TED (15) – 3013

(REVISION — 2015)

Reg. No. ....

Signature ....

DIPLOMA EXAMINATION IN ENGINEERING/TECHNOLOGY/ MANAGEMENT/COMMERCIAL PRACTICE — APRIL, 2019

THEORY OF STRUCTURES - I

[*Time* : 3 hours

(Maximum marks : 100)

PART — A

(Maximum marks : 10)

Marks

I Answer *all* questions in one or two sentences. Each question carries 2 marks.

1. State the principle of moments.
2. Define centre of gravity.
3. State Hook's law.
4. Define circumferential and longitudinal stress.
5. What do you mean by section modulus ? (5×2 = 10)

PART — B

(Maximum marks : 30)

II Answer any *five* of the following questions. Each question carries 6 marks.

1. A simply supported beam of span 6m carries a uniformly distributed load of 1.5 KN/M over a length of 3.5m from the right support. In addition to a point load of 2KN at a distance of 1m from the right support. Find the support reactions.
2. Define the (a) Moment of Inertia, (b) Polar moment of inertia, and (c) Radius of gyration.
3. List any six mechanical properties of materials.
4. Define the (a) Poisson's ratio, (b) Bulk modulus, and (c) Modulus of rigidity.
5. Draw SFD and BMD for a cantilever beam of length '1' and carrying a point load of 'W' at the free end.
6. State the assumptions in pure torsion.
7. List the assumptions in the theory of simple bending. (5×6 = 30)

Marks

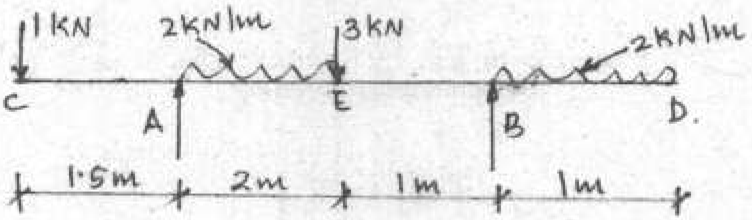
PART — C

(Maximum marks : 60)

(Answer *one* full question from each unit. Each full question carries 15 marks.)

UNIT — I

III (a) Calculate the support reactions of the overhanging beam as shown in figure. 8



(b) Find the Centre of gravity of a channel section 100mm × 50mm × 20mm. 7

OR

IV (a) Find the moment of inertia of a 'T' section with flange as 100mm × 50mm and web as 100mm × 50mm about X-X axis and Y-Y axis through the centre of gravity of the section. 8

(b) A simply supported beam ABCD is of 5m span. Such that AB =2m, BC = 1m and CD =2m. It is loaded with 5KN/m over AB and 2KN/m over CD. Calculate the support reactions. 7

UNIT — II

V (a) Draw and explain the stress strain curve for Mild steel. 8

(b) A steel rod 20mm diameter is 2m long. Find the maximum instantaneous stress and work done at maximum elongation, when an axial load of 50KN is suddenly applied to it. Also calculate the maximum dynamic force in the rod. Take $E = 2 \times 10^5 N/mm^2$. 7

OR

VI (a) In an experiment, a bar of 20mm diameter is subjected to a pull of 40KN. The measured extension on gauge length of 150mm is 0.08mm and change in diameter is 0.0029mm. Calculate the Poisson's ratio, Young's modulus, Modulus of rigidity and Bulk modulus. 9

(b) Define resilience, proof resilience and modulus of resilience. 6

UNIT — III

VII (a) A simply supported beam AB of length 6m, it carries a uniformly distributed load of 4KN/m over a length of 1.5m from left end and 2KN/m over a length of 3m from right end, also it carries a point load of 5KN at a distance of 1.5m from the right end. Draw Shear force and Bending moment diagrams. 9

(b) A cylindrical shell 2m long and lm internal diameter is made up of 20mm thick plates. Find the circumferential and longitudinal stresses in the shell material, if it is subjected to an internal pressure of $5N/mm^2$. 6

OR

Marks

VIII (a) A cylindrical vessel 1m long and 250mm in diameter with 8mm thick plates is subjected to an internal pressure of 2 MPa. Calculate the change in volume in the vessel. Take E = 200GPa and Poisson's ratio 1/m = 0.3. 9

