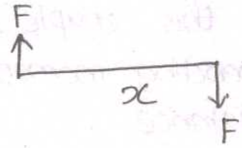
SCHEME OF VALUATION

Course Code: 3013

Revision : 2015

Course Title: Theory of structures I

Qstn No.	Scoring Indicator	Split up score	Sub total	Total
I	PART A			
1.	Two equal, unlike parallel forces whose lines of action are different form a couple. 	2	2	
2.	Varignon's theorem states that the moment of a force about any axis is equal to the sum of moments of its components about that axis. $Fd = F_1d_1 + F_2d_2$.	2	2	
3.	If the body is not allowed to expand or contract freely, stresses are set up in the body. Such stresses induced in a body due to change in temperature are called thermal stresses.	2	2	
4.	$\frac{T}{J} = \frac{C\theta}{L} = \frac{\tau}{R}$ – Torsion Equation	1		
	where T – Torque in Nmm J – Polar Moment of Inertia. C – Modulus of rigidity θ – Angle of twist in rad L – Length of the shaft in mm τ – Shear stress induced R – Radius of the circular shaft in mm	1	2	

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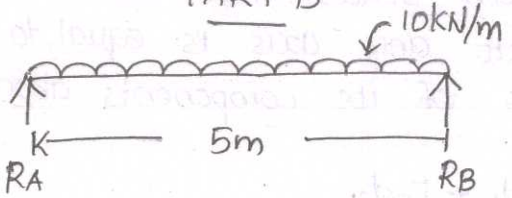
5.	On one side of the neutral axis there are compressive stresses, and on the other there are tensile stresses. These stresses form a couple whose moment must be equal to the external moment M. the moment of this couple, which resists the external bending moment is known as moment of resistance.	2	2	
II	PART B			
1.				
	Equillibrium Conditions are $\Sigma F_H = 0$; $\Sigma F_V = 0$; $\Sigma M = 0$	1		
	Applying Equillibrium conditions, $\Sigma F_V = 0$; $\Sigma F_V = 50 - R_A - R_B = 0$ $\therefore R_A + R_B = 50kN$.	2		
	$\Sigma M = 0$; Taking moment about A, $\Sigma M_A = 0$;	2		
	$\Sigma M_A = 10 \times 5 \times 2.5 - R_B \times 5 = 0$ $\therefore R_B = \underline{25kN}$ $R_A + R_B = 50kN$; $R_A = 50 - 25 = \underline{\underline{25kN}}$	1		

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Qstn No.	Scoring Indicator	Split up score	Sub total	Total
2.	Given data : $d = 25mm$ $L = 250mm$ $P = 50kN = 50 \times 10^3 N$ $\delta l = 0.3mm.$ Area of rod $= \frac{\pi}{4} \times 25^2 = 490.87 mm^2.$			
	Stress, $\sigma = \frac{P}{A} = \frac{50 \times 10^3}{490.87} = 101.86 N/mm^2.$	2		
	Strain $e = \frac{\delta L}{L} = \frac{0.3}{250} = 0.0012$	2		
	Young's modulus $E = \frac{\sigma}{e} = \frac{101.86}{0.0012} = 84883.33 N/mm^2$	2	6	
3.	Given : $d = 40mm$ Area $= \frac{\pi}{4} \times 40^2 = 400\pi mm^2.$ $L = 5000mm$ $V = A \times L = 2 \times 10^6 \pi mm^3$ $P = 60 \times 10^3 N.$ $E = 2 \times 10^5 N/mm^2.$			

