Important Instructions to examiners:

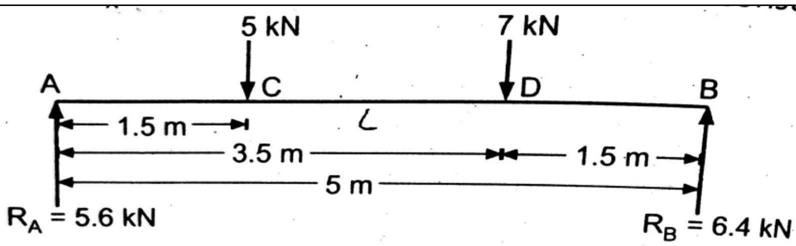
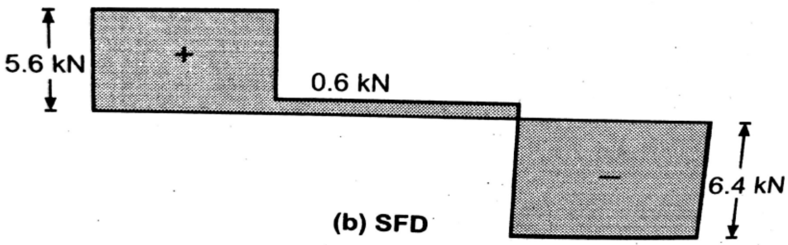
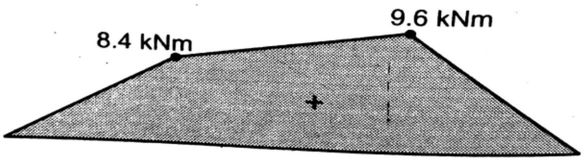
1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling 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 Answers	Marks	Total Marks
1.	(A)	**Attempt any Six of the following.**		(12)
	(a)	**Define elasticity and plasticity.**		
	Ans.	**Elasticity: -** It is property of a material by virtue of which it regains its original size and shape after deformation, when the loads causing deformation are removed.	01	02
		Plasticity: - Lack of elasticity is called plasticity. The plasticity of a material is the ability to change without destruction under the action of external loads and to regain the shape given to it's the forces are removed.	01	
	(b)	**Define principal plane and principal stress.**		
	Ans.	**Principal Plane: -** A plane which carry only normal stress and no shear stress is called a principal plane.	01	02
		Principal Stress: - The magnitude of normal stress acting on the principal plane is called principal stress.	01	
	(c)	**Define moment of inertia.**		
	Ans.	Moment of inertia of a body about any axis is defined as the second moment of all elementary areas about that axis	02	02

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1.	(d)	**What is core section?**		
	Ans.	The centrally located portion of a within which the load must act so as to produce only compressive stress is called a Core OR Kernel section.	02	02
	(e)	**State the torsion equation along with meaning of each term in it.**		
	Ans.	**Torsion Equation: -** $\frac{T}{I_P}=\frac{C\theta}{L}=\frac{f_s}{R}$	01	
		Where, T = Torque Or Turning moment (N.mm) I_P = Polar momet of inertia of the shaft section $=I_{xx}+I_{yy}$ C= Modulus of rigidity of the shaft material (N/mm^2) θ = Angle through which the shaft is twisted due to torque i.e. angle of twist (radians) L = Lenght of the shaft (mm) f_s = Maximum shear stress induced at the outermost layer of the shaft (N/mm^2) R = Redius of the shaft (mm)	01	02
	(f)	**State the relationship between Young's Modulus, Modulus of Rigidity and Bulk Modulus.**		
	Ans.	$E=\frac{9KG}{G+3K}$ **OR** $E=2G(1+\mu)$ $E=3K(1-2\mu)$	02	02

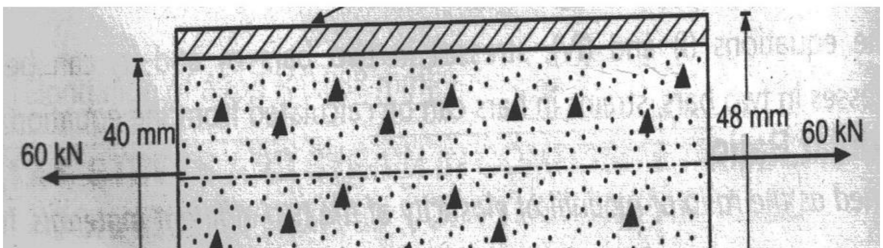
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1.	(g)	**Define Hoop Stress and Longitudinal Stress.**		
	Ans.	**Hoop Stress: -** The stress which act in the tangential direction to the perimeter (Circumference) of the cylinder are called as Hoop Stresses Or Circumferential Stress. Its denoted as by $[\sigma_c]$	01	02
		Longitudinal Stress: - The stresses which act parallel to the longitudinal axis of cylinder are called as Longitudinal Stress. Its denoted as by $[\sigma_L]$	01	
	(h)	**What is eccentric loading? State two example of eccentric loading.**		
	Ans.	**Eccentric loading: -** A load whose line of action does not coincide the axis of a member is called an eccentric Load.	01	02
		Example: - a) C- Clamp b)Hook c)Offset link d) Drilling Machine Frame	½ Mark (Any two)	
	B)	**Attempt any Two of the following**		(8)
	a)	**A bar 500mlong and 22 mm in diameter is elongated by 1.2 mm under the effect of axil pull of 105 kN. Calculated the intensities of stress, strain and the modulus of elasticity of the bar**		
	Ans.	Given: $L = 500\,mm \; d = 22\,mm \; \partial_L = 1.2\,mm$ $P = 105\,kN = 105 \times 10^3\,N$		
		i) Stress, $\sigma = \frac{P}{A} = \frac{105 \times 10^3}{\frac{\pi}{4}(22)^2} = 276.22\,N/mm^2$	01	04
		ii) Strain, $e = \frac{\partial_L}{L} = \frac{1.2}{500} = 0.0024$	01	
		iii) Modulus of Elasticity, $E = \frac{\sigma}{e} = \frac{276.22}{0.0024} = 115091.67\,N/mm^2$	02	
		i) $\sigma = 276.22\,N/mm^2$, ii) $e = 0.0024$, iii) $E = 115091.67\,N/mm^2$		

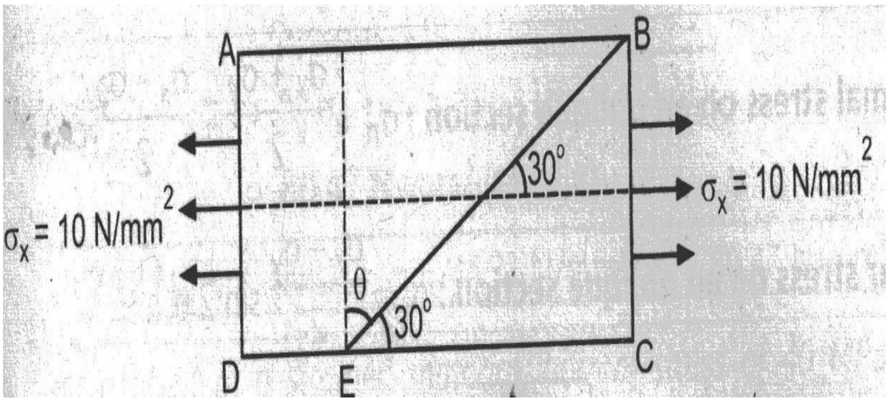
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1.	b)	**A simply supported beam of span 5 m carries two point loads of 5 kN and 7 kN at 1.5 m and 3.5 m from the left hand support respectively. Draw shear force and bending moment diagram.**		
	Ans.	Reactions: $\sum M_A = 0$ $5\times1.5+7\times3.5-R_B\times5 = 0$ $5\times R_B = 32$ $R_B = 6.4\,kN................(i)$ $\sum F_y = 0$ $R_A + R_B - 5 + 7 = 0$ $R_A + R_B = 12$ $R_A = 5.6\,kN.......................(ii)$ *Shear Force* (S.F) at any section between A and C, $F_x = R_A = 5.6\,kN$ *Shear Force* (S.F) at any section between C and D, $F_x = 5.6 - 5 = 0.6\,kN$ *Shear Force* (S.F) at any section between D and B, $F_x = 5.6 - 6 - 7 = -6.4\,kN$	1	
		B.M. calculation:- B.M at A and B= 0 B.M at C = 5.6 × 1.5=8.4 kN-m B.M at D = 6.4× 1.5=9.6 kN-m	1	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1.		 (a) Beam  (b) SFD  (c) BMD	01 01	04