(b) A circular shaft of 80mm diameter is required to transmit power at 120 r.p.m. If the shear stress is not to exceed $40N/mm^2$, find the power transmitted by the shaft. 6

Unit — IV

IX (a) An I section beam 400mm × 200mm has a web thickness of 12.5mm and a flange thickness of 25mm. It carries a shear force of 250KN at a section. Sketch the shear stress distribution across the section. 9

(b) A steel wire of 3mm diameter is to be wound around a circular component. If the bending stress in the wire is limited to 80MPa, find the radius of the component. Take E = 200GPa. 6

Or

X (a) A rectangular beam 80mm wide and 120mm deep is simply supported over a span of 3m. If the beam is subjected to a uniformly distributed load of 10KN/m, find the maximum bending stress induced in the beam section and sketch the stress distribution. 8

(b) A wooden beam 80mm wide, 200mm deep and 3m long is carrying a uniformly distributed load of 30KN/m. Determine the maximum shear stress and sketch the variation of shear stress along the depth of the beam. 7

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Version: A

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. $\frac{Stress}{Strain} = E = Constant.$	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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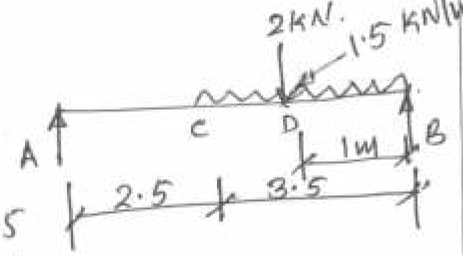
Subject Code : 3013 Version:

Qs No	Scoring indicators	Split score	Total score
	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. $R_A = 1.87$ KN.	2 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	

Qs No	Scoring indicators	Split score	Total score
	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 $1 \times 6 = 6$	6	6

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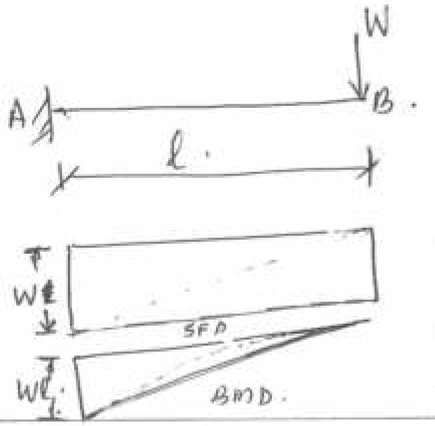
Qs No	Scoring indicators	Split score	Total score
4.	(1) Poisson's ratio:- It is the ratio of lateral strain to the linear strain. $\frac{\text{lateral strain}}{\text{linear strain}}$ = constant. This constant is known as poisson's ratio. It is denoted by $1/m$ or μ	2	
	(2) Bulk modulus: It is the ratio 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

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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

Scoring indicators

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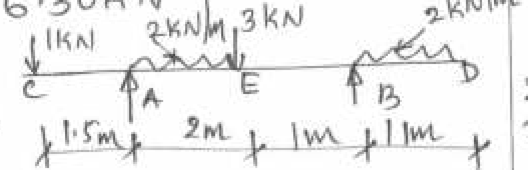
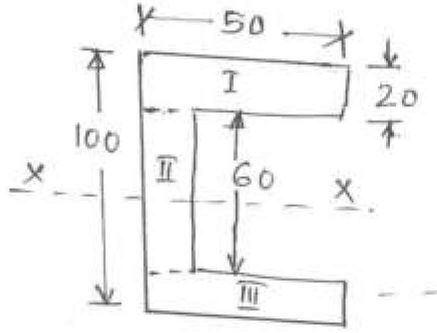
Qs No	Scoring indicators	Split score	Total score
III a.	$R_A + R_B = 1 + (2\times2) + 3 + (2\times1) = 10\,kN.$		
	Taking moment about A.		
	$R_B \times 3 = 2\times1\times(1/2+3) + (3\times2) + 2\times2\times 2/2 - 1\times1.5$	2	
	$R_B = \frac{10.5+6+4-1.5}{3} = 6.30\,kN$	2	
			
