166

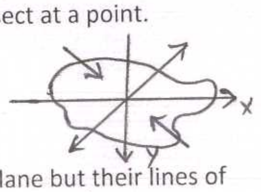
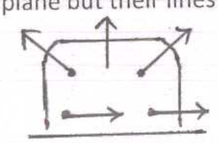
24-11-23

13 Nov. 23

SCHEME OF VALUATION

(Scoring Indicator)

Revision(15) Course Title: Theory of structure - I	Course code: 3013

Qst.No	Scoring Indicator	Split Up score	Sub Score	Total
I	PART A			
1.	i)Magnitude ii)Direction iii)Point of application		2	
2.	Total strain energy stored in a body or it is the capacity of a strained body for doing work, on the removal of the straining force.		2	
3.	Hooke's law states that, when a material is loaded, within its elastic limit, the stress is proportional to strain. Mathematically, Stress/strain= E = Constant		2	
4.	Cantiliver, Simply supported, Fixed, Contineous, and Over hanging beam.		2	
5.	$\frac{M}{I} = \frac{\sigma_b}{y} = \frac{E}{R}$ Where, M = Bending moment I = Moment of inertia σ_b= Bending stress y = Distance of fiber from neutral axis E = Young's modulus R = Radius of curvature		2	10
II	PART B			
1.	1. Coplanar concurrent forces, This system consist of a group of forces lying in a same plane and their lines of action meet or intersect at a point.  2. Coplanar non concurrent forces, In this system of forces lie in a same plane but their lines of action do not intersed. 			

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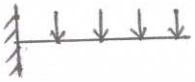
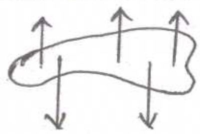
	3. <u>Coplanar like parallel forces,</u> In this system lines of action of forces are parallel. Their direction is same and all of them lie in a same plane.  4. <u>Coplanar unlike parallel forces,</u> Forces in this system are parallel to each other but with different directions of action and all of them lie in a same plane.  5. <u>Collinear forces,</u> Forces lying in a frame straight line are collinear forces.  6. <u>Non coplanar concurrent forces.</u> 7. <u>Non coplanar non-concurrent forces.</u>	3x2	6	
2.	(1) Strength - Ability of a material to resist breakdown. (2) Stiffness - Ability of a material to resist deformation. (3) Elasticity - Property of a material to regain its original shape after the removal of external load. (4) Plasticity - Property by which material retains the deformation even after the removal of load. (5) Malleability - Property by which material can be drawn into sheets. (6) Ductility – Property by which material can be drawn into wires. (7) Hardness – Property by which a material resists penetration. (8) Toughness – Property of a material to resist fracture due to impact Loads.	4x1.5	6	
3.	d= 30mm l= 6000mm $E = 2 \times 10^5 \, N/mm^2$ $P = 40 \times 10^3 \, N$ 1) Stress $= \frac{40 \times 10^3}{\pi/4 \, (30)^2} = 56.62 \, N/mm^2$ 2) Strain $= \frac{\sigma}{E} = \frac{56.62}{2 \times 10^5} = 2.83 \times 10^{-4}$ 3) Elongation, $\delta l = e \times l = 2.83 \times 10^{-4} \times 6000$ $= 1.698 \, mm$	2x3	6	