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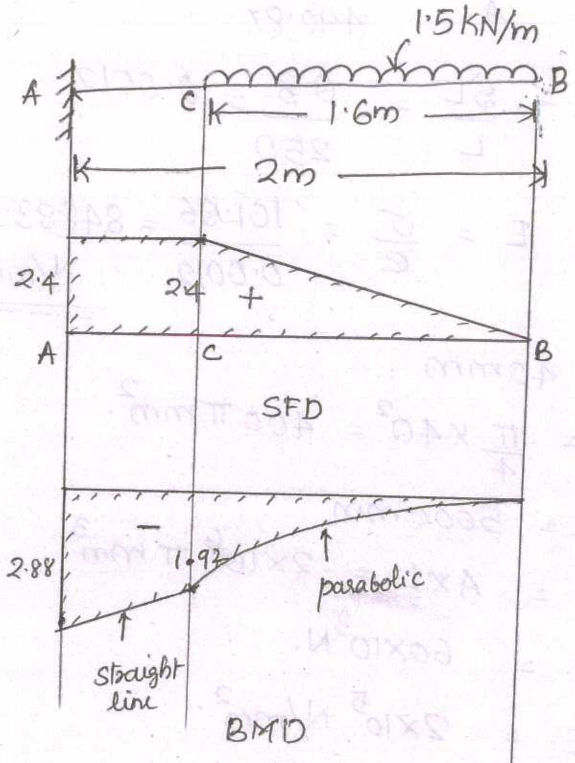
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
	i) Maximum instantaneous stress induced $\sigma = 2\times\frac{P}{A} = \frac{2\times 60\times 10^3}{400\pi} = 95.49\ N/mm^2$	2		
	ii) Instantaneous elongation in the rod $x = \frac{\sigma}{E}\times L = \frac{95.49}{2\times 10^5}\times 5000 = 2.38\ mm$	2		
	iii) Strain Energy $U = \frac{\sigma^2}{2E}\times V = \frac{95.49^2}{2\times 2\times 10^5}\times 2\times 10^6\pi = 143238\ Nmm$	2	6	
4.		1 1		

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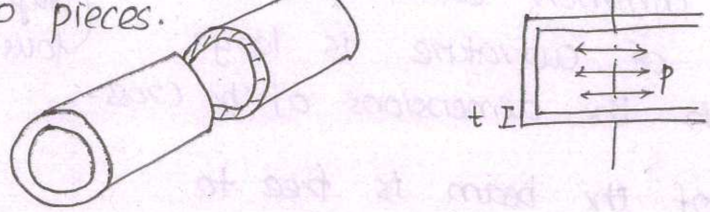
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
	Shear force diagram SF at B = 0 SF at C = $^{+}2.4kN$ SF at A = 2.4kN	2		
	Bending moment diagram BM at B = 0 BM at C = $^{-}1.92kNm$ BM at A = $-2.88kNm$.	2	6	
5.	Consider the cylindrical shell, subjected to the fluid pressure. As a result of internal pressure, the cylinder has a tendency to split into two pieces.  Force due to fluid pressure $= p\times\frac{\pi}{4}d^2$ —①	2		
	Force due to longitudinal stress $= \sigma_l \times \pi d t$ —②	2		

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Qstn No.	Scoring Indicator	Split up score	Sub total	Total
	Equating two equations, $\sigma_l \times \pi d t = p \times \frac{\pi}{4} \times d^2$ $\sigma_l = \frac{pd}{4t}$	2	6	
6.	Assumptions : 1. The material of the beam is homogeneous and isotropic. 2. The value of young's modulus of elasticity is the same in tension and compression. 3. The transverse sections which were plane before bending, remain plane after bending also. 4. The beam is initially straight and all longitudinal filaments bend into circular arcs with a common centre of curvature 5. The radius of curvature is large compared with the dimensions of the cross-section. 6. Each layer of the beam is free to expand or contract, independently of the layer, above or below it.	1.5X4 (any four)	6	

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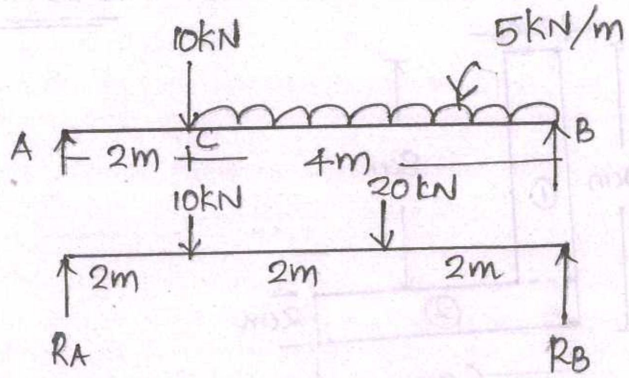
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
7.	$F = \frac{Wl}{2}$	1		
	$\tau_{max} = 1.5 \times \frac{F}{A} = 0.6$	1		
	$0.6 = 1.5 \times \frac{Wl}{2} \times \frac{1}{A}$	1		
	$0.6 = \frac{1.5 \times W \times 4000}{2} \times \frac{1}{100 \times 200}$	2		
	$W = 4\ N/mm$	1	6	
	PART C			
III a.				
	Equillibrium Conditions are	1		

