Model Answer: Summer-2019

Subject: Mechanics of Structures | **Sub. Code: 17311**

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	(A)	**Solve any SIX of the following:**		(12)
	(i)	**Define Moment of Inertia. State the relation between moment of inertia and radius of gyration.**		
	Ans.	**Moment of Inertia:** It is the second moment of area which is equal to product of area of the body and square of the distance of its centroid from that axis, is called as moment of Inertia. **OR** Moment of inertia of a body about any axis is defined as the sum of second moment of all elementary areas about that axis.	1	
		Relation between moment of inertia and radius of gyration: $$K = \sqrt{\frac{I}{A}}$$ Where, I = Moment of Inertia (mm^4) A = Cross Sectional Area (mm^2) K = Radius of Gyration. (mm)	1	2
	(ii)	**State perpendicular axis theorem of M.I.**		
	Ans.	**Perpendicular Axis Theorem:** It states that, if I_{XX} and I_{YY} are the moments of inertia of a plane section about the two mutually perpendicular axes meeting at O, then the moment of inertia I_{ZZ} about the third axis ZZ perpendicular to the plane and passing through the intersection of XX and YY is equal to addition of moment of inertia about X-X and Y-Y axes.	2	2

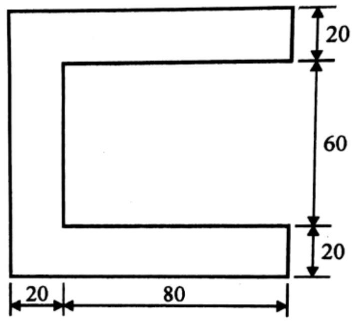
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1	(iii)	**Define strain. State various types of strain.**		
	Ans.	When a body of an elastic material is loaded upon by an axial force it undergoes change in dimensions. The change in dimension per original dimension is called as strain.	1	
		Types of Strain: a) Linear strain or Longitudinal strain. i) Tensile ii) Compression b) Lateral strain. c) Volumetric strain. d) Shear strain.	1	2
	(iv)	**State Hooke's law giving it's expression.**		
	Ans.	**Hook's law.** It states that when a material is loaded within its elastic limit, the stress produced is directly proportional to the strain.	1	
		$\sigma \ \alpha \ e$ $\frac{\sigma}{e} = \text{Constant} = E$	1	2
	(v)	**State the relation between linear strain & lateral strain.**		
	Ans.	**Relation between linear strain and lateral strain.** Lateral strain is directly proportional to linear strain. When a homogeneous material is loaded within its elastic limit, the ratio of lateral strain to linear strain is constant and is known as Poisson's ratio.	2	2
	(vi)	**State any four assumptions made in Euler's theory of long column.**		
	Ans.	a) The compressive load is exactly axial. b) The material of the column is perfectly homogenous and isotropic. c) The column is initially straight and of uniform lateral dimensions. d) The self-weight of column is neglected. e) The column is long and fails due to buckling only.	½ each (any four)	2

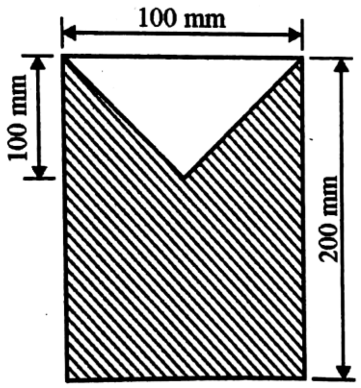
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1		f) Shorting of the column due to direct compression is neglected.		
		g) The stresses do not exceed the limit of proportionality.		
	(vii)	**Differentiate between gradually applied load and suddenly applied load with suitable example.**		
	Ans.	(see table below)	½ each	2
	(viii)	**Define Resilience. State it's SI unit.**		
	Ans.	**Resilience:** When a body is made up of an elastic material is loaded within its elastic limit the energy is stored in the body or material, is called as strain energy or resilience.	1	
		Unit: N-mm, N-m or J	1	2

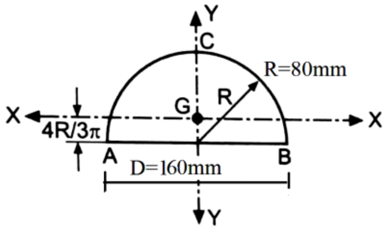
	Gradually Applied Load	Suddenly Applied Load
i.	Load increases gradually from zero to maximum.	Load increases suddenly from zero to maximum.
ii.	The stress developed is exactly half to that of stress due to sudden load for same loading.	The stress developed is double to that of stress due to gradual load for same loading.
iii.	The stress due to gradual load is, $\sigma = \frac{P}{A}$	The stress due to sudde applied load is, $\sigma = \frac{2P}{A}$
iv.	e.g. Tension test on steel bar using UTM. e.g. Compression test on concrete cube using CTM.	e.g. Measurement of self weight by using weighing machine. e.g. Loading container on truck with the help of crane.