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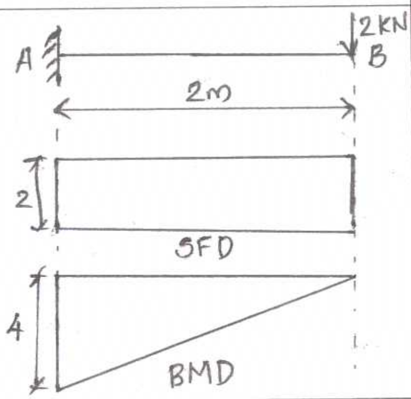
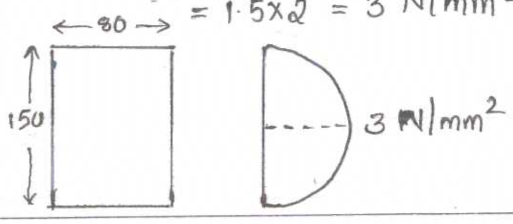
4.	Diameter, $D = 30mm$ Radius, $R = \frac{30}{2} = 15mm$ Torque, $T = 8KNm = 8\times10^6 Nmm$ Polar moment of Inertia, $J = \frac{\pi}{32} D^4$ $= \frac{\pi}{32}(30)^4 = 79481.25 mm^4$ Max. shear stress, $q_s = \frac{I}{J}\times R$ $= \frac{8\times10^6}{79481.25}\times 15 = 1509.79 N/mm^2$	3x2	6	
5.	SF at B = 2KN SF at A = 2KN BM at B = 0 BM at A = 2x2 =4KNm  	3x2	6	
6.	b = 100mm d = 150mm Shearing Force, F = 30KN = $30\times10^3 N$ Average shear stress, $\tau_{av} = \frac{F}{A} = \frac{30\times10^3}{100\times150} = 2 N/mm^2$ Maximum shear stress, $\tau_{max} = 1.5\,\tau_{av}$ $= 1.5\times2 = 3 N/mm^2$  	2x3	6	

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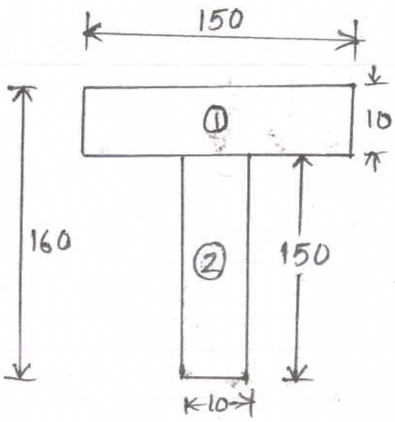
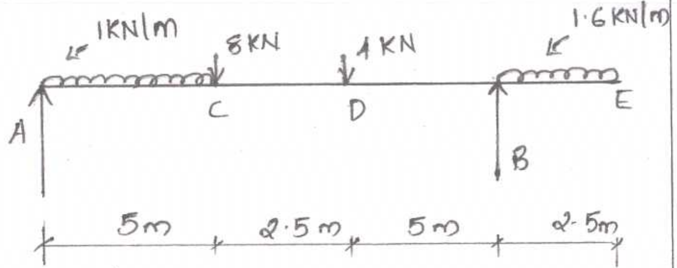
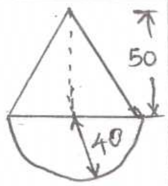
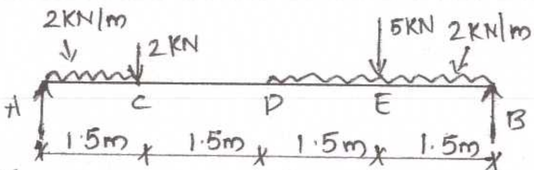
7.	l = 4m = 4000mm b = 80mm d = 120mm w = 10KN/m = 10N/mm Section modulus, Z= $\frac{bd^2}{6} = \frac{80 \times 120^2}{6} = 192 \times 10^3 mm^3$ Max. Bending moment, $M = \frac{wl^2}{8} = \frac{10 \times 4000^2}{8} = 20 \times 10^6 Nmm$ Max. Bending stress, $\sigma_b = \frac{M}{Z} = \frac{20 \times 10^6}{192 \times 10^3} = 104.16 N/mm^2$	2x3	6	
III (a)	PART C $a_1 = 150 \times 10 = 1500 mm^2$ $y_1 = 160 - \frac{10}{2} = 155 mm$ $a_2 = 150 \times 10 = 1500 mm^2$ $y_2 = 150/2 = 75 mm$ $\bar{y} = \frac{a_1 y_1 + a_2 y_2}{a_1 + a_2} = 115 mm$  	fig=1 $a_1 = 1$ $y_1 = 1$ $a_2 = 1$ $y_2 = 1$ $\bar{y} = \frac{3}{8}$	8	

