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SWANSEA - ABERTAWE

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		
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Question No	Question	Marks
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Continuation Sheet

Module/Unit:	ADVANCED STRESS	Page:	2 of
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Question No	Question	Marks
10	COMPLETE SECTION:	
	$I_{xx} = 2 \times I_{xx} \text{ CHANNEL} + 2 \times I_{xx} \text{ PLATE}$	
	$= 2 \times 26.2 \times 10^6 + 2 \times (I_c + Ah^2)$	
	$= 2 \times 26.2 \times 10^6 + 2 \times \left(\frac{bd^3}{12} + Ah^2 \right)$	
	$= 2 \times 26.2 \times 10^6 + 2 \times \left(\frac{300 \times 10^3}{12} + 300 \times 10 \times 105^2 \right)$	
	$= 52.4 \times 10^6 + 66.2 \times 10^6$	
	$= 118.6 \times 10^6 \text{ mm}^4$	2
	$I_{zz} = 2I_{zz} \text{ CHANNEL} + 2 \times I_{zz} \text{ PLATE}$	
	$= 2(I_{yy} + Ah^2) + 2 \times I_{zz} \text{ PLATE}$	
	$= 2 \times (1.57 \times 10^6 + 4400 \times 76^2) + 2 \times \frac{10 \times 300^3}{12}$	
	$= 53.97 \times 10^6 + 45 \times 10^6$	
	$= 98.97 \times 10^6 \text{ mm}^4$	2
	IT WILL BUCKLE ABOUT ZZ	1