	$R_A = 10 - 6.3 = 3.7\,kN.$	2 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	
	$a_3 = 50\times20 = 1000\,mm^2$		
	$x_3 = 50/2 = 25\,mm.$ — $\frac{1}{2}\times6 = 3$		
	$\bar{x} = \frac{a_1x_1 + a_2x_2 + a_3x_3}{a_1+a_2+a_3}$	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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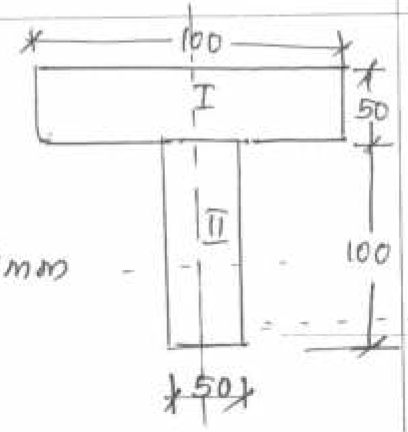
Qs No	Scoring indicators	Split score	Total score
	$\bar{y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2}$ - - - - 	1	
	$= \frac{(5000 \times 125)+(5000 \times 50)}{5000 + 5000} = \underline{87.5\,mm}$	1	
	MI about x-x axis		
	$I_{xx} = I_{ca} + ah^2$ - - - -	1	
	$I_{xx} = I_{xx_1} + I_{xx_2}$		
	$I_{xx_1} = I_{ca_1} + a_1 h_1^2$		
	$I_{ca_1} = \frac{bd^3}{12} = \frac{100 \times 50^3}{12} = 1041\,666.667\,mm^4$		
	$h_1 = y_1 - \bar{y} = 125 - 87.5 = 37.5$		
	$I_{ca_2} = \frac{50 \times 100^3}{12} = 4166666.667\,mm^4$		
	$h_2 = y_2 - \bar{y} = 87.5 - 50 = 37.5$		
	$I_{xx_1} = 1041666.667 + (5000 \times 37.5^2) = 8072916.667\,mm^4$		
	$I_{xx_2} = 4166\,666.667 + (5000 \times 37.5^2) = 11197916.67\,mm^4$		
	$I_{xx} = 19.27 \times 10^6\,mm^4$. - - - -	2	
	MI about YY axis.		
	$I_{yy_1} = db^3/12 = \frac{50 \times 100^3}{12} = 4166666.667\,mm^4$		
	$I_{yy_2} = \frac{100 \times 50^3}{12} = 1041666.667\,mm^4$		
	$I_{YY} = I_{YY_1} + I_{YY_2} = \underline{5.2 \times 10^6}\,mm^4$	2	8

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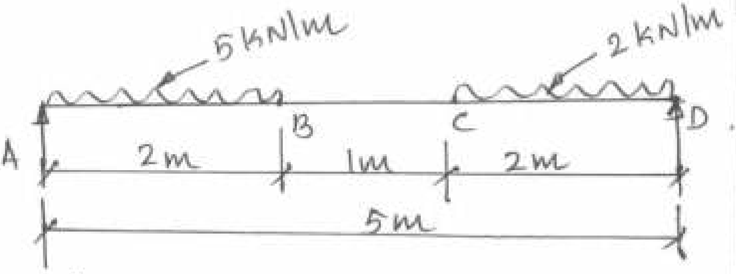
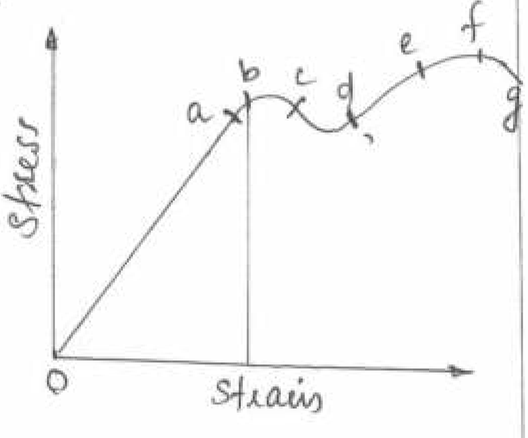
Qs No	Scoring indicators	Split score	Total score
(b)		2	
	$R_A + R_D = (5\times2) + (2\times2) = 14\,kN.$	1	
	Taking moment about A,		
	$R_D \times 5 = 2\times2\times(2/2+3) + 5\times2\times2/2$		
	$R_D = \frac{16+10}{5} = 5.2\,kN.$	2	7
	$R_A = 14 - 5.2 = 8.8\,kN.$	2	
V (a)	(a) limit of proportionality – 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

