TED (15) – 3013

(REVISION – 2015)

Reg. No...

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THIRD SEMESTER DIPLOMA EXAMINATION IN ENGINEERING/ TECHNOLOGY — APRIL, 2017

THEORY OF STRUCTURES

(Common for CE and AR)

[*Time* : 3 hours

(Maximum marks : 100)

PART — A

(Maximum marks : 10)

Marks

I Answer the following questions in one or two sentences. Each question carries 2 marks.

1. State the parallel axis theorem.
2. Identify the property of ductility in the metals.
3. Define modulus of resilience.
4. Write down the expression for power transmitted by the shaft.
5. Define section modulus. (5 × 2=10)

PART — B

(Maximum marks : 30)

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

1. Calculate the reactions at supports of a simply supported beam of length 6m, it carries a point load of 100KN at a distance of 2m from the left end and also it carries a udl of 20KN/m over a length of 3m from the right end.
2. Find the moment of Inertia of a rectangular section 60mm wide and 40mm deep about its centre of gravity.
3. A circular alloy bar 2m long uniformly tappers from 30mm diameter to 20mm diameter. Calculate the elongation of the rod under an axial force of 50KN. Take E for the alloy as 140GPa.
4. Sketch the stress strain diagram for mild steel and mark the important points.
5. Calculate the maximum torque of a solid shaft of 100mm diameter can transmit, if the maximum angle of twist is 1.5° in a length of 2m. Take C=70GPa.

Marks

6. A cylindrical shell 2m long and 1m internal diameter is made up of 20mm thick plates. Find the circumferential and longitudinal stress in the shell material, if it is subjected to an internal pressure of 5MPa.

7. List the assumptions in the theory of simple bending. $(5 \times 6 = 30)$

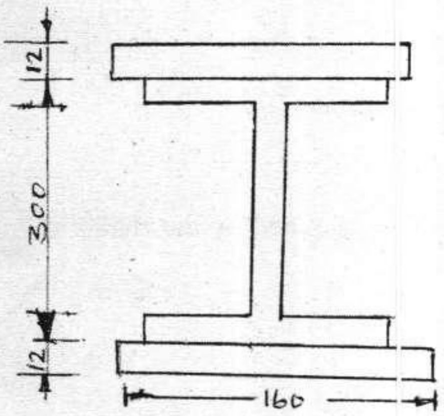
PART — C

(Maximum marks : 60)

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

UNIT — I

III (a) A compound beam is made by welding two steel plates 160mm × 12mm one on each flange of an ISLB 300 section as shown in figure. Find the moment of inertia the beam section about an axis passing through its centre of gravity and parallel to XX axis. Take moment of inertia of the ISLB 300 section about XX axis as $73.329 \times 10^6 mm^4$.



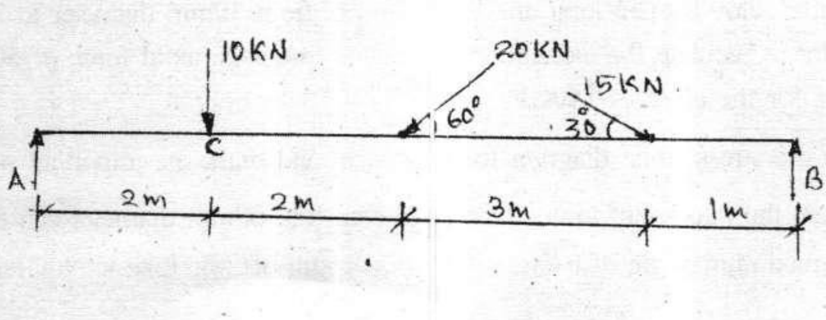
8

(b) Locate the centroid of a circle and Triangle. 7

OR

IV (a) Find the moment of inertia and least radius of gyration about the centroidal axes of rectangle section of width 60mm and depth 120mm. 8

(b) Find the reactions of a loaded beam 8m long as shown in figure.