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
1.	c)	**A circular beam of 120 mm diameter is simply supported over a span of 10 m and carries a UDL of 1000 N/m. Find the maximum bending stress produced.**		
	Ans.	*Given date:*		
		daimeter $d = 120\,mm,\ L = 10\,m,\ w = 1000\,N/m$		
		Step i) $M_{max} = \frac{wL^2}{8} = \frac{1000\times 10^2}{8} = 12500\,N\text{-}m = 125\times 10^5\,N-m$	01	
		Step ii) $I = \frac{\pi}{64}d^4 = \frac{\pi}{64}(120)^4 = 10178760.2\,mm^4$	01	
		Step iii) $y = \frac{d}{2} = \frac{120}{2} = 60\,mm$	½	04
		Step iv) Using the relation $\frac{M}{I} = \frac{\sigma}{y}$	½	
		$\sigma = \frac{M}{I}\times y = \frac{125\times 10^5}{10178760.2}(60) = 73.68\,N/mm^2$	01	
2.		**Attempt any four of the following:**		(16)
	(a)	**i) Define lateral strain.** **ii) State Rankine's formula for column giving meaning of each term used in it.**		
	Ans.	i) **Lateral Strain :** - Strain in a direction at right angle to the direction of applied force is known as lateral strain or secondary strain	01	
		In mathematically, $$\text{Lateral strain} = \frac{\text{Change in the lateral dimension}}{\textit{Original}\ \text{lateral dimension}}$$	01	
		iii) Rankine formula: -		

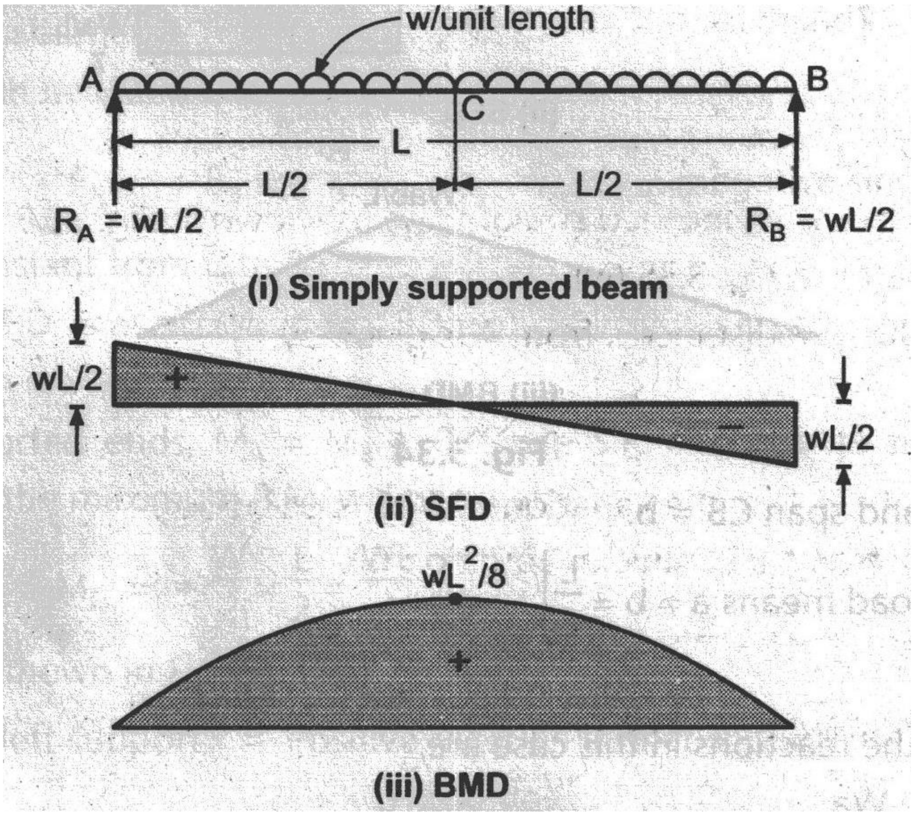
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2.		$P_R = \frac{\sigma_C A}{1 + a\left(\frac{L_e}{K}\right)^2}$	01	04
		Where, P_R = Rankine's Crippling load σ_c = Ultimate crushing stress for the column material A = Area of c/s L_e = Effective lenght or effective height of the column which depends upon the column end conditions K = Minimum Radious gyrations a = Rankine Constant	01	
	(b)	**A steel rod 3 m long and 40 mm diameter is used a column with one end is fixed and other end is free. Find the bucking load by Euler's formula (E=210nkN/mm²)**		
	Ans.	*Given* data:- $D = 40\text{ mm}, L = 3\text{m}, E = 210\text{ kN/mm}^2 = 210\times10^3\text{ N/mm}^2$		
		Condition one end fixed, other is Free $L_e = 2L = 3\times2 = 6\text{ m} = 6000\text{mm}$	01	
		For a solid circular section, $I = \frac{\pi}{64}D^4 = \frac{\pi}{64}(40)^4 = 125663.71\text{ mm}^2$	01	04
		Using Euler's formula, $P = \frac{\pi^2 EI}{(L_e)^2} = \frac{\pi^2\times(210\times10^3)\times125663.71}{(6000)^2}$	01	
		$P = 7234.79\text{ N} = 7.23\text{ kN}$	01	
	(c)	**A rod has a length of 10 m at 10 ^{0}C and its temperature is raised to 70 ^{0}C. If the free expansion is prevented, find the magnitude and nature of stress produced. Take E= 210 k N/mm² and α = 12×10⁻⁶ / ^{0}C**		

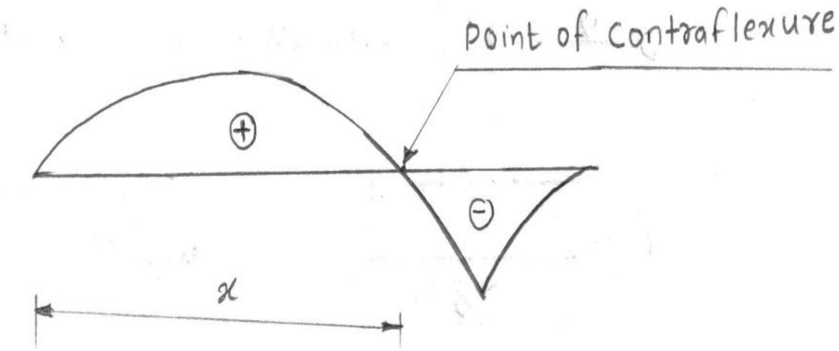
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2.	Ans.	Given data:- $L = 10m = 10\times10^3 mm,\ t_1 = 10^0C,\ t_2 = 70^0C$ $E = 2.1\times10^5\ N/mm^2,\ \alpha = 12\times10^{-6}/^0C$ $i)$ Rise in temperature, $t = t_2 - t_1 = 70 - 10 = 60^0C$ $ii)$ Free expansion of the rod, $\partial_L = \alpha t L = (12\times10^{-6})\times60\times(10\times10^3)$ $= 7.2\ mm$ If this expansion is prevented, compressive stress will be induced in the rod. Compressive Stress, $\sigma = \alpha t E = (12\times10^{-6})\times60\times(2.1\times10^5)$ $= 151.2\ N/mm^2$ i) $\sigma = 151.2\ N/mm^2$ ii) Nature of σ: Compressive	01 01 01 01	04
	(d)	**A steel tube of 40 mm inside diameter and 4 mm thickness is filled with concrete. Determine the stress in each material due to an axial thrust of 60 kN. (E steel =2.1×10^5 N/mm^2 and E concrete = 0.14×10^5 N/mm^2).**		
	Ans.	Given data: Inside diameter of steel tube, d= 40 mm, Outside daimeter of steel tube, $D = d + 2t = 40 + (2\times4) = 48mm$ Area of steel, $A_s = \frac{\pi}{4}(D^2 - d^2) = \frac{\pi}{4}(48^2 - 40^2) = 552.92\,mm^2$ Area of Concrete, $A_C = \frac{\pi}{4}(d^2) = \frac{\pi}{4}(40^2) = 1256.64\,mm^2$ Axial thrust, $P = 60kN = 60\times10^3\,N$ 	½ ½	

