



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 <u>FIVE</u> 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. $\text{Shear Modulus } (G) = \frac{\text{Shear Stress}}{\text{Shear Strain}} \quad (\text{N/mm}^2)$	1 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. Proof Resilience: Proof resilience is defined as the maximum energy that can be absorbed within elastic limit without creating permanent deformation.	1 1	2
	(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. $e_v = \frac{\delta v}{V} \quad \text{Where: } \delta v = \text{Change in volume, } V = \text{Original volume}$ Relation between lateral strain and linear strain: Lateral Strain = $\mu \times$ Linear Strain Where, μ is Poission's ratio.	1 1	2

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Q.1	(d)	For a certain material, the modulus of elasticity is 200 N/mm². If Poisson's ratio is 0.35, calculate Bulk modulus.		
	Ans.	Data: E=200 N/mm ² , Poisson's ratio=0.35 $E = 3K(1 - 2\mu)$ $200 = 3K(1 - 2 \times 0.35)$ $K = 222.22 \text{ N/mm}^2$	1 1	2
	(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 = $w \times l = 25 \times 4 = 100 \text{ kN}$ ii) Maximum bending Moment = $\frac{wl^2}{2} = \frac{25 \times 4^2}{2} = 200 \text{ kN-m}$	1 1	2
	(f)	Give the expression for maximum bending stress with meaning of each term.		
	Ans.	Maximum bending stress (σ_b) = $\frac{M}{I} \times Y$ 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 1	2
	(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. Slenderness Ratio (λ) = $\frac{\text{Effective Length}}{\text{Least radius of Gyration}} = \frac{L_e}{K_{\min}}$	1 1	2	

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Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2		<p>Attempt any THREE of the following :</p> <p>(a) Along with the expression define radius of gyration and sectional modulus.</p> <p>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.</p> $K = \sqrt{\frac{I}{A}}$ <p>Where, I = Moment of Inertia (mm⁴) A = Cross Sectional Area (mm²) K = Radius of Gyration. (mm)</p> <p>Sectional Modulus (Z): It is the ratio of moment of inertia to the distance of extreme fiber from neutral axis.</p> $Z = \frac{I}{Y}$ <p>Where, Z= Section Modulus (mm³) I = Moment of Inertia (mm⁴) Y= Distance of neutral axis from top or bottom (mm)</p> <p>(b) For a circular lamina of diameter 100mm, calculate the moment of inertia and radius of gyration about any tangent.</p> <p>Ans. Data: d = 100mm Calculate: i) M.I. about tangent:</p> <p>$I_{AB} = \frac{\pi}{64} d^4 + Ah^2$</p> <p>$I_{AB} = \frac{\pi}{64} (100)^4 + \pi(50)^2 \times (50)^2$</p> <p>$I_{AB} = 24543692.61 \text{ mm}^4$</p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p>	<p>(12)</p> <p>4</p>

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Q.2	(b)	<p>ii) Radius of gyration about tangent:</p> $K_{AB} = \sqrt{\frac{I_{AB}}{A}}$ $K_{AB} = \sqrt{\frac{24543692.61}{7853.982}} = \sqrt{3125} = 55.90\text{mm}$	1	4
	(c)	<p>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</p>		
	Ans.	<p>Find: $I_{xx}=?$</p> <p> $\bar{X} = \frac{\text{Flange Width}}{2} = \frac{100}{2} = 50\text{mm}$ $A_1 = 100 \times 30 = 3000 \text{ mm}^2$ $A_2 = 120 \times 30 = 3600 \text{ mm}^2$ $Y_1 = \frac{30}{2} = 15\text{mm}$ $Y_2 = 30 + \frac{120}{2} = 90\text{mm}$ $\bar{Y} = \frac{A_1 Y_1 + A_2 Y_2}{A_1 + A_2} = \frac{(3000 \times 15) + (3600 \times 90)}{3000 + 3600} = 55.91\text{mm}$ </p> <p>To find I_{xx},</p> $I_{xx} = I_{xx1} + I_{xx2}$ $I_{xx} = (IG + Ah^2)_1 + (IG + Ah^2)_2$	1	