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

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Qs No	Scoring indicators	Split score	Total score
VI (a).	$d = 20\,mm$		
	$P = 40KN = 40 \times 10^3 N.$		
	$l = 150\,mm.$		
	$\delta l = 0.08$		
	$\delta d = 0.0029$		
	Poisson's ratio ($1/m$).		
	linear strain $= \frac{\delta l}{l} = \frac{0.08}{150} = 0.00053$	[illegible]	
	lateral strain $= \frac{\delta d}{d} = \frac{0.0029}{20} = 0.00014$	[illegible]	
	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	
	$0.08 = \frac{40 \times 10^3 \times 150}{\frac{\pi}{4}(20)^2 \times E}.$		
	$\therefore E = 238.853 \times 10^3 = 2.38 \times 10^5\, N/mm^2.$	1	
	Modulus of rigidity		
	$C = \frac{m \cdot E}{2(m+1)}$	1	

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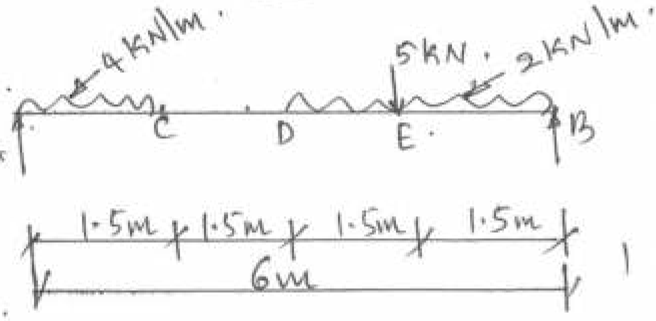
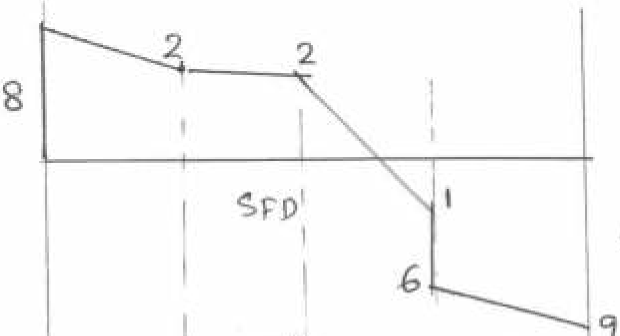
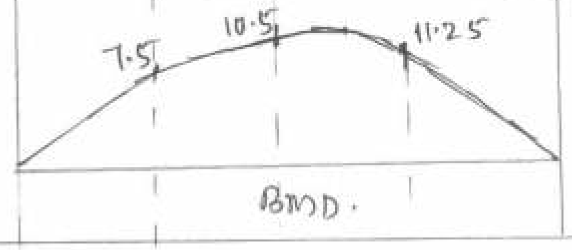
Qs No	Scoring indicators	Split score	Total score
	$\frac{1}{m} = 0.274$, $m = \frac{1}{0.274} = 3.649$.		
	$C = \frac{3.649 \times 238.853 \times 10^3}{2(3.649+1)} = 93.737 \times 10^3 \ N/mm^2 = \underline{93.73 \ GPa}$	1	
	Bulk modulus, (K.). $K = \frac{m \cdot E}{3(m-2)}$	1	
	$= \frac{3.649 \cdot 238.853 \times 10^3}{3(3.649-2)} = 176.182 \times 10^3 \ N/mm^2 = \underline{176.182 \ GPa}$.	1	8
VII (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.		
	$R_B \times 6 = 5\times4.5 + 2\times3(3/2+3) + 4\times1.5\times1.5/2$		
	$R_B = 9$ kN	1	
	$R_A = 8$ kN	1	
	shear force		
	SF at A, $F_A = +R_A = +8$ kN.		
	$F_C = +8 - 4\times1.5 = +2$ kN		
	$F_D = +2$ kN		
	$F_E = +2 - 2\times1.5 = -1$ kN		
	$F_E' = -1 - 5 = -6$ kN.		
	$F_B = -6 - 2\times1.5 = -9$ kN.		
	Bending moment,		
	BM at A, $M_A = 0$.		
	$M_C = 8\times1.5 - 4\times1.5\times\frac{1.5}{2} = 7.5$ kNm.		
	$M_D = 8\times3 - 4\times1.5\times(\frac{1.5}{2}+1.5) = 10.5$ kNm		
	$M_E = 9\times1.5 - 2\times1.5\times\frac{1.5}{2} = 11.25$ kNm.		9
	$M_B = 0$.		
VII (b).	$d = 1000$ mm		
	$t = 20$ mm		
	$l = 2$ m $= 2\times10^3$ 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	
	$= \frac{5\times1000}{2\times20} = 125$ MPa.	1	
	longitudinal stress, $\sigma_l = \frac{pd}{4t}$	2	
	$= \frac{5\times1000}{4\times20} = 62.5$ MPa.	1	6
VIII (a).	$d = 250mm$		
	$l = 1m = 1\times10^3 mm$		
	$t = 8mm$		
	$P = 2$ MPa $= 2\ N/mm^2$		
	$E = 200$ GPa $= 2\times10^5\ N/mm^2$		
	$\frac{1}{m} = 0.30$		
	Circumferential strain, $\varepsilon_c = \frac{pd}{2tE}\left[1-\frac{1}{2m}\right]$.	2	
	$= \frac{2\times250}{2\times8\times2\times10^5}\left[1-\frac{1}{2}\times0.30\right]$.		
	$= 1.32\times10^{-4}$	1	
	longitudinal strain, $\varepsilon_l = \frac{pd}{2tE}\left(\frac{1}{2}-\frac{1}{m}\right)$.	2	
	$= \frac{2\times250}{2\times8\times2\times10^5}\left[\frac{1}{2}-0.3\right]$		
	$= 0.3\times10^{-4}$	1	