7

Marks

UNIT — II

V (a) A prismatic metallic bar of rectangular section 500mm × 200mm and 2m long is subjected to a load of 150 KN applied gradually on it. If the stress at elastic limit of bar material is 200 N/mm^2, determine (i) strain energy at the given load (ii) Proof resilience (iii) Modulus of resilience, Take $E=200KN/mm^2$. 8

(b) A steel bar 6m long and its both ends are firmly fixed to two walls. The original temperature of the bar is 60°C. If the bar is cooled to 30°C, determine the thermal strain and stress in the bar. Assume $E_s = 200\ KN/mm^2$, and $\alpha_s = 12 \times 10^{-6}/^0C$. State the nature of stress. 7

OR

VI (a) In an experiment a bar of 40mm diameter is subjected to a pull of 50KN. The measured extension on gauge length of 200mm is of 0.08mm and the change in diameter is 0.0039mm. Calculate the Poisson's ratio and the values of the Young's modulus, modulus of rigidity and bulk modulus. 8

(b) A mild steel rod of 25mm diameter and 320mm long is enclosed centrally inside a hollow copper tube of external diameter 30mm and internal diameter 25mm. Ends of rods are braced together and composite bar is subjected to an axial pull of 60KN. Find the stress developed in the rods. $E_s = 200GPa$, $E_c = 100GPa$. 7

UNIT — III

VII (a) A simply supported beam AB of length 5m, it carries two point loads 6KN and 4KN at C and D. AC=2m, CD = 1m, Draw the SFD and BMD for the beam and find the value of maximum bending moment. 8

(b) A steam boiler 3m diameter is required to carry a net working pressure of 1 N/mm^2 stress in the metal should not exceed 90 N/mm^2. Find the thickness of the metal if efficiency of the joint is 80%. 7

OR

VIII (a) Draw SFD and BMD for a overhanging beam ABC, AB = 4m, BC = 1m, AD = 2m. Beam having 5m span, it carries two point loads 10KN at a distance of 2m from the left end and 7KN at the right end point. AB is simply supported of span 4m and BC is over hang of span 1m. Also find the point of contraflexure. 8

(b) A hollow shaft of external diameter 150mm transmits 400 KW power 200rpm. Determine the maximum internal diameter, if the maximum stress in the shaft is not to exceed 50N/mm^2. 7

Marks

UNIT — IV

IX (a) A beam of I section 300mm × 120mm has flanges 20mm thick and web 10mm thick. Calculate the maximum stress developed in I section for a bending moment of 30KNm. 8

(b) A simply supported beam has a span of 5m and rectangular cross section 100mm × 200mm. Find the uniformly distributed load it can carry, if the maximum shear stress is not to exceed 0.6 N/mm². 7

OR

X (a) A rectangular beam 200mm deep and 300mm wide is simply supported over a span of 8m, find the udl per meter run the beam can carry, if bending stress is not to exceed 120 N/mm². 8

(b) A rectangular beam 100mm wide and 300mm deep is subjected to a maximum shear force of 60KNM. Determine (i) average shear stress (ii) Maximum shear stress (iii) Shear stress at a distance of 30mm above the neutral axis. 7

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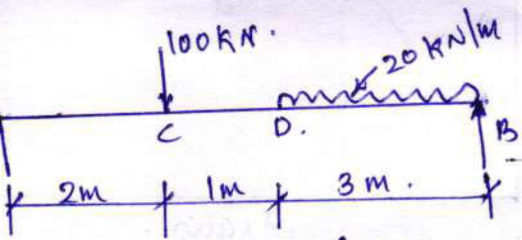
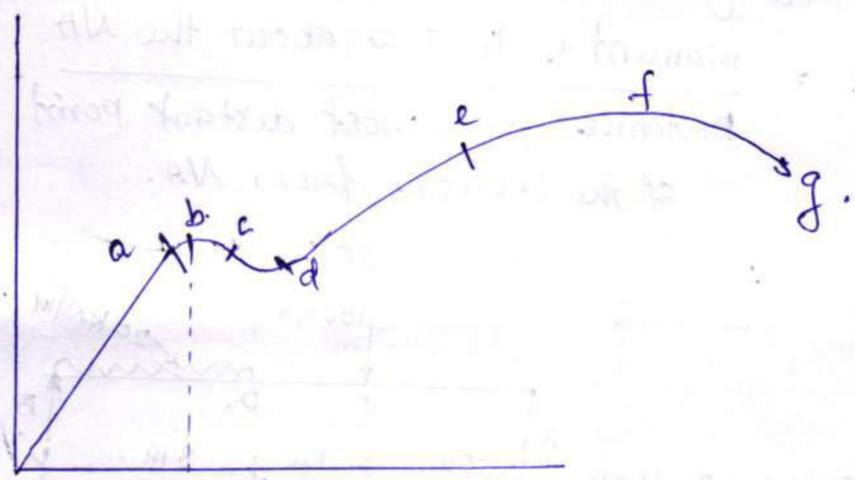
Scoring Indicators