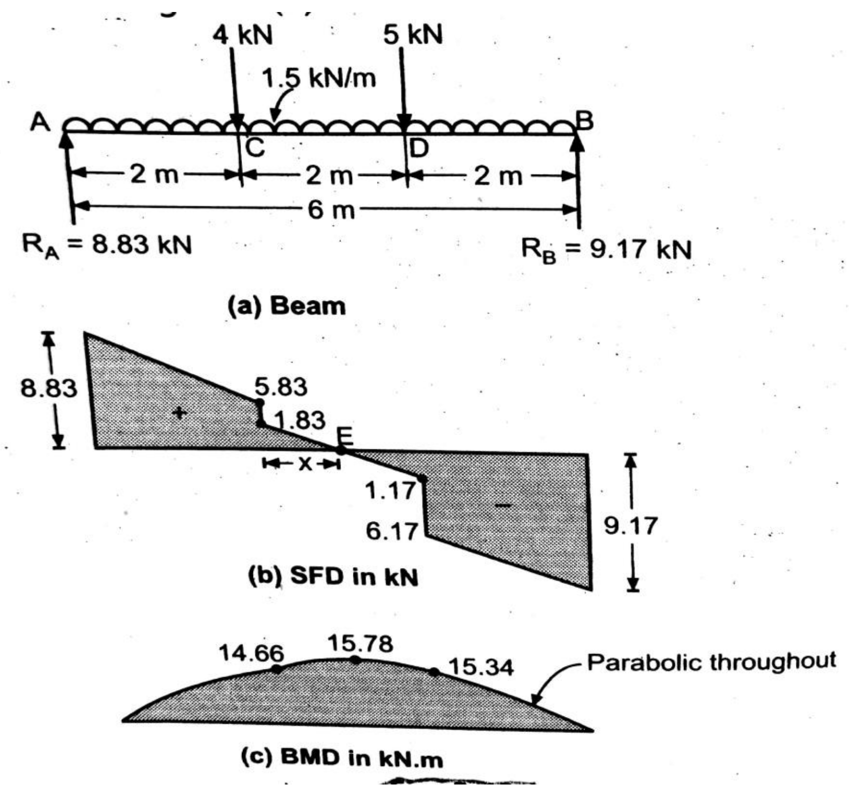
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2.		$P=\sigma_1 A_1+\sigma_2 A_2$ $P=\sigma_S A_S+\sigma_C A_C$ $\therefore\ 60\times10^3=\sigma_S\times552.92+\sigma_C\times1256.64.........(i)$	01	
		$\sigma_1=\frac{E_1}{E_2}\sigma_2$ $\sigma_s=\frac{E_s}{E_c}\sigma_c=\frac{2.1\times10^5}{0.14\times10^5}\sigma_c$		04
		$\sigma_s=15\times\sigma_C$ ....(ii)	01	
		Substituting this value in equetion (i), $60\times10^3=15\times\sigma_C\times552.92+\sigma_C\times1256.64$		
		$\sigma_C=\frac{60\times10^3}{9550.44}=6.28N/mm^2$ $\sigma_c=6.28N/mm^2$ $\sigma_s=94.2N/mm^2$	01	
	(e)	**A tension member is subjected to axial stress 10 N/mm² and the plane of oblique is 30⁰ to the axis of stress. Compute the normal and shear stress on oblique section.**		
	Ans.	*Given* data Axial Stress, $\sigma_1=10\,N/mm^2$, $\theta=90^0-30^0=60^0$  		
		Here the oblique plane BE is inclined at 30^0 to the axis of σ_x i.e. with the horizontal. $\therefore\ \theta=$ angle made by oblique plane BE with vertical $=90^0-30^0=60^0$		
		$\sigma_1=\sigma_X\cos^2\theta=10\times\cos^2 60^0=2.5N/mm^2$ (*Tensile stress*)	02	
		$\sigma_1=\frac{\sigma_x}{2}\sin2\theta=\frac{10}{2}\sin(2\times60^0)=4.33N/mm^2$	02	04

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
2.	f)	**A cylinder shell 3m long has 1.2 m internal diameter and 20 mm metal thickness. Calculated the longitudinal stress induced and change in the length of the shell, if it is subjected to internal pressure of 8 N/mm^2.**		
	Ans.	*Given data:*		
		$L = 3m = 3000mm, d = 1.2m = 1200mm, t = 20mm$		
		$p = 8\ N/mm^2,\ E = 2.1\times10^5 N/mm^2, \mu = 0.32$		
		Using the relation,		
		$\sigma_L = \frac{pd}{4t}$		
		$\sigma_L = \frac{8\times1200}{4\times20} = 120 N/mm^2$	01	
		$\sigma_c = \frac{pd}{2t}$		
		$\sigma_c = \frac{8\times1200}{2\times20} = 240 N/mm^2$	01	04
		$e_L = \frac{1}{E}[\sigma_L - \mu\sigma_c]$	01	
		$\frac{\delta_L}{L} = \frac{1}{2.1\times10^5}[120 - 0.32\times240]$		
		$\delta_L = 0.617mm$	01	
4.		**Attempt any Four of the following**:		(16)
	(a)	**Draw SF and BM diagram for a Simply supported beam L carrying an udl w/unit length over the entire span.**		
	Ans.	Take a section XX at distance X from A		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
		SF calculation: Take a section XX at distance x from A F_x = SF at section XX = (wL/2)-wx $At\ A,\ x=0,$ $F_A=\frac{wL}{2}-w\times 0=\frac{wL}{2}=+R_A$ $At\ B,\ x=L,$ $F_B=\frac{wL}{2}-w\times L=-\frac{wL}{2}=-R_B$ $At\ C,\ x=\frac{L}{2},$ $F_C=\frac{wL}{2}-w\times\frac{L}{2}=0$	01	
		$B.M.\ Calculation:-$ $B.M.$ at a section XX At a distance x from A $M_x=\frac{wL}{2}\times x-wx.\frac{x}{2}=\frac{wL}{2}\times x-\frac{wx^2}{2}$ BM at A, x = 0 $M_A=\frac{wL}{2}\times 0-\frac{w}{2}\times 0^2=0$ BM at B, x = 0 $M_B=\frac{wL}{2}\times L-\frac{w}{2}\times L^2=0$ *To find* the maximum BM- At center C, $x=\frac{L}{2}$ $M_C=M_{max}=\frac{wL}{2}\times\frac{L}{2}-\frac{w}{2}\times\left(\frac{L}{2}\right)^2=\frac{wL}{8}$	01	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3.		(i) Simply supported beam (ii) SFD (iii) BMD	01 01	04
	(b) Ans.	**(i) Define shear force and bending moment.** **(ii) Define point of contraflexture with a neat sketch.** **Shear Force**: - Shear force at any section of the beam is the algebraic sum of all vertical forces on the beam acting on the right or left side of the section. **OR** **Shear Force**: - A shear force is the resultant vertical force acting on either side of section of a beam. **Bending Moment: -** Bending moment at any cross-section of the beam is the algebraic sum of the moment of all the forces acting on the right or left side of the section.	01 01	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3.		**Point of Contraflexture: -** A point where bending moment is change its sign from positive to negative or vice-versa. At that point bending moment is equal to zero Such point called as point of contraflexture.	01	04
		 **BMD**	01	
	(c)	**A simply supported beam of 6 m span is loaded with a udl of 1.5 kN/m over the entire span and concentrated load of 4 kN and 5 kN at distance of 2m & 4m from the left end support. Find the magnitude and position of the maximum B.M.**		
	Ans.	*i) Reactios :–* *Take a moment about A,* $4\times2+5\times4+(1.5\times6)\times\frac{6}{2}=R_B\times6$ $R_B=9.17kN$ $R_A=4+5+(1.5\times6)-9.17$ $R_A=8.83kN$	01	
		ii) Shear force calculations : $F_A=+R_A=8.83kN$ $F_{C_L}=8.83-1.5\times2=5.83kN$ $F_{C_R}=8.83-1.5\times2-4=1.83kN$ $F_{D_L}=8.83-1.5\times2-4-1.5\times2=-1.17kN$ $F_{D_R}=8.83-1.5\times2-4-1.5\times2-5=-6.17kN$ $F_B=8.83-1.5\times2-4-1.5\times2-5-1.5\times2=-9.17kN$ $-R_B=-9.17kN$	01	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3.				04

iii)

iii) B.M calculation:-

$$M_A = M_B = 0$$

$$M_A = (8.83 \times 2 - (1.5 \times 2)\frac{2}{2} = 14.66\ kN - m$$

$$M_A = (9.17 \times 2 - (1.5 \times 2)\frac{2}{2} = 15.34\ kN - m$$

01

Find the M_{max} :

$$\frac{x}{1.83} = \frac{2 - x}{1.17}$$

$$x = 1.22 m$$

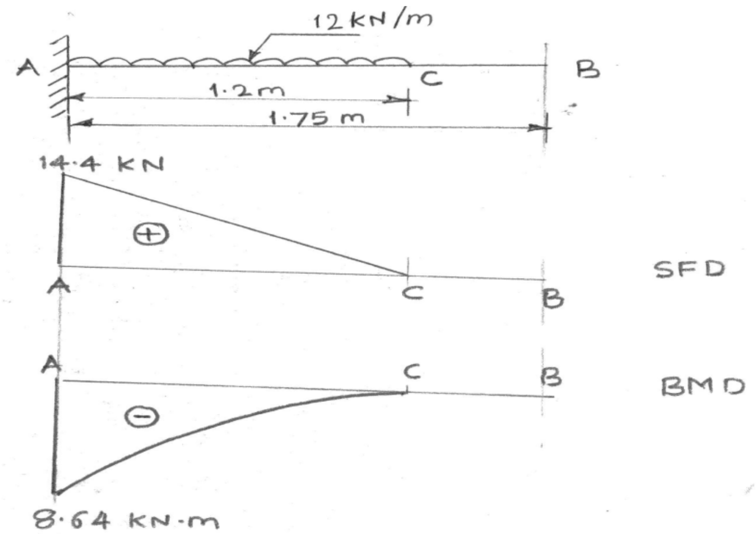
Distance Between E from A = 2 + x = 3.22m

