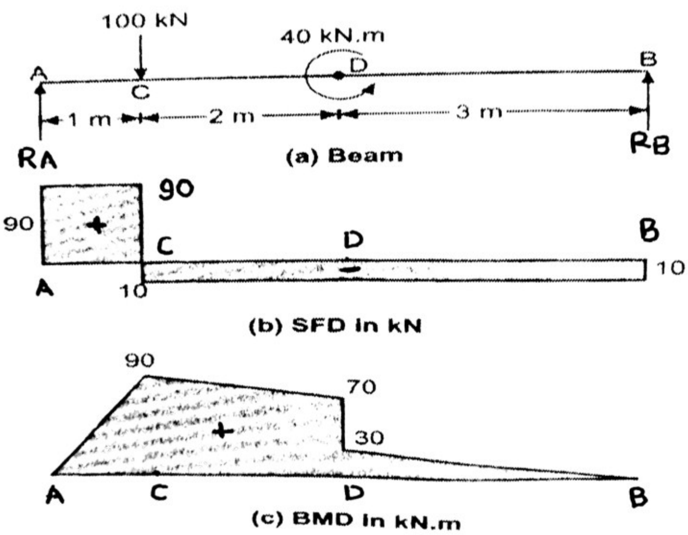
BMD (kN-m) **1**

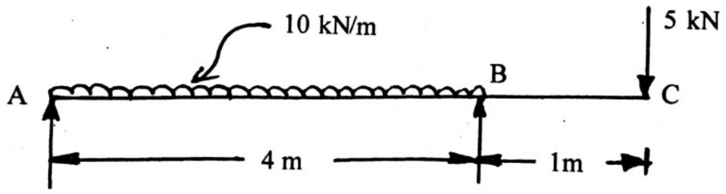
Total Marks: **4**

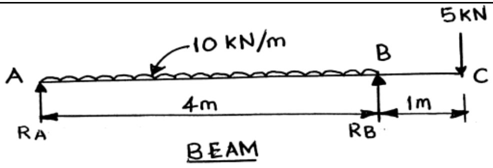
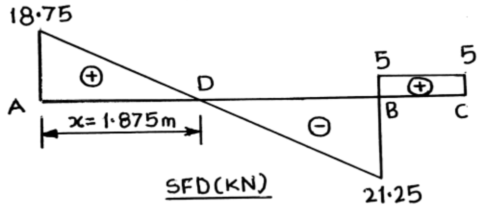
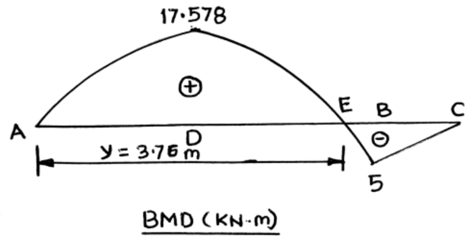
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(d)	**A solid circular column is 4m long with both ends fixed, carries a safe axial load 500kN. Using Euler's equation, calculate the diameter of column. Take E=100kN/m^2 and Factor of safety 2.5.**		
	Ans.	Data: L=4m P_{safe}=500kN E= 100kN/m^2= 100×10^{-3}N/mm^2 F.O.S.=2.5 Find: D		
		$L_e = \frac{L}{2} = \frac{4\times10^3}{2} = 2000\text{mm}$		
		$P_E = P_{safe} \times FOS = 500\times10^3 \times 2.5 = 1.25\times10^6 N$	1	
		$P_E = \frac{\pi^2 E I\min}{(L_e)^2}$	1	
		$1.25\times10^6 = \frac{\pi^2 \times 100\times10^{-3} \times \left(\frac{\pi}{64}\times D^4\right)}{(2000)^2}$	1	4
		$D^4 = 1.03\times10^{14}$		
		$D = 3187.315\text{mm}$	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
Q.4	(e)	**Determine the safe load on column of 6m length, with both ends fixed. The properties of section are:** **A=1777mm^2, I_{xx}= 1.16 × 10^7mm^4, Iyy= 0.84 ×10^6mm^4, σc=320MPa,** $\alpha = \frac{1}{7500}$ **Take, factor of safety =4. Use Rankine's formula.**		
	Ans.	**Data:** L= 6m =6000mm, Both ends are fixed. A= 1777mm^2, I_{xx}= 1.16×10^7mm^4, Iyy= 0.84×10^6mm^4, σc=320MPa, $\alpha = \frac{1}{7500}$, FOS=4		
		Find: P_{safe}=?		
		By using Rankine's Formula,		
		$L_e = \frac{L}{2} = \frac{6\times10^3}{2} = 3000\text{mm}$	½	
		$(\lambda)^2 = \left(\frac{L_e}{K\min}\right)^2 = \left(\frac{L_e}{\left(\sqrt{\frac{\text{Imin}}{\text{A}}}\right)}\right)^2 = \left(\frac{(3000)^2}{\left(\frac{0.84\times10^6}{1777}\right)}\right) = 19039.286$	1	
		$P_R = \frac{\sigma_c A}{1+\alpha\lambda^2}$	1	4
		$P_R = \frac{320\times1777}{1+\frac{1}{7500}\times(19039.286)}$	1	
		$P_R = 160697.618\text{N}$		
		$\text{P}_{safe} = \frac{P_R}{FOS} = \frac{160697.618}{4} = 40174.4\text{N}$		
		$\text{P}_{safe} = 40.174\text{kN}$	½	