Code : 3013 Version: ~~2015~~ A C

Qn. No.	Scoring Indicators	Split score	Total score
	Part. A.		
1.	The moment of inertia of a lamina about a line parallel to its centroidal line is equal to its moment of inertia about its own centroid plus area of lamina x (distance)^2, where the distance is the distance between centroid and that line, $I_{AB} = I_{xx} + Ay^2$.		2
2.	Property by which a material can be drawn into wires.		2
3.	The proof resilience per unit volume of a material, is		2
4.	$P = \frac{2\pi NT}{60}$ watts, $P = \frac{2\pi NT}{60 \times 1000}$ KW. P = Power transmitted by the shaft. T = Average torque in N-m. N = Number of revolutions.		2
5.	$Z = I/y = \frac{\text{Moment of Inertia about the NA}}{\text{Distance of the most distant point of the section from NA.}}$		2
	Part B.		
II. 1.	 $R_A + R_B = 100 + 20 \times 3 = 160kN$. Taking moment about A. $R_B \times 6 = 20 \times 3 \times (1.5+3) + (100 \times 2) = 470$ $R_B = 78.33$ KN $R_A = 81.67$ KN.	fig-2 R_A-2 R_B-2 6	6

Scoring Indicators

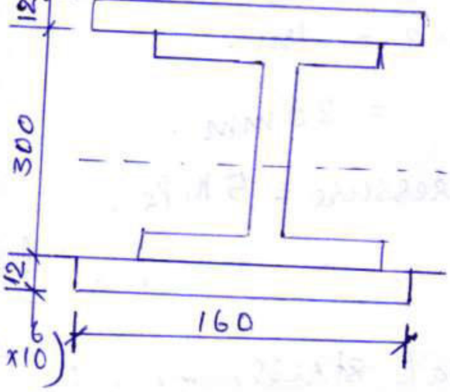
Code : 3013 **Version: A**

Qn. No.	Scoring Indicators	Split score	Total score
2.	$b = 60mm$. $d = 40mm$. $I_{xx} = bd^3/12 = \frac{60 \times 40^3}{12} = 32 \times 10^3\ mm^4$. $I_{yy} = db^3/12 = \frac{40 \times 60^3}{12} = 720 \times 10^3\ mm^4$.	$I_{xx} = 3$ $I_{yy} = 3$ 6.	6
3.	$l = 2m = 2000mm$. $d_1 = 30mm$ $d_2 = 20mm$. $P = 50kN = 50 \times 10^3 N$. $E = 140GPa = 140 \times 10^3 N/mm^2$ Elongation, $\delta l = \frac{Pl}{AE}$ $= \frac{50 \times 10^3 \times 2000}{\frac{\pi}{4} 30 \times 20 \times 140 \times 10^3} = 1.52\ mm$	$\delta l = 6$	6
4.	 a = limit of proportionality b = elastic limit c = upper yield point d = Lower yield point. d-e - Ductile stage. e-f - plastic stage. f - ultimate load g - Breaking point.	fig-3 Parts-3 6	6

Scoring Indicators

Code : 3013 **Version: A** (~~2015~~)

Qn. No.	Scoring Indicators	Split score	Total score
5	diameter = 100 mm. length = 2 m = 2000 mm. Angle of twist = 1.5°. $C = 70\ GPa = 70\times10^3\ N/mm^2$. Polar moment of Inertia, $J = \frac{\pi D^4}{32} = \frac{\pi (100)^4}{32}$ $= 9.81\times10^6\ mm^4$. from the relation, $\frac{T}{J} = \frac{C\theta}{l}$. $\frac{T}{9.81\times10^6} = \frac{70\times10^3 \times 1.5\times\frac{\pi}{180}}{2\times10^3}$ $T = 8.98\ KNm$.	3 3/6	6
6.	length = 2 m = 2000 mm. Internal dia = 1 m. thickness = 20 mm. Internal pressure = 5 MPa. Circumferential stress, $\sigma_c = \frac{pd}{2t} = \frac{5\times1\times10^3}{2\times20} = 125\ N/mm^2$ longitudinal stress, $\sigma_l = \frac{pd}{4t} = \frac{5\times1\times10^3}{4\times20} = 62.5\ N/mm^2$	3 3/6.	6
7	1. The material of the beam is perfectly homogeneous and isotropic. 2. The beam material is stressed within its elastic limit and thus obeys Hooke's law.		