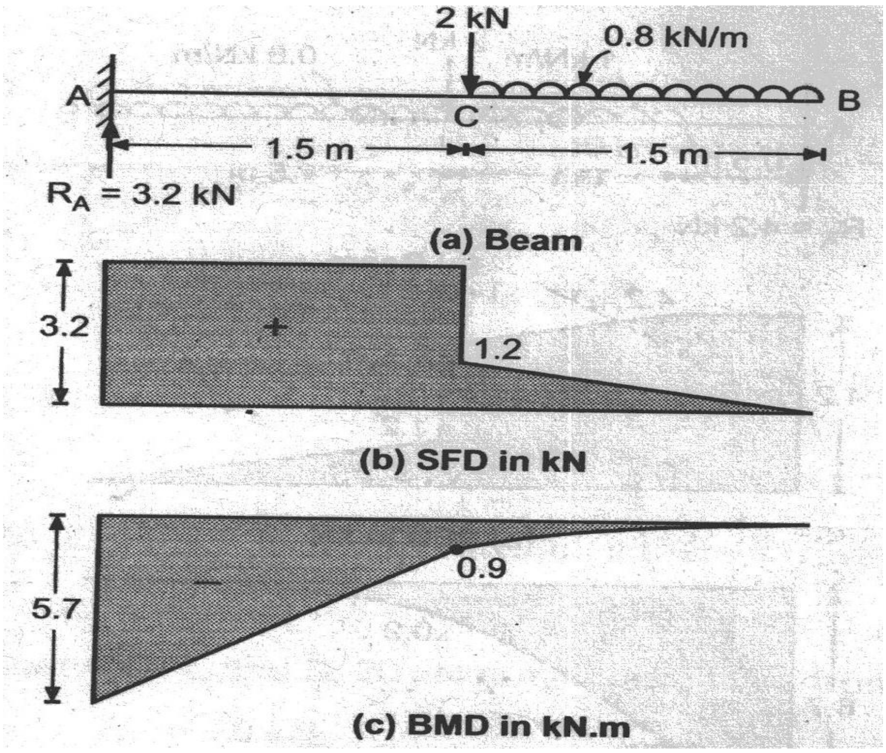
B.M at 3.22 m from A given by,

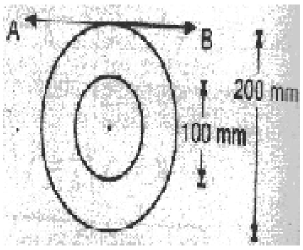
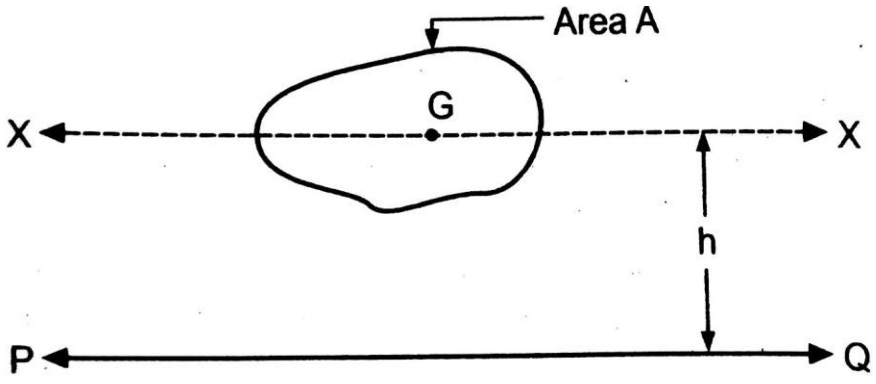
$$M_E = M_{max} = 8.83 \times 3.22 - 4 \times 1.22 - (1.5 \times 3.22) \times \left[\frac{3.22}{2}\right]$$

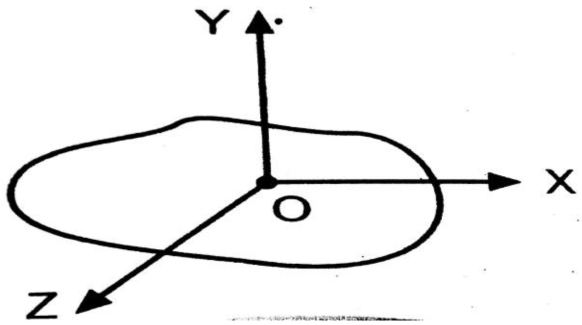
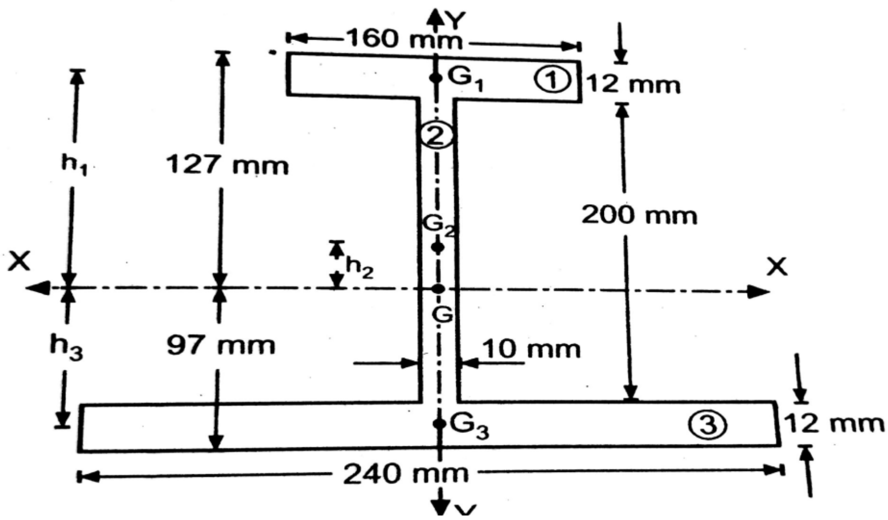
$$M_E = M_{max} = 15.78 kN\text{-}m$$

01

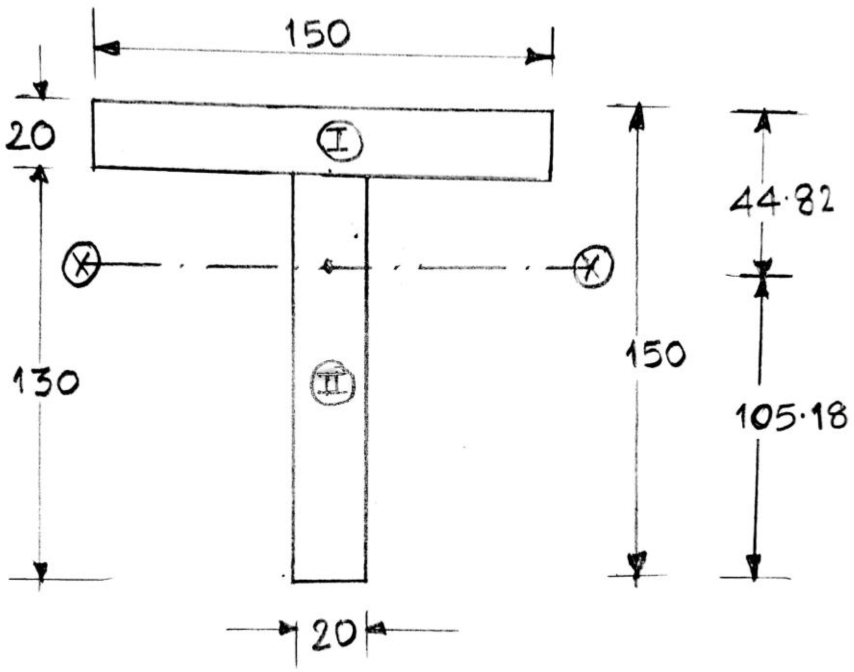
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3.	(d)	**Draw SFD and BMD for a cantilever bean 1.75 m long carrying a udl of 12kN/m run over a length of 1.2 m from the fixed end.**		
	Ans.	**Shear force calculation; -** **S. F. at A = 1.2×12=14.4kN** **S. F. at C = 0** **S. F. at D = 0**	01	
		Bending moment calculation: - **B.M. at B = 0** **B.M. at C = 0** **B.M. at A = 1.2×12×0.6=8.64 kN-m**	01	
		 	01 01	04

