(17)

Scoring indicators

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Qs No	Scoring indicators	Split score	Total score
I 1.	It states, If a number of coplanar forces are acting simultaneously on a particle, the algebraic sum of the moments of all the forces about any point is equal to the moment of their resultant force about the same point.	2	
2.	The point through which the whole weight of the body acts irrespect of it's position is known as centre of gravity. It is written as C.G.	2	
3.	It states, when a material is loaded, within it's elastic limit the stress is proportional to strain. $\frac{\text{Stress}}{\text{Strain}} = E = \text{Constant}$.	2	
4.	whenever a cylindrical shell is subjected to an internal pressure, it's walls are subjected to tensile stresses. Due to the internal pressure, the cylinder has a tendency to split up into two troughs, corresponding stress is called circumferential stress.	2	

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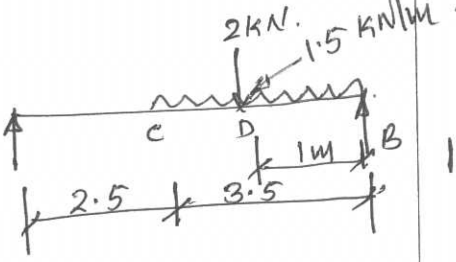
	Due to the internal pressure, the cylinder has a tendency to split up into two pieces, the stress is called longitudinal stress.		
5.	Section modulus is defined as the ratio of moment of inertia to the distance between the CG of the section and the extreme fibre of the stress. It is denoted as 'Z' $Z = I/y_{max}$.	2	10
II 1.	$l = 6m$. udl = 1.5 kN/m. Point load = 2 kN.  Total load, $R_A + R_B = 2 + 1.5 \times 3.5 = 7.25$ kN.	1	
	Taking moment about A. $R_B \times 6 = 1.5 \times 3.5 \times (3.5/2 + 2.5) + (2 \times 5)$	1	
	$R_B = 5.38$ kN.	2	
	$R_A = 1.87$ kN.	2	6
2.	Moment of Inertia:- Moment of a force, is the product of force and perpendicular distance between the point and the line of action of the force. This moment is again multiplied by the	2	

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	perpendicular distance between the point and line of action of the force, this is called moment of Inertia.		
	(2) Polar moment of Inertia:- The moment of Inertia of a plane area, with respect to an axis perpendicular to the plane of the figure is called polar moment of Inertia.	2	
	(3) Radius of gyration:- It is the ratio of square root of moment of Inertia to the area of cross section. $k = \sqrt{I/A}$.	2	6
3.	1. Strength 2. Stiffness 3. Elasticity 4. plasticity 5. Ductility 6. Malleability 7. Brittleness 8. Toughness 9. Hardness 1x6=6	6	6

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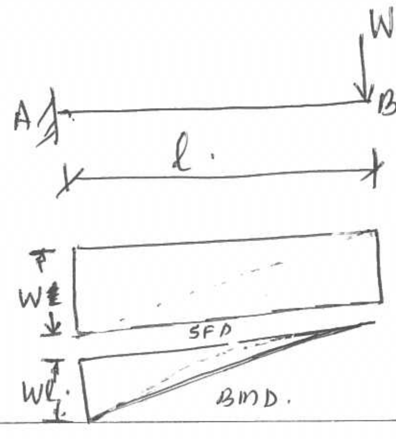
4.	(1) Poisson's ratio:- It is the ratio of lateral strain to the linear strain, $\frac{\text{lateral strain}}{\text{linear strain}}$ = constant. This constant is known as poisson's ratio. It is denoted by $1/m$ or μ	2	
	(2) Bulk modulus: It is the ratio of Direct stress to the volumetric strain. It is denoted as K. $K = \frac{\text{Direct stress}}{\text{Volumetric strain}} = \frac{\sigma}{\delta V/V}$.	2	
	(3) Modulus of rigidity:- within the elastic limit shear stress is proportional to shear strain. It is denoted as 'C' $\tau \propto \phi$ $\tau = C\phi$. $C = \tau/\phi$.	2	6
5.	SF at B = W. " A = W. BM at B = 0 " A = Wl. 	3 3	6