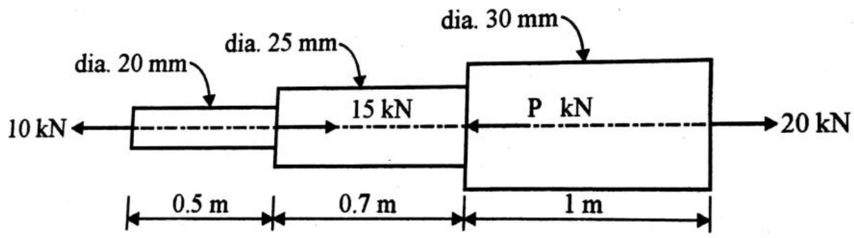
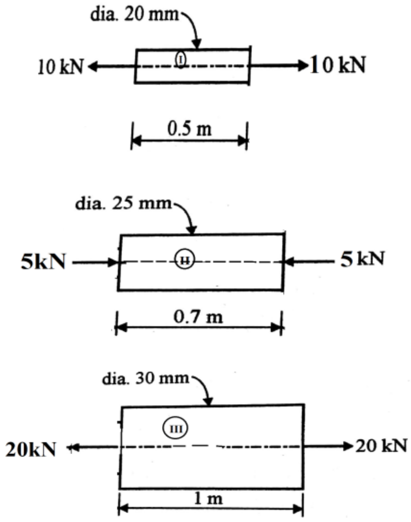
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 1	(B)	**Attempt any TWO of the following:**		(08)
	(i)	A steel rod of 20mm diameter is to bent into a circular arc of radius of 10m. Find the necessary bending moment required. Take E= $2\times10^5 N/mm^2$.		
	Ans.	**Data:** d=20mmØ, R=10m, E= $2\times10^5 N/mm^2$		
		Find: σ_b		
		$I=\frac{\pi d^4}{64}=\frac{\pi\times20^4}{64}=7854mm^4$	1	
		$\frac{M}{I}=\frac{E}{R}$	1	
		$M=\frac{E}{R}\times I$		
		$M=\frac{2\times10^5}{10\times10^3}\times7854$	1	
		M=1570790.63N-mm	1	4
		M=1.571kN-m		
	(ii)	A 12mm diameter pin is in double shear, carries a force of 12kN. Determine the shear stress induced in the pin.		
	Ans.	**Data:** d=12mmØ, P=12kN		
		Calculate: q		
		$q=\frac{P}{2A}$	1	
		$A=\frac{\pi d^2}{4}=\frac{\pi\times12^2}{4}=113.097mm^2$	1	
		$q=\frac{12\times10^3}{2\times113.097}$	1	4
		$q=53.05N/mm^2$	1	

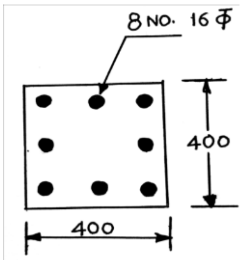
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.1	(iii)	**Calculate slenderness ratio of a rectangular column 300mm × 500mm having length 4m, fixed at both ends.**		
	Ans.	**Data: b = 300mm, d= 500mm, L= 4m** **Calculate: λ**		
		$A = b \times d = 300 \times 500 = 150000 mm^2$		
		$Le = \frac{L}{2} = \frac{4 \times 10^3}{2} = 2000mm$	1	
		$Ixx = \frac{bd^3}{12} = \frac{300 \times 500^3}{12} = 31.25 \times 10^8 mm^4$		
		$Iyy = \frac{b^3 d}{12} = \frac{300^3 \times 500}{12} = 11.25 \times 10^8 mm^4$	1	
		$Kmin = \sqrt{\frac{Imin}{A}} = \sqrt{\frac{11.25 \times 10^8}{150000}} = 86.60mm$	1	
		$\lambda = \frac{Le}{Kmin} = \frac{2000}{86.60} = 23.09$	1	4

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2		**Attempt any TWO of the following:**		(16)
	(a)	**Calculate M.I. about centroidal horizontal and vertical axes for the channel as shown in Fig. No. 1.**  **Fig. No. 1**		
	Ans.	**Distance of X-X axis from bottom:** $\overline{Y}=\frac{20+60+20}{2}=\frac{100}{2}=50mm$	½	
		$a_1=100\times20=2000mm^2 \quad x_1=\frac{20+80}{2}=50mm$ $a_2=60\times20=1200mm^2 \quad x_2=\frac{20}{2}=10mm$ $a_3=100\times20=2000mm^2 \quad x_3=\frac{20+80}{2}=50mm$		
		Distance of YY axis from left face: $\overline{X}=\frac{a_1x_1+a_2x_2+a_3x_3}{a_1+a_2+a_3}$ $\overline{X}=\frac{2000\times50+1200\times10+2000\times50}{5200}=40.77mm$	1 ½	
		$I_{XX}=\left(\frac{BD^3}{12}-\frac{bd^3}{12}\right)=\left(\frac{100\times100^3}{12}-\frac{80\times60^3}{12}\right)=6893333.33=6.89\times10^6mm^4$	2	