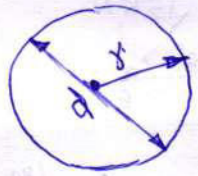
Qn. No.	Scoring Indicators	Split score	Total score
	(3) The traverse sections which were plane before bending remains plane after bending.		
	(4) Each layer of the beam is free to expand or contract, independently, of the layer above or below it.		
	5) the value of Young's modulus (E) is the same in tension and compression.		
	6) The beam is in equilibrium, there is no resultant pull or push in the beam section.	any 4 $4 \times 1\frac{1}{2} = 6$	6
	PART-C		
III (a)	Moment of inertia of one plate section about xx axis $= I_{CG} + ah^2$		
	$I_{CG} = bd^3/12 = \frac{160 \times 12^3}{12} = 0.023 \times 10^6\ mm^4$.	eqn - 2	
	$h = 150 + 12/2 = 156\ mm$.	I_{CG} plate - 2	
	$I_{CG} + ah^2 = 0.023 \times 10^6 + (160 \times 12) 156^2 = 46.748 \times 10^6\ mm^4$	fig - 2	
	MI of compound section = MI of ISLB + MI of two plate section.	MI - 2 8	
			
	$= 73.329 \times 10^6 + 2(46.748 \times 10^6)$ $= 166.825 \times 10^6\ mm^4$.		8

Scoring Indicators

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score

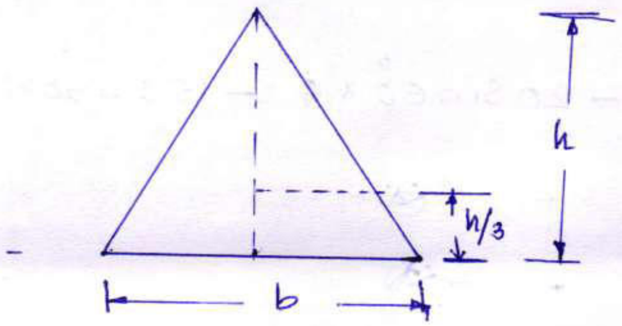
(b).



Area $= \pi r^2$ or $\frac{\pi d^2}{4}$

Position of centroid at the centre of circle.

fig - 1½
Area - 1
Position - 1
3½



Area $= \frac{1}{2} b h$

Centroid at $h/3$ from base.

fig - 1½
Area - 1
Position - 1
3½

Total score: 7

IV (a)

$b = 60$ mm

$d = 120$ mm

$I_{xx} = bd^3/12 = \frac{60 \times 120^3}{12} = 864 \times 10^4 \text{ mm}^4$ — (2)

$I_{yy} = \frac{db^3}{12} = \frac{120 \times 60^3}{12} = 216 \times 10^4 \text{ mm}^4$. — (2)

by perpendicular axe's theorem,

$I_{zz} = I_{xx} + I_{yy} = 1080 \times 10^4 \text{ mm}^4$

Least radius of gyration, $k = \sqrt{\frac{I_{least}}{A}}$ — (2)

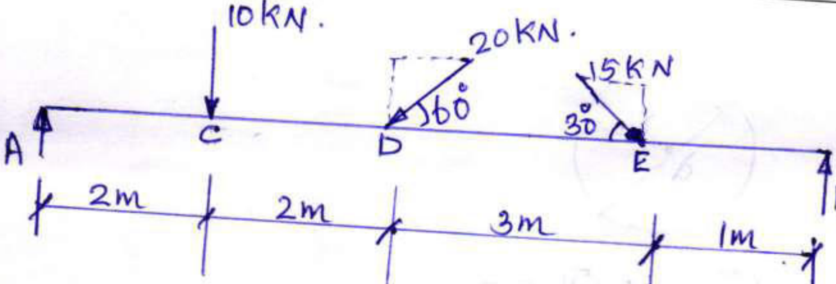
$= \sqrt{\frac{I_{yy}}{A}} = \sqrt{\frac{216 \times 10^4}{60 \times 120}} = 17.32$ mm. — (2)

Total score: 8

Scoring Indicators

Code :

Version:

Qn. No.	Scoring Indicators	Split score	Total score
(b).	 — (1)		
	$R_A + R_B = 10 + 20\sin 60^\circ + 15\sin 30^\circ$		
	$= 34.82$ KN. — (2)		
	Moment about B,		
	$R_A \times 8 - 10\times 6 - 20\sin 60^\circ \times 4 - 15\sin 30\times 1 = 0$.		
	$R_A = 17.1$ KN — (2)	2	
	$R_B = 17.72$ KN. — (2)	2	7
		7	
V (a).	$A. = 500\times 200 = 1\times 10^5\ mm^2$		
	$l = 2m = 2000mm$.		
	$P = 150KN = 150\times 10^3 N$		
	$E = 200\ KN/mm^2 = 2\times 10^5\ N/mm^2$		
	Stress at elastic limit $= 200\ N/mm^2$		
	(a) strain energy, $U = \frac{\sigma^2}{2E}\times V$ — eqn - 2		
	Stress, $\sigma = \frac{150\times 10^3}{1\times 10^5} = \frac{P}{A} = 1.5\ N/mm^2$	σ - 2	
		V = 1	
	Volume, $V = A\times l = 1\times 10^5 \times 2000 = 2\times 10^8\ mm^3$	ans - 3	
	$\therefore U = \frac{\sigma^2}{2E}\times V = \frac{(1.5)^2\times 2\times 10^8}{2\times 2\times 10^5} = 1125$ N mm	8	
	$= 1.125$ KN mm		8

Scoring Indicators

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Qn. No.	Scoring Indicators	Split score	Total score
(b)	$l = 6m = 6000\,mm$. Initial temperature $= 60^\circ c$ Final temperature $= 30^\circ c$. $E_s = 200\,kN/mm^2, = 2\times10^5\,N/mm^2$ $\alpha_s = 12\times10^{-6}/^\circ c$ $\alpha_s = \frac{\delta l}{l \times t}$ $\frac{\delta l}{l} = t \times \alpha_s$ $\delta l = l \times t \times \alpha_s$. t = temperature change $= 60-30 = 30^\circ C$ Thermal strain, $e_e = \delta l / l = \alpha_s t$ $= 12\times10^{-6}\times30 = 3.6\times10^{-4}$. Thermal stress, $\sigma = e_e . E = \alpha_s . t . E$ $= 12\times10^{-6}\times30\times2\times10^5$ $= 72\,N/mm^2$. Nature - Tensile.	$\delta l = 2$ $\varepsilon_e = 2$ $\sigma = 3$ 7	7
VI (a).	$d = 40\,mm$. $P = 50\,kN = 50\times10^3\,N$. $l = 200\,mm$. $\delta l = 0.08\,mm$. $\delta d = 0.0039$ Linear strain, $\varepsilon_e = \delta l / l = \frac{0.08}{200} = 0.00040$. lateral strain, $= \frac{\delta d}{d} = \frac{0.0039}{40} = 0.0000975$		

Scoring Indicators

Version:

Code :

Qn. No.	Scoring Indicators	Split score	Total score
	Poisson's ratio, $\frac{1}{m} = \frac{\text{lateral strain}}{\text{linear strain}}$ $= \frac{0.0000975}{0.00040} = 0.244$ Area, $A = \pi/4\, d^2 = \frac{\pi}{4}(40)^2 = 1256\ mm^2$ $\delta l = \frac{Pl}{AE}$, $0.08 = \frac{50\times10^3 \times 200}{1256 \times E}$ Young's modulus, $E = 99.522\ GPa$. $\frac{1}{m} = 0.244$, $m = 4.098$. Modulus of rigidity, $N = \frac{m \cdot E}{2(m+1)}$. $= \frac{4.098 \times 99.522 \times 10^3}{2(4.098+1)}$ $= 40\times10^3\ N/mm^2 = 40\ GPa$. Bulk modulus, $k = \frac{m \cdot E}{3(m-2)} = \frac{4.098 \times 99.522 \times 10^3}{3(4.098-2)}$ $= 64.798\times10^3\ N/mm^2$ $= 64.798\ GPa$.	Pois. − 2 E = 2 N = 2 K = 2 8	8
	(b) $D = 25mm$. $l = 320mm$. Outside dia of copper tube = 30mm Inside " " " = 25mm. $P = 60KN = 60\times10^3 N$. $E_s = 200\times10^3\ N/mm^2$. $E_c = 100\times10^3\ N/mm^2$		