Qst.No	Scoring Indicator	Split Up score	Sub Total	Total
(b)	 $R_A + R_B = 21 KN$ Taking moment about A $R_B \times 12.5 = 1.6 \times 2.5 \times (\frac{2.5}{2} + 12.5) + 4 \times 7.5 + 8 \times 5 + 1 \times 5/2$ $R_B = 11$ $R_A = 10 KN$ OR	fig = 2 $R_A = 2\frac{1}{2}$ $R_B = \frac{2\frac{1}{2}}{7}$	7	15
IV (a)	(1) Hemisphere, $V_1 = \frac{2}{3}\pi r^3 = \frac{2}{3} \times \pi \times 40^3 = 133973.33 mm^3$ $y_1 = r - \frac{3r}{8} = \frac{5r}{8} = \frac{5 \times 40}{8} = 25 mm$  (2) Right circular cone, $V_2 = \frac{\pi r^2}{3} h \times \pi/3 \times 40^2 \times 50 = 83733.33 mm^3$ $y_2 = r + \frac{h}{4} = 40 + \frac{50}{4} = 52.5 mm$ $\bar{y} = \frac{V_1 y_1 + V_2 y_2}{V_1 + V_2} = 35.57 mm$	fig = 1 $V_1 = 1$ $y_1 = 1$ $V_2 = 1$ $V_2 = 1$ $\bar{y} = 3/8$	8	
(b)	 $R_A + R_B = 16 KN$ $R_B \times 6 = 2 \times 3 \times 4.5 + 5 \times 4.5 + 2 \times 1.5 + 2 \times 1.5 \times 1.5/2$ $R_B = 9.125 KN$ $R_A = 6.875 KN$	fig = 1 $R_A = 3$ $R_B = 3/7$	7	15

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V (a)	Area of column, $A = \frac{\pi d^2}{4} = \pi/4 \times 400^2$ $= 125663.70 \, mm^2$ Area of steel $A_s = 4 \times \pi/4 \times 25^2 = 1962.5 mm^2$ Area of concrete $A_c = A - A_s = 123701 \, mm^2$ stress in the concrete, $\sigma_c = 4.5 \, N/mm^2$ stress in steel, $\sigma_s = \frac{E_s \times \sigma_c}{E_c} = 18 \times 4.5$ $= 81 \, N/mm^2$ safe load, $P = \sigma_s \cdot A_s + \sigma_c \cdot A_c$ $= 715.61 \, KN$	$A=1$ $A_s=1$ $A_c=1$ $\sigma_c=1$ $p=4/8$	8	
(b)	$l = 3m = 3000mm$ $d = 25mm$ Area $= \pi/4 \times d^2 = 490.625 \, mm^2$ Axial pull on the rod, $P = 15KN = 15 \times 10^3 N$ when the load is suddenly applied stress, $\sigma = 2 \cdot \frac{P}{A} = \frac{2 \times 15 \times 10^3}{490.625} = 61.15 \, N/mm^2$ Strain energy, $u = \frac{\sigma^2}{2E} \cdot V$ volume, $V = A \times l = 490.625 \times 3000$ $= 1471875 \, mm^3$ $u = \frac{(61.15)^2}{2 \times 100 \times 10^3} \times 1471875$ $= 27519.07 \, Nmm = 27.51 \, KNmm$	$A=1$ $\sigma=1$ $V=1$ $u=4/7$	7	15