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Q. 2	(c)	<p>Here, $h_1 = \bar{Y} - Y_1 = 55.91 - 15 = 40.91\text{mm}$</p> <p>$h_2 = Y_2 - \bar{Y} = 90 - 55.91 = 34.09\text{mm}$</p> $I_{xx} = \left(\frac{100 \times 30^3}{12} + 3000 \times 40.91^2 \right)_1 + \left(\frac{30 \times 120^3}{12} + 3600 \times 34.09^2 \right)_2$ <p>$I_{xx} = (5245884.3)_1 + (8503661.16)_2$</p> <p>$I_{xx} = 13.75 \times 10^6 \text{mm}^4$</p>	2 1	4
	(d)	<p>Determine the moment of inertia of an angle section 100 mm × 80mm × 10 mm about vertical centroidal axis. Longer leg is vertical.</p>		
	Ans.	<p>Find: MI about vertical centroidal axis = $I_{yy} = ?$</p> <p>$A_1 = 10 \times 90 = 900 \text{mm}^2$ $A_2 = 80 \times 10 = 800 \text{mm}^2$</p> <p>$X_1 = 10/2 = 5 \text{mm}$ $X_2 = 80/2 = 40 \text{mm}$</p> $\bar{X} = \frac{A_1 X_1 + A_2 X_2}{A_1 + A_2} = \frac{(900 \times 5) + (800 \times 40)}{900 + 800} = 21.47 \text{mm}$ <p>To find $I_{YY} = (I_{YY})_1 + (I_{YY})_2$</p> <p>$I_{YY} = (IG + Ah^2)_1 + (IG + Ah^2)_2$</p>	1	

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Q.2	(d)	<p>Here, $h_2 = X_1 - \bar{X} = 40 - 21.47 = 18.53\text{mm}$</p> <p>$h_1 = \bar{X} - X_2 = 21.47 - 5 = 16.47\text{mm}$</p> <p>$I_{yy} = \left(\frac{90 \times 10^3}{12} + 900 \times 16.47^2 \right)_1 + \left(\frac{10 \times 80^3}{12} + 800 \times 18.53^2 \right)_2$</p> <p>$I_{yy} = (251634.81)_1 + (701355.39)_2$</p> <p>$I_{yy} = 9.53 \times 10^3 \text{mm}^4$</p>	<p>2</p> <p>1</p>	4

Pinnacle



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Q.3	(a)	<p>Attempt any THREE of the following :</p> <p>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/mm².</p>		(12)
	Ans.	<p>Data : P = 6kN $\sigma = 110N/mm^2$</p> <p>Find: $d_{\min} = ?$</p> $\sigma_{\max} = \frac{P_{\max}}{A_{\min}}$ $A_{\min} = \frac{P_{\max}}{\sigma_{\max}}$ $A_{\min} = \frac{6 \times 10^3}{110} = 54.54mm^2$ $\frac{\pi}{4} \times d_{\min}^2 = 54.54mm^2$ $d_{\min}^2 = 54.54 \times \frac{4}{\pi} = 69.442$ $d_{\min} = 8.33mm$	1	4
	(b)	<p>A Steel rod 15 m long is at a temperature of 15°C. Find the free expansion of the length when the temperature is raised to 65°C. Find the temperature stresses when the expansion of the rod is fully prevented.</p> <p>Take, $\alpha = 12 \times 10^{-6}$ per °C. $E = 2 \times 10^5$ N/mm²</p>		
	Ans.	<p>Data: $L = 15m$ $t_1 = 15^\circ C$ $t_2 = 65^\circ C$ $\alpha = 12 \times 10^{-6} / ^\circ C$</p> $E = 2 \times 10^5 N/mm^2$ <p>Find: $\delta L_t = ?$ $\sigma_t = ?$</p> $t = t_1 - t_2 = 50^\circ C$	1	