Scoring indicators

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Qs No	Scoring indicators	Split score	Total score
6	(1). The material of the shaft is homogeneous and isotropic. 2. The twist along the shaft is uniform. 3. Circular sections remains circular after loading 4. Cross sections of the shaft which are plane before twist remains plane after twist 5. Hooke's law is applicable with shear stress being proportional to the shearing strain. any four (1½ x4 =6)		6
7	(1) The material of the beam is homogeneous and isotropic (2) The beam material is stressed within its elastic limit. (3) The transverse sections which were plane before bending, remains plane after bending (4) Each layer of the beam is free to expand or contract (5) The value of 'E' is the same in tension and compression. (6) The beam is in equilibrium, any four (1½x4=6)		6

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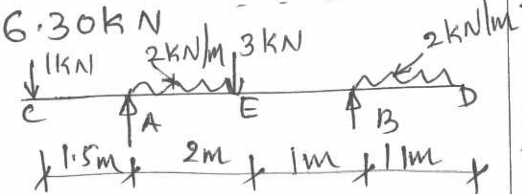
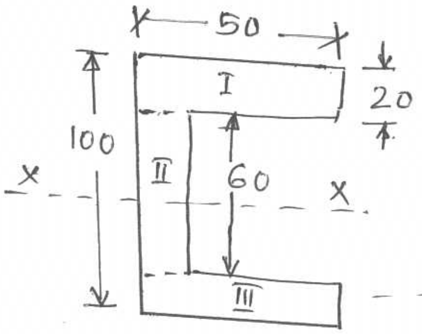
Qs No	Scoring indicators	Split score	Total score
III a.	$R_A + R_B = 1 + (2\times2) + 3 + (2\times1) = 10\,kN.$		
	Taking moment about A.		
	$R_B \times 3 = 2\times1\times(1/2+3) + (3\times2) + 2\times2\times 2/2 - 1\times1.5$	2	
	$R_B = \frac{10.5+6+4-1.5}{3} = 6.30\,kN$	2	
		2	
	$R_A = 10 - 6.3 = 3.7\,kN.$	2	8
(b)	$a_1 = 50\times20 = 1000\,mm^2$		
	$x_1 = \frac{50}{2} = 25\,mm.$		
	$a_2 = 60\times20 = 1200\,mm^2$		
	$x_2 = \frac{20}{2} = 10\,mm.$		
		1	
	$a_3 = 50\times20 = 1000\,mm^2$		
	$x_3 = 50/2 = 25\,mm.$ — $1/2\times6 = 3$		
	$\bar{x} = \frac{a_1x_1 + a_2x_2 + a_3x_3}{a_1+a_2+a_3}$	2	
	$= \frac{(1000\times25)+(1200\times10)+(1000\times25)}{1000+1200+1000} = 19.4\,mm$	1	7
IV (a).	$a_1 = 100\times50 = 5000\,mm^2$		
	$y_1 = 100 + 50/2 = 125\,mm$		
	$a_2 = 100\times50 = 5000\,mm^2$		
	$y_2 = 100/2 = 50\,mm.$		