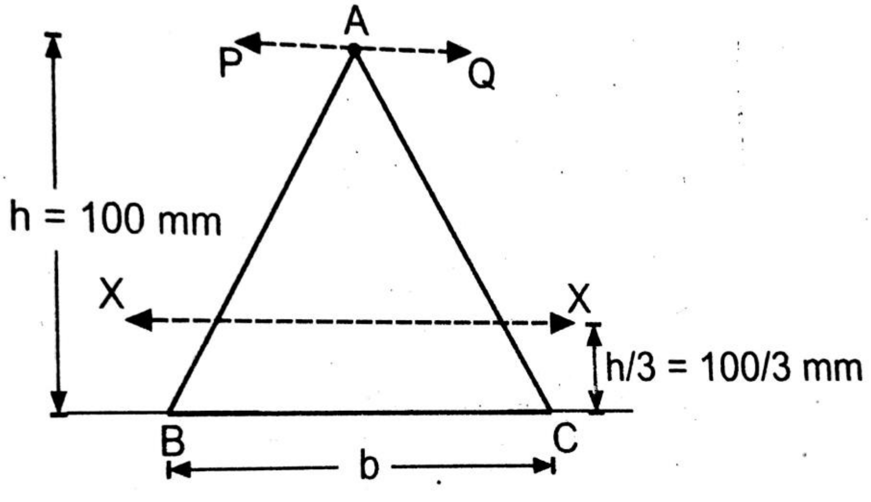
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3.	(e)	**Draw the SFD and BMD for the bean as shown in fig.**		
	Ans.	$i)$ *To* find the R_A : *For the* equilibrium of the beam,		
		Upward reaction at A= Total downward load		
		$R_A = 2 + 0.8 \times 1.5 = 3.2 kN$		
		ii) S.F. calculation: $F_A = R_A = 3.2 kN$		
		S.F. just to the right of C, $F_{C_R} = 3.2 - 2 = 1.2 kN$		
		S.F. just to the left and right of B, $F_B = 3.2 - 2 - 0.8 \times 1.5 = 0\ kN$		
		Hence,	01	
		$F_A = F_{B_L} = F_{B_R} = 0$		
		$iii)$ *B.M. calculation*: $M_B = 0$		
		$M_C = -(0.8 \times 1.5) \times (\frac{1.5}{2}) = -0.9 kN.m$		
		$M_A = -(0.8 \times 1.5) \times (\frac{1.5}{2} + 1.5) - 2 \times 1.5 = -5.7 kN.m$	01	
				04
		(a) Beam		
		(b) SFD in kN	01	
		(c) BMD in kN.m	01	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
3.	(f)	**A hollow circular section is of 200mm external diameter and 100 mm internal diameter. Calculate the M.I. of the section about ant of its tangent.**		
	Ans.	Given data: D=200mm, d=100 mm.  i) M.I. of hollow circular section about xx- axis, $I_{xx} = \frac{\pi}{64} \times (D^4 - d^4)$ $I_{xx} = \frac{\pi}{64} \times (200^4 - 100^4)$ $I_{xx} = 73631077.82 \text{ mm}^4$	01	
		ii) Distance between tangent AB and XX-axis=h= $\frac{200}{2} = 100mm$	01	
		iii) M.I. about tangent AB (I_{AB}): The tangent Ab is parallel to xx-axis. so, using parallel axis theorem, $I_{AB} = I_{XX} + Ah^2$	01	04
		$I_{AB} = 73631077.82 + \frac{\pi}{4}(200^2 - 100^2) \times (100)^2$ $I_{AB} = 309250526.8 \text{mm}^4$	01	
4.		**Attempt any <u>FOUR</u> of the following:**		(16)
	(a)	**State parallel axis theorem and perpendicular axis theorem of M.I. along with sketches.**		
	Ans.	**Parallel Axis Theorem: -** It State, The moment of inertia of plane section about any axis parallel to the centroidal axis is equal to the moment of inertia of the section about the centroidal axis plus the product of the areas of the section the square of the distance between the axes.	01	
		 	01	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4.		**Perpendicular Axis Theorem: -**		
		It state, if I_{XX} and I_{YY} are the moments inertia of a plane section about the two mutually perpendicular axes meeting at O, then the moment of inertia about the third axis Z-Z i.e. I_{ZZ} is equal to addition of moment of inertia about X-X and Y-Y axes.	01	04
			01	
	(b)	**Determine the M.I about XX-axis of an unsymmetrical I-section having following details. Top flange - 160 mm X 12 mm, Bottom flange- 240 mm X 12 mm and web - 200m X 10 mm.**		
	Ans.			

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4.		Step ii) Areas: $a_1 = 160 \times 12 = 1920 mm^2$ $a_2 = 200 \times 20 = 2000 mm^2$ $a_3 = 240 \times 12 = 2880 mm^2$ *Total areas,* $A = a_1 + a_2 + a_3$ $A = 6800 mm^2$		
		Step i) Distance of the centroid from the bottom face: $y_1 = 218 mm$ $y_1 = 112 mm$ $y_1 = 6 mm$ *Dis*tan*ce* of horizontal centriodal axis from the bottom face. $\bar{y} = \frac{a_1 y_1 + a_2 y_2 + a_3 y_3}{A}$ $\bar{y} = 97 mm$	½	
		*Dis*tan*ce* of horizontal centriodal axis from the top face. $=$ Total depth - $\bar{y}$ from bottom face $= 12 + 120 + 12 - 97 = 127 mm$		
		Step ii) To find I_{xx} : *M.I. of the section about the horizontal centroidal axis is given*: $I_{xx} = I_{xx1} + I_{xx2} + I_{xx3}$		
		$I_{xx1} = \frac{160 \times 12^3}{12} + 1920 \times (121^2) = 28133760 mm^4$	**01**	**04**
		$I_{xx2} = \frac{10 \times 200^3}{12} + 2000 \times (15^2) = 7116666.67 mm^4$	**01**	
		$I_{xx3} = \frac{240 \times 12^3}{12} + 2880 \times (91)^2 = 23883840 mm^4$	**01**	
		$I_{xx} = 28133760 + 7116666.67 + 23883840$ $I_{xx} = 59134266.67 mm^4 = 59.13 \times 10^6 mm^4$ $\boxed{I_{xx} = 59.13 \times 10^6 mm^4}$	½	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4.	**(c)**	**Find the M.I of a T-section having flange 150mmX20mm, web-130mm x 20mm and overall depth -150 mm about an axis passing through its C.G. and parallel to XX-axis.**		
	Ans.	**Area calculation-** $a_1 = 150 \times 20$ $= 3000 mm^2$ $a_2 = 20 \times 130$ $= 2600 mm^2$ 		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4.		$y_1 = 10mm$ $y_2 = 20 + \frac{130}{2} = 85mm$ $\bar{y} = \frac{a_1y_1 + a_2y_2}{a_1 + a_2} = \frac{3000\times10 + 2600\times85}{3000+2600}$ $= \frac{30000+221000}{5600}$ $= 44.82mm\ from\ Top$	01	
		$Ixx = Ixx_1 + Ixx_2$ $Ixx_1 = I_{G1} + a_1h_1^2$ $= \frac{1}{12}\times b_1d_1^3 + a_1h_1^2$ $= \frac{1}{12}\times150\times20^3 + 3000\times(44.82-10)^2$ $= 3.74\times10^6 mm^4$	01	04
		$Ixx_2 = I_{G2} + a_2h_2^2$ $= \frac{1}{12}\times20\times130^3 + 2600\times(105.12-65)^2$ $= 7.85\times10^6 mm^4$	01	
		$Ixx = Ixx_1 + Ixx_2$ $= 3.74\times10^6 + 7.85\times10^6$ $= 11.59\times10^6 mm^4$	01	
	(d)	**Calculate M.I for a triangle of height 100 mm about axis passing through vertex and parallel to base. If M.I about the base is $10^7 mm^4$.**		
	Ans.			