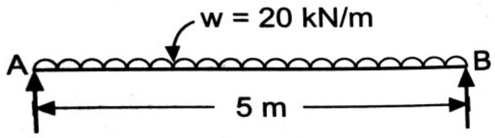
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5		**Attempt any <u>TWO</u> of the following :**		(12)
	(a)	**Draw shear force and bending moment diagrams for the cantilever beam loaded as shown in figure 1. Indicate all important values.**  [Figure 1]		
	Ans.	**I) Reaction Calculation:** $\sum Fy = 0$ $R_A = 3+(1\times3.5)+2 = 8.5kN$ **II) SF Calculation:** SF at A = +8.5kN $B_L = +8.5-1\times1 = +7.5kN$ $B_R = +7.5-3 = 4.5kN$ $C = 4.5 - 1\times2.5 = 2.0kN$ $D_L = +2.0kN$ $D_R = +2 - 2 = 0kN$ E = 0kN (□ ok)	2	
		III) BM Calculation: BM at E = 0kN-m (Eis Free end) E = 0kN-m C = -2×1 =- 2kN-m B = -2×3.5 - (1×2.5) ×1.25 = -10.125kN-m A = -2×4.5 - (1×3.5) ×1.75 - 3×1 = -18.125kN-m	2	6
		 	1 1	

