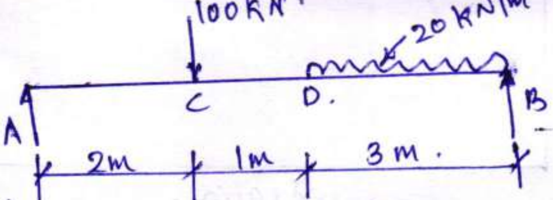
Scoring Indicators

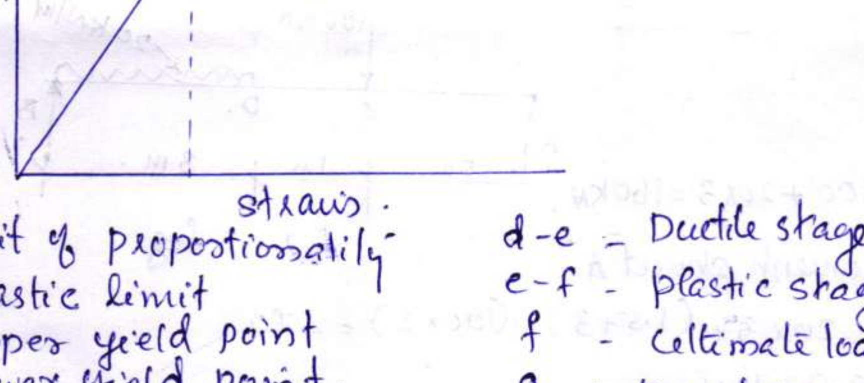
(15) 3013

Code : 3013 Version: ~~2015~~ AC

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 × (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.	 $R_A + R_B = 100 + 20 \times 3 = 160 kN$. 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

Scoring Indicators

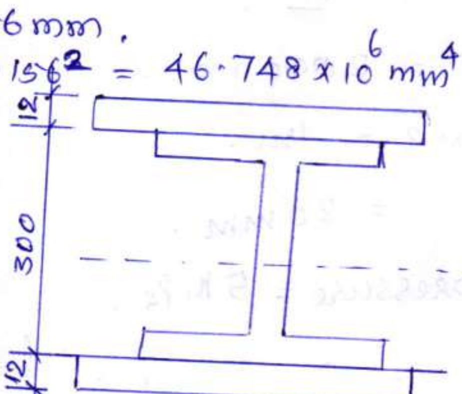
Code : 3013 Version: A

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**

Qn. No.	Scoring Indicators	Split score	Total score
5	diameter = 100 mm. length = 2 m = 2000 mm. Angle of twist = 1.5°. $C = 70\,GPa = 70 \times 10^3\,N/mm^2$. Polar moment of Inertia, $J = \frac{\pi D^4}{32} = \frac{\pi (100)^4}{32}$	3.	
	$= 9.81 \times 10^6\,mm^4$. from the relation, $\frac{T}{J} = \frac{C\theta}{l}$. $\frac{T}{9.81 \times 10^6} = \frac{70 \times 10^3 \times 1.5 \times \frac{\pi}{180}}{2 \times 10^3}$		6
	$T = 8.98\,KNm$.	3/6	
6.	length = 2 m = 2000 mm. Internal dia = 1 m. thickness = 20 mm. Internal pressure = 5 MPa. Circumferential stress, $\sigma_c = \frac{pd}{2t} = \frac{5 \times 1 \times 10^3}{2 \times 20} = 125\,N/mm^2$	3	
	longitudinal stress, $\sigma_l = \frac{pd}{4t} = \frac{5 \times 1 \times 10^3}{4 \times 20} = 62.5\,N/mm^2$	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 $= I_{CG} + ah^2$ $I_{CG} = bd^3/12 = \frac{160 \times 12^3}{12} = 0.023 \times 10^6\ mm^4$. $h = 150 + 12/2 = 156\ mm$. $I_{CG} + ah^2 = 0.023 \times 10^6 + (160 \times 12)\, 156^2 = 46.748 \times 10^6\ mm^4$ MI of compound section = MI of ISLB + MI of two plate section.  $= 73.329 \times 10^6 + 2\,(46.748 \times 10^6)$ $= 166.825 \times 10^6\ mm^4$.	eqn - 2 I_{CG} plate - 2 fig - 2 MI - 2 8	8

Scoring Indicators

Code : **Version:**

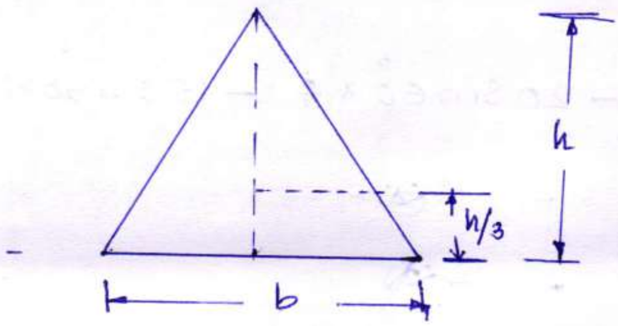
<table>
<tr><th>Qn. No.</th><th>Scoring Indicators</th><th>Split score</th><th>Total score</th></tr>
<tr><td>(b).</td><td>
Area $= \pi r^2$ or $\frac{\pi d^2}{4}$
Position of centroid at the centre of circle.