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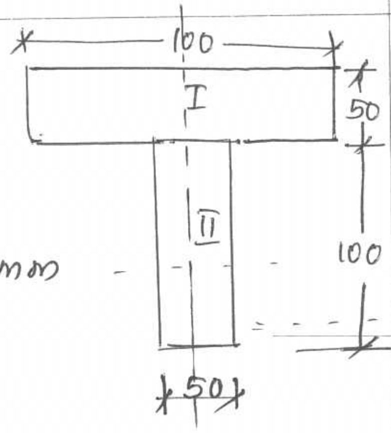
Qs No	Scoring indicators	Split score	Total score
	$\bar{y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2}$	1	
	$= \frac{(5000 \times 125) + (5000 \times 50)}{5000 + 5000} = 87.5\,mm$	1	
		1	
	MI about x-x axis		
	$I_{xx} = I_{cg} + a h^2$	1	
	$I_{xx} = I_{xx_1} + I_{xx_2}$		
	$I_{xx_1} = I_{cg_1} + a_1 h_1^2$		
	$I_{cg_1} = \frac{bd^3}{12} = \frac{100 \times 50^3}{12} = 1041\,666.667\,mm^4$		
	$h_1 = y_1 - \bar{y} = 125 - 87.5 = 37.5$		
	$I_{cg_2} = \frac{50 \times 100^3}{12} = 4166666.667\,mm^4$		
	$h_2 = y_2 - \bar{y} = 87.5 - 50 = 37.5$		
	$I_{xx_1} = 1041666.667 + (5000 \times 37.5^2) = 8072916.667\,mm^4$		
	$I_{xx_2} = 4166\,666.667 + (5000 \times 37.5^2) = 11197916.67\,mm^4$		
	$I_{xx} = 19.27 \times 10^6\,mm^4.$	2	
	MI about YY axis.		
	$I_{yy_1} = db^3/12 = \frac{50 \times 100^3}{12} = 4166666.667\,mm^4$		
	$I_{yy_2} = \frac{100 \times 50^3}{12} = 1041666.667\,mm^4$		
	$I_{YY} = I_{YY_1} + I_{YY_2} = 5.2 \times 10^6\,mm^4$	2	8

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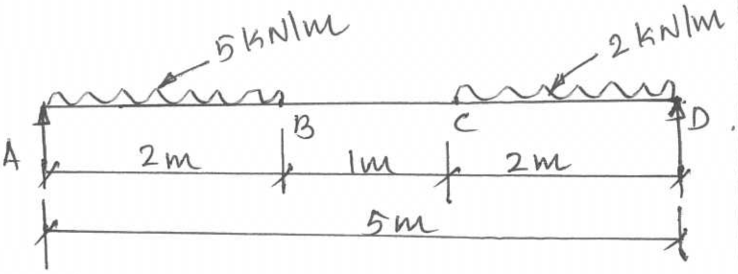
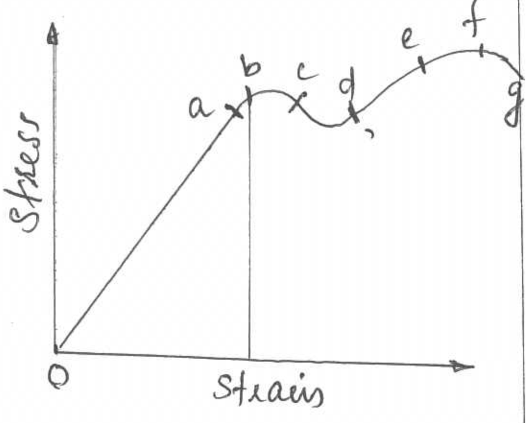
Qs No	Scoring indicators	Split score	Total score
(b)		2	
	$R_A + R_D = (5\times2) + (2\times2) = 14$ kN.	1	
	Taking moment about A,		
	$R_D \times 5 = 2\times2\times(2/2+3) + 5\times2\times2/2$		
	$R_D = \frac{16+10}{5} = 5.2$ kN.	2	
	$R_A = 14 - 5.2 = 8.8$ kN.	2	7
V (a)	(a) limit of proportionality – ie stress strain relation is linear		
	(b) Elastic limit – material retain elasticity		
		2	
	(c) upper yield point – the point at which material yields and yield stress is the lowest stress at which material is appreciably deformed without increase of load.		
	(d) lower yield point – material enters ductile stage. any four – $1\frac{1}{2}\times4 = 6$		8

