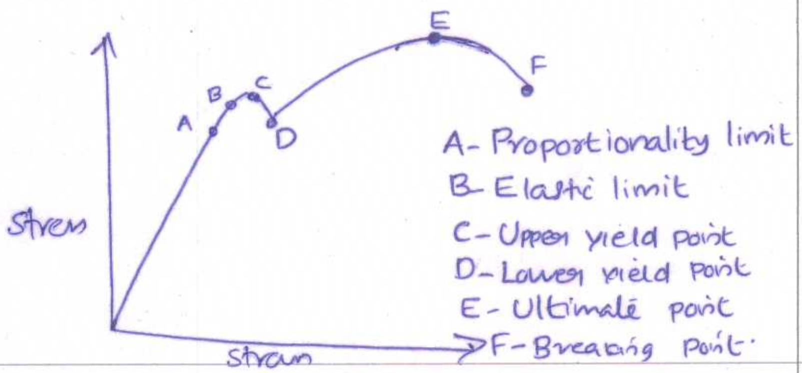
Scoring Indicators

Code: TED (15) 4021

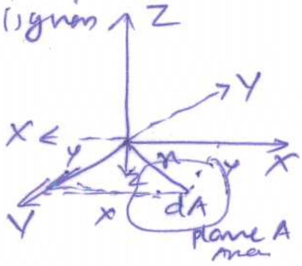
APPLIED MECHANICS AND STRENGTH OF MATERIALS

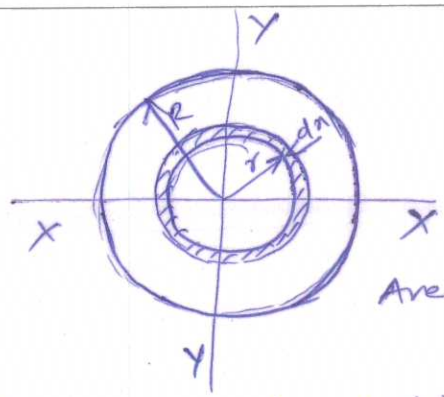
Q No.	Scoring Indicators	Split Score	Total Score
	PART A		
I.1	Hooks law states that when a material is loaded within its elastic limits the stress is directly proportional to the strain		2
I.2	Radius of gyration is defined as the distance from an axis of reference where the whole mass(or area)of a body is assumed to be concentrated.	½ x4	2
I.3	Butt weld and Lap weld		2
I.4	Polar modulus is defined as the ratio of the polar moment of inertia to the radius of the shaft	1 Mark for each	2
I.5	The maximum axial compressive load which a column can take without failure is known as crippling load		2
	PART B		
II.1			6
II.2	$P = 5\times10^3 N$ $\sigma_U = 360 N/mm^2$ $\sigma = 72 N/mm^2 \left(\frac{\sigma_U}{FS} = \frac{360}{5}\right)$ $A = \frac{P}{\sigma} = \frac{5\times10^3}{72} = 69.44 mm^2$ $A = \frac{\pi}{4} d^2$ $d = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4\times69.44}{\pi}} = 9.4 mm$		6
II.3	If Ixx & Iyy be the MI of a plane section about xx & yy		

<table>
<tr><td></td><td>then the M I of section I_{zz} is given by $I_{zz} = I_{xx} + I_{yy}$

$I_{xx} = \Sigma dA y^2$

$I_{yy} = \Sigma dA x^2$



$I_{zz} = \Sigma dA r^2 = \Sigma dA(x^2+y^2)$
$= \Sigma dA x^2 + \Sigma dA y^2$
$= I_{xx} + I_{yy}$</td><td></td><td>6</td></tr>
<tr><td>II.4</td><td>

Area of circular ring $= 2\pi r$

MI of the circular section about an axis passing through O & ⊥r to the plane of the paper $=$ (Area of ring × radius of ring^2)
$= 2\pi r dr \times r^2 = 2\pi r^3 dr$

∴ polar M I J or $I_{zz} = \int_0^R 2\pi r^3 dr = 2\pi \left(\frac{r^4}{4}\right)_0^R$