Area $= \frac{1}{2} b h$
Centroid at $h/3$ from base.</td><td>fig - 1½
Area - 1
Position - 1
3½

fig - 1½
Area - 1
Position - 1
3½</td><td>7</td></tr>
<tr><td>IV (a)</td><td>$b = 60$ mm
$d = 120$ mm
$I_{xx} = bd^3/12 = \frac{60 \times 120^3}{12} = 864 \times 10^4$ mm^4 — (2)
$I_{yy} = \frac{db^3}{12} = \frac{120 \times 60^3}{12} = 216 \times 10^4$ mm^4. — (2)
by perpendicular axe's theorem,
$I_{zz} = I_{xx} + I_{yy} = 1080 \times 10^4$ 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)</td><td></td><td>8</td></tr>
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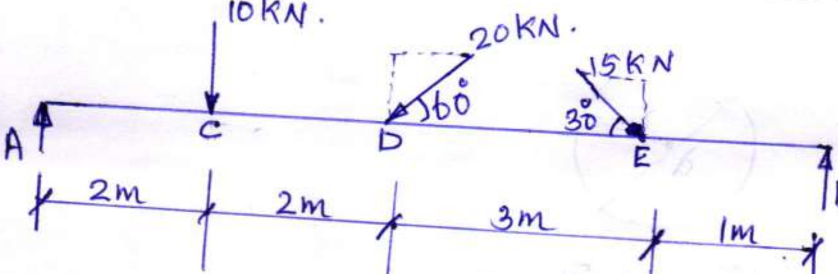
Qn. No.	Scoring Indicators	Split score	Total score
(b).	 — (1)		
	$R_A + R_B = 10 + 20\sin 60^\circ + 15\sin 30^\circ$		
	$= 34.82$ KN. — (2) — (2)		
	Moment about B,		
	$R_A \times 8 - 10\times 6 - 20\sin 60^\circ \times 4 - 15\sin 30 \times 1 = 0$.		
	$R_A = 17.1$ KN — (2)	2	
	$R_B = 17.72$ KN. — (2)	2	7
		7	
V (a).	A. $= 500 \times 200 = 1\times 10^5\ mm^2$		
	$\ell = 2m = 2000\ mm$.		
	$P = 150\ KN = 150\times 10^3\ N$		
	$E = 200\ KN/mm^2 = 2\times 10^5\ N/mm^2$		
	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	
	Volume, $V = A\times \ell = 1\times 10^5 \times 2000 = 2\times 10^8\ mm^3$	V = 1 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

Code : **Version:**

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, $\sigma = e_e.E = \alpha_s.t.E$	$\delta l = 2$	
	$= 12\times10^{-6}\times30\times2\times10^5$	$\varepsilon_e = 2$	
	$= 72\,N/mm^2$.	$\sigma = 3$ / 7	7
	Nature = Tensile.		
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

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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, $N = \frac{m \cdot E}{2(m+1)}$. $= \frac{4.098 \times 99.522\times10^3}{2(4.098+1)}$ $= 40\times10^3\ N/mm^2 = 40\ GPa$. Bulk modulus, $k = \frac{m \cdot E}{3(m-2)} = \frac{4.098\times 99.522\times10^3}{3(4.098-2)}$ $= 64.798\times10^3\ N/mm^2$ $= 64.798\ GPa$.	Pois. – 2 E = 2 N = 2 k = 2 8	8
	(b) $D = 25mm$. $l = 320mm$. Outside dia of copper tube = 30mm Inside " " = 25mm. $P = 60kN = 60\times10^3 N$. $E_s = 200\times10^3\ N/mm^2$. $E_c = 100\times10^3\ N/mm^2$		