$\Sigma F_H = 0$; $\Sigma F_V = 0$; $\Sigma M = 0$

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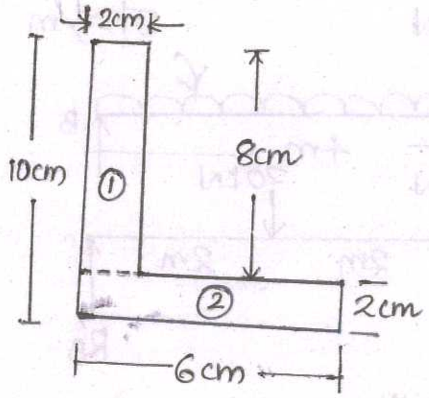
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
	Applying Equillibrium Conditions,			
	$\Sigma F_V = 0$;			
	$10 + 20 - R_A - R_B = 0$			
	$R_A + R_B = 30 kN$	2		
	$\Sigma M = 0$;			
	Taking moment about A,			
	$\Sigma M_A = 10 \times 2 + 20 \times 4 - R_B \times 6 = 0$	2		
	$20 + 80 - 6 R_B = 0$			
	$R_B = \frac{100}{6} = 16.67 kN$	1		
	$R_A = 30 - R_B = 30 - 16.67 = 13.33 kN$	1	7	
b.				

$$\bar{x} = \frac{a_1 x_1 + a_2 x_2}{a_1 + a_2} \qquad \bar{y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2}$$

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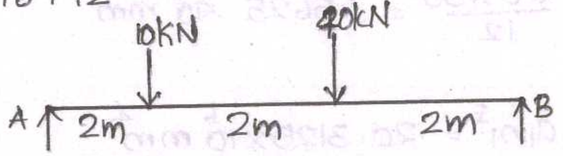
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
	Rectangle 1 $a_1 = 8\times2 = 16\,cm^2$ $y_1 = 2+4 = 6cm$ $x_1 = 1\,cm$	2		
	Rectangle 2 $a_2 = 6\times2 = 12cm^2$ $y_2 = \frac{2}{2} = 1cm$ $x_3 = 6/2 = 3cm$	2		
	$\bar{x} = \frac{16\times1 + 12\times3}{16+12} = 1.857cm$	2		
	$\bar{y} = \frac{16\times6 + 12\times1}{16+12} = 3.857\,cm$	2	8	15
IV 7(a)				
	Equillibrium Conditions are $\Sigma F_H=0; \Sigma F_V=0; \Sigma M=0$	1		
	$\Sigma F_V=0;\ 10+40-R_A-R_B=0$ $R_A+R_B = 50kN$	2		
	$\Sigma M_A=0;\ \Sigma M_A = 10\times2 + 40\times4 - R_B\times6 = 0$	2		
	$R_B = 30kN$	1		
	$R_A = 50-30 = 20kN$	1		7

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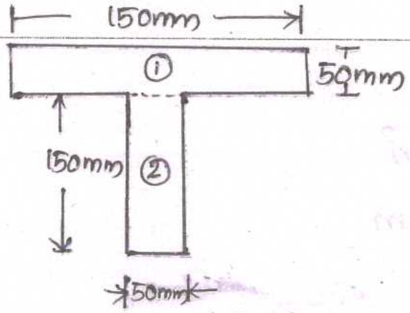
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
b.	 1. Find out the C.G of Section Rectangle 1 $a_1 = 150 \times 50 = 7500\,mm^2$ $y_1 = 150 + \frac{50}{2} = 175mm$ Rectangle 2 $a_2 = 7500mm^2$ $y_2 = 75mm$ $\bar{y} = \frac{a_1 * y_1 + a_2 y_2}{a_1 + a_2} = \frac{7500 \times 175 + 7500 \times 75}{7500 + 7500}$ $= 125mm$	2		
	Moment of inertia about x-x axis Rectangle 1 $I_{G1} = \frac{bd^3}{12} = \frac{150 \times 50^3}{12} = 1.5625 \times 10^6\, mm^4$ $h_1 = 50mm$ $I_{xx1} = I_G + a_1 h_1^2 = 20.3125 \times 10^6\, mm^4$	2		
	Rectangle 2 $I_{G2} = \frac{bd^3}{12} = \frac{50 \times 150^3}{12} = 14.0625 \times 10^6\, mm^4$ $h_2 = 50mm$	2		
	$I_{xx2} = 32.8125 \times 10^6\, mm^4$ $I_{xx} = I_{xx1} + I_{xx2} = 53.125 \times 10^6\, mm^4$ Moment of Inertia about Y-Y axis $I_{yy1} = \frac{db^3}{12} = 14.0625 \times 10^6\, mm^4$ $I_{yy2} = \frac{db^3}{12} = \frac{150 \times 50^3}{12} = 1.5625 \times 10^6\, mm^4$ $I_{yy} = 15.625 \times 10^6\, mm^4$	2	8	15