Scoring Indicators

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score
	Area of steel $= \frac{\pi}{4}(25)^2 = 490.625\ mm^2$		
	Area of copper $= \frac{\pi}{4}(30^2 - 25^2) = 216\ mm^2$		
	Total load, $P = P_s + P_c$.		
	deformation of both materials same.		
	$\delta l_s = \delta l_c$.		
	$\frac{P_s l_s}{A_s E_s} = \frac{P_c l_c}{A_c E_c}$		
	length same, $l_s = l_c$.		
	$\therefore \frac{P_s}{A_s E_s} = \frac{P_c}{A_c E_c}$.		
	$\frac{P_s}{490.6 \times 2 \times 10^5} = \frac{P_c}{216 \times 1 \times 10^5}$		
	$P_s = 4.54\ P_c$		
	$P = P_s + P_c$		
	$60 \times 10^3 = 4.54\ P_c + P_c$.	$P_c = 1$ $P_s = 1$ $\sigma_c = 2\frac{1}{2}$ $\sigma_s = 2\frac{1}{2}$ 7	
	$P_c = 10830\ N = 10.83\ kN$		
	$P_s = 49170\ N = 49.17\ kN$		
	Stress in copper tube, $\sigma_c = \frac{P_c}{A_c} = \frac{10830}{216} = 50.14\ N/mm^2$		
	Stress in steel, $\sigma_s = \frac{P_s}{A_s} = \frac{49170}{490.6} = 100.22\ N/mm^2$		7
VII (a)	$R_B \times 5 = 4 \times 3 + 6 \times 2$		
	$R_B = 4.8\ kN$		
	$R_A + R_B = 10\ kN$		
	$R_A = 5.2\ kN$.		

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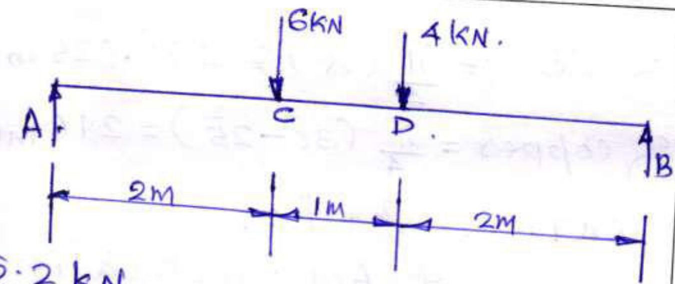


SF at A $= R_A = \overset{+}{5.2}$ kN.

C $= 5.2 - 6 = \bar{0}.8$ kN.

D $= -(0.8+4) = \bar{4}.8$ kN.

B $= \bar{4}.8$ kN

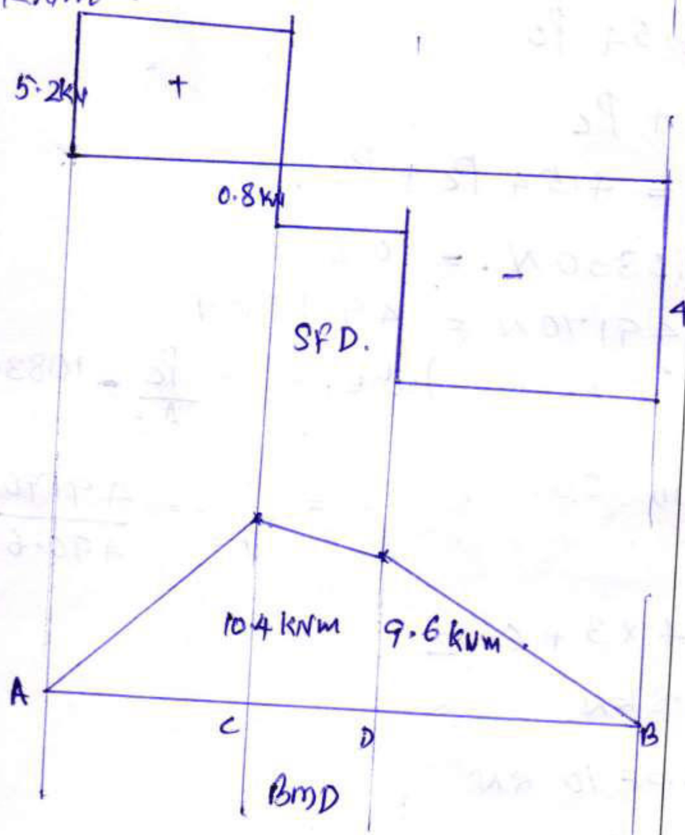
Bm at B $= 0$

D $= 4.8 \times 2 = 9.6$ kNm.

C $= 4.8 \times 3 - 4 \times 1 = 10.4$ kNm.

A $= 0$.

Max Bm $= 10.4$ kNm.