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Qs No	Scoring indicators	Split score	Total score
	d.e.f. – This is the stage of ductility ecom plasticity		
	g – specimen breaks.		
(b)	$d = 20mm$		
	$l = 2m = 2\times10^3 mm$.		
	$P = 50 kN$.		
	$E = 2\times10^5 N/mm^2$		
	(1) Maximum instantaneous stress,		
	$A = \frac{\pi}{4}(d)^2 = \frac{\pi}{4}(20)^2 = 314 mm^2$		
	$\sigma max = \frac{2P}{A} = \frac{2\times50\times10^3}{314} = 318.47 N/mm^2$	2	
	(2) work done at maximum elongation.		
	$\delta l = \frac{\sigma max . l}{E} = \frac{318.47\times2\times10^3}{2\times10^5} = 3.18 mm$.	1	
	work done $= P\times\delta l = 50\times10^3\times3.18 = 159\times10^3 Nmm$.		
	$= 159 kN.mm$.	2	
	(3) Maximum dynamic force,		
	$= A\times\sigma max = 314\times318.47 = 99999.58N$		
	$= 99.99\times10^3 N$		
	$= 100 kN$.	2	7

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Qs No	Scoring indicators	Split score	Total score
VI (a).	$d = 20\,mm$		
	$P = 40\,KN = 40\times10^3\,N.$		
	$l = 150\,mm.$		
	$\delta l = 0.08$		
	$\delta d = 0.0029$		
	Poisson's ratio ($1/m$).		
	linear strain $= \frac{\delta l}{l} = \frac{0.08}{150} = 0.00053$		
	lateral strain $= \frac{\delta d}{d} = \frac{0.0029}{20} = 0.00014$		
	Poisson's ratio $= 1/m = \frac{\text{lateral strain}}{\text{linear strain}}$	1	
	$= \frac{0.00014}{0.00053} = 0.274$	1	
	Young's modulus, E.		
	$\delta l = \frac{Pl}{AE}.$	1	
	$0.08 = \frac{40\times10^3\times150}{\frac{\pi}{4}(20)^2\times E}.$		
	$\therefore E = 238.853\times10^3 = 2.38\times10^5\,N/mm^2.$	1	
	Modulus of rigidity		
	$C = \frac{m.E}{2(m+1)}$	1	

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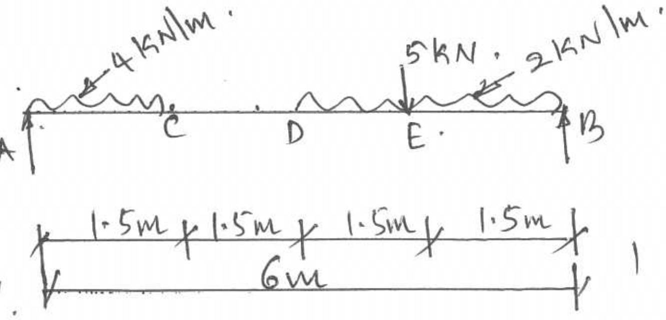
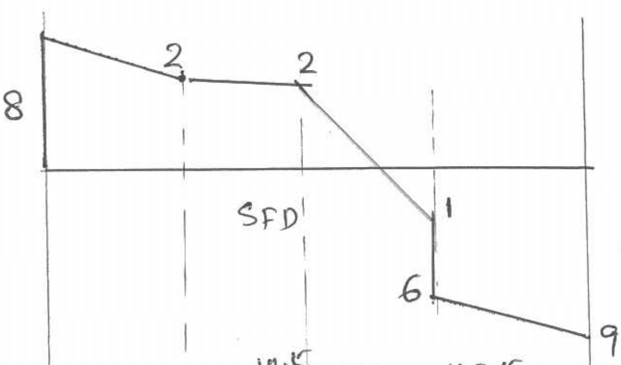
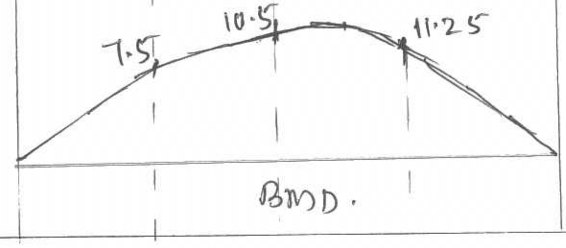
	$\frac{1}{m} = 0.274$, $m = \frac{1}{0.274} = 3.649.$		
	$C = \frac{3.649 \times 238.853 \times 10^3}{2(3.649+1)} = 93.737 \times 10^3\ N/mm^2$ $= 93.73\ GPa$	1	
	Bulk modulus, (K.). $K = \frac{m \cdot E}{3(m-2)}$	1	
	$= \frac{3.649 \cdot 238.853 \times 10^3}{3(3.649-2)} = 176.182 \times 10^3\ N/mm^2$ $= 176.182\ GPa.$	1	8
VIII (a).			
	$RA + RB = (4 \times 1.5) + 5 + (2 \times 3) = 17\ kN.$	1	
		3	
		3	[illegible]