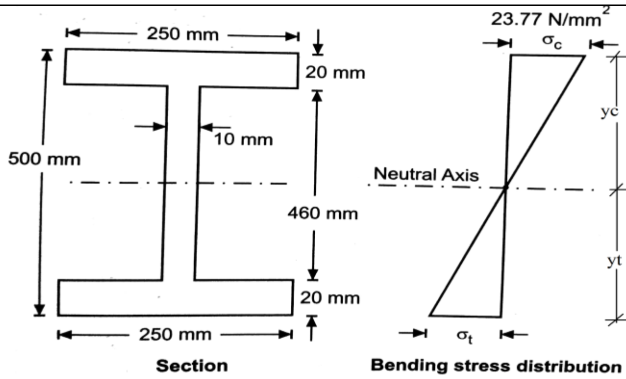
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(b)	**Draw shear force and bending moment diagrams for the beam as shown in fig. 2.**		
		 [Figure 2]		
	Ans.	**I) Reaction Calculation:** $\sum M_A = 0$ $R_B \times 6 + 40 = 100 \times 1$ □ $R_B = 10kN$ $\sum Fy = 0$ $R_A + R_B = 100kN$ $R_A + 10 = 100kN$ □ $R_A = 90kN$	1	
		II) SF Calculation: SF at A = +90kN $C_L = +90kN$ $C_R = +90 - 100 = -10kN$ $B_L = -10kN$ B = -10+10 = 0kN (□ ok)	1	
		III) BM Calculation: BM at A and B = 0 (□ Supports are simple) C = 90×1 = +90kN-m $D_L = +90 \times 3 - 100 \times 2 = +70kN\text{-}m$ $D_R = +10 \times 3 = +30kN\text{-}m$ OR $D_R = +90 \times 3 - 100 \times 2 - 40 = +30kN\text{-}m$	2	6
		 	1 1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(c)	**Draw shear force and bending moment diagram for an overhang beam loaded as shown in fig.3**  [Figure 3]		
	Ans.	**I) Reaction Calculation:** $\sum M_A = 0$ $R_B \times 4 = (10\times4)\times2+5\times5$ □ $R_B = 26.25kN$ $\sum Fy = 0$ $R_A + R_B = 10\times4 + 5kN$ $R_A + 26.25 = 45kN$ □ $R_A = 18.75kN$	1	
		II) SF Calculation: SF at A = +18.75kN B_L = +18.75 - (10×4) = - 21.25kN B_R = - 21.25 +26.25 = +5kN B = +5 - 5 = 0kN (□ ok)	1	
		III) BM Calculation: BM at A = 0 (Support A is simple) C = 0 (Support C is free) B = - 5×1 = -5kN-m	1	6
		IV) Maximum BM Calculation: SF at D = 0 $18.75X - 10X = 0$ □ $X = 1.875$m from support A BM_{max} at D = + 18.75 × 1.875 – 10×1.875×0.9375 BM_{max} = + 17.578kN-m	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(c)			
			1	
			1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6		**Attempt any <u>TWO</u> of the following :**		**(12)**
	(a)	**Attempt the following :**		
	(i)	**Find the bending stress at a distance of 25 mm below top edge of rectangular beam section 80mm x 240 mm deep if maximum bending moment is 5 kN.m.**		
	Ans.	**Data:** : b= 80mm, d= 240 mm B_{max} = 5 kN-m		
		Calculate σ_b at 25 mm from top edge.	½	
		$Y=\frac{D}{2}=\frac{240}{2}-25=95mm$		
		$B_{max}=5\times10^6 N-mm$		
		$I_{NA}=\frac{bd^3}{12}=\frac{80\times120^3}{12}=11520000mm^4$	1	
		$\sigma_b=\frac{M}{I}\times Y$	½	
		$\sigma_b=\frac{5\times10^6}{11520000}\times95$	1	
		$\sigma_b=41.233N/mm^2$		
	(ii)	**A circular beam carries a maximum shear force of 10kN. Find the necessary diameter of the beam if maximum shear stress is limited to 1.5 N/mm^2.**		
	Ans.	Data: S= 10kN, q_{max} = 1.5 N/mm^2		
		Calculate D=?	1	
		$q_{max}=\frac{4}{3}(q_{avg})$		
		$q_{max}=\frac{4}{3}\times\frac{S}{A}$		
		$q_{max}=\frac{4}{3}\times\frac{S}{\frac{\pi d^2}{4}}$	1	
		$1.5=\frac{4}{3}\times\frac{10\times10^3}{\frac{\pi\times d^2}{4}}$		
		$d^2=11317.684$ $d=106.384$ mm	1	6
		OR		

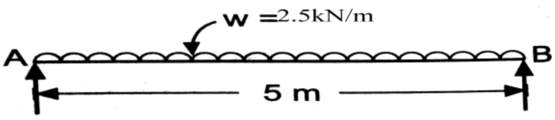
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	ii)	$A=\frac{1}{2}\times\frac{\pi}{4}\times d^2=\frac{\pi}{8}d^2$		
		$\overline{Y}=\frac{4R}{3\pi}=\frac{2d}{3\pi}$	1	
		$b=d$		
		$I=\frac{\pi}{64}d^4$		
		$q_{\max}=\frac{SA\overline{Y}}{bI}$	1	
		$1.5=\frac{10\times10^3\times\frac{\pi}{8}d^2\times\frac{2d}{3\pi}}{d\times\frac{\pi}{64}d^4}$		
		$d^2=11317.684$	1	
		$d=106.384$ mm		
	(b)	**A symmetrical I section 500mm deep is simply supported at ends having span 5 m and udl 20kN/m over entire span. Size of flanges are 250mmX20mm and web 10mm thick. Calculate the magnitude of maximum bending stress induced. Draw stress distribution diagram.**		
	Ans.			
		$M_{\max}=\frac{wL^2}{8}=\frac{20\times5^2}{8}=62.5kNm=62.5\times10^6\,Nmm$	1	
		$I_{XX}=\left(\frac{BD^3-bd^3}{12}\right)=\left(\frac{250\times500^3}{12}-\frac{240\times460^3}{12}\right)=6.57\times10^8\,mm^4$	1 ½	
		$y_c=y_t=\left(\frac{500}{2}\right)=250mm$	½	6
		$\sigma_c=\sigma_c=\left(\frac{M}{I}\right)y_c=\left(\frac{62.5\times10^3}{657446666\ \ .7}\right)\times250=23.77N/mm^2$	2	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	(b)		1	