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Q.3	(b)	$\delta L_t = \alpha \times t \times L$ $\delta L_t = 12 \times 10^{-6} \times 50 \times 15 \times 10^3$ $\delta L_t = 9 \text{ mm}$ $\sigma_t = \alpha \times t \times E$ $\sigma_t = 12 \times 10^{-6} \times (65 - 15) \times 2 \times 10^5$ $\sigma_t = 120 \text{ N/mm}^2$	1 1 1 1	4
	(c)	<p>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.</p>		
	Ans.	<p>Assume: $E_{\text{steel}} = 2 \times 10^5 \text{ N/mm}^2$ Find: $\delta_L = ?$</p> <p>The diagram shows a composite bar with three sections labeled I, II, and III. Section I has a length of 200 mm and a diameter of 40 mm. Section II has a length of 500 mm and a diameter of 15 mm. Section III has a length of 200 mm and a diameter of 30 mm. Axial loads of 15 kN are applied at both ends of the bar.</p>		
		$\delta L = \delta L_1 + \delta L_2 + \delta L_3$ $\delta L = \left(\frac{PL}{AE} \right)_1 + \left(\frac{PL}{AE} \right)_2 + \left(\frac{PL}{AE} \right)_3$ $\delta L = \frac{P}{E} \left(\frac{L_1}{A_1} + \frac{L_2}{A_2} + \frac{L_3}{A_3} \right)$ $\delta L = \frac{P}{E \left(\frac{\pi}{4} \right)} \left(\frac{L_1}{d_1^2} + \frac{L_2}{d_2^2} + \frac{L_3}{d_3^2} \right)$ $\delta L = \frac{15 \times 10^3}{2 \times 10^5 \left(\frac{\pi}{4} \right)} \left(\frac{200}{40^2} + \frac{500}{15^2} + \frac{200}{30^2} \right)$ $\delta L = 0.245 \text{ mm}$	1 1 1 1	4

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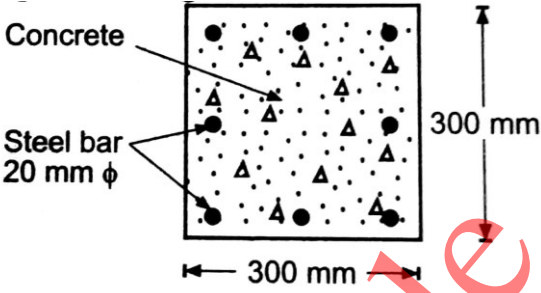
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Q.3	(d)	<p>A R.C.C. column is 300 mm X 300 mm in section. It is provided with 8 bars of 20 mm diameter. Determine the stresses induced in concrete and steel bars, if it carries a load of 180 kN. Take $E_s = 210 \text{ GPa}$, $E_c = 14 \text{ GPa}$</p> <p>Ans.</p> <p>Data: $P = 180 \text{ kN}$ $E_s = 210 \text{ GPa} = 210 \times 10^3 \text{ N/mm}^2$ $E_c = 14 \text{ GPa} = 14 \times 10^3 \text{ N/mm}^2$ Find: $\sigma_s = ?$ $\sigma_c = ?$</p>  <p>$\frac{\sigma_s}{E_s} = \frac{\sigma_c}{E_c}$ $\sigma_s = \frac{E_s}{E_c} \times \sigma_c$</p> <p>$\sigma_s = \frac{210 \times 10^3}{14 \times 10^3} \times \sigma_c$</p> <p>$\sigma_s = 15 \times \sigma_c$</p> <p>$P = \sigma_s \times A_s + \sigma_c \times A_c$</p> <p>$A = 300 \times 300 = 90000 \text{ mm}^2$</p> <p>$A_s = \frac{\pi}{4} \times 20^2 = 2513.27 \text{ mm}^2$</p> <p>$A_c = A - A_s = 87486.73 \text{ mm}^2$</p> <p>$180 \times 10^3 = (15 \times \sigma_c \times 2513.27) + (\sigma_c \times 87486.73)$</p> <p>$180 \times 10^3 = (37699.05 \times \sigma_c) + (\sigma_c \times 87486.73)$</p> <p>$180 \times 10^3 = (125185.78 \times \sigma_c)$</p> <p>$\sigma_c = \frac{180 \times 10^3}{125185.78}$ $\sigma_c = 1.437 \text{ N/mm}^2$</p> <p>$\sigma_s = 15 \times \sigma_c$</p> <p>$\sigma_s = 15 \times 1.437$</p> <p>$\sigma_s = 21.555 \text{ N/mm}^2$</p>	<p>1</p> <p>1</p> <p>1</p> <p>1</p>	<p>4</p>