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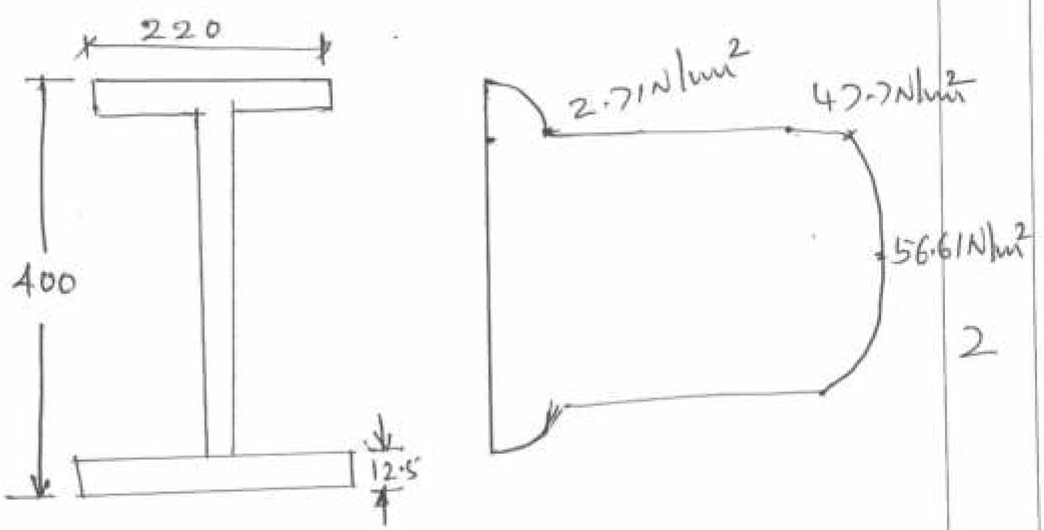
Qs No	Scoring indicators	Split score	Total score
	Original volume, $V = \frac{\pi}{4}(d^2) \times l$		
	$= \frac{\pi}{4}(250)^2 \times 1000 = 49.06 \times 10^6 mm^3$		
	Change in volume $= \delta V = V(\varepsilon_l + 2\varepsilon_c)$	2	
	$= 49.06 \times 10^6 (0.3 \times 10^{-4} + 2 \times 1.32 \times 10^{-4})$		
	$= 14.228 \times 10^3 mm^3$	1	9
VIII (b)	$d = 80 mm$		
	$N = 120 rpm$		
	$\tau = 40 N/mm^2$		
		2	
	Torque, $T = \frac{\pi}{16} \tau D^3$	1	
	$= \frac{\pi}{4}(40 \times 80^3) = 4.019 kN \cdot m$		
	Power, $P = \frac{2\pi N T}{60}$	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	

