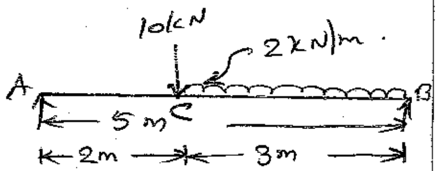
TED(15) 3013 Scoring Indicators 421

Code : 3013. Theory of Structures. Version: A

Qn. No.	Scoring Indicators	Split score	Total score
	<u>Part A</u>		
I 1.	Principle of moments states that if a member of coplanar forces acting simultaneously on a particle, the algebraic sum of ~~all the forces~~ moments of all the forces about any point is equal to the moment of their resultant about the same point.	2	
2.	Moment of inertia is defined as the moment of the moment of area or force about a point. It is the second moment of area. $I = Px^2$ or Ax^2 ~~out~~ I = Moment of inertia, P = Force, A = Area, x = distance to the centre of force or area to the point from which moment is taken.	2	
3.	Hardness is the property of a material to resist intendation or surface abrasion	2	
4.	It is the point at which the BMD changes sign.	2.	
5.	It is the ratio of moment of inertia of a section to the distance from N.A to the ~~Ponesan~~ point of maximum bending stress. ie $Z = \frac{I}{y_{max}}$.	2	10
	<u>Part B</u>		
II 1.	$R_B \times 5 = 2 \times 3 \times 3.5 + 10 \times 2$ $= 41$ 	Fig - 2	

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	$R_B = \underline{8.2\,kN}$	2	
	$R_A = 16 - 8.2 = \underline{7.8\,kN}$	2	
		6	
2.	Parallel axis – If the moment of inertia of an area (A) about an axis through it C.G is I_G, the moment of inertia of the area about any other axis AB parallel to the first and a distance 'h' from the C.G is given by $I_{AB} = I_G + Ah^2$.	3	
	Perpendicular axis:- It states that sum of moments of inertia of a plane section about two ⊥r axis intersecting at a point is equal to the moment of inertia about ~~the~~ an axis passing through the intersecting point and ⊥r to the plane of the area. i.e. $I_{zz} = I_{xx} + I_{yy}$.	3	
		6	
3.	$D = 75\,mm$. $d = 60\,mm$. $P = 50\,kN$ $E = 100 \times 10^3\,N/mm^2$ $l = 4\,m$.		
	$A = \frac{\pi}{4}(75^2 - 60^2) = 1590.43\,mm^2$		
	$\sigma = \frac{P}{A} = \frac{50\times10^3}{1590.43} = \underline{31.44\,N/mm^2}$	σ – 3	
	$\delta l = \frac{Pl}{AE} = \frac{\sigma . l}{E} = \frac{31.44 \times 4000}{100\times10^3} = \underline{1.26\,mm}$	δl – 3	
		6	

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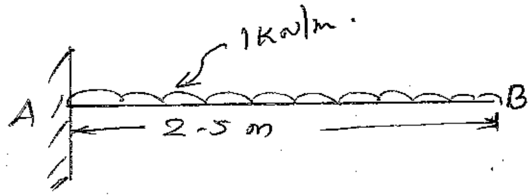
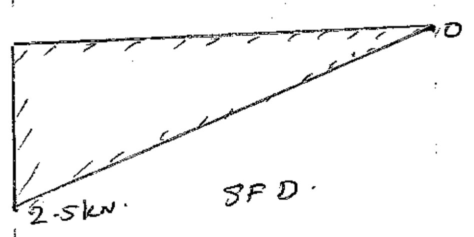
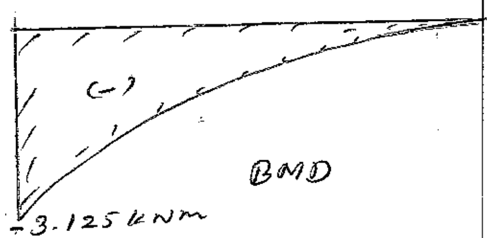
4.	Resilience - It is the energy stored in a material when deformed by an external load, within elastic limit. Proof resilience :- The maximum strain energy that can be stored in an elastic material within elastic limit. Modulus of resilience: Proof resilience per unit volume.	$3 \times 2 = 6$.	
5.	SF at $B = 0$ at $A = 1 \times 2.5 = 2.5\,kN$. BM at $B = 0$. at $A = -1 \times 2.5 \times 1.25$ $= -3.125\,kNm$.	SFD - 3 BMD - 3 6	
6.	$d = 1.5m$, $t = 4mm$, $\sigma_c = 80N/mm^2 = \sigma_l$. $\sigma_c = \frac{pd}{2t}$, $\therefore p = \frac{\sigma_c \times 2t}{d} = \frac{80 \times 2 \times 4}{1500} = 0.4267\,N/mm^2$ $\sigma_l = \frac{pd}{4t}$; $\therefore p = \frac{\sigma_l \times 4t}{d} = \frac{80 \times 4 \times 4}{1500} = 0.8534\,N/mm^2$ Safe pressure = $0.4267\,N/mm^2$	- 2 - 2 - 2 6	