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Q.4	(a)	<p>Attempt any THREE of the following :</p> <p>For a given material, Young's modulus is 110GN/m^2 and shear modulus is 42GN/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.</p>		(12)
	Ans.	<p>Data- $E=110\text{GN/m}^2=110\times 10^3\text{N/mm}^2$ $G=42\text{GN/m}^2=42\times 10^3\text{N/mm}^2$ $d=37.5\text{mm}$, $L=2.4\text{m}=2400\text{mm}$, $\delta l=2.5\text{mm}$ Find- $K=?$, $\delta b=?$</p> <p>To Calculate Poisson's ratio (μ): $E=2G(1+\mu)$ $110\times 10^3=2\times 42\times 10^3(1+\mu)$ $\mu=0.309$</p> <p>To Calculate Bulk Modulus (K): $E=3K(1-2\mu)$ $110\times 10^3=3K(1-2\times 0.309)$ $K=95.986\times 10^3\text{N/mm}^2$</p> <p>To Calculate change in diameter(δd): $\mu = \frac{\text{Lateral Strain}}{\text{Linear Strain}} = \left(\frac{e_L}{e}\right) = \left(\frac{\delta d/d}{(\delta_L/L)}\right)$ $0.309 = \frac{(\delta d/37.5)}{(2.4/2400)}$ $\delta d = 0.012\text{mm}$</p>	1	
	(b)	<p>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 $K=1.3\text{GPa}$ and $\mu=0.30$.</p>		
	Ans.	<p>Given, $K=1.3\text{GPa}=1.3\times 10^3\text{N/mm}^2$, $\mu=0.30$ Find- $\delta v=?$</p> <div style="text-align: center;"> </div>		

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Q.4	(b)	<p>To find E: $E = 3K(1-2\mu)$ $E = 3 \times 1.3 \times 10^3 (1-2 \times 0.30)$ $E = 1.56 \times 10^3 \text{ N/mm}^2$</p> <p>To find δ_v: $\sigma_x = \sigma_y = \sigma_z = -\frac{P_x}{A}$ $\sigma_x = \sigma_y = \sigma_z = -\frac{(50 \times 10^3)}{100 \times 100} = -5 \text{ N/mm}^2$ $e_v = \frac{\sigma_x + \sigma_y + \sigma_z}{E} (1-2\mu)$ $e_v = \frac{-5-5-5}{1.56 \times 10^3} \times (1-2 \times 0.30)$ $e_v = -3.846 \times 10^{-3}$ $\frac{\delta_v}{V} = -3.846 \times 10^{-3}$ $\delta_v = -3.846 \times 10^{-3} \times V$ $\delta_v = -3.846 \times 10^{-3} \times 100^3$ $\delta_v = -3846 \text{ mm}^3$ $\delta_v = 3846 \text{ mm}^3 \text{ (Decrease)}$</p>	<p>1</p> <p>1/2</p> <p>1/2</p> <p>1</p> <p>1</p>	4
	(c)	<p>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.</p>		
	Ans.	<p>I) Reaction Calculation: $\sum F_y = 0$ $R_A + R_D - (10 \times 2) - 20 = 0$ $R_A + R_D - 40 = 0$ $R_A + R_D = 40 \dots \dots \dots (i)$ $\sum M_A = 0$ $(10 \times 2 \times 1) + (20 \times 4) - (R_D \times 6) = 0$ $R_D = 16.66 \text{ kN}$ From (i), $R_A + 16.66 = 40$ $R_A = 23.34 \text{ kN}$</p>		

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Q.4	(c)	<p>II) SF Calculation: SF at $A_L = 0$ $A_R = +23.34 \text{ kN}$ $B_L = +23 - (10 \times 2) = +3.34 \text{ kN}$ $B_R = +3.34 \text{ kN}$ $C_L = +3.34 \text{ kN}$ $C_R = +3.34 - 20 = -16.66 \text{ kN}$ $D_L = -16.66 \text{ kN}$ $D_R = -16.66 + 16.66 = 0 \text{ kN}$</p> <p>III) BM Calculation: BM at $A = 0$ and $D = 0$ $B = +(23.34 \times 2) - (10 \times 2 \times 1) = 26.68 \text{ kN.m}$ $C = +(23.34 \times 2) - (10 \times 2 \times 3) = 33.36 \text{ kN.m}$</p>	1	
			1	
			1	
			4	

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Q.4	(d)	<p>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 $E=100\text{kN/m}^2$ and Factor of safety 2.5.</p>		
	Ans.	<p>Data: $L=4\text{m}$ $P_{\text{safe}}=500\text{kN}$ $E=100\text{kN/m}^2=100\times 10^{-3}\text{N/mm}^2$ F.O.S.=2.5 Find: D</p> $L_e = \frac{L}{2} = \frac{4 \times 10^3}{2} = 2000\text{mm}$ $P_E = P_{\text{safe}} \times \text{FOS} = 500 \times 10^3 \times 2.5 = 1.25 \times 10^6\text{N}$ $P_E = \frac{\pi^2 E I_{\text{min}}}{(L_e)^2}$ $1.25 \times 10^6 = \frac{\pi^2 \times 100 \times 10^{-3} \times \left(\frac{\pi}{64} \times D^4\right)}{(2000)^2}$ $D^4 = 1.03 \times 10^{14}$ $D = 3187.315\text{mm}$	1 1 1 1	4