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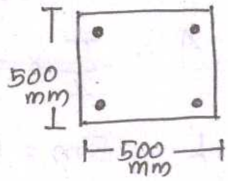
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
V a.	Given data:			
	$P = 2MN = 2\times10^6 N$			
	$E_s = 2.1\times10^5\ N/mm^2$			
	$E_c = 1.4\times10^4\ N/mm^2$			
				
	Area of Column $= 500\times500 = 250000\ mm^2$			
	Area of Steel bars, $A_s = 4\times\frac{\pi}{4}\times10^2 = 314.159\ mm^2$	1		
	Area of Concrete, A_c = Area of Column − Area of steel bars			
	$= 250000 - 314.159$			
	$= 249685.841\ mm^2$	2		
	Strain in steel = Strain in Concrete			
	$\frac{\sigma_s}{E_s} = \frac{\sigma_c}{E_c}$			
	$\sigma_s = \frac{E_s}{E_c}\times\sigma_c = \frac{2.1\times10^5}{1.4\times10^4} = 15\sigma_c$	2		
	Total load = Load on steel + Load on concrete			
	$2\times10^6 = \sigma_s A_s + \sigma_c A_c$			
	$2\times10^6 = 15\sigma_c\times314.159 + \sigma_c\times249685.84$	2	7	

$\sigma_c = 7.86 N/mm^2$ $\quad \sigma_s = 15\times7.86 = 117.92 N/mm^2$

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Qstn No.	Scoring Indicator	Split up score	Sub total	Total
b.	Given: $d = 3cm = 30mm$			
	$A = \frac{\pi}{4} \times 30^2 = 225\pi \ mm^2 = 706.85 mm^2$	1		
	$L = 5m = 5000mm$; $T_1 = 95^\circ C$, $T_2 = 30^\circ C$			
	Fall in Temperature $T = T_1 - T_2 = 95 - 30$ $= 65^\circ C$	1		
	$E = 2 \times 10^5 \ MN/m^2 = 2 \times 10^{11} \ N/m^2$			
	$\alpha = 12 \times 10^{-6} /^\circ C$.			
	i) when the ends do not yield.			
	Stress $= \alpha \cdot T \cdot E$			
	$= 12 \times 10^{-6} \times 65 \times 2 \times 10^{11}$			
	$= 156 \times 10^6 \ N/m^2$			
	$= 156 N/mm^2$	2		
	Pull in the rod $= \sigma \times A = 156 \times 706.85$ $= 110269.9 N$	1		
	ii) when the ends yield by 0.12 cm			
	$\delta = 0.12cm = 0.12mm$			
	Stress $= (\alpha T L - \delta) \times \frac{E}{L}$			

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	$= \frac{(12\times10^{-6}\times 65\times 5000 - 1.2)}{5000}\times 2\times10^{5}$			
	$= \frac{3.9-1.2}{5000}\times 2\times10^{5} = 108\ N/mm^2$	2		
	Pull in the rod $= \sigma \times A = 108\times 706.85$ $= 76340.7N$	1	8	15
VI a.	$L = 1.2m,\ P = 200\times10^{3}N,\ \mu = 0.3$ $E = 200\times10^{3} N/mm^2,\ A = 50\phi\times 50\phi = 25\times10^{2} mm^2$	1		
	i) Change in length $\delta l = \frac{Pl}{AE} = \frac{200\times10^{3}\times1.2\times10^{3}}{2500\times200\times10^{3}}$ $= 0.48mm$	2		
	ii) Change in width Linear strain $= \frac{\delta l}{l} = \frac{0.48}{1.2\times10^{3}} = 0.0004$ Lateral Strain $(\delta b/b) = \mu\times$ linear strain $= 0.3\times0.0004 = 0.00012$ $\delta b = 0.00012\times50 = 0.006mm$	2		