SFD – 4

BmD – 4

8

Scoring Indicators

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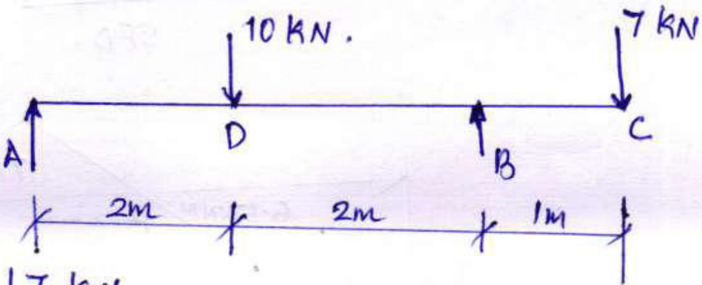
Qn. No.	Scoring Indicators	Split score	Total score
(b).	$d = 3m = 3000mm$. Pressure, $P = 1 N/mm^2$ stress, $\sigma = 90 N/mm^2$ efficiency, $\eta = 80\%$. Safe design, $t \geq \frac{Pd}{2\sigma\eta}$ for a steam boiler $t = \frac{1 \times 3000}{2 \times 90 \times 0.80} = 20.8 mm$.	condition -2 $t = 5$	7
VIII (a)	 $R_A + R_B = 10 + 7 = 17 kN$. Taking moment about A. $R_B \times 4 = 7 \times 5 + 10 \times 2$ $R_B = 55/4 = 13.75 kN$. $R_A = 3.25 kN$. SF at A = $^{+}3.25 kN$. D = $3.25 - 10 = ^{-}6.75 kN$. B = $-6.75 + 13.75 = ^{+}7 kN$ C = $7 kN$. BM at C = 0 B = $7 \times 1 = 7 kNm$. D = $7 \times 3 - 13.75 \times 2 = ^{-}6.5 kNm$. A = 0		

Scoring Indicators

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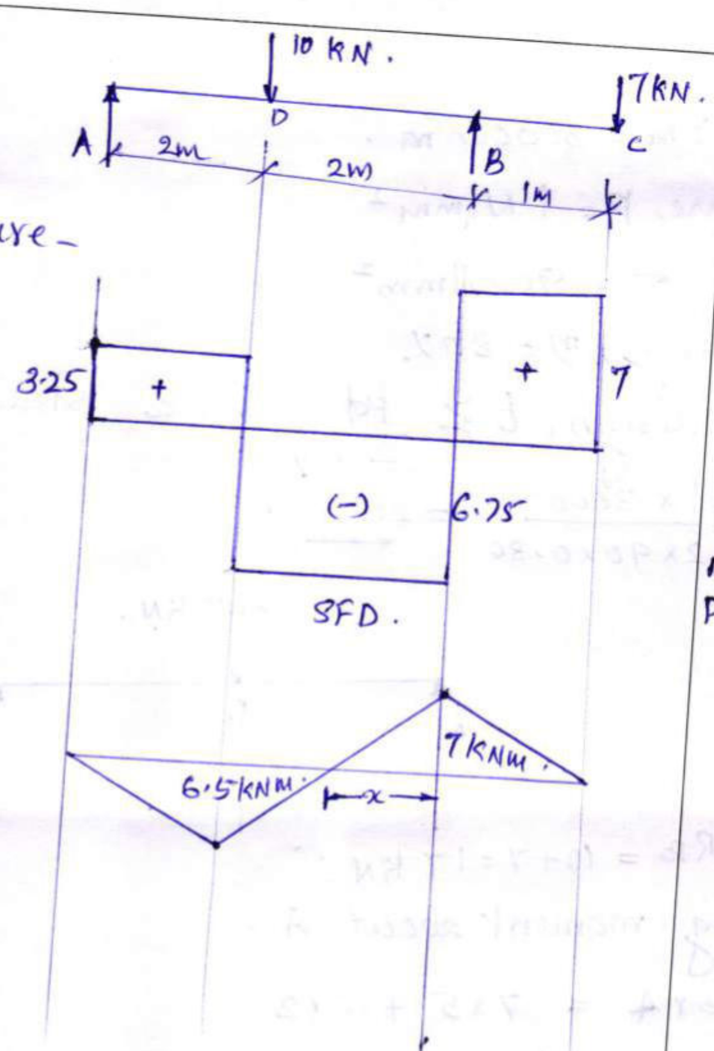

Point of contraflexure –

$x = \frac{1}{6.5} = 1.037\,m$

SFD = 3
BMD = 3
P.C = 2

Total score: 8

(b) D = 150 mm

P = 400 kW

N = 200 rpm.

