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Faculty of Applied Design
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EXAMINATION SOLUTIONS: SESSION 2013 2014

School:	LOGISTICS & MANUFACTURING		
Programme:	MECHANICAL & MANUFACTURING ENGINEERING	Year:	3
Module/Unit:	ADVANCED STRESS - PART TIME		
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Question No	Question	Marks
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Question No.	Question	Marks
15		
①	$v = \frac{F}{A} \quad \therefore F = v \times A$ $= 400 \times 10^6 \times (10 \times 10) \times 10^{-6}$ $= \underline{\underline{40 \text{ kN}}}$	1
	$\text{AREA} = (10 \times 10) \times 10^{-6}$ $= 1 \times 10^{-4} \text{ m}^2$	
	$U = \frac{P^2 L}{2AE}$	
	$= \frac{40000^2 \times 2}{2 \times 1 \times 10^{-4} \times 200 \times 10^9}$	
	$= \frac{3200 \times 10^6}{40 \times 10^6}$	
	$= \underline{\underline{80 \text{ J}}}$	2

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Question No	Question	Marks
(16)		
(ii)	P.E. WHEN WEIGHT IS ADDED.	
	$P.E. = mgh$	1
	THAT ENERGY IS ABSORBED BY SHAFT	
	$U = \frac{P^2 L}{2AE} = \frac{\sigma^2 A^2 L}{2AE} = \frac{\sigma^2 AL}{2E}$	
	$= \frac{\sigma^2}{2E} \times V$	1
	$\frac{\sigma^2}{2E} \times V = mgh$	
	$h = \frac{\sigma^2 V}{2Emg}$	1
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Question No	Question	Marks
(d) 1	$h = \frac{\sigma^2 V}{2E_m g}$ $= \frac{(70 \times 10^6)^2 \times 1 \times 10^{-4} \times 2}{2 \times 200 \times 10^9 \times 100 \times 9.81}$ $= \frac{9.8 \times 10^{11}}{3.924 \times 10^{14}}$ $= 2.50 \times 10^{-3}$ $= \underline{\underline{2.5 \text{ mm}}}$	2

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Question No.	Question	Marks
1 (b) (i)	$V_{solid} = V_{hollow}$ $\frac{\pi D_s^2 L}{4} = \frac{\pi (D_s^2 - d_s^2) L}{4}$ $D_s^2 = D_s^2 - d_s^2$ $(100 \times 10^{-3})^2 = D_s^2 - d_s^2$ $0.01 m^2 = D_s^2 - d_s^2$	2
(ii)	MAX SHEAR STRESS IS SAME $\frac{T}{J} = \frac{\tau}{r}$ $\tau = \frac{T r}{J}$ $\frac{T_A D_s}{2 J_A} = \frac{T_B D_s}{2 J_B}$ $T_A D_s J_B = T_B D_s J_A$ $\frac{T_A}{T_B} = \frac{D_s J_A}{D_s J_B}$	2

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Question No	Question	Marks
(i) (iv)	$U = T^2 L$ $26J$	
	HOLLOW SHAFT STRENGTH 25% MORE ENERGY.	
	$\frac{T_B^2 L_B}{26AJ_B} = \frac{1.25 T_A^2 L_A}{26AJ_A}$	
	SINCE $L_A = L_B$ & $J_A = J_B$	
	$\frac{T_B^2}{T_A} = \frac{1.25 T_A^2}{J_A}$	
	$\frac{J_A}{1.25 J_B} = \frac{T_A^2}{T_B^2}$	2
(iv)	FROM (iv)	
	$\frac{J_A}{1.25 J_B} = \frac{D_B^2 T_A^2}{D_A^2 T_B^2}$	1
	$\frac{1}{1.25 J_A} = \frac{D_B^2 T_A}{D_A^2 T_B^2}$	
	$\frac{1}{1.25} = \frac{D_B^2 T_A}{D_A^2 T_B}$	

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Question No.	Question	Marks
	$\frac{J_B}{1.25 J_A} = \frac{D_B^2}{D_A^2}$	
	SOLID SHAFT $J_A = \frac{\pi D_A^4}{32}$	
	HOLLOW SHAFT $J_B = \frac{\pi (D_B^4 - d_B^4)}{32}$	1
	$\frac{J_B}{1.25 J_A} = \frac{D_B^2}{D_A^2}$	
	$\frac{\frac{\pi}{32} (D_B^4 - d_B^4)}{1.25 \times \frac{\pi}{32} D_A^4} = \frac{D_B^2}{D_A^2}$	
	FROM (i)	
	$D_B^2 - d_B^2 = 0.01$	
	$(D_B^2 - 0.01)^2 = d_B^4$	
	$\frac{D_B^2}{D_A^2} = \frac{D_B^4 - (D_B^2 - 0.01)^2}{1.25 \times (0.6)^4}$	
	$\therefore 1.25 \times 10^{-4} D_B^4 = D_A^2 \times (D_B^4 - (D_B^2 - 0.01)^2)$	
	$= 0.01 \times (D_B^4 - (D_B^2 - 0.01)^2)$	
	$= 0.01 (D_B^4 - (D_B^4 - 0.02 D_B^2 + 1 \times 10^{-4}))$	
	$= 0.01 (0.02 D_B^2 - 1 \times 10^{-4})$	
	$= 2 \times 10^{-4} D_B^2 - 1 \times 10^{-6}$	