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Q.4	(e)	<p>Determine the safe load on column of 6m length, with both ends fixed. The properties of section are: $A=1777\text{mm}^2$, $I_{xx}= 1.16 \times 10^7\text{mm}^4$, $I_{yy}= 0.84 \times 10^6\text{mm}^4$, $\sigma_c=320\text{MPa}$, $\alpha = \frac{1}{7500}$ Take, factor of safety =4. Use Rankine's formula.</p> <p>Ans. Data: $L= 6\text{m}=6000\text{mm}$, Both ends are fixed. $A= 1777\text{mm}^2$, $I_{xx}= 1.16 \times 10^7\text{mm}^4$, $I_{yy}= 0.84 \times 10^6\text{mm}^4$, $\sigma_c=320\text{MPa}$, $\alpha = \frac{1}{7500}$, $\text{FOS}=4$</p> <p>Find: $P_{\text{safe}}=?$ By using Rankine's Formula,</p> $L_e = \frac{L}{2} = \frac{6 \times 10^3}{2} = 3000\text{mm}$ $(\lambda)^2 = \left(\frac{L_e}{K_{\min}} \right)^2 = \left(\frac{L_e}{\left(\sqrt{\frac{I_{\min}}{A}} \right)} \right)^2 = \left(\frac{(3000)^2}{\left(\frac{0.84 \times 10^6}{1777} \right)} \right) = 19039.286$ $P_R = \frac{\sigma_c A}{1 + \alpha \lambda^2}$ $P_R = \frac{320 \times 1777}{1 + \frac{1}{7500} \times (19039.286)}$ $P_R = 160697.618\text{N}$ $P_{\text{safe}} = \frac{P_R}{\text{FOS}} = \frac{160697.618}{4} = 40174.4\text{N}$ $P_{\text{safe}} = 40.174\text{kN}$	<p>1/2</p> <p>1</p> <p>1</p> <p>1</p> <p>1/2</p>	4

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Q.5	(a)	<p>Attempt any <u>TWO</u> of the following :</p> <p>Draw shear force and bending moment diagrams for the cantilever beam loaded as shown in figure 1. Indicate all important values.</p> <p>[Figure 1]</p>		(12)
	Ans.	<p>I) Reaction Calculation: $\sum F_y = 0$ $R_A = 3 + (1 \times 3.5) + 2 = 8.5 \text{ kN}$</p> <p>II) SF Calculation: SF at A = +8.5 kN $B_L = +8.5 - 1 \times 1 = +7.5 \text{ kN}$ $B_R = +7.5 - 3 = 4.5 \text{ kN}$ $C = 4.5 - 1 \times 2.5 = 2.0 \text{ kN}$ $D_L = +2.0 \text{ kN}$ $D_R = +2 - 2 = 0 \text{ kN}$ $E = 0 \text{ kN}$ (□ ok)</p> <p>III) BM Calculation: BM at E = 0 kN-m (E is Free end) $E = 0 \text{ kN-m}$ $C = -2 \times 1 = -2 \text{ kN-m}$ $B = -2 \times 3.5 - (1 \times 2.5) \times 1.25 = -10.125 \text{ kN-m}$ $A = -2 \times 4.5 - (1 \times 3.5) \times 1.75 - 3 \times 1 = -18.125 \text{ kN-m}$</p>	2	6
			2	
			1	
			1	