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Qstn No.	Scoring Indicator	Split up score	Sub total	Total
	iii) Change in volume $V = l \cdot b \cdot t = 1.2\times10^{3} \times 50 \times 50$ $= 3\times10^{6}\ mm^{3}$. $\frac{\delta V}{V} = \frac{P}{btE}(1-\mu)$ $\frac{\delta V}{3\times10^{6}} = \frac{200\times10^{3}}{50\times50\times200\times10^{3}}(1-0.3)$ $\delta V = \underline{\underline{480 mm^{3}}}$	2	7	
b.	i) Strain Energy :- The energy which is absorbed in the body due to straining effect is known as strain energy. The strain energy stored in the body is equal to the workdone by the applied load in stretching the body.	2		
	ii) Resilience - It is the total strain energy in a member when strained within elastic limit is known as resilience.	2		
	iii) Modulus of resilience - It is defined as the proof resilience per unit volume.	2		

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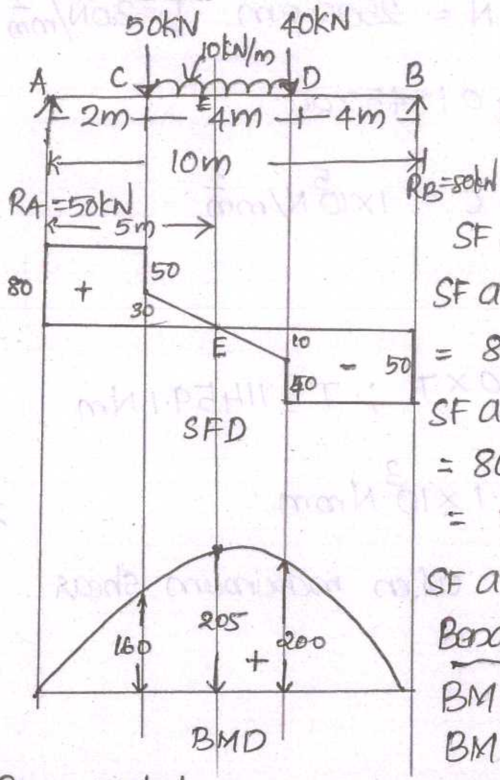
Qstn No.	**Scoring Indicator**	**Split up score**	**Sub total**	**Total**
VII a.	Proof resilience - The maximum strain energy stored in a body is known as proof resilience.  Shear force diagram SF at A = 80kN SF at C = 80-50=30kN SF at D (left of D) = 80-50-40=-10kN SF at D(right of D) = 80-50-40-40 = -50kN SF at B = -50kN Bending moment diagram BM at A =0 BM at C = 160kNm BM at E = 205kNm BM at D = 200kNm BM at B =0. $R_A + R_B = 130kN$ $\Sigma M_A = 0$; $R_B \times 10 - 40\times6 - 10\times4\times4 - 100 = 0$ $R_B = 50kN$ $R_A = 80kN$ Max. BM = 205kNm	2 2 2 SFD-1 BMD-1	8	15
	SF at E =0 $50 - 10x = 0$ $x = 5m.$	1	7	

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Qstn No.	Scoring Indicator	Split up score	Sub total	Total
b.	Given : $P = 300\,kW$, $N = 250\,rpm$ $\tau = 30\,N/mm^2$			
	$\theta = 1^\circ = \frac{\pi}{180}\,rad = 0.01745\,rad$	1		
	$L = 2m = 2000\,mm$, $C = 1\times10^5\,N/mm^2$			
	$P = \frac{2\pi NT}{60}$			
	$300 = \frac{2\pi \times 250 \times T}{60}$; $T = 11459.1\,Nm$			
	$T = 11459.1\times10^3\,Nmm$	2		
	i) Diameter of shaft when maximum shear stress,			
	$\tau = 30\,N/mm^2$			
	$T = \frac{\pi}{16}\tau D^3$			
	$11459.1\times10^3 = \frac{\pi}{16}\times 30\times D^3$			
	$D = 124.5\,mm$	2		