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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, $l_s = l_c$. $\therefore \frac{P_s}{A_s E_s} = \frac{P_c}{A_c E_c}$. $\frac{P_s}{490.6 \times 2 \times 10^5} = \frac{P_c}{216 \times 1 \times 10^5}$ $P_s = 4.54\ P_c$ $P = P_s + P_c$ $60 \times 10^3 = 4.54\ P_c + P_c$. $P_c = 10830\ N. = 10.83\ kN$ $P_s = 49170\ N = 49.17\ kN$ Stress in copper tube, $\sigma_c = \frac{P_c}{A_c} = \frac{10830}{216} = 50.14\ N/mm^2$ Stress in steel, $\sigma_s = \frac{P_s}{A_s} = \frac{49170}{490.6} = 100.22\ N/mm^2$	$P_c = 1$ $P_s = 1$ $\sigma_c = 2\frac{1}{2}$ $\sigma_s = 2\frac{1}{2}$ 7	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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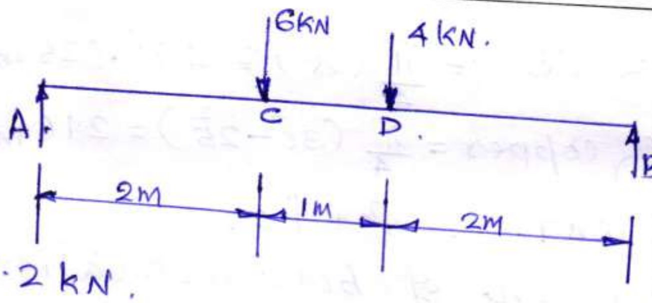


SF at A = R_A = 5.2 kN.

C = 5.2 − 6 = −0.8 kN.

D = −(0.8+4) = −4.8 kN.

B = −4.8 kN

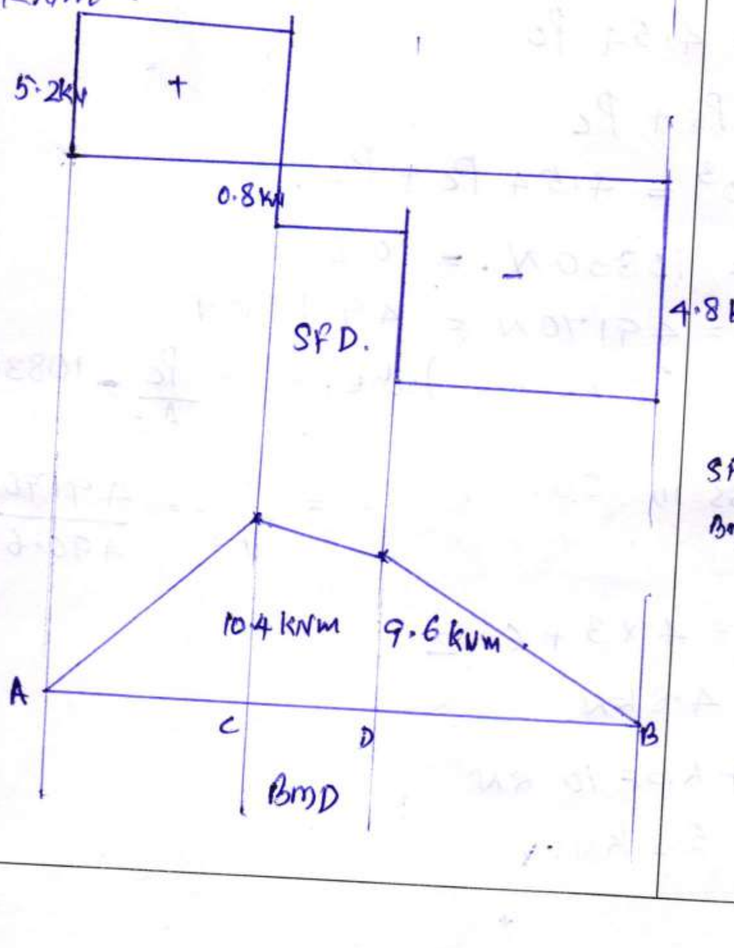
Bm at B = 0

D = 4.8×2 = 9.6 kNm.

C = 4.8×3 − 4×1 = 10.4 kNm.

A = 0.

Max. Bm = 10.4 kNm.



SFD − 4

BmD − 4

8

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(b). $d = 3m = 3000mm$.

Pressure, $P = 1\ N/mm^2$

Stress, $\sigma = 90\ N/mm^2$

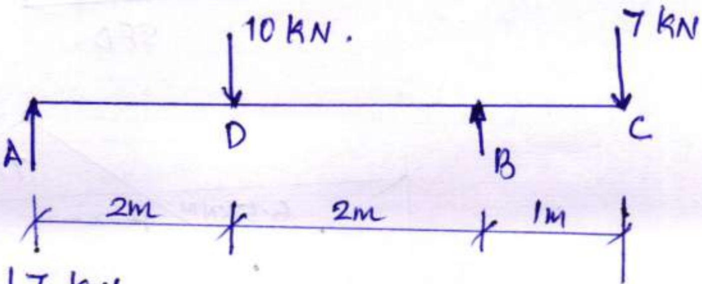
efficiency, $\eta = 80\%$.