Scoring Indicators

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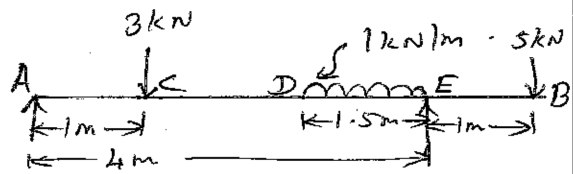
7.	Assumptions. 1) The material of the beam is homogeneous and isotropic 2) The value of young's modulus of elasticity is same in tension and compression. 3) The transverse sections which are plane before bending remain plane after bending. 4) The beam is initially straight and all longitudinal layers bend into circular arcs with a common centre of curvature. 5) The radius of curvature is large compared with the dimensions of cross section. 6) Each layer of the beam is free to expand or contract independently of the layer above or below it.	$6 \times 1 = 6$	42
	Part C		
III a).	 $R_E \times 4 = 5 \times 5 + 1 \times 1.5 \times 3.25 + 3 \times 1$ $= 32.875$ $\therefore R_E = \frac{32.875}{4} = \underline{\underline{8.22\,kN}}$. $R_A + R_E = 9.5\,kN$ $\therefore R_A = 9.5 - 8.22 = \underline{\underline{1.28\,kN}}$	moment – 2 $R_A, R_E = 3$ $R_E = 3$ 8	

Scoring Indicators

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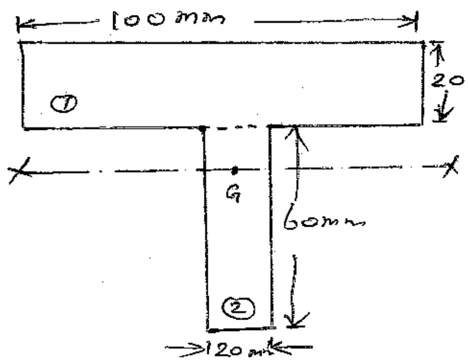
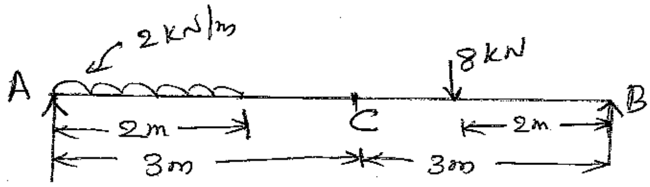
III b)	$a_1 = 100 \times 20 = 2000\,mm^2$ $y_1 = 10\,mm$ (from top) $a_2 = 60 \times 20 = 1200\,mm^2$ $y_2 = 20 + 30 = 50\,mm^2$. $\bar{y} = \frac{2000 \times 10 + 1200 \times 50}{(2000 + 1200)}$ $= \underline{25\,mm}$ (from top).  $I_{G_1} = \frac{100 \times 20^3}{12} = \underline{66666.67}$ $h_1 = 15\,mm$ $I_{G_2} = \frac{20 \times 60^3}{12} = 360000$ $h_2 = 25\,mm$ $I_{xx} = I_{G_1} + a_1 h_1^2 + I_{G_2} + a_2 h_2^2$ $= 66666.67 + 2000 \times 15^2 + 360000 + 1200 \times 25^2$ $= \underline{\underline{1626666.67\,mm^4}}$	$\bar{y} = 2$ eqn $= 1$ $I_{xx} = 4$ $\underline{7}$	15
IV a)	 $R_B \times 6 = 8 \times 4 + 2 \times 2 \times 1$ $\therefore R_B = 6\,kN$ $\therefore R_A = 12 - 6 = 6\,kN$ Moment at $C = R_B \times 3 - 8 \times 1$ $= 6 \times 3 - 8 = \underline{\underline{10\,kNm}}$.	moment - 2 R_B - 2 R_A - 2 M_c - 2 $\underline{8}$	