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VI (a)	OR $l = 5m = 5000\,mm$ $b = 30mm$ $t = 20mm$ Axial pull, $P = 120KN = 120\times10^3\,N$ $E = 200\times10^3\,N/mm^2$ Poisson's ratio = 0·30 change in length, $\delta l = \frac{Pl}{AE} = \frac{120\times10^3\times5\times10^3}{30\times20\times200\times10^3}$ $= 5mm$ Change in width, $\delta b = b\times$ lateral strain lateral strain, $= \frac{1}{m}\times e$ linear strain, $e = \delta l/l = \frac{5}{5\times10^3} = 1\times10^{-3}$ lateral strain $= 0\cdot3\times1\times10^{-3} = 3\times10^{-4}$ $\delta b = 30\times3\times10^{-4} = 0\cdot009\,mm = 9\times10^{-3}\,mm$ change in thickness, $\delta t = t\times$ lateral strain $= 20\times3\times10^{-4} = 0\cdot006 = 6\times10^{-3}\,mm$	$\delta l = 2$ $\delta b = 2$ $\delta t = 3/7$	7	
(b)	$l = 2\cdot5m = 2500mm$ temperature, $t = 30K$ (i) stress in the bar do not yield $\sigma_1 = \alpha t E$ $= 24\times10^{-6}\times30\times120\times10^3$ $= 86\cdot4\,N/mm^2$. (ii) Stress in the bar when the ends yield by 1mm $\sigma_2 = \left[\alpha t - \frac{\Delta}{l}\right]E$ $= \left[24\times10^{-6}\times30 - \frac{1}{2500}\right]120\times10^3$ $= 38\cdot4\,N/mm^2$	$\sigma_1 = 4$ $\sigma_2 = 4/8$	8	15

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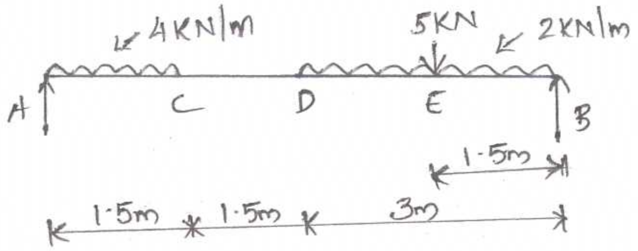
VII (a)	Torque $T = 7\ KNm = 7\times10^6\ Nmm$ Max. shear stress $\tau = 40\ MPa = 40\ N/mm^2$ $T = \frac{\pi}{16}\ \tau D^3$ $6.5\times10^6 = \frac{\pi}{16}\times 40\times D^3$ $D^3 = \frac{7\times10^6}{7.85} = 891719.7$ $D = 96.25\ mm$		7	
(b)	 $R_A + R_B = 17\ KN$ Taking moment about A $R_B\times6 = (4\times1.5\times0.75) + (2\times3\times4.5) + 5\times4.5$ $R_B = 9\ KN$ $R_A = 8\ KN$ SF at $B = -9$ $E = -6\ KN$ $D = +2KN$ $C = +2KN$ $A = +8\ KN$			

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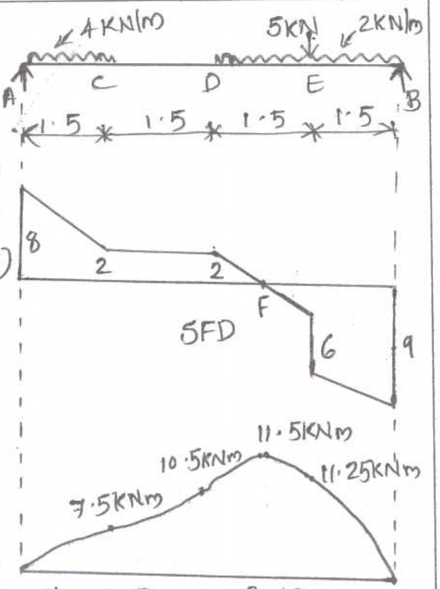
	BM at B = 0 $E = (9 \times 1.5) - (2 \times 1.5 \times 0.05)$ $= 11.25$ KNm $D = (8 \times 3) - (4 \times 1.5 \times 2.25)$ $= 10.5$ KNm $C = 8 \times 1.5 - (4 \times 1.5 \times 0.75)$ $= 7.5$ KNm $A = 0$ Max. BM will occur at M_F, where the shear force changes sign, from the geometry of figure $\frac{x}{1} = \frac{1.5 - x}{2}$ $2x = 1.5 - x$,  $x = 0.5$ m BMD Max BM $= 9(1.5 + 0.5) - (2 \times 2 \times 1) - (5 \times 0.5) = 11.5$ KNm OR	SFD = 4 BMD = 4 point of cont: = 2/8	8	15
VIII (a)	$d = 5m = 5000mm$ Pressure $P = 2MPa = 2N/mm^2$ $t = 10mm$ $E = 200GPa = 200 \times 10^3 N/mm^2$ Poisson's ratio, $1/m = 0.30$ 1) change in diameter, $\delta d = \frac{Pd^2}{4tE}[1 - 1/m]$ $= \frac{2 \times (5 \times 10^3)^2}{4 \times 10 \times 200 \times 10^3}[1 - 0.30]$ $= 4.375$ 2) Change in volume, $\delta v = \frac{\pi \cdot Pd^4}{8tE}[1 - 1/m]$ $= \frac{\pi \times 2 \times (5 \times 10^3)^4}{8 \times 10 \times 200 \times 10^3}[1 - 0.30]$ $= 171.80 \times 10^6 mm$	$\delta d = 3½$ $\delta v = \frac{3½}{7}$	7	