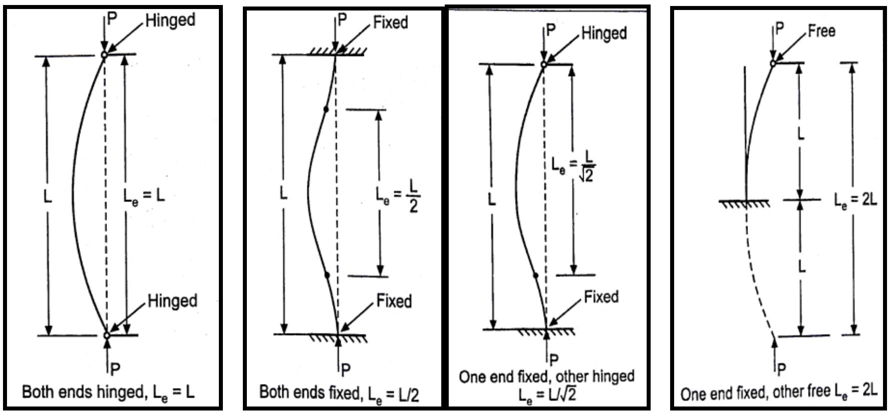
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2				
	(a)	$I_{YY1}=\left(\frac{bd^3}{12}+ah^2\right)_1=\left(\frac{20\times100^3}{12}+(20\times100)\left(\frac{100}{2}-40.77\right)^2\right)=1837052.47mm^4$	1	
		$I_{YY2}=\left(\frac{bd^3}{12}+ah^2\right)_2=\left(\frac{60\times20^3}{12}+(60\times20)\left(40.77-\frac{20}{2}\right)^2\right)=1176151.48mm^4$	1	
		$I_{YY3}=\left(\frac{bd^3}{12}+ah^2\right)_3=\left(\frac{20\times100^3}{12}+(20\times100)\left(\frac{100}{2}-40.77\right)^2\right)=1837052.47mm^4$	1	
		$I_{YY}=I_{YY1}+I_{YY2}+I_{YY3}$		
		$I_{YY}=1837052.47+1176151.48+1837052.47$		
		$I_{YY}=4850256.42mm^4$	1	8
		$I_{YY}=4.85\times10^6mm^4$		
	(b)	**Determine MI of shaded area about its base as shown in Fig.No. 2.**  **Fig. No. 2**		
	Ans.	**Data:** b=100mm, d=200mm, h=100mm.		
		h'=h/3=100/3=33.33mm	1	
		$I_{AB}=\left[\left(I_{XX}\right)+\left(Ah^2\right)\right]_1-\left[\left(I_{XX}\right)+\left(Ah^2\right)\right]_2$	1	
		$I_{AB}=\left[\frac{bd^3}{12}+\left(bd\right)\left(\frac{d}{2}\right)^2\right]_1-\left[\frac{bh^3}{36}+\left(\frac{bh}{2}\right)\times\left(d-h'\right)^2\right]$	1	
		$I_{AB}=\left[\frac{100\times200^3}{12}+\left(100\times200\right)\left(100\right)^2\right]_1-\left[\frac{100\times100^3}{36}+\left(\frac{100\times100}{2}\right)\left(166.6\right)^2\right]_2$	3	
		$I_{AB}=\left(266666666.7\right)_1-\left(141666666.7\right)_2$	1	
		$I_{AB}=125\times10^6mm^4$	1	8

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.2	(c) (i)	**Find MI of semicircular lamina having radius 80mm, about centroidal horizontal and vertical centroidal axes.**		
	Ans.	**Data: R=80mm** **Calculate: Ixx, Iyy.**		
			1	
		$I_{xx} = 0.11R^4$ $I_{xx} = 0.11 \times 80^4$ $I_{xx} = 4505600 mm^4$	1	
		$I_{yy} = \frac{\pi d^4}{128}$	1	
		$I_{yy} = \frac{\pi \times 160^4}{128}$ $I_{yy} = 16084954.4 mm^4$	1	4
	(ii)	**Calculate the force requried to puch a hole of 25mm diameter in a plate of 3mm thckness.Take permissible shear stress as 120Mpa.**		
	Ans.	**Data: d=25mm Ø, t=3mm, q=120Mpa.** **Calculate: F**		
		$A = \pi dt = \pi \times 25 \times 3 = 235.62 mm^2$	1	
		$\sigma = \frac{F}{A}$ $F = \sigma \times A$	1	
		$F = 120 \times 235.62$ $F = 28274.33 N$	1	
		$F = 28.274 kN$	1	4