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Question No	Question	Marks
	$1.25 \times 10^{-4} D_1^2 = 2 \times 10^{-4} D_2^2 - 1 \times 10^{-6}$ $7.5 \times 10^{-5} D_1^2 = 1 \times 10^{-6}$ $D_1 = 0.11547 \text{ m}$ $D_1 = \underline{\underline{115.47 \text{ mm}}} \quad (\text{ATANK } \phi)$	1
	From (1) $D_1^2 - d_1^2 = 0.01$ $\therefore D_1^2 - 0.01 = d_1^2$ $0.11547^2 - 0.01 = d_1^2$ $0.05774 = d_1^2$ $\underline{\underline{57.74 \text{ mm}}} = d_1$	1
		20

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Question No	Question	Marks
(2) (a)	WHILST ALUMINIUM OFFERS NO ADVANTAGE IN TERMS OF TENSILE LOADING, DUE TO ITS LOWER DENSITY, LARGER SECTIONS CAN BE USED WHICH OFFER BENEFITS IN TERMS OF BENDING & BUCKLING DUE TO THE INCREASED SECOND MOMENT OF AREA WHEN COMPARED TO STEEL ALTERNATIVES.	(2)
(b) (i)	COMPLETE SECTION $ \begin{aligned} I_{xx} &= 2 \times I_{xx}' + 2 \times I_{xx} \text{ PLATE} \\ &= 2 \times 1.5 \times 10^6 + 2 \times (I_c + Ah^2) \\ &= 2 \times 1.5 \times 10^6 + 2 \times \left(\frac{bd^3}{12} + Ah^2 \right) \\ &= 2 \times 1.5 \times 10^6 + 2 \times \left(\frac{150 \times 2^3}{12} + 150 \times 2 \times 74^2 \right) \\ &= 3 \times 10^6 + 3.29 \times 10^6 \\ &= \underline{\underline{6.29 \times 10^6 \text{ mm}^4}} \end{aligned} $	(2)

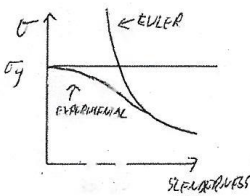
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Question No	Question	Marks
	$I_{yy} = 2 \times I_{yy}'C' + 2 \times I_{yy} \text{ PLATE}$ $= 2 \times (I_{yy} + Ah^2) + 2 \times I_{yy} \text{ PLATE}$ $= 2 \times (5.5 \times 10^5 + 384 \times 60^2) + 2 \times \frac{2 \times 150^3}{12}$ $= 3.86 \times 10^6 + 1.13 \times 10^6$ $= \underline{4.99 \times 10^6 \text{ mm}^4}$	(2)
	$\therefore I_{xx} > I_{yy}$ so it will buckle about I_{yy}	(1)
(b)(ii)	RADIUS OF GYRATION $K = \sqrt{\frac{I_{yy}}{A}}$ $= \sqrt{\frac{4.99 \times 10^6}{1368}}$ $= \underline{60.4 \text{ mm}}$	(1)
(ii)	SLENDerness RATIO = $\frac{L}{K} = \frac{L}{60.4 \times 10^{-3}} = \underline{16.6}$	(1)

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Question No	Question	Marks
(iv)	EULER, FIXED END/FREE END $P_e = \frac{\pi^2 EI}{4L^2} = \frac{\pi^2 \times 200 \times 10^9 \times 4.99 \times 10^{-6}}{4 \times 1^2}$ $= \underline{\underline{2.46 \times 10^6 N}}$	(3)
(v)	RAANKINE GORDON $P_R = \frac{\sigma_y A}{1 + \alpha \left(\frac{L}{K}\right)^2}$ $= \frac{320 \times 10^6 \times 1.368 \times 10^{-3}}{1 + \frac{1}{7500} \times 16.6^2}$ $= \frac{437760}{1.0367}$ $= \underline{\underline{0.42 \times 10^6 N}}$	(3)
(vi)	 EULER IS ONLY VALID FOR LARGE & SLENDERNESS RATIOS. FOR SMALLER VALUES RAANKIN GORDON SHOULD BE USED ⇒ IN THIS CASE THIS IS LIKELY TO	(2)

BE MORE ACCURATE.