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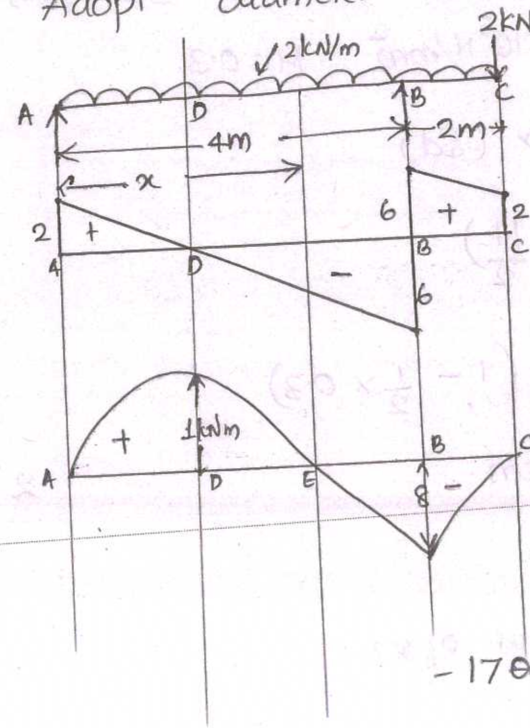
Qstn No.	**Scoring Indicator**	**Split up score**	**Sub total**	**Total**
	ii) Diameter of shaft when twist should not be more than 1°. $\frac{T}{J} = \frac{C\theta}{l}$ $\frac{11459.1\times10^{3}}{\frac{\pi}{2}\times D^{4}} = \frac{1\times10^{5}\times0.01745}{2000}$ $D^{4} = 13377.81\times10^{4}$ $D = (13377.81\times10^{4})^{1/4}$ $= \underline{107.5mm}$	2		
	Adopt diameter of 124.5mm ≃ 125mm	1	8	15
VIII a.		1 1		

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Qstn No.	Scoring Indicator	Split up score	Sub total	Total
	$R_A + R_B = 12+2 = 14kN$ $\Sigma M_A = 0;\ 2\times6 + 2\times6\times3 - R_B\times4 = 0;\ R_B = 12kN$ $R_A = 2kN$	1		
	Shear force diagram SF at A = 2kN SF at B (left of B) = 2−8 = −6kN SF at B (right of B) = −6+12 = 6KN SF at C = 2kN Bending moment diagram BM at A = 0 BM at D ($x = 1m$) = 2×1 − 2×1×.5 = 1kNm BM at B = −8kNm BM at C = 0	3		
	$2 - 2x = 0$ $x = 1m$. Point of Contraflexure. $M_E = 2x - 2\times x\times x/2 = 0$ $x = 2m$ from A.	1	7	
b.	Given: $d = 100cm$, $t = 1$ cm, $L = 5m = 5000mm$ $p = 3 N/mm^2$, $E = 2\times10^5 N/mm^2$, $\mu = 0.3$. i) Change in diameter (δd) $\delta d = \frac{pd^2}{2tE}\left(1 - \frac{\mu}{2}\right)$ $= \frac{3\times100^2}{2\times1\times2\times10^5}\left(1 - \frac{1}{2}\times0.3\right)$ $= 0.06375cm$.	2		

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	ii) Change in Length (δL) $\delta L = \frac{pdL}{2tE}\left(\frac{1}{2} - \mu\right)$ $= \frac{3 \times 100 \times 500}{2 \times 1 \times 2 \times 105}\left(\frac{1}{2} - 0.3\right)$ $= 0.075 cm$	2		
	iii) Change in volume $\delta V = V(2e_1 + e_2)$ $\delta V = V\left(2\frac{\delta d}{d} + \frac{\delta L}{L}\right)$ $V = \frac{\pi}{4} \times d^2 \times L = \frac{\pi}{4} \times 100^2 \times 500$ $= 3926990.817 cm^3$ $\delta V = 3926990.817\left(2 \times \frac{0.06375}{100} + \frac{0.075}{500}\right)$ $= 5595.96 cm^3$	2	8	15

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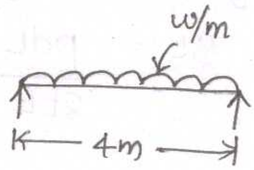
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
IX (a)	$d = 300mm$, $L = 4m$, $\sigma_{max} = 120 N/mm^2$			
	$I = 8 \times 10^6 mm^4$.			
				