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3		**Attempt any TWO of the following:**		(16)
	(a)	**Determine the magnitude of force P and the total elongation of a bar as shown in Fig. No. (3). Take E= 210 GPa.**  **Fig. No. 3**		
	Ans.	**Data:** E= 210GPa **Find:** P, $\delta_L = ?$ To find unknown force P, $\sum Fx=0$ +15+20-10-P=0 P-25=0 P=25kN	1	
		To find forces acting on individual part of compound rod. 	1	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(a)	$\delta L = \delta L_1 + \delta L_2 + \delta L_3$		
		$\delta L = \left(\frac{PL}{AE}\right)_1 - \left(\frac{PL}{AE}\right)_2 + \left(\frac{PL}{AE}\right)_3$	1	
		$\delta L = \left(\frac{10\times10^3\times0.5\times10^3}{\frac{\pi}{4}\times20^2\times210\times10^3}\right)_1 - \left(\frac{5\times10^3\times0.7\times10^3}{\frac{\pi}{4}\times25^2\times210\times10^3}\right)_2 + \left(\frac{20\times10^3\times1\times10^3}{\frac{\pi}{4}\times30^2\times210\times10^3}\right)_3$	3	
		$\delta L = +0.076 - 0.034 + 0.135$	1	
		$\delta L = 0.177$ mm (Increase)	1	8
	(b)	**A concrete column 400mm square is reinforced with 4 bars of 16 mm diameter. It carries a load of 800 kN. Determine the stress induced in each material. Take $E_S = 15E_C$**		
	Ans.	Data: $A=400\times400\ mm^2$, $d=16mm\Phi$ No. of steel bar =4, P=800kN, Es=15Ec Find- $\sigma_c, \sigma_s = ?$ $A_s = n\times\frac{\pi}{4}d^2 = 4\times\frac{\pi}{4}\times16^2 = 804.25mm^2$  		
		$A_c = A_g - A_s$ $A_c = 400\times400 - 804.25$ $A_c = 159195.75mm^2$	1	
		$\sigma_s = m\times\sigma_c$ $\sigma_s = 15\sigma_c$	1	
		$P = P_s + P_c$	1	
		$P = \sigma_s A_s + \sigma_c A_c$ $800\times10^3 = 804.25\sigma_s + 159195.75\sigma_c ....(1)$	1	
		Strain in each material are same. $e_s = e_c$	1	
		$\frac{\sigma_s}{Es} = \frac{\sigma_c}{Ec}$ $\sigma_s = \frac{Es}{Ec}\sigma_c$ $\sigma_s = 15\sigma_c ....(2)$	1	

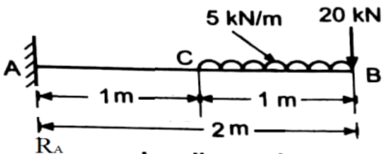
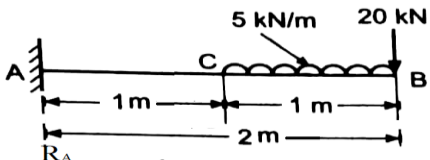
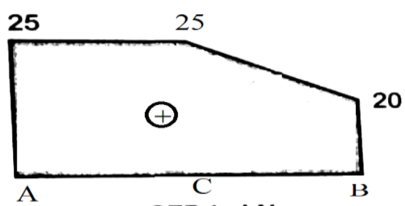
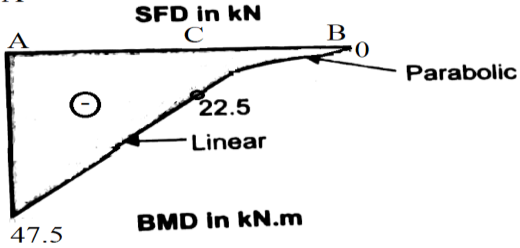
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(b)	Substitute the value of $\sigma_s = 15\sigma_c$ in equation (1) $800\times10^3 = 804.25\times15\sigma_c + 159195.75\sigma_c$ $\sigma_c = 4.67 N/mm^2$ $\sigma_s = 15\times4.67$....from equation (2) $\sigma_s = 70.07 N/mm^2$	1 1	8
	(c) (i)	**A square rod 10 mm x 10 mm in cross section and 1 m long is fixed at both ends. Calculate magnitude and nature of temperature stress induced due to rise in temperature of 50° C. Also find end reaction. Take E= = 2 x 10^5 N/mm^2 and α = 12 x 10^{-6} / ° C.**		
	Ans.	**Data :** A =10x10 mm^2, L = 2 m, T= 50° C, E= 2 x 10^5 N/mm^2 and α = 12 x 10^{-6} / ° C **Find :** σ_t, End Reaction=? Temperature stress $\sigma = \alpha\times T\times E$ $\sigma = 12\times10^{-6}\times50\times2\times10^5$ $\sigma = 120 N/mm^2 (C)$ Free expansion $\delta L = L\times\alpha\times T$ $\delta L = 1.0\times10^3\times12\times10^{-6}\times50$ $\delta L = 0.6 mm$ If the expansion is prevented, compressive force is developed in the steel rod. $\sigma = \frac{P}{A}$ $P = \sigma\times A$ $P = 120\times10\times10$ $P = 12000 N$ $P = 12 kN (C)$	1 1 1 1	4