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
4.		$I_{Base} = I_{BC} = b \times \frac{h^3}{12}$		
		$10^7 = b \times \frac{100^3}{12}$	01	
		$b = \frac{10^7 \times 12}{100^3} = 120 mm$	01	04
		$I_{apex} = I_{PQ} = b \times \frac{h^3}{4}$	01	
		$= 120 \times \frac{100^3}{4}$	01	
		$I_{PQ} = 30 \times 10^6 mm^4$		
	e)	**State any four assumptions in the theory of simple bending.**		
	Ans.	1. The martial of the beam homogeneous and isotropic i.e. the beam made of the same material throughout and it has the elastic properties in all the directions. 2. The beam is straight before loading and is of uniform cross section throughout. 3. The beam material is stressed within its elastic limit and this obeys Hooke's law 4. The transverse sections which where plane before bending remain plane after bending. 5. The beam is subjected to pure bending i.e. the effect of shear stress is totally neglected. 6. Each layer of the beam is free to expand or contact independently of the layer above or below it. **7.** Young's modulus E for the material has the same value in tension and compression**.**	**1 Mark each (Any four)**	04
	(f)	**Draw shear stress distribution diagram for hollow rectangular and symmetrical I-section.**		

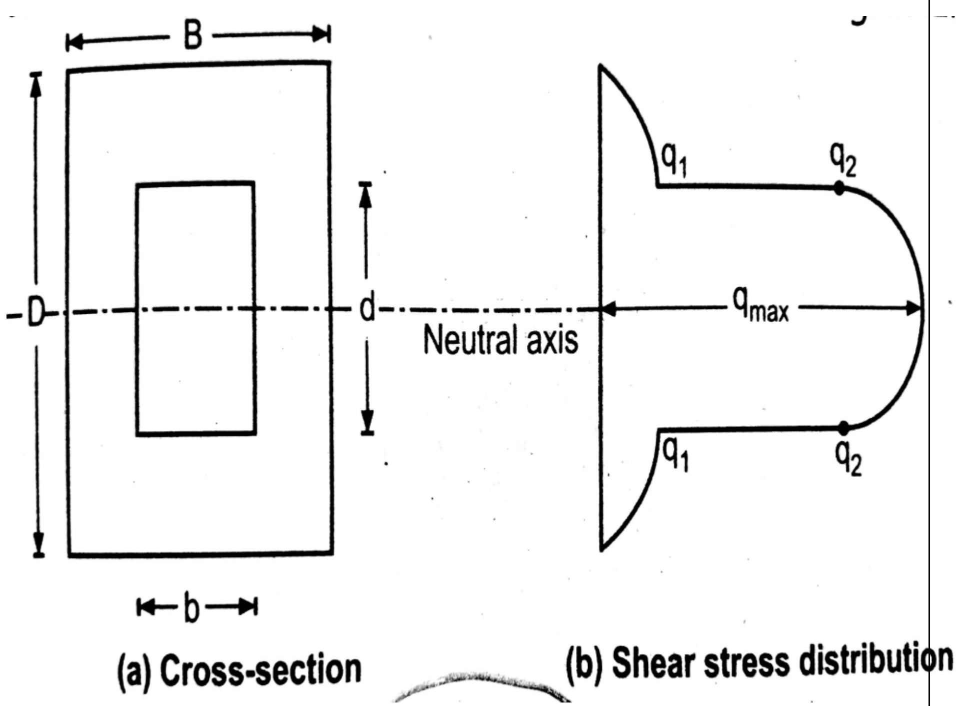
<table>
<tr><th>Que. No.</th><th>Sub. Que.</th><th>Model Answers</th><th>Marks</th><th>Total Marks</th></tr>
<tr><td>4.</td><td>Ans.</td><td>

Fig. Stress distribution diagram for Hollow Rectangular

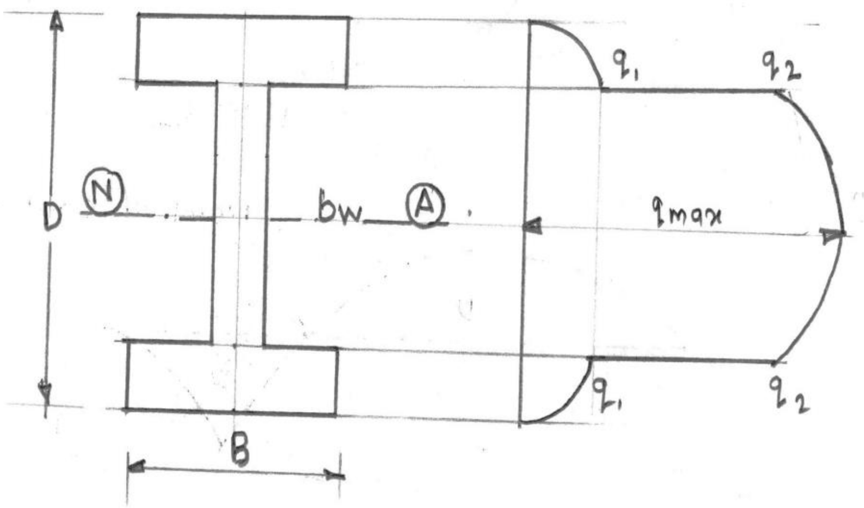
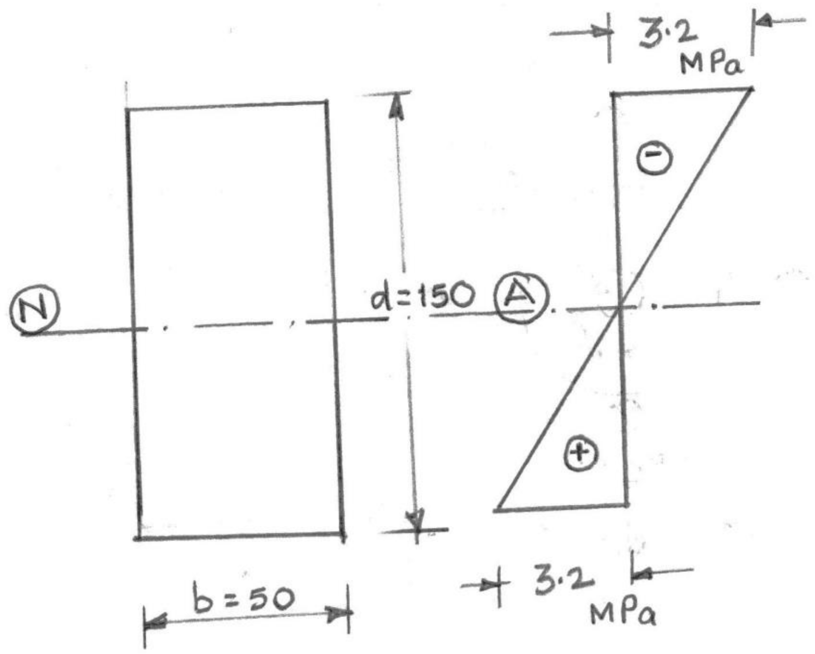
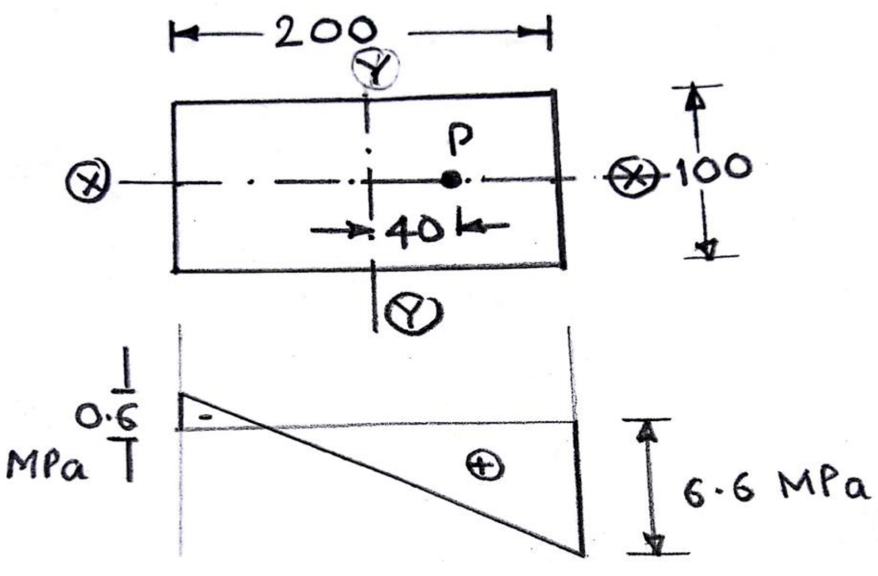