$\frac{\pi R^4}{2} = \frac{\pi D^3}{32}$, From perpendicular theorem.
$I_{zz} = I_{xx} + I_{yy}$
$I_{xx} = I_{yy} = \frac{I_{zz}}{2} = \frac{\pi D^4}{64}$</td><td>3</td><td>6</td></tr>
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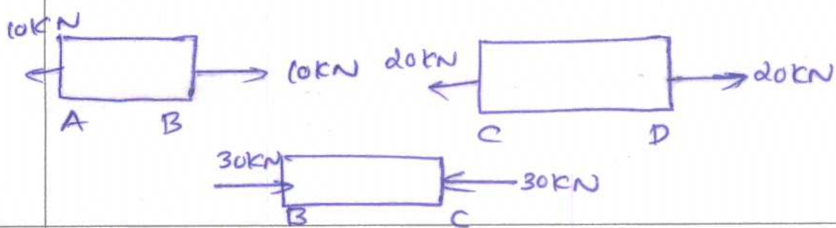
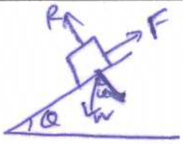
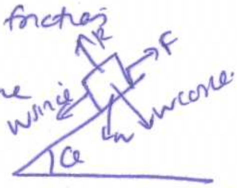
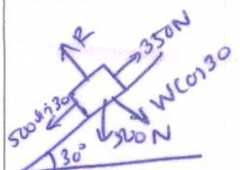
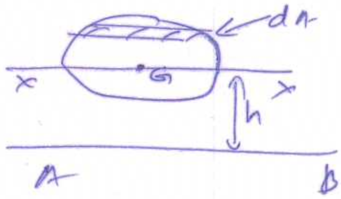
II.5	a) Shearing of rivets - $P_s = \frac{\pi}{4} d^2 \times \sigma_s$ b) Crushing - one of the plate in a joint is weaker than other $P_b = \sigma_b \times t \times d$. c) Tearing off the plate - the plate will tear between the rivet holes across a row. $P_t = \sigma_t (p-d) t$ Strength of the joint will be equal to the least value of P_s, P_b & P_t.		6
II.6	The stress acting along the circumfience of the cylinder is called as circumfrential or hoop stress. Stress along the length of the cylinder (i.e in the longitudinal direction) is known as longitudinal stress. hoop stress: $\sigma_h = \frac{Pd}{2t}$ longitudinal stress: $\sigma_t = \frac{Pd}{4t}$		6
II.7	1. Both ends hinged $L = l$ $P = \frac{\pi^2 EI}{l^2}$ 2. One end fixed and other end is free $L = 2l$ $P = \frac{\pi^2 EI}{4l^2}$ 3. Both ends fixed $L = l/2$ $P = \frac{4\pi^2 EI}{l^2}$ 4. One end fixed & other end is hinged. $L = l/\sqrt{2}$ $P = \frac{2\pi^2 EI}{l^2}$		6

III. a	Strain along lateral direction is called Lateral strain strain along longitudinal direction is called longitudinal strain poissons ratio $= \frac{\text{Lateral strain}}{\text{Longitudinal strain}}$		6
III. b	$d = 30mm$, $P = 60\times10^3 N$, $l = 200mm$, $\delta l = 0.09mm$ $\delta d = 0.0039mm$ $A = \frac{\pi}{4}\times30^2 = 706.86mm^2$ $\varepsilon = \frac{\delta l}{l} = \frac{0.09}{200} = 4.5\times10^{-4}$ $\varepsilon_L = \frac{\delta d}{d} = \frac{0.0039}{30} = 1.3\times10^{-4}$ $\mu = \frac{\varepsilon_L}{\varepsilon} = \frac{1.3\times10^{-4}}{4.5\times10^{-4}} = 0.29$, $E = \frac{Pl}{A\delta l} = 188627 N/mm^2$. $C = \frac{E}{2(1+\mu)} = 73168.2 N/mm^2$ $K = \frac{E}{3(1-2\mu)} = 148994.9 N/mm^2$.		9
IV. a	• within the elastic limit, the stress is proportional to strain. This constant of proportionality is known as youngs modulus(E). $\frac{\sigma}{\varepsilon} = E$ σ= stress, ε= strain • The ratio of shear stress to shear strain		

	is Called modulus of rigidity (C) $C = \frac{\tau}{\phi}$ $\quad \tau$ = shear stress ϕ = shear strain.		5
IV. b	$l_1 = 200mm$, $A_2 = 500mm^2$, $P_2 = 30\times10^3 N/mm^2$ $l_2 = 600mm$ $\quad A_3 = 400mm^2$ $\quad P_3 = 20\times10^3 N/mm^2$ $l_3 = 200mm$ $\quad E = 2\times10^5$ $\delta l = \frac{1}{E} = \frac{1}{E}\left[\frac{P_1 l_1}{A_1} - \frac{P_2 l_2}{A_2} + \frac{P_3 l_3}{A_3}\right]$ $= \bar{0}.097mm$ $= 0.097mm$ (decrease)  		10
V. a	 Let the angle of inclination (θ) be gradually increased, till the body just starts sliding down the plane. This angle of plane at which a body just begins to slide down the plane, is called angle of friction The maximum inclination of the plane at which a body can remain in equilibrium over the plane entirely by the assistance of friction is called angle of repose.  		5
V. b	 W = 500N, P = 300N $\quad$ Resolving force along plane $500\sin 30 + \mu R = 350$ — (1) Resolving force ⊥r to the plane. $R = 433N$ — (2)		7