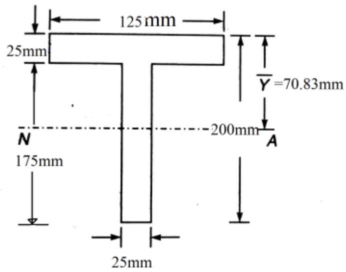
(c) **A simply supported beam carries a udl of intensity 2.5kN/m over entire span of 5m. The cross section of beam is a T-section having the dimensions given below. Flange: 125mm x 25mm, Web; 175mm x 25mm, overall depth=200mm. Calculate the maximum shear stress for the section of the beam. Construct shear distribution diagram.**

Ans.

Data: L=5m, W=2.5kN/m,
Flange: 125mm x 25mm, Web; 175mm x 25mm, overall depth=200mm.



$$S = \frac{wL}{2} = \frac{2.5 \times 5}{2} = 6.25\text{kN-m} = 6.25 \times 10^6 \text{ N-mm}$$ ½

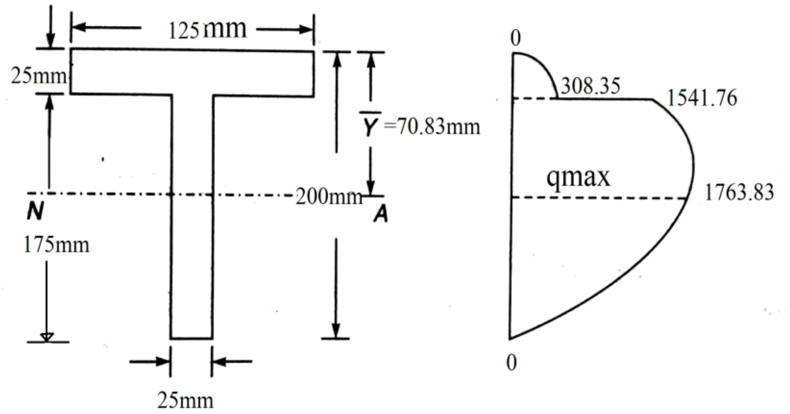


$$\bar{Y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2}$$

$$\bar{Y} = \frac{(125 \times 25) \times 12.5 + (25 \times 175)(25 + \frac{175}{2})}{(125 \times 25) + (25 \times 175)}$$

$$\bar{Y} = \frac{(3125 \times 12.5) + (4375 \times 112.50)}{7500}$$

$$\bar{Y} = 70.83\text{mm from top}$$ ½

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	(c)	$I_{NA} = (I)_{Flange} + (I)_{Web}$ $I_{NA} = (I_G + ah^2)_{Flange} + (I_G + ah^2)_{Web}$ $I_{NA} = \left(\frac{bd^3}{12} + ah^2\right)_{Flange} + \left(\frac{bd^3}{12} + ah^2\right)_{Web}$ $I_{NA} = \left(\frac{125\times25^3}{12} + (125\times25)(70.83 - \frac{25}{2})^2\right) + \left(\frac{25\times175^3}{12} + (25\times175)(25 + \frac{175}{2} - 70.83)^2\right)$ $I_{NA} = (10795225.73) + (18762066.02)$ $I_{NA} = 29557291.75 mm^4$	1	
		$A\bar{Y} = (125\times25)(70.83 - 12.5) + [25\times(70.83-25)]\times\left(\frac{70.83-25}{2}\right)$ $A\bar{Y} = (3125\times58.33) + (1145.75\times22.915)$ $A\bar{Y} = 208536.11 \text{mm}^3$	½	6
		$q = \frac{SA\bar{Y}}{bI}$	½	
		$q_1 = \frac{6.25\times10^6\times3125\times58.33}{125\times29557291.75} = 308.352 \text{ N/mm}^2$	½	
		$q_2 = \frac{6.25\times10^6\times3125\times58.33}{25\times29557291.75} = 1541.762 \text{ N/mm}^2$	½	
		$q_{(\max)} = \frac{6.25\times10^6\times208536.11}{25\times29557291.75} = 1763.83 \text{N/mm}^2$	1	
		 **Fig. Cross Section** **Shear Stress Distribution (N/mm²)**	1	