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, $= \frac{F}{8I}[D^2 - d^2]$.	2	
	$= \frac{250 \times 10^3}{8 \times 431.95 \times 10^6}[400^2 - 350^2] = 2.71\ N/mm^2$	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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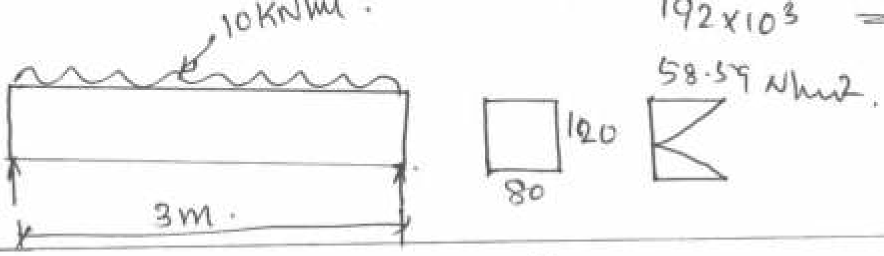
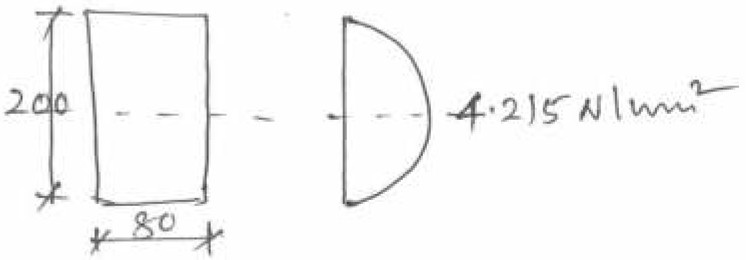
Qs No	Scoring indicators	Split score	Total score
IX b.	$d = 3\,mm$		
	$\sigma_b = 80\,MPa = 80\,N/mm^2$		
	$E = 200\,GPa = 2\times10^5\,N/mm^2$		
	$\frac{\sigma_b}{y} = \frac{E}{R}$.	2	
	Radius, $R = \frac{E \cdot y}{\sigma_b}$.		
	$y = d/2 = 3/2 = 1.5\,mm$.	1	
	$R = \frac{2\times10^5 \times 1.5}{80} = 3750\,mm = 3.75\,m$.	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

Qs No	Scoring indicators	Split score	Total score
X (b)	b = 80 mm		
	d = 200 mm		
	$l = 3\,m = 3 \times 10^3\,mm$		
	w = 30 kN/m.		
	Shear force, $F = \frac{wl}{2} = \frac{30 \times 3}{2} = 45\,kN = 45 \times 10^3\,N$.	1	
	Area of section, $A = b.d = 80 \times 200 = 16000\,mm^2$		
	Average shear stress, $\tau_{av} = \frac{F}{A}$.	1	
	$= \frac{45 \times 10^3}{16000} = 2.81\,N/mm^2$		
	$= 2.81\,MPa$	1	
	Max. shear stress $\tau_{max} = 1.5\,\tau_{av}$.	1	
	$= 1.5 \times 2.81 = 4.215\,N/mm^2$	1	
		2	7