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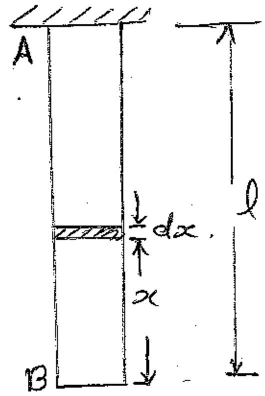
b)	$a_1 = \frac{\pi}{4} \times 100^2 = 7853.98\,mm^2$ $a_2 = \frac{\pi}{4} \times 50^2 = 1963.5\,mm^2$ $x_1 = 50\,mm$. $x_2 = 100 - 25 = 75\,mm$. $\bar{x}$ from A $= \frac{a_1 x_1 - a_2 x_2}{a_1 - a_2} = \frac{7853.98 \times 50 - 1963.5 \times 75}{7853.98 - 1963.5}$ $= \underline{\underline{41.67\,mm}}$.	eqn - 2 $\bar{x}$ - 5 $\overline{\underline{7}}$	15
Va)	Consider a bar AB hanging freely under its own weight.  A - cross sectional area of bar E = Youngs modulus w - specific weight of material l - length of bar. Consider a small section dx of the bar at a distance x from B. weight of bar for a length of x, $P = w \cdot A \cdot x$ Elongation of the section dx due to weight of bar $= \frac{Pl}{AE} = \frac{w \cdot A \cdot x \cdot dx}{AE} = \frac{w \cdot x \cdot dx}{E}$ Total elongation of bar, $\delta l = \int_0^l \frac{w x\, dx}{E}$		

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	$= \frac{\omega}{E}\int_0^l x\,dx = \frac{\omega}{E}\left[\frac{x^2}{2}\right]_0^l$	f_δ - 2	
	$\delta l = \frac{\omega l^2}{2E}$	δl - 6 8	
b)	$P = 20kN$, $L = 2.5m$, $A = 1000mm^2$, $E = 200\times10^3 N/mm^2$.		
	$\sigma = 2\times\frac{P}{A} = \frac{2\times20\times10^3}{1000} = 40N/mm^2$.		
	$V = 2.5\times10^3\times1000 = 2.5\times10^6 mm^3$.	eqn - 2	
	Strain energy stored $= \frac{\sigma^2}{2E}\times V = \frac{40^2\times2.5\times10^6}{2\times200\times10^3}$	S.E = 5 7	15
	$= 10kN.mm$		
VI(a)	$d = 30mm$, $P = 80kN$, $l = 200mm$, $\delta l = 0.12mm$,		
	$\delta d = 0.004mm$.		
	$A = \frac{\pi}{4}\times30^2 = \cancel{706mm^2}$ $706.86mm^2$		
	Poisson's ratio, $\frac{1}{m} = \frac{\delta d/d}{\delta l/l} = \frac{0.004/30}{0.12/200} = 0.222$.		
	$E = \frac{Pl}{A\cdot\delta l} = \frac{80\times200}{706.86\times0.12} = 188.63kN/mm^2$.		
	Bulk modulus, $K = \frac{E}{3(1-\frac{2}{m})} = 113.08kN/mm^2$.		
	Shear modulus, $N = \frac{E}{2(1+\frac{1}{m})} = \frac{188.63}{2(1+.222)} = 77.18kN/mm^2$	2x4 = 8	

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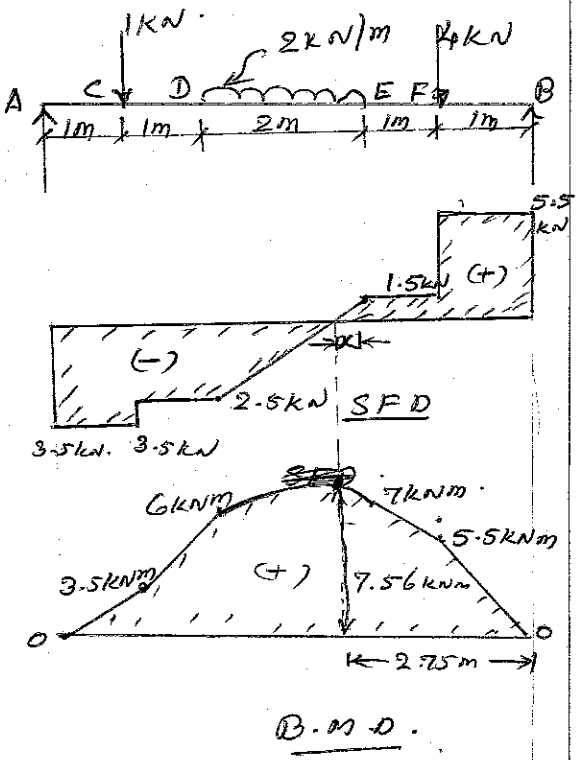
(b)	$l = 6m$, $d = 25mm$, $t = (100-60) = 40^{\circ}$, $E = 200\,GPa$, $\alpha = 12\times10^{-6}/^{\circ}C$ $\sigma = \alpha t E = 12\times10^{-6}\times 40\times 200\times10^{3} = \underline{96\,N/mm^2}$.	t - 2 eqn - 2 σ - 3 7	15
	Module III		
VII (a)	 Find R_A & R_B $R_B\times6 = 4\times5 + 2\times2\times3 + 1\times1$ $\therefore R_B = \frac{33}{6} = \underline{5.5\,kN}$ $R_A = 9 - 5.5 = \underline{3.5}\,kN$ SF at B = 5.5 at F = 5.5 − 4 = 1.5 kN " E = 1.5 kN. " D = 1.5 − 4 = −2.5 kN. " C = −2.5 − 1 = −3.5 kN " A = −3.5 kN BM BM at B = 0 " F = 5.5×1 = 5.5 kNm. " E = 5.5×2 − 4×1 = 7 kNm " D = 3.5×2 − 1×1 = 6 kNm. " C = 3.5×1 = 3.5 kNm. " A = 0. Max. BM $\frac{x}{1.5} = \frac{(2-x)}{2.5}$ $2.5x = 3 - 1.5x$ $4x = 3$ $x = \frac{3}{4} = 0.75m$. Max B.M at 2.75m from B. $= 5.5\times2.75 - 4\times1.75 - 2\times\frac{.75^2}{2}$ Max BM = $\underline{7.56\,kNm}$.	SFD - 4 BMD - 4 8	