	sub R in eqn ① $500 \sin 30 + \mu \times 433 = 350$ $\mu = 0.23$		
VI. a	Theorem of parallel axis states that if the moment of inertia of a plane area about an axis in the plane of area through CG of the plane area be represented by I_G then the MI of the given plane area about a parallel axis AB in the plane of area at a distance h from CG of the area is given by  $I_n = \sum dA y^2$ MI of total Area $= dA(h+y^2)$ $= dA(h^2+y^2+2hy)$ $I_{AB} = \sum dA(h^2+y^2+2hy) = \cancel{h^2 \sum dA}$ $= \sum dA h^2 + \sum dA y^2 + \sum dA 2hy$ $I_{AB} = h^2 \sum dA + \sum dA y^2 + 2h \sum dA y$ $I_{AB} = Ah^2 + I_G + 2h \sum dAY$ $\because \sum dAy = 0$ $I_{AB} = Ah^2 + I_G$		5
VI. b	$a_1 = \frac{1}{2} \times 100 \times 90 = 4500mm^2$ $Y_1 = \frac{1}{3} \times 90 = 30mm$ $a_2 = 20 \times 30 = 600mm^2$ $Y_2 = 30 + \frac{30}{2} = 45mm$ $\bar{y} = \frac{\sum ay}{\sum a} = 27.69mm$ $I_{xx1} = \frac{bh^3}{36} + a_1 h_1^2 =$ $= 2049012.45mm^4$ $I_{xx2} = 224781.66mm^4$ MI passing thy CG $I_{xx} = I_{xx1} - I_{xx2}$ $I_{xx} = I_{xx1} \cancel{+} I_{xx2} = 1824230.79mm^4$. MI passing thy BC $I_{xx1} = \frac{bd^3}{12} = 6075000mm^4$ $I_{xx1} = 1260000 mm^4$ $I_{xx} = I_{xx1} - I_{xx2} \Rightarrow I_{xx} = 4815000mm^4$ $\cancel{4815000mm^4}$		10

VII. a	To make the joints leak proof or Fluid tight in pressure vessels like steam boilers, air receivers, tanks etc process known as caulking is employed. In this process a narrow tool called caulking tool about 5mm thick & 38mm breadth is used. A more satisfactory way of making the joint is known as fullering. In this A fullering tool of with a thickness at the greatest pressure due to the blows occur near the joint, with less risk of damaging the plate		6
VII b	$n=2,\ t=20mm,\ d=25mm,\ p=100mm$ $\sigma_s=80MPa,\ \sigma_b=160MPa,\ \sigma_t=100MPa$ $P_s=2\times\frac{\pi}{4}d^2\sigma_s n=157079.63N$ $P_b=\sigma_b\times t\times d\times n=160000\ N$ $P_t=\sigma_t(p-d)\times t=C00\times(100-25)\times 20$ $=150000N$ $P=\sigma_t\times p\times t=100\times100\times20=200000N$ $\eta=\frac{\text{Least of } P_s \times P_b \times P_t}{\sigma_t \times p \times t}=\frac{150000}{200000}=75\%.$		9
VIII. a	The strength of a shaft means the maximum torque or maximum power the shaft can transmit. Torsional rigidity or stiffness of the shaft is defined as the product of modulus of rigidity (C) & polar moment of inertia of the shaft (J) Torsional rigidity $= C\times J$		5
VIII. b	$D=160mm\quad P=150\times10^3W\quad N=1800rpm.$ $T=\frac{60P}{2\pi N}=7957.75\times10^{3}Nmm$ $\tau=\frac{16T}{\pi D^3}=\frac{16\times7957.75\times10^3}{\pi\times160^3}=9.89MPa$		10

IX. a	1. The column is initially perfectly straight 2. cross section of the column is uniform throughout. 3. The column material is perfectly elastic, homogeneous & isotropic 4. The colum will fail by buckling alone 5. Self weight of colum is negligible		5
IX. b	$l = 1.5\times10^3 mm$, $d = 50mm$ $A = \frac{\pi}{4}50^2 = 625\pi mm^2$ $I = \frac{\pi}{64}\times50^4 = 97656.25\pi mm^4$ $K = \sqrt{\frac{I}{A}} = 12.5$ (a) $L = 2l = 3\times10^3 mm$ Rankine's Formula $P = \frac{\sigma_c A}{1+a(\frac{L}{K})^2} = 29717.77N$ Safe load $= \frac{29717.77}{3} = 9905.9N$ (b) Eulers Formula		10

$$P = \frac{\pi^2 EI}{L^2} = 40372.15N$$

$$\text{Safeload} = \frac{40372.15}{3} = 13457.6N$$

X.a	(a) Bending springs The types of springs which are subjected to bending only and the resilience occurs due to this is called bending springs eg: (i) Laminated spring (ii) Leaf springs (b) Torsion springs The types of springs which are subjected to torsion or twisting only and the resilience occurs due to this are called Torsion springs Eg: (i) Helical spring		5

X6	$d = 10mm$ $n = 10$ $D = 120mm$ $W = 200N$ $C = 8 \times 10^4 N/mm^2$ (a) $\delta = \frac{64WR^3n}{Cd^4} = 34.5\ mm.$ (b) $\tau = \frac{16WR}{\pi d^3} = 61.1 N/mm^2$ (c) $S = \frac{W}{\delta} = \frac{200}{34.5} = 5.8 N/mm$		10