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

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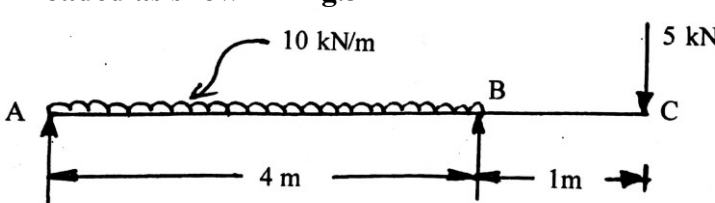
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Q.5	(c)	<p>Draw shear force and bending moment diagram for an overhang beam loaded as shown in fig.3</p>  <p>[Figure 3]</p>		
	Ans.	<p>I) Reaction Calculation:</p> $\sum M_A = 0$ $R_B \times 4 = (10 \times 4) \times 2 + 5 \times 5 \quad \square R_B = 26.25 \text{ kN}$ $\sum F_y = 0$ $R_A + R_B = 10 \times 4 + 5 \text{ kN}$ $R_A + 26.25 = 45 \text{ kN} \quad \square R_A = 18.75 \text{ kN}$ <p>II) SF Calculation:</p> <p>SF at A = +18.75 kN</p> $B_L = +18.75 - (10 \times 4) = -21.25 \text{ kN}$ $B_R = -21.25 + 26.25 = +5 \text{ kN}$ $C = +5 - 5 = 0 \text{ kN} \quad (\square \text{ ok})$ <p>III) BM Calculation:</p> <p>BM at A = 0 (Support A is simple)</p> <p>C = 0 (Support C is free)</p> $B = -5 \times 1 = -5 \text{ kN-m}$ <p>IV) Maximum BM Calculation:</p> <p>SF at D = 0</p> $18.75X - 10X = 0 \quad \square X = 1.875 \text{ m from support A}$ $BM_{\max} \text{ at D} = +18.75 \times 1.875 - 10 \times 1.875 \times 0.9375$ $BM_{\max} = +17.578 \text{ kN-m}$	1 1 1 1	6

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Q.5	(c)	<p>The diagram shows a beam ABC. From A to B, there is a uniformly distributed load (UDL) of 10 kN/m over a length of 4 m. At B, there is a reaction force R_B. From B to C, there is a point load of 5 kN at C and a reaction force R_C. The distance BC is 1 m. The beam is supported at A by a reaction force R_A.</p> <p>The Shear Force Diagram (SFD) is shown below the beam. It starts at 18.75 kN at A, decreases linearly to -21.25 kN at B, crossing the zero line at point D where $x = 1.875$ m. From B to C, the shear force is constant at 5 kN.</p> <p>The Bending Moment Diagram (BMD) is shown below the SFD. It starts at 0 at A, increases parabolically to a maximum of 17.578 kN-m at point D, then decreases linearly to -5 kN-m at B. From B to C, the bending moment is constant at -5 kN-m.</p>	1 1	

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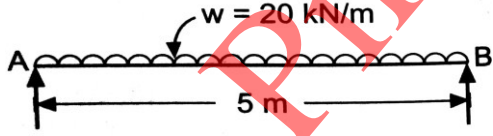
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.6	(a) (i)	<p>Attempt any TWO of the following :</p> <p>Attempt the following :</p> <p>Find the bending stress at a distance of 25 mm below top edge of rectangular beam section 80mm x 240 mm deep if maximum bending moment is 5 kN.m.</p> <p>Ans.</p> <p>Data: : b= 80mm, d= 240 mm $B_{\max} = 5 \text{ kN-m}$</p> <p>Calculate σ_b at 25 mm from top edge.</p> $Y = \frac{D}{2} = \frac{240}{2} - 25 = 95\text{mm}$ $B_{\max} = 5 \times 10^6 \text{ N - mm}$ $I_{NA} = \frac{bd^3}{12} = \frac{80 \times 120^3}{12} = 11520000 \text{ mm}^4$ $\sigma_b = \frac{M}{I} \times Y$ $\sigma_b = \frac{5 \times 10^6}{11520000} \times 95$ $\sigma_b = 41.233 \text{ N / mm}^2$	<p>$\frac{1}{2}$</p> <p>1</p> <p>$\frac{1}{2}$</p> <p>1</p>	(12)
	(ii)	<p>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/mm².</p> <p>Ans.</p> <p>Data: S= 10kN, $q_{\max} = 1.5 \text{ N/mm}^2$</p> <p>Calculate D=?</p> $q_{\max} = \frac{4}{3}(q_{\text{avg}})$ $q_{\max} = \frac{4}{3} \times \frac{S}{A}$ $q_{\max} = \frac{4}{3} \times \frac{S}{\frac{\pi d^2}{4}}$ $1.5 = \frac{4}{3} \times \frac{10 \times 10^3}{\frac{\pi \times d^2}{4}}$ $d^2 = 11317.684$ $d = 106.384 \text{ mm}$	<p>1</p> <p>1</p> <p>1</p>	6