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b) $T = 3157\ Nm$

$\sigma_s = 45\ N/mm^2$

$T = \frac{\pi}{16} \sigma_s D^3$ — eqn - 2

$\therefore D = \sqrt[3]{\frac{16T}{\pi \cdot \sigma_s}} = \sqrt[3]{\frac{16 \times 3157 \times 10^3}{\pi \times 45}} = \underline{\underline{70.96mm}}$ — D - 5

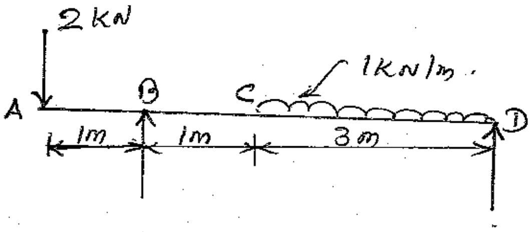
7 — 15

VIII (a)

$R_D \times 4 = 3 \times 1 \times 2.5 - 2 \times 1$

$\therefore R_D = \underline{1.375\ kN}$

$\therefore R_B = 5 - 1.375 = \underline{3.625\ kN}$



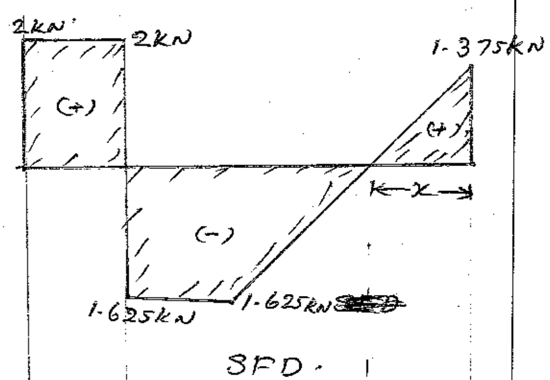
<u>SF</u>

at $D = 1.375\ kN$

" $C = 1.375 - 3 = -1.625\ kN$

" $B = -1.625 + 3.625 = +2\ kN$

" $A = \underline{2\ kN}$.



<u>BM</u>

at $D = 0$

" $C = 1.375 \times 3 - 1 \times 3 \times 1.5 = \underline{-0.375\ kNm}$

" $B = -2 \times 1 = -2\ kNm$.

" $A = 0$.

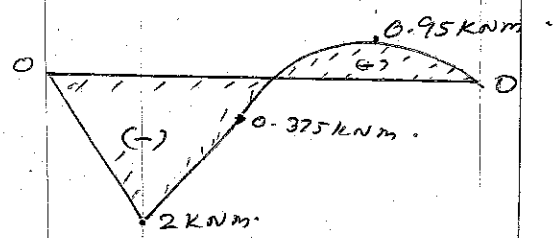
<u>BM max</u>

$\frac{x}{1.375} = \frac{3-x}{1.625}$

$1.625x + 1.375x = 4.125$

$\therefore x = 1.375\ m$.