Safe design, $t \geq \frac{pd}{2\sigma\eta}$ for a steam boiler — condition – 2

$t = \frac{1 \times 3000}{2 \times 90 \times 0.80} = 20.8\ mm$. — $t = 5$

Total score: 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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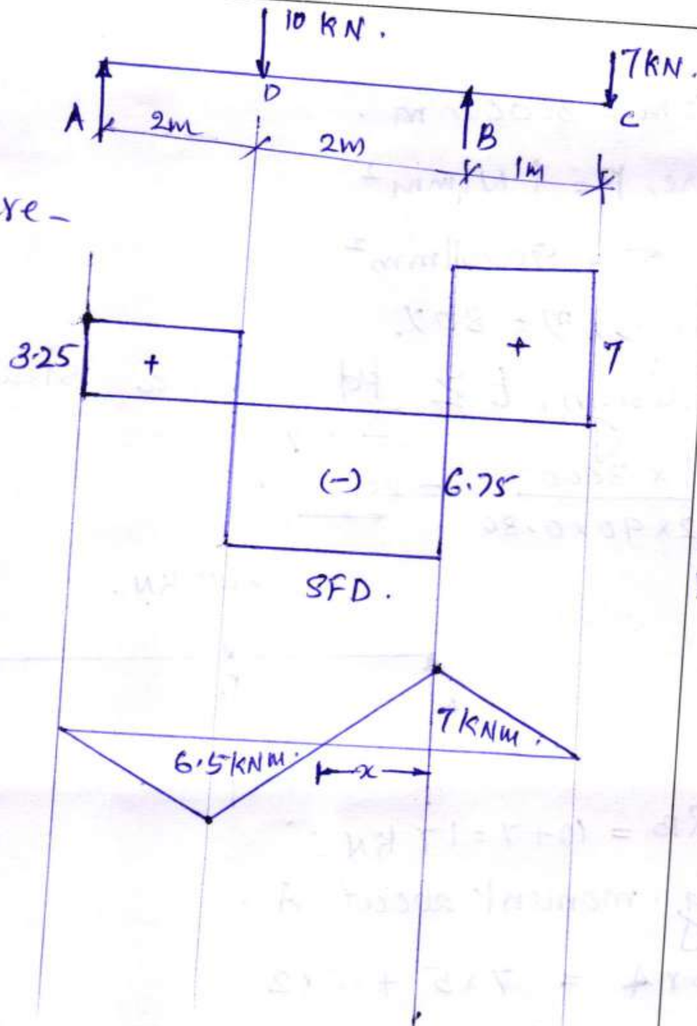
Point of contraflexure –

$x = \frac{7}{6.5} = 1.037m$



SFD = 3
BMD = 3
P.C = 2

8

(b). $D = 150\,mm$

$P = 400\,kW$

$N = 200\,rpm.$

$\tau = 50\,N/mm^2$

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

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

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

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

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

$d = 121\,mm$

P = 1
T = 3
d = 3
7

7

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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
	$0.6 = 1.5 \times \frac{wl}{2A}$		
	$0.6 = 1.5 \times \frac{w \times 5000}{2 \times 100 \times 200}$	F = 1 eqn = 2	
	$w = \underline{3.2}$ N/mm.	w = 4	
IX (a)	$d = 200$ mm.		7
	$b = 300$ 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.		
	$M = wl^2/8$.		
	$\sigma_b \cdot Z = \frac{wl^2}{8}$		
	$120 \times 2 \times 10^6 = \frac{w \times 8000^2}{8}$	bending eqn = 2 Z = 1 M = 1	
	$w = 30$ N/mm $= \underline{30 \text{ kN/m}}$.	w = 4 8	8
(b)	$b = 100$ mm.		
	Depth, $d = 300$ mm		
	Shear force $= 60$ kN $= 60 \times 10^3$ N.		
	a) Average shear stress,		
	$\tau_{av} = \frac{F}{A} = \frac{60 \times 10^3}{100 \times 300} = \underline{2 \text{ N/mm}^2}$		

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	(b) Maximum shear stress, $\tau_{max} = 1.5\ \tau_{av}$ $= 1.5 \times 2 = 3\ N/mm^2$		
	(c) shear stress at a distance of 30mm above NA		
	$y = 30mm$.		
	$I = bd^3/12 = \frac{100 \times 300^3}{12} = 225 \times 10^6 mm^4$.		
	$\tau = \frac{F}{2I}\left\{\frac{d^2}{4} - y^2\right\}$.	$\tau_{av} = 2$	
	$= \frac{60 \times 10^3}{2 \times 225 \times 10^6}\left[\frac{300^2}{4} - 30^2\right]$.	$\tau_{max} = 2$ $\tau_{at 30} = 3$	
	$= 2.88\ N/mm^2$.	7	7