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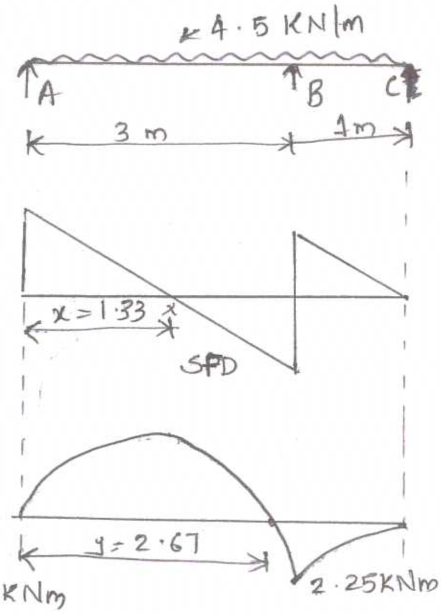
(b)	$R_A + R_B = 4.5 \times 4 = 18$ KN $R_B \times 3 = 4.5 \times 4 \times 2 = 36$ $R_B = 12$ KN $R_A = 6$ KN SF at A $= 6$ KN $B = 6 - (4.5 \times 3) + 12$ $= 4.5$ KN $C = 4.5 - (4.5 \times 1) = 0$ BM, at $A = 0$ $B = 4.5 \times 1 \times 0.5 = 2.25$ KNm $C = 0$.  Max. BM will occur at x $\frac{x}{6} = \frac{3-x}{7.5}$ $13.5x = 18$ $x = \underline{1.33 m}$ Max. BM $= 6 \times 1.33 - 4.5 \times 1.33 \times \frac{1.33}{2}$ $= 4$ KNm Point of contraflexure $M_E = 6 \times y - 4.5 \times y \times y/2 = 0$ $2.25y^2 - 6y = 0$ $y = \underline{\underline{2.67 m}}$	SFD=2 BMD=2 P.C=2 max BM = 2/8	8	15