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Q.6	ii)	$A = \frac{1}{2} \times \frac{\pi}{4} \times d^2 = \frac{\pi}{8} d^2$ $\bar{Y} = \frac{4R}{3\pi} = \frac{2d}{3\pi}$ $b = d$ $I = \frac{\pi}{64} d^4$ $q_{\max} = \frac{SA\bar{Y}}{bI}$ $1.5 = \frac{10 \times 10^3 \times \frac{\pi}{8} d^2 \times \frac{2d}{3\pi}}{d \times \frac{\pi}{64} d^4}$ $d^2 = 11317.684$ $d = 106.384 \text{ mm}$	1 1 1	
	(b)	<p>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.</p>		
Ans.		 $M_{\max} = \frac{wL^2}{8} = \frac{20 \times 5^2}{8} = 62.5 \text{ kNm} = 62.5 \times 10^6 \text{ Nmm}$ $I_{xx} = \left(\frac{BD^3 - bd^3}{12} \right) = \left(\frac{250 \times 500^3}{12} - \frac{240 \times 460^3}{12} \right) = 6.57 \times 10^8 \text{ mm}^4$ $y_c = y_t = \left(\frac{500}{2} \right) = 250 \text{ mm}$ $\sigma_c = \sigma_t = \left(\frac{M}{I} \right) y_c = \left(\frac{62.5 \times 10^6}{657446666.7} \right) \times 250 = 23.77 \text{ N/mm}^2$	1 1 ½ ½ 2	6

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Q.6	(b)		1	
	(c)	<p>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.</p>		
	Ans.	<p>Data: L=5m, W=2.5kN/m, Flange: 125mm x 25mm, Web; 175mm x 25mm, overall depth=200mm.</p> $S = \frac{wL}{2} = \frac{2.5 \times 5}{2} = 6.25 \text{ kN-m} = 6.25 \times 10^6 \text{ N-mm}$ $\bar{Y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2}$ $\bar{Y} = \frac{(125 \times 25) \times 12.5 + (25 \times 175) \left(25 + \frac{175}{2}\right)}{(125 \times 25) + (25 \times 175)}$ $\bar{Y} = \frac{(3125 \times 12.5) + (4375 \times 112.50)}{7500}$ <p>$\bar{Y} = 70.83 \text{ mm from top}$</p>	½	
			½	

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Q.6	(c)	$I_{NA} = (I)_{Flange} + (I)_{Web}$ $I_{NA} = (I_G + ah^2)_{Flange} + (I_G + ah^2)_{Web}$ $I_{NA} = \left(\frac{bd^3}{12} + ah^2 \right)_{Flange} + \left(\frac{bd^3}{12} + ah^2 \right)_{Web}$ $I_{NA} = \left(\frac{125 \times 25^3}{12} + (125 \times 25) \left(70.83 - \frac{25}{2} \right)^2 \right) + \left(\frac{25 \times 175^3}{12} + (25 \times 175) \left(25 + \frac{175}{2} - 70.83 \right)^2 \right)$ $I_{NA} = (10795225.73) + (18762066.02)$ $I_{NA} = 29557291.75 \text{ mm}^4$ $\bar{A}\bar{Y} = (125 \times 25)(70.83 - 12.5) + [25 \times (70.83 - 25)] \times \left(\frac{70.83 - 25}{2} \right)$ $\bar{A}\bar{Y} = (3125 \times 58.33) + (1145.75 \times 22.915)$ $\bar{A}\bar{Y} = 208536.11 \text{ mm}^3$ $q = \frac{S\bar{A}\bar{Y}}{bI}$ $q_1 = \frac{6.25 \times 10^6 \times 3125 \times 58.33}{125 \times 29557291.75} = 308.352 \text{ N/mm}^2$ $q_2 = \frac{6.25 \times 10^6 \times 3125 \times 58.33}{25 \times 29557291.75} = 1541.762 \text{ N/mm}^2$ $q_{(\max)} = \frac{6.25 \times 10^6 \times 208536.11}{25 \times 29557291.75} = 1763.83 \text{ N/mm}^2$	<p>1</p> <p>½</p> <p>½</p> <p>½</p> <p>1</p>	6	
		<p>Fig. Cross Section</p>	<p>Shear Stress Distribution (N/mm²)</p>	1	