B.M at $x = 1.375 \times 1.375 - \frac{1 \times 1.375^2}{2} = \underline{0.95\ kNm}$



Scoring Indicators

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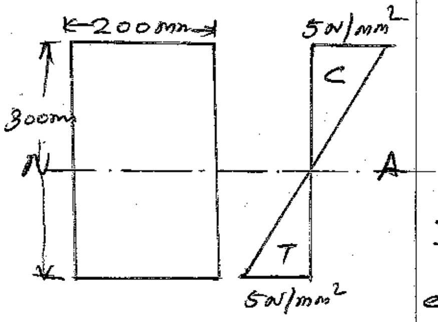
Qn. No.	Scoring Indicators	Split score	Total score
b)	$d = 400\,mm$, $t = 10\,mm$, $P = 2.5\,MPa$, Circumferential stress, $\sigma_c = \frac{Pd}{2t} = \frac{2.5 \times 400}{2 \times 10} = \underline{\underline{50\,N/mm^2}}$ Longitudinal stress, $\sigma_l = \frac{Pd}{4t} = \frac{2.5 \times 400}{4 \times 10} = \underline{\underline{25\,N/mm^2}}$.	$\sigma_c = 4$ $\sigma_l - 3$ $\overline{7}$	15
IX(a)	$l = 3\,m$, $W = 20\,kN$, $d = 300\,mm$, $b = 200\,mm$. $I = \frac{bd^3}{12} = \frac{200 \times 300^3}{12} = 450 \times 10^6\,mm^4$, $y = \frac{d}{2} = 150\,mm$ $\frac{M}{I} = \frac{f}{y}$; $f = \frac{M \cdot y}{I}$ $M = \frac{Wl}{4} = \frac{20 \times 3}{4} = 15\,kNm$. $\therefore f = \frac{15 \times 10^6 \times 150}{450 \times 10^6} = 5\,N/mm^2$.  	$I - 2$ egn $- 2$ $f - 2$ sketch $- 2$ $\overline{8}$	
(b)	$\tau_{av} = 0.4\,N/mm^2$, Size of beam $- 100 \times 200\,mm$. $\tau_{av} = \frac{F}{bd}$. $\therefore F = \tau_{av} \times b \times d = 0.4 \times 100 \times 200 = 8000\,N$ $= \underline{\underline{8\,kN}}$ $\tau_{max} = 1.5\,\tau_{av} = 1.5 \times 0.4 = \underline{\underline{0.6\,N/mm^2}}$	$F - 4$ $\tau_{max} - 3$ $\overline{7}$	15

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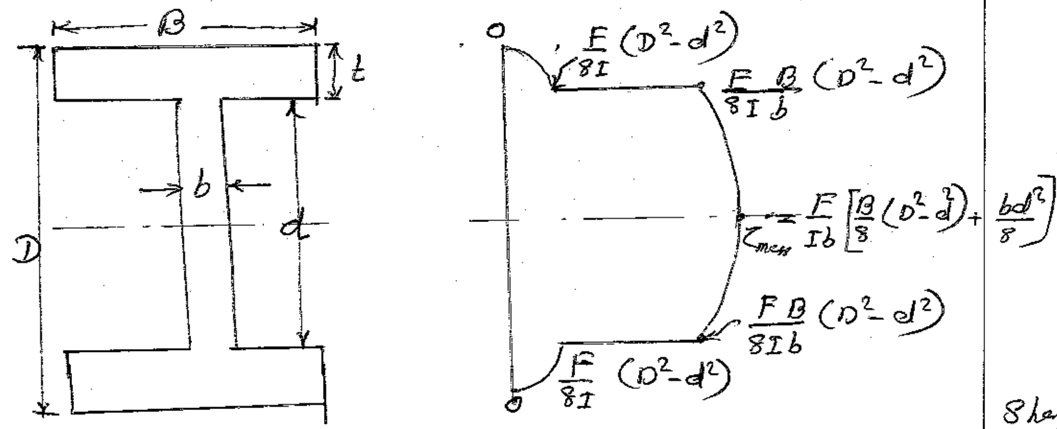
X (a)			
	F = Shear force I = Moment of inertia.	Shape - 2 Values - 6 8	
(b)	$b = 60mm$, $d = 150mm$, $l = 4m$, $\omega = 4.5\,kN/m$		
	$Z = \frac{bd^2}{6} = \frac{60\times150^2}{6} = 225\times10^3\ mm^3$	Z - 2	
	$M = \frac{\omega l^2}{8} = \frac{4.5\times4^2}{8} = 9\ kNm$	M - 2	
	Maximum bending stress $\sigma_{max} = \frac{M}{Z} = \frac{9\times10^6}{225\times10^3}$ $= 40\,N/mm^2$	σ - 3 7	15

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