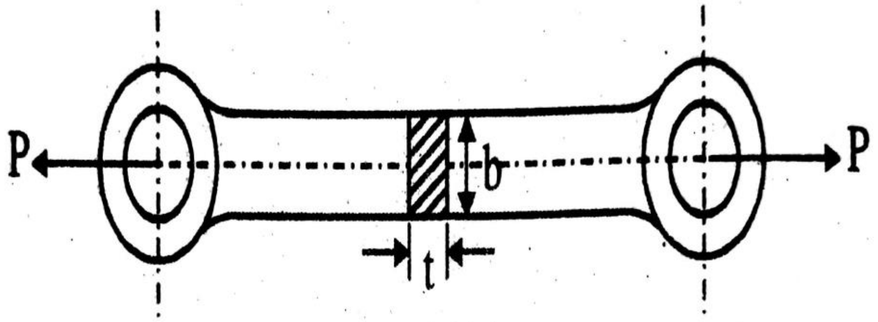
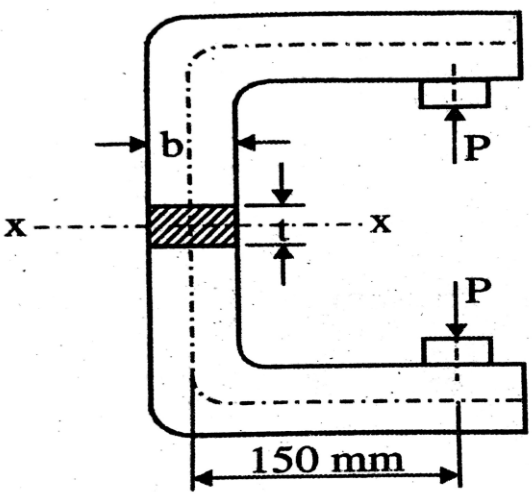
Fig. Stress distribution diagram for Symmetrical I-section</td><td>02

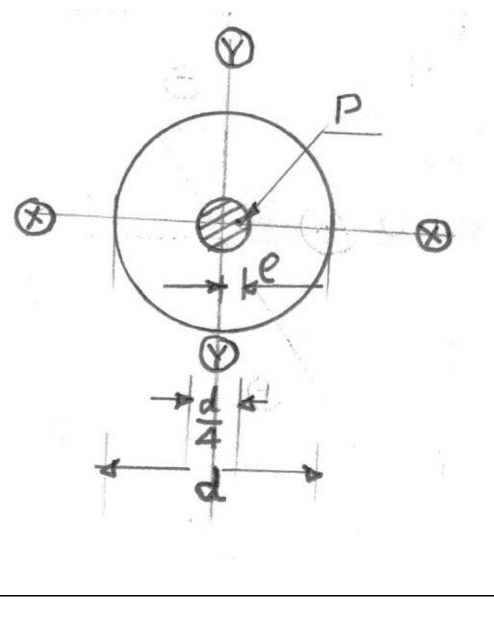
02</td><td>02</td></tr>
</table>

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5.		**Attempt any FOUR of the following:**		**(16)**
	(a)	**Determine the maximum bending stress developed in a bean of rectangular cross-section 50mm x 150 mm when a bending moment of 600N-m is applied about XX-axis.**		
	Ans.	*Given* data: Rectangular secton is given $b = 50mm, d = 150mm, M = 600N.m = 600 \times 10^3 N.mm$		
		Step i) $I_{xx} = \frac{bd^3}{12} = \frac{50 \times 150^3}{12} = 14062500 mm^4$	**01**	
		Step ii) $y = \frac{d}{2} = \frac{150}{2} = 75mm$	**1/2**	
		Step iii) *Using* the relation, $\frac{M}{I} = \frac{\sigma}{y}$	**01**	**04**
		$\frac{600 \times 10^3}{14062500} = \frac{\sigma}{75}$	**1/2**	
		$\sigma = 3.2 N/mm^2$	**01**	
				

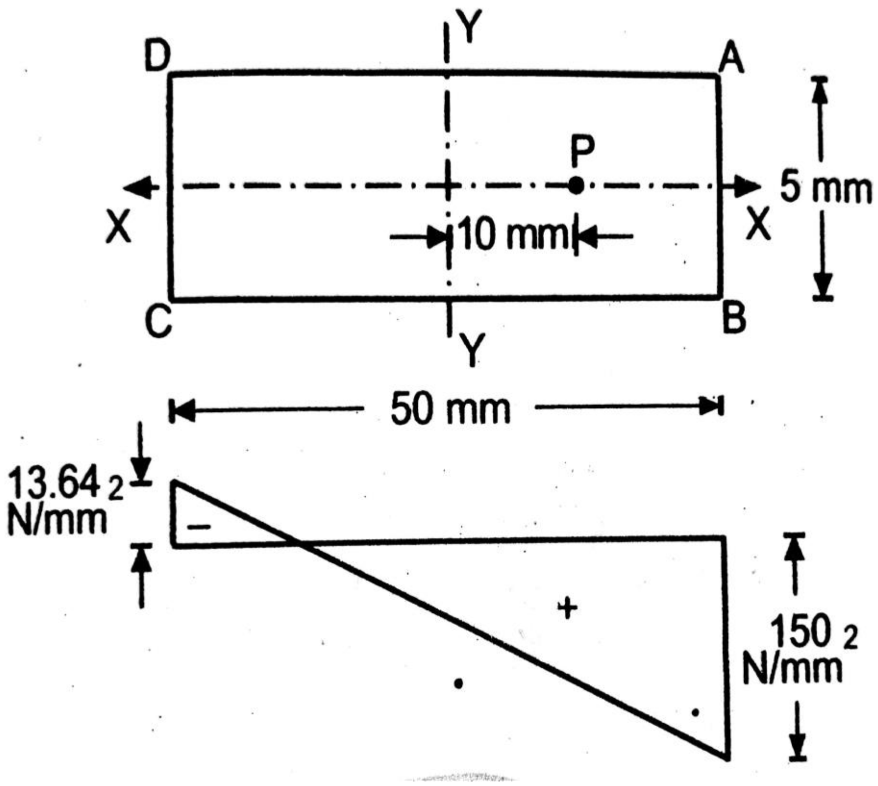
Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5.	(b)	**A short column 200mm x 100mm is subjected to an eccentric load of 60kN at an eccentricity of 40mm in the plane bisecting the 100mm side. Find the maximum and minimum intensities of stress at the base.**		
	Ans.	*Given* data: b=200mm, d=100mm, P=60kN, e=40mm. $A = b\times d = 200\times 150 = 2\times 10^4\, mm^2$		
		$\sigma_o = \frac{P}{A} = \frac{60\times 10^3}{2\times 10^2} = 3 N/mm^2$	01	
		$\sigma_b = \frac{M}{Z_{yy}} = \frac{P\times e}{\frac{db^2}{6}} = 3.6 N/mm^2$	02	04
		$\sigma_{max} = \sigma_o + \sigma_b = 3 + 3.6 = 6.6 N/mm^2 (Compressive)$	1/2	
		$\sigma_{min} = \sigma_o - \sigma_b = 3 - 3.6 = -0.6 N/mm^2 (Tensile)$	1/2	



Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5.	(c) Ans.	**A M.S. link as shown in Fig. 2 transmits a pull of 80kN. Find the dimension b and f if b=3t. Assume the permissible tensile stress as 70 MPa.**  let b and t in mm $A = t\times b = t\times 3t = 3t^2$ $\sigma = \frac{P}{A} = \left(\frac{80\times10^3}{3t^2}\right)$ $= 70MPa = 70\ N/mm^2$ $\left(\frac{80\times10^3}{3t^2}\right) = 70$ $t = 19.52mm\ Say\ 20mm$ $b = 3t = 60mm$	 01 01 01 01	 04
	(d) Ans.	**A C-clamp as shown in Fig. 3, carries a load P=25kN. The cross-section of the clamp at X-X is rectangular, having width equal to twice thickness. Assuming that the C-clamp is made of steel casting with an allowable stress of 100N/mm^2. Find its dimension.**  		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5.		*Given* data, b=2t, $\sigma = 100 N/mm^2, e = 150 mm, P = 25 kN = 25\times10^3 N$ $A = b\times t = 2t\times t = 2t^2 mm^2$ $\sigma = \left(\frac{25\times10^3}{2t^2}\right) = \frac{12500}{t^2} N/mm^2$ $M = (25\times10^3)\times150 = 3750\times10^3 N.mm$ $Z = \frac{t\times b^2}{6} = \frac{2}{3}t^3 N.mm$ $\sigma_b = \frac{M}{Z} = \frac{3750\times10^3}{\frac{2}{3}t^3} = \frac{5625\times10^3}{t^3} N/mm^2$ $\sigma_{max} = \sigma_o + \sigma_b = \frac{12500}{t^2} + \frac{5625\times10^3}{t^3}$ $100 = \frac{12500}{t^2} + \frac{5625\times10^3}{t^3}$ $100t^3 - 12500t - 56250 = 0$ by trail and error $t = 39.4 mm$ i.e. $40 mm$ $b = 2t = 78.8 mm$ say $80 mm$	½ 02 01 1/2	04
	(e)	**A circular section of diameter'd' is subjected to load 'p' eccentric to the axis YY. The eccentricity of load is 'e'. Obtain the limit of eccentricity such that no tension is induced at the section.**		
	Ans.	**Let us consider a solid circular section of diameter d as shown.** 		

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5.		*Section* modulus, $Z = Z_{xx} = Z_{YY}$ $= \frac{I}{y} = \frac{\frac{\pi}{64}d^4}{\frac{d}{2}} = \frac{\pi}{32}d^3$	01	
		Area of section, $A = \frac{\pi}{4}d^2$ *For no tension condition,* $\sigma_0 = \sigma_b$	01	
		$\frac{P}{A} = \frac{M}{Z_{YY}}$ $\frac{P}{A} = \frac{P \times e}{\left(\frac{I_{YY}}{Y}\right)}$ $e = \frac{1}{A} \times \left(\frac{I_{YY}}{Y}\right) = \left(\frac{1}{\frac{\pi}{4}d^2}\right) \times \left(\frac{\pi}{32}d^3\right)$	01	04
		$e = \frac{d}{8}$ $2e = \frac{2d}{8} = \frac{d}{4}$ For no tension condition load must lie within a circle diameter $2e = \frac{d}{4}$	01	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
5.	(f)	**A M.S. flat 50mm wide and 5 mm thick is subjected to load 'p' acting in a plane bisecting thickness at a point 10mm away from the centroid of the section. If the tensile is not to exceed 150 MPa, calculate the magnitude of 'p'.**		
	Ans.	Given data:		
		$b=50mm,\ d=5mm,\ e=10mm,\ \sigma_{max}=150MPa(Tensile)$		
		$\sigma_o=\frac{P}{A}=\frac{P}{250}$	01	
		$\sigma_b=\frac{M}{Z_{yy}}=\frac{P\times e}{\frac{db^2}{6}}=\frac{6P\times e}{db^2}$	01	
		$\sigma_b=0.0048\,P$	01	04
		$\sigma_{max}=\sigma_o+\sigma_b$		
		$150=\frac{P}{250}+0.0048\,P$		
		$P=17045.45N$ $P=17.045kN$	01	
				

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6.		**Attempt any FOUR of the following.**		**(16)**
	(a)	**State any four assumptions made in the theory of pure torsion.**		
	Ans.	In deriving the torsional formula, we make the following assumptions: 1. The shaft is straight having uniform circular cross-section. 2. The shaft is homogeneous and isotropic. 3. Circular sections remain circular even after twisting. 4. Plain section before twisting remain plain after twisting and do not twist or wrap. 5. A diameter in the section before determination remains a diameter or straight line after deformation. 6. Stresses do not exceed the proportional limit. 7. Shaft is loaded by twisting couples in the planes are perpendicular to the axis of the shaft. 8. Twist along the shaft is uniform.	**1 Mark each (Any four)**	**04**
	(b)	**A solid circular shaft of 100mm diameter is transmitting power 100kW at 150 rpm. Find the intensity of the induced shear stress in the shaft.**		
	Ans.	Given data, Solid shaft, $D = 100mm$, $P = 100kW = 100\times10^3 W$, $N = 150$ r.p.m		
		i) $P = \frac{2\pi NT}{60}$	**01**	
		$100\times10^3 = \frac{2\times\pi\times150\times T}{60}$ $T = 6366.1977\ Nm$	**01**	
		$T = 6366.1977\times10^3 N.mm$		**04**
		ii) $T = \frac{\pi}{16} f_s D^3$	**01**	
		$6366.1977\times10^3 = \frac{\pi}{16} f_s (100)^3$		
		$f_s = 32.42 N/mm^2$	**01**	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6.	(c)	**A hollow shaft is of external diameter and internal diameter 400mm and 200mm respectively. Find the maximum torque is can transmit, if the angle of twist is not exceed 150^0in a length of 10m. Take $C=0.8x15^5 N/mm^2$.**		
	Ans.	**Given-** D = 400mm, d = 200mm, L = 10m, $C=0.8x15^5\ N/mm^2$		
		$\theta = 150^0 = \left(150 \times \frac{\pi}{180}\right) = 2.618\ rad$	01	
		$\frac{T}{I_p} = \frac{C\theta}{L}$	01	04
		$T = I_p \frac{C\theta}{L}$	01	
		$= \frac{\pi}{32}(D^4 - d^4)\frac{C\theta}{L}$ $= \frac{\pi}{32}(400^4 - 200^4) \times \frac{0.8 \times 10^5 \times 2.618}{10 \times 10^3}$ $= 4.93 \times 10^{10} N-mm$	01	
	(d)	**Find the power transmitted by a solid shaft of 60mm diameter running at 220 rpm, if the permissible shear is 68 MPa. The maximum torque is likely to exceed the mean torque by 25%.**		
	Ans.	**Given- d=60mm, N=220rpm, fs=68 MPa, T_{max}=1.25Tmean** $T\max = \frac{\Pi}{16} \times fs \times D^3$ $= \frac{\Pi}{16} \times 68 \times (60)^3$ =2883982.056 N.mm =2883.982 N.m		
		$Tmean = \frac{T\max}{1.25} = \frac{2883.982}{1.25} = 2307.185 N.m$	02	
		$P = \frac{2\Pi N Tmean}{60} = \frac{2\Pi \times 220 \times 2307.185}{60}$ =53153.74 W **P =53.154 KW**	02	04

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
6.	(e)	**A hollow shaft is required to transmit a torque of 36kN-m. The inside diameter is 0.6 times the external diameter. Calculate both diameters, if the allowable shear stress is 80 MPa.**		
	Ans.	**Given:- T = 36 kN.m , fs = 80 N/mm^2 , d = 0.6D**		
		$T=\frac{\Pi}{16}\times fs\times\left(\frac{D^4-d^4}{D}\right)$	01	
		$36\times10^6=\frac{\Pi}{16}\times80\times\left(\frac{D^4-(0.6D)^4}{D}\right)$	01	
		$36\times10^6=\frac{\Pi}{16}\times80\times\left(0.8704D^3\right)$		04
		$D^3=2633078.103$	01	
		$D=138.08mm$		
		$d=82.85mm$	01	
	(f)	**i) Write the flexural formula. State the meaning of each term.** **ii) Compare solid shaft and hollow shaft.**		
	Ans.	**Flexural formula: -**		
		$\frac{M}{I}=\frac{\sigma}{y}=\frac{E}{R}$	01	
		Where, $M=$ Maximum bending moment which is equal to moment of resistance of a beam $I=$ Moment of inertia of the beam section about the neutral axis $\sigma=$ Bending stress in layer at a distance 'y' from N.A. $y=$ Distance of the layer from N.A. of the beam cross section $E=$ Modulus of elasticity of the beam material $R=$ Radius of curvature of a bent of beam	01	

Que. No.	Sub. Que.	Model Answers	Marks	Total Marks
		(table below)	02	04

Sr. No	Parameter	Solid shaft	Hollow shaft
1	Polar MI	$I_p = \frac{\pi}{32} x (D)^4$	$\frac{\pi}{32} X \frac{(D^4 - d^4)}{D}$
2	Polar Modulus	$Z_p = \frac{\pi}{16} X D^3$	$\frac{\pi}{16} X (D^4 - d^4)$
3	Torque Transmitted	$T = \frac{\pi}{16} F_s D^3$	$T = \frac{\pi}{16} F_s \left(\frac{D^4 - d^4}{D}\right)$
4	Stiffness	Solid shaft has less strength and stiffness than a hollow shaft.	Hollow shaft has greater strength and stiffness than a solid shaft.