τ = 50 N/mm²

$P = \frac{2\pi N T}{60}$.

$400 = \frac{2 \times \pi \times 200 \times T}{60}$.

$T = 19.10\,kNm = 19.10 \times 10^6\,Nmm$.

$T = \frac{\pi \tau}{16}\left[\frac{D^4 - d^4}{D}\right]$.

$19.10 \times 10^6 = \frac{\pi \times 50}{16}\left[\frac{150^4 - d^4}{150}\right]$.

d = 121 mm

P = 1
T = 3
d = 3
7

Total score: 7

Scoring Indicators

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Qn. No.	Scoring Indicators	Split score	Total score
IX (a)	$B = 120\,mm$ $D = 300\,mm$. $D_f = 20\,mm$. $b_w = 10\,mm$. Moment, $M = 30\,kNm = 30\times10^6\,Nmm$. From bending eqn. $\frac{M}{I} = \frac{\sigma_b}{y} = \frac{E}{R}$ for symmetrical section, $I = \frac{BD^3}{12} - \frac{bd^3}{12}$. $= \frac{120\times300^3}{12} - \frac{110\times260^3}{12} = 108.88\times10^6\,mm^4$ Section modulus, $Z = I/y$. $y = d/2 = 300/2 = 150\,mm$. $Z = \frac{108.88\times10^6}{150} = 725911.11\,mm^3$ Bending stress, $M = \sigma_b \cdot Z$ $\sigma_b = \frac{M}{Z} = \frac{30\times10^6}{725911.11} = 41.33\,N/mm^2$.	eqn = 2 I = 1 y = 1 Z = 2 σ_b = 2 8	8
(b)	$l = 5m = 5000\,mm$. $b = 100\,mm$. $d = 200\,mm$. $\tau_{max} = 0.6\,N/mm^2$. Shear force, $F = Wl/2$ for a rectangular section, $\tau_{max} = 1.5\,\tau_{av}$. $0.6 = 1.5\times\frac{F}{A}$.		

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Qn. No.	Scoring Indicators	Split score	Total score
	$0.6 = 1.5 \times \frac{wl}{2A}$. $0.6 = 1.5 \times \frac{w \times 5000}{2 \times 100 \times 200}$. $w = \underline{3.2}$ N/mm.	F = 1 eqn = 2 w = 4	7
IX (a)	d = 200 mm. b = 300 mm. l = 8m = 8000 mm. $\sigma_b = 120$ N/mm^2. from bending eqn, $\frac{M}{I} = \frac{\sigma_b}{y} = \frac{E}{R}$. Section modulus, $Z = I/y$. $Z = \frac{bd^3}{12} \times \frac{2}{d} = bd^2/6$. $Z = \frac{300 \times 200^2}{6} = 2 \times 10^6$ mm^3. $M = wl^2/8$. $\sigma_b \cdot Z = \frac{wl^2}{8}$. $120 \times 2 \times 10^6 = \frac{w \times 8000^2}{8}$. $w = 30$ N/mm = $\underline{30}$ kN/m.	bending eqn = 2 Z = 1 M = 1 w = 4 8	8
(b)	b = 100 mm. Depth, d = 300 mm Shear force = 60kN = 60×10^3 N. a) Average shear stress, $\tau_{av} = \frac{F}{A} = \frac{60 \times 10^3}{100 \times 300} = \underline{2}$ N/mm^2		

Version:

Scoring Indicators

Code : **Version:**

Qn. No.	Scoring Indicators	Split score	Total score
	(b) Maximum shear stress, $\tau_{max} = 1.5\ \tau_{av}$ $= 1.5 \times 2 = \underline{3}\ N/mm^2$ (c) shear stress at a distance of 30mm above NA $y = 30mm$. $I = bd^3/12 = \frac{100 \times 300^3}{12} = 225 \times 10^6\ mm^4$. $\tau = \frac{F}{2I}\left[\frac{d^2}{4} - y^2\right]$. $= \frac{60 \times 10^3}{2 \times 225 \times 10^6}\left[\frac{300^2}{4} - 30^2\right]$. $= \underline{\underline{2.88\ N/mm^2}}$.	$\tau_{av} = 2$ $\tau_{max} = 2$ $\tau_{at\,30} = 3$ 7	7