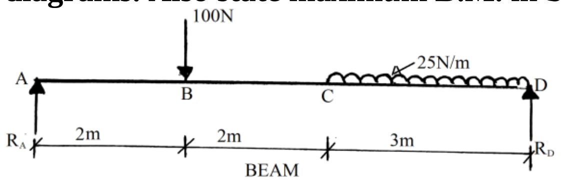
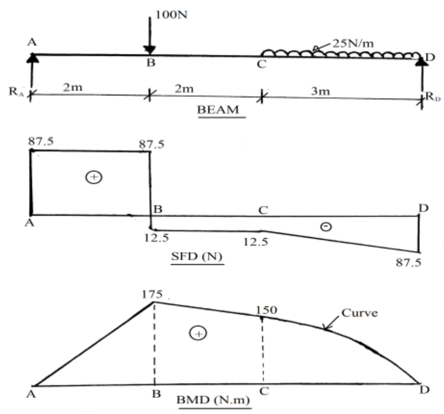
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.3	(c) (ii)	**With a neat sketch, state effective lengths of column for various end conditions.**		
	Ans.		1 each	4

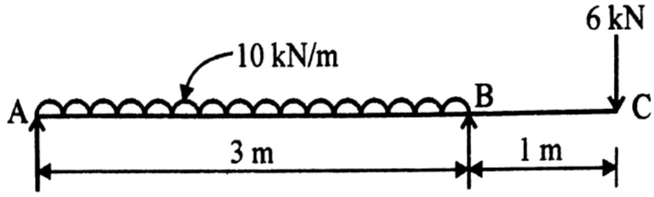
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4		**Attempt any TWO of the following:**		(16)
	(a)	**A steel bar 40 mm wide and 20 mm thick is 500 mm long. It is subjected to axial tensile force of 80 kN. If the change in length of bar is 2 mm, calculate change in width and change in thickness of bar. Take Poisson's ratio μ= 0.30. Also find E, G and K.**		
	Ans.	Data: b=40mm, t = 20mm, L=500mm, P=80kN, δL=2mm, μ=0.30		
		$\mu=\frac{\text{Lateral strain}}{\text{Linear strain}}=\frac{e_L}{e}=\frac{\left(\frac{\delta t}{t}\right)}{\left(\frac{\delta L}{L}\right)}$		
		$0.30=\frac{\left(\frac{\delta t}{20}\right)}{\left(\frac{2}{500}\right)}$		
		δt=0.024mm (Decrease)	1	
		$0.30=\frac{\left(\frac{\delta b}{20}\right)}{\left(\frac{2}{500}\right)}$		
		δb = 0.048mm (Decrease)	1	
		$\delta L=\frac{PL}{AE}$	1	
		$E=\frac{P\times L}{b\times t\times \delta L}$		
		$E=\frac{80\times 10^3\times 500}{40\times 20\times 2}$		
		$E=25000=0.25\times 10^5\ N/mm^2$	1	
		$E=2G(1+\mu)$	1	
		$25000=2G(1+0.30)$		
		$G=0.9615\times 10^4\ N/mm^2$	1	
		$E=3K(1-2\mu)$	1	
		$25000=3K(1-2\times 0.30)$		
		$K=0.20833\times 10^5\ N/mm^2$	1	8