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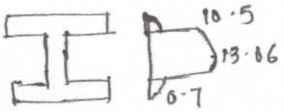
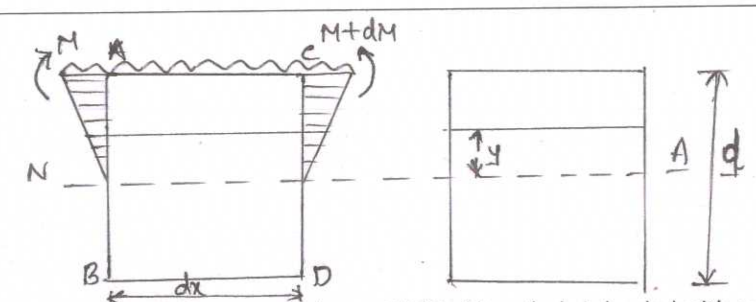
IX (a)	1) The beam is subjected to pure bending and is therefore free from shear force 2) The material of the beam is homogeneous and Isotropic 3) Each longitudinal fibre is free to expand (or) contract independently 4) The value of the young's modulus is the same for beam material in tension as well as compression 5) A transverse section of the beam which is a plane before bending will remain a plane after bending. 6) The elastic limit is not exceeded. 7) The resultant thrust (or) pull on a transverse section of the beam is zero. 8) The radius of curvature of the deflected beam is very large compared with the dimensions of the cross section of the beam	1X7	7	
(b)	$I_{xx} = \frac{BD^3}{12} - \frac{bd^3}{12} = \frac{150 \times 350^3}{12} - \frac{140 \times 310^3}{12} = 188.38 \times 10^6 \, mm^4$ Shear stress at upper edge of the upper flange is zero. Shear at the joint of the upper flange and web = $\frac{F}{8I}[D^2 - d^2]$ $= \frac{40 \times 10^3}{8 \times 188.83 \times 10^6}[350^2 - 310^2] = 0.7 \, N/mm^2$ shear stress at the junction, $= 0.70 \times \frac{B}{b}$  $= 0.70 \times \frac{150}{10} = 10.5 \, N/mm^2$ Max. shear stress $\tau_{max} = \frac{F}{Ib}\left[\frac{B}{8}(D^2 - d^2)\right] + \left[\frac{bd^2}{8}\right]$ $= \frac{40 \times 10^3}{188.38 \times 10^6 \times 10}\left[\frac{150}{8}(350^2 - 310^2)\right] + \left[\frac{10 \times 310^2}{8}\right]$ $= 13.06 \, N/mm^2$		8	15

Qst.No	Scoring Indicator	Split Up score	Sub Total	Total
X (a)	$d = 300\,mm$ $l = 3.5m = 3500\,mm$ $\sigma_{max} = 120\,N/mm^2$ $I = 225 \times 10^6\,mm^4$ distance b/w NA and extreme fibre $y = d/2 = 150\,mm$ section modulus, $Z = I/y = \frac{225 \times 10^6}{150} = 1.5 \times 10^6\,mm^3$ Moment of resistance, $M = \sigma_{max} \times Z$ $= 120 \times 1.5 \times 10^6 = 180 \times 10^6\,Nmm$ Max. bending moment $= wl^2/8$ $MR = BM$ $180 \times 10^6 = wl^2/8$, $180 \times 10^6 = \frac{w \times 3500^2}{8}$ $\therefore w = 117.35\,KN/m$	$y=1$ $Z=1$ $M=3$ $w=3/8$	8	
(b)	Consider a small element of a beam ABCD of length dx is loaded with a udl as shown in fig Let, M = BM at section AB M+dM = BM at section CD F = Shear force at AB F+dF = Shear force at CD I = Moment of inertia of the section about its NA Consider an elementary strip at a distance 'y' from NA, Let σ_b = Intensity of bending stress across AB at a distance y from NA			

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	a = area of strip $\frac{M}{I} = \frac{\sigma b}{y}$ or $\sigma b = \frac{M.y}{I}$ $\therefore \sigma + d\sigma = (M+dm) \times y/I$ Force across AB = stress x area = $\sigma b \times a$ $= \frac{M}{I} \times y \times a$ Force across CD = $(\sigma + d\sigma) a = \frac{(M+dm)}{I} y \times a$ Net unbalanced force = $\frac{M+dm}{I} \times y \times a - \frac{m}{3} \cdot y \cdot a$ $= \frac{dm}{I} \times y \times a$ The total unbalanced force (F) above the NA $= \int_0^{d/2} \frac{dm}{I} \cdot a \cdot y \cdot dy = \frac{dm}{I} \int_0^{d/2} a \cdot y \cdot dy = \frac{dm}{I} a \cdot \bar{y}$ where A = Area of the beam above NA and $\bar{y}$ = distance between CG of the area and NA we know that $\tau = \frac{\text{force}}{\text{area}} = \frac{\frac{dM}{I} \cdot A \cdot \bar{y}}{dx \cdot b}$ $= \frac{dM}{dx} \cdot \frac{A\bar{y}}{Ib}$ $\therefore (\frac{dm}{dx} = F)$ $\tau = \frac{F}{Ib} \cdot A \cdot \bar{y}$		7	15