Qs No	Scoring indicators	Split score	Total score
	Taking moment about A.		
	$R_B \times 6 = 5 \times 4.5 + 2 \times 3 (3/2 + 3) + 4 \times 1.5 \times 1.5/2$		
	$R_B = 9$ kN	1	
	$R_A = 8$ kN	1	
	shear force		
	SF at A, $F_A = +R_A = +8$ kN.		
	$F_C = +8 - 4 \times 1.5 = +2$ kN		
	$F_D = +2$ kN		
	$F_E = +2 - 2 \times 1.5 = -1$ kN		
	$F_E' = -1 - 5 = -6$ kN.		
	$F_B = -6 - 2 \times 1.5 = -9$ kN.		
	Bending moment,		
	BM at A, $M_A = 0$.		
	$M_C = 8 \times 1.5 - 4 \times 1.5 \times \frac{1.5}{2} = 7.5$ kNm.		
	$M_D = 8 \times 3 - 4 \times 1.5 \times (1.5/2 + 1.5) = 10.5$ kNm		
	$M_E = 9 \times 1.5 - 2 \times 1.5 \times 1.5/2 = 11.25$ kNm.		9
	$M_B = 0$.		
VII (b).	$d = 1000$ mm		
	$t = 20$ mm		
	$l = 2$ m $= 2 \times 10^3$ mm.		
	$p = 5$ N/mm^2.		

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Qs No	Scoring indicators	Split score	Total score
	Circumferential stress, $\sigma_c = \frac{pd}{2t}$	2	
	$= \frac{5 \times 1000}{2 \times 20} = 125$ MPa.	1	
	longitudinal stress, $\sigma_l = \frac{pd}{4t}$	2	
	$= \frac{5 \times 1000}{4 \times 20} = 62.5$ MPa.	1	6
VIII (a).	$d = 250$ mm $l = 1$ m $= 1 \times 10^3$ mm $t = 8$ mm $P = 2$ MPa $= 2$ N/mm^2 $E = 200$ GPa $= 2 \times 10^5$ N/mm^2 $\frac{1}{m} = 0.30$		
	Circumferential strain, $\varepsilon_c = \frac{pd}{2tE}\left[1 - \frac{1}{2m}\right]$.	2	
	$= \frac{2 \times 250}{2 \times 8 \times 2 \times 10^5}\left[1 - \frac{1}{2} \times 0.30\right]$.		
	$= 1.32 \times 10^{-4}$	1	
	longitudinal strain, $\varepsilon_l = \frac{pd}{2tE}\left(\frac{1}{2} - \frac{1}{m}\right)$.	2	
	$= \frac{2 \times 250}{2 \times 8 \times 2 \times 10^5}\left[\frac{1}{2} - 0.3\right]$		
	$= 0.3 \times 10^{-4}$	1	