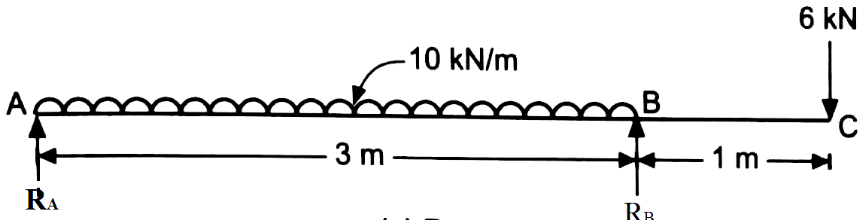
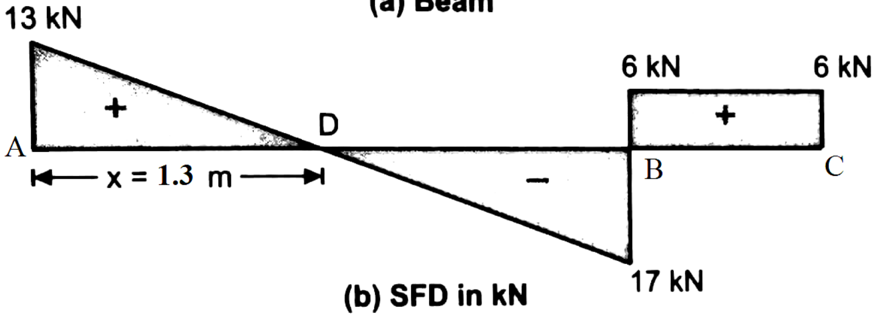
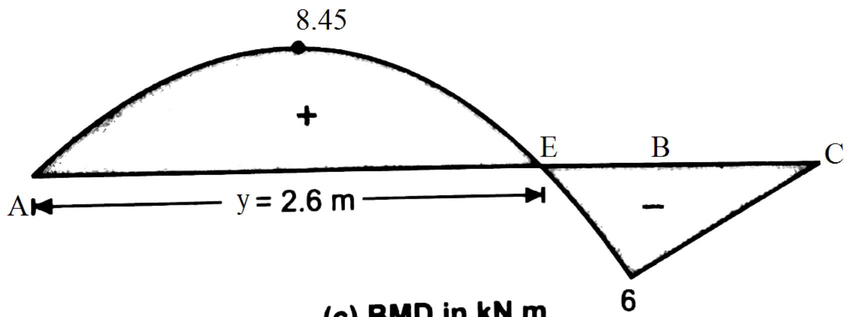
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(b)	**A cube of 100 mm side is subjected to stresses along three directions such that σx= 80N/mm² (tensile) σy= 60N/mm² (compressive) and σz=0. Calculate strains in all three directions. Also calculate change in volume of cube. Take E= 2x10⁵N/mm², μ=0.25.**		
	Ans.	Data: l = b = t = 100 mm, $\sigma_x = 80 N/mm^2$ (T), $\sigma_y = 60 N/mm^2$ (C), $\sigma_z = 0$, $E = 2\times10^5 N/mm^2$, $\mu = 0.25$		
		Find: ev, δv		
		Original volume		
		$V = L\times b\times t$		
		$V = 100\times100\times100$		
		$V = 1\times10^6 mm^3$		
		$e_x = \frac{\sigma_x}{E} - \frac{\mu\sigma_y}{E} - \frac{\mu\sigma_z}{E}$	1	
		$e_x = \frac{80}{2\times10^5} - \frac{0.25\times(-60)}{2\times10^5} - \frac{0.25\times0}{2\times10^5}$		
		$e_x = 0.000475$	1	
		$e_y = \frac{\sigma_y}{E} - \frac{\mu\sigma_z}{E} - \frac{\mu\sigma_x}{E}$	1	
		$e_y = \frac{-60}{2\times10^5} - \frac{0.25\times0}{2\times10^5} - \frac{0.25\times80}{2\times10^5}$		
		$e_y = -0.0004$	1	
		$e_z = \frac{\sigma_z}{E} - \frac{\mu\sigma_x}{E} - \frac{\mu\sigma_y}{E}$	1	
		$e_z = \frac{0}{2\times10^5} - \frac{0.25\times80}{2\times10^5} - \frac{0.25\times(-60)}{2\times10^5}$		
		$e_z = -0.000025$	1	
		$e_v = e_x + e_y + e_z$		
		$e_v = 0.000475 - 0.0004 - 0.000025$		
		$e_v = 5\times10^{-5}$	1	
		$e_v = \frac{\delta v}{v}$		
		$\delta v = e_v \times v$		
		$\delta v = 5\times10^{-5}\times1\times10^6$		
		$\delta v = 50 mm^3$ (Increase)	1	8

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(c) (i)	**Define shear force and bending moment. Also state relation between Bending Moment, Shear force and rate of loading.**		(16)
	Ans.	**Shear force:** Shear force at any cross section of the beam is the algebraic sum of vertical forces on the beam acting on right side or left side of the section is called as shear force. **OR** A shear force is the resultant vertical force acting on the either side of a section of a beam. Unit :- kN or N	1	
		Bending Moment: Bending moment at any section at any cross section is the algebraic sum of the moment of all forces acting on the right or left side of section is called as bending moment. Unit: - kN-m or N-m	1	
		Relation between rate of loading and shear force $\frac{dF}{dx} = W$ The rate of change of shear force with respect to the distance is equal to the intensity of loading.	1	
		Relation between shear force and bending moment. $\frac{dM}{dx} = F$ The rate of change of bending moment at any section is equal to the shear force at that section with respect to the distance. Where, W – Intensity if loading F - Shear force M - bending moment x – distance	1	4

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.4	(c) (ii)	**A cantilever of 2 m span carries a point load 20kN at its free end and a udl of 5kN/m upto 1 m from free end. Draw S.F. & B.M. diagrams.**		
	Ans.	 Loading on beam		
		I) Reaction Calculation:		
		$\sum Fy = 0$		
		RA = 5×1+20 = 25kN		
		II) SF Calculation:		
		SF at A = +25kN		
		C_L = +25kN	1	
		B_L = +25-5×1=20kN		
		B = +20-20=0kN (∴ ok)		
		III) BM Calculation:		
		BM at B = 0 kN-m (B is Free end)		
		C = -20×1-5×1×0.5 = -22.5 kN-m	1	
		A = -20×2-5×1×1.5 = -47.5 kN-m		
		 Loading on beam		
		 SFD in kN	1	
		 BMD in kN.m	1	4