	$M = \frac{wL^2}{8}$	*		
	$= \frac{w \times 4^2}{8} = 2w \; N/m = 2000 w N/mm$	2		
	$M = \sigma_{max} \times Z$			
	$Z = \frac{I}{y_{max}} = \frac{8 \times 10^6}{150}$	1		
	$M = \sigma_{max} \times Z$	1		
	$2000 w = 120 \times \frac{8 \times 10^6}{150}$			
	$w = \frac{120 \times 8 \times 10^6}{2000 \times 150}$	2		
	$= 3200 N/m$.	1	7	

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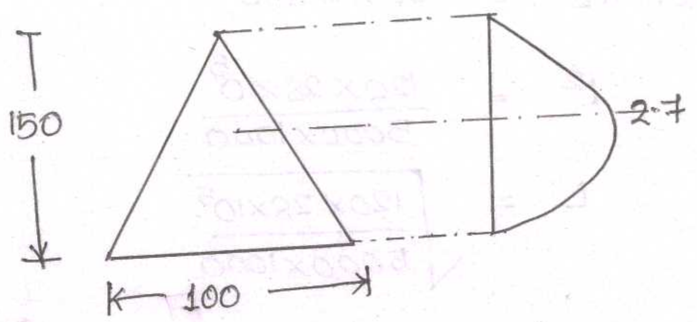
b)	$b = 100mm$, $h = 150mm$, $F = 13.5kN = 13.5\times10^3 N$ $A = \frac{1}{2} b\times h = \frac{100\times150}{2} = 7500mm^2$.	2		
	$\tau_{avg} = \frac{F}{A} = \frac{13.5\times10^3}{7500} = 1.8 N/mm^2$	2		
	Maximum shear stress $\tau_{max} = 1.5\tau_{avg}$ $\tau_{max} = 1.5\times1.8 = 2.7 N/mm^2$	2		
		2	8	15
X a.	Given: $\omega = 40kN/m = 40\times1000 N/m$ $d = 500mm$; $\sigma_{max} = 120N/mm^2$, $I = 7\times10^8 mm^4$			
	$Z = \frac{I}{y_{max}}$ $y_{max} = d/2 = 500/2 = 250mm$.	1		

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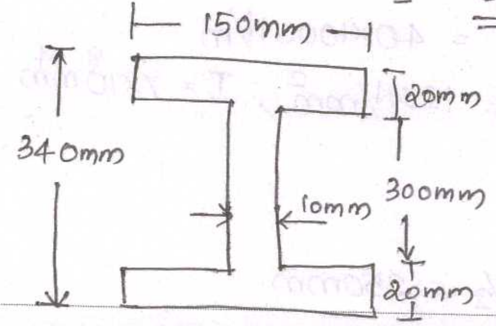
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
	$Z = \frac{7\times10^8}{250} = 28\times10^5\,mm^3$.	1		
	Maximum bending moment $M = \frac{wL^2}{8}$			
	$= \frac{4000\times L^2}{8}\,Nm$			
	$= 5000L^2\times1000\,Nmm$	2		
	$M = \sigma_{max}\times Z$	1		
	$5000\times1000\times L^2 = 120\times28\times10^5$			
	$L^2 = \frac{120\times28\times10^5}{5000\times1000}$	1		
	$L = \sqrt{\frac{120\times28\times10^5}{5000\times1000}}$			
	$= 8.2m$	1	7	
b.				

SCHEME OF VALUATION

Revision : 2015 Course Title: Theory of structures I		Course Code: 3013		
Qstn No.	Scoring Indicator	Split up score	Sub total	Total
	$I_{xx} = \frac{150\times340^3}{12} - \frac{14\times300^3}{12}$	4		
	$= 176.3\times10^6\ mm^4$			
	$\tau_{max} = \frac{F}{Ib}\left[\frac{B}{8}(D^2-d^2) + \frac{bd^2}{8}\right]$			
	$= \frac{50\times10^3}{176.3\times10^6\times10}\left[\frac{150}{8}(340^2-300^2) + \frac{10\times300^2}{8}\right]$	4	8	15
	$= 16.8\ N/mm^2$			