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	Original volume, $V = \frac{\pi}{4}(d^2) \times l$		
	$= \frac{\pi}{4}(250)^2 \times 1000 = 49.06 \times 10^6 mm^3$		
	Change in volume $= \delta V = V(\varepsilon_l + 2\varepsilon_c)$	2	
	$= 49.06 \times 10^6 (0.3 \times 10^{-4} + 2 \times 1.32 \times 10^{-4})$		
	$= 14.228 \times 10^3 mm^3$	1	9
VIII (b)	$d = 80 mm$		
	$N = 120 rpm$		
	$\tau = 40 N/mm^2$		
	Torque, $T = \frac{\pi}{16} \tau D^3$	2	
	$= \frac{\pi}{4}(40 \times 80^3) = 4.019 kN \cdot m$	1	
	Power, $P = \frac{2\pi NT}{60}$	1	
	$= \frac{2 \times 3.14 \times 120 \times 4.019}{60} = 50.47 kW$	2	6
IX (a)	$D = 400 mm$		
	$B = 220 mm$		
	$b_w = 12.5 mm$		
	$D_f = 25 mm$		
	$F = 250 kN$		
	$I_{xx} = \frac{bd^3}{12} = \frac{220 \times 400^3}{12} - \frac{207.5 \times 350^3}{12} = 431.95 \times 10^6 mm^4$	1	

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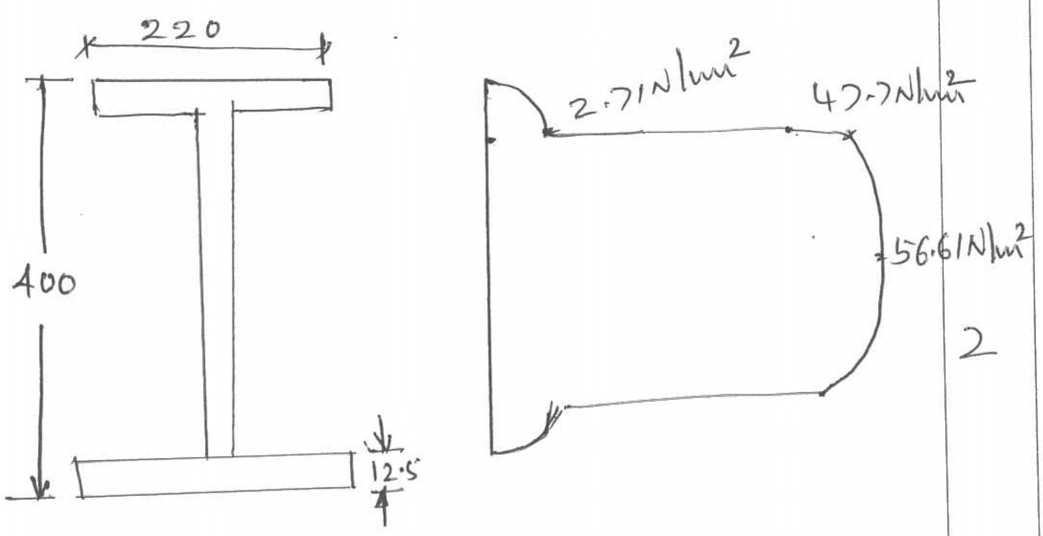
Qs No	Scoring indicators	Split score	Total score
	Shear stress in the upper edge of the upper flange = 0		
	Shear stress at the point of upper flange and web, $= \frac{F}{8I}\left[D^2 - d^2\right]$.	2	
	$= \frac{250 \times 10^3}{8 \times 431.95 \times 10^6}\left[400^2 - 350^2\right] = 2.71\ N/mm^2$	1	
	Shear stress at the junction $= 2.71 \times \frac{220}{12.5}$		
	$= 47.7\ N/mm^2$		
	Max. shear stress, $\tau_{max} = \frac{F}{Ib}\left[\frac{B}{8}(D^2 - d^2) + \frac{bd^2}{8}\right]$	2	
	$= \frac{250 \times 10^3}{431.95 \times 10^6 \times 12.5}\left[\frac{220}{8}(400^2 - 350^2) + \frac{12.5 \times 350^2}{8}\right]$.		
	$= 56.61\ N/mm^2$	1	
		2	9