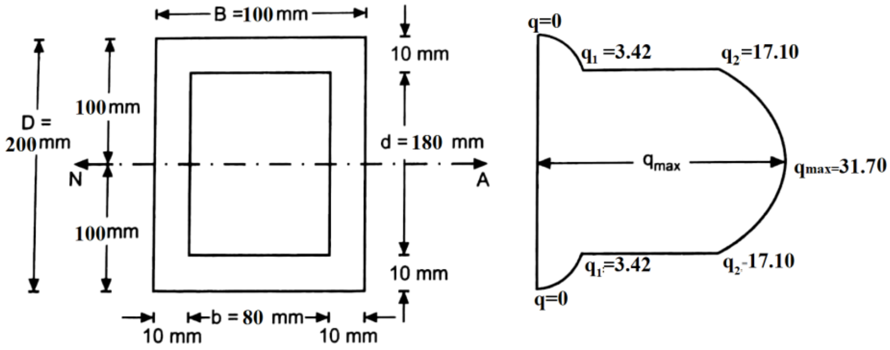
Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5		**Attempt any TWO of the following:**		(16)
	(a)	**A simply supported beam ABCD, AB = BC = 2m and CD = 3m carries point load 100N at B and udl 25N/m over a span CD. Draw S.F. and B.M. diagrams. Also state maximum B.M. in beam.**		
	Ans.			
		I) Reaction Calculation:		
		$\sum M_A = 0$		
		$R_D \times 7 = 100 \times 2 + (25 \times 3) \times 5.5$	1	
		$R_D = 87.5N$		
		$\sum Fy = 0$		
		$R_A + R_D = 100 + (25 \times 3)$		
		$R_A = 87.5N$		
		II) SF Calculation:		
		SF at A = +87.5N		
		B_L = +87.5N	1	
		B_R = +87.5-100= -12.5N		
		C = -12.5N		
		D_L = -12.5-25×3=-87.5N		
		D = -87.5+87.5=0 (∴ ok)		
		III) BM Calculation:		
		BM at A and D = 0 (∵ Supports A and D are simple)		
		B = +87.5×2=+175N-m	2	
		C = +87.5×2-100×2 =+150N-m		
		IV) Bmax:		
		BM = +175N-m at point B.		
			2, 2	8

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(b)	**Draw SFD and BMD for a overhanging beam as shown in Fig. No.4. Determine maximum B.M. and also locate point of contraflexure.**		
		 **Fig. No. 4**		
		1. **Support Reactions:** $\sum M_A = 0$ $3 \times R_B = 6 \times 4 + (10 \times 3) \times 1.5$ $R_B = 23$ kN $\sum F_y = 0$ $R_A + R_B = (10 \times 3) + 6$ $R_A + 23 = 36$ $R_A = 13$kN	1	
		2. **SF Calculations:** SF at A = +13 kN B_L = +13- (10×3) = -17 kN B_R = -17 +23= +6 kN C_L = +6 kN C = +6 - 6= 0 kN ($\therefore$ ok)	1	
		3. **BM Calculations:** BM at A = 0 (Support A is simple) C = 0 (C is free end) B = -6×1 = - 6 kN.m	1	
		4. **Maximum BM Calculations:** Let AD = x SF at D = 0 13 - 10x = 0 x = 1.3 m from support A	1	
		BM at D = $+13 \times 1.3 - 10 \times \frac{(1.3)^2}{2}$ = + 8.45 kN.m	1	
		5. **Location of point of contra flexure:** Let, E be point of contra-flexure (AE = y) BM at E = 0		

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(b)	$13y - 10\frac{y^2}{2} = 0$ $13 - 5y = 0$ y = 2.6m from support A	1	
		(a) Beam		
		(b) SFD in kN	1	
		(c) BMD in kN.m	1	8

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q.5	(c) (i)	**State flexural formula giving meaning of each term.**		
	Ans.	Flexural formula $\frac{M}{I}=\frac{\sigma}{y}=\frac{E}{R}$	2	
		Where, M = Maximum bending moment (N.mm) I = Moment of inertia about N.A. (mm^4) σ = Maximum bending stress (N/mm^2) y = Distance of extreme fiber from N.A.(mm) E = Modulus of elasticity (N/mm^2) R = Radius of curvature (mm)	2	4
	(c) (ii)	**A timber beam 200mm wide & 300mm deep is simply supported over a span of 4m carrying 20kN/m over entire span. Calculate maximum bending stress.**		
	Ans.	**Data:** b=200mm, d=300mm, L=4m, *w* =20kN/m.		
		$M=\frac{wl^2}{8}=\frac{20\times4^2}{8}$ = 40kN-m = 40×10^6 N-mm	1	
		$I_{NA}=\frac{bd^3}{12}=\frac{200\times300^3}{12}=450\times10^6 mm^4$	1	
		$Y=\frac{d}{2}=\frac{300}{2}=150$ mm		
		$\frac{M}{I}=\frac{\sigma}{Y}$	1	
		$\sigma_b=\frac{M}{I}\times Y$ $\sigma_b=\frac{40\times10^6}{450\times10^6}\times150$		
		$\sigma_b=13.33N/mm^2$	1	4