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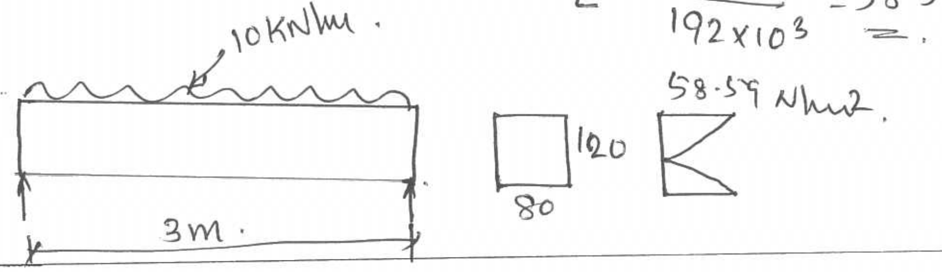
Qs No	Scoring indicators	Split score	Total score
IX b.	$d = 3\,mm$		
	$\sigma_b = 80\,MPa = 80\,N/mm^2$		
	$E = 200\,GPa = 2\times10^5\,N/mm^2$		
	$\frac{\sigma_b}{y} = \frac{E}{R}$.	2	
	Radius, $R = \frac{E\cdot y}{\sigma_b}$.		
	$y = d/2 = 3/2 = 1.5\,mm$.	1	
	$R = \frac{2\times10^5\times1.5}{80} = 3750\,mm = 3.75\,m$.	3	6
X(a).	$b = 80\,mm$		
	$d = 120\,mm$		
	$l = 3\,m = 3\times10^3\,mm$.		
	$w = 10\,kN/m$.		
	Max. Bm $= \frac{wl^2}{8} = \frac{10\times3^2}{8} = 11.25\,kNm$.	2	
	Section modulus, $Z = \frac{bd^2}{6} = \frac{80\times120^2}{6} = 192\times10^3\,mm^3$.	2	
	Max. Bending stress, $\sigma_{max} = \frac{M}{Z} = \frac{11.25\times10^6}{192\times10^3} = 58.59\,N/mm^2$	2	
		2	8

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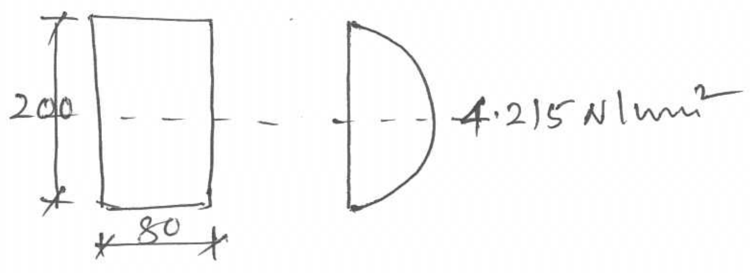
Qs No	Scoring indicators	Split score	Total score
X (b)	b = 80 mm		
	d = 200 mm		
	$l = 3m = 3\times10^3 mm$		
	w = 30 kN/m.		
	Shear force, $F = \frac{wl}{2} = \frac{30\times3}{2} = 45 kN = 45\times10^3 N.$	1	
	Area of Section, $A = b.d = 80\times200 = 16000 mm^2$		
	Average shear stress, $\tau_{av} = \frac{F}{A}.$	1	
	$= \frac{45\times10^3}{16000} = 2.81 N/mm^2$		
	$= 2.81 MPa$	1	
	Max. shear stress $\tau_{max} = 1.5\tau_{av}$.	1	
	$= 1.5\times2.81 = 4.215 N/mm^2$	1	
		2	7