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6		**Attempt any TWO of the following:**		(16)
	(a)	**A beam has hollow rectangular section with external 100mm x 200mm and uniform thickness of 10mm. Draw shear stress distribution diagram. If section is subjected to the shear force of 100kN. Also determine ratio of maximum shear stress and average shear stress.**		
	Ans.	**Data:** B=100mm, D=200mm, S=100kN		
		b=(100-2t)=(100-2×10)=80mm d=(200-2t)=(200-2×10)=180mm A=(BD-bd)=(100×200-80×180)= 5600 mm^2	½	
		$I_{NA}=\frac{1}{12}(BD^3-bd^3)=\frac{1}{12}(100\times200^3-80\times180^3)=27786666.67\ mm^4$	1	
		$q_{avg}=\frac{S}{A}=\frac{100\times10^3}{5600}=17.857N/mm^2$	1	
		$q_0=0$ At top and bottom of section.		
		$q_1=\frac{SA\bar{Y}}{bI}=\frac{100\times10^3\times(100\times10)\times\left(\frac{180}{2}+\frac{10}{2}\right)}{100\times27786666.67}=3.42N/mm^2$	1	
		$q_2=\frac{SA\bar{Y}}{bI}=\frac{100\times10^3\times(100\times10)\times\left(\frac{180}{2}+\frac{10}{2}\right)}{20\times27786666.67}=17.10N/mm^2$	1	
		$q_{NA}=q_{max}=\frac{SA\bar{Y}}{bI}=\frac{100\times10^3\times(100\times10\times95+2\times10\times90\times45)}{2\times10\times27786666.67}=31.70N/mm^2$	1	
		$Ratio=\frac{q_{max}}{q_{avg}}=\frac{31.70}{17.857}=1.774$	½	

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6	(a)	 (a) Cross-section (b) Shear stress distribution (N/mm^2)	2	8

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6	(b)	**Calculate slenderness ratio for which Euler's crippling load and Rankine's failure load is of same magnitude. Take E=200GPa, α=1/7500, σ_c=300MPa**		
	Ans.	**Data:** E = 200GPa, α = 1/7500, σ_c = 300MPa **Calculate: λ**		
		$P_E = P_R$ $\frac{\pi^2 E I_{min}}{(Le)^2} = \frac{\sigma_c A}{1+\alpha\left(\frac{Le}{K}\right)^2}$	1	
		$\frac{\pi^2 EAK^2}{(Le)^2} = \frac{\sigma_c A}{1+\alpha\left(\frac{Le}{K}\right)^2}$	1	
		$\frac{\pi^2 E}{\left(\frac{Le}{K}\right)^2} = \frac{\sigma_c}{1+\alpha\left(\frac{Le}{K}\right)^2}$	1	
		$\frac{\pi^2 E}{(\lambda)^2} = \frac{\sigma_c}{1+\alpha(\lambda)^2}$	1	
		$\pi^2 E\left(1+\alpha(\lambda)^2\right) = \sigma_c(\lambda)^2$ $\pi^2 E + \pi^2 E\alpha(\lambda)^2 = \sigma_c(\lambda)^2$ $\pi^2 E = \sigma_c(\lambda)^2 - \pi^2 E\alpha(\lambda)^2$	1	
		$\pi^2 E = \lambda^2(\sigma_c - \pi^2 E\alpha)$ $\lambda^2 = \frac{\pi^2 E}{\sigma_c - \pi^2 E\alpha}$	1	
		$\lambda = \sqrt{\frac{\pi^2 E}{\sigma_c - \pi^2 E\alpha}}$ $\lambda = \sqrt{\frac{\pi^2 \times 200\times 10^3}{300-\pi^2\times 200\times 10^3\times\frac{1}{7500}}}$	1	
		$\lambda = \sqrt{53623.78225}$ $\lambda = 231.568$	1	8

Que. No.	Sub. Que.	Model Answer	Marks	Total Marks
Q. 6	(c) (i)	**A bar 2m long and 25mm diameter is subjected to an axial load 40kN applied suddenly. Calculate instantaneous stress, deformation and modulus of resilience. Take $E=2\times10^5 n/mm^2$.**		
	Ans.	**Data:** L=2m, d=25mmØ, P=40kN, $E=2\times10^5 N/mm^2$ **Calculate:** σ, δL, Modulus of Resilience		
		$\sigma = 2\left(\frac{P}{A}\right)$	1	
		$\sigma = 2\left(\frac{P}{\frac{\pi d^2}{4}}\right) = 2\left(\frac{40\times10^3}{\frac{\pi\times25^2}{4}}\right) = 163 N/mm^2$	1	
		$\delta l = \frac{\sigma L}{E} = \frac{163\times2\times10^3}{2\times10^5} = 1.63mm$	1	
		$MR = \frac{\sigma^2}{2E} = \frac{(163)^2}{2\times2\times10^5} = 0.0664 N\text{-}mm/mm^3$	1	4
	(ii)	**A load of 800N falls through a height of 80mm on a collar attached at the lower end of the bar having length 505m. If diameter of bar is 10mm. What stress will be induced in the bar? Take E=200GPa.**		
	Ans.	**Data:** L=5.5m, d=10mmØ, W=800N, h=80mm, E=200GPa **Calculate:** σ_{max}		
		$\sigma = \frac{W}{A} + \sqrt{\left(\frac{W}{A}\right)^2 + \frac{2WEh}{AL}}$	1	
		$\sigma = \frac{800}{\frac{\pi}{4}\times10^2} + \sqrt{\left(\frac{800}{\frac{\pi}{4}\times10^2}\right)^2 + \frac{2\times800\times200\times10^3\times80}{\frac{\pi}{4}\times10^2\times5.5\times10^3}}$	1	
		$\sigma = 10.186 + \sqrt{(10.186)^2 + 59263.51335}$	1	
		$\sigma = 253.84 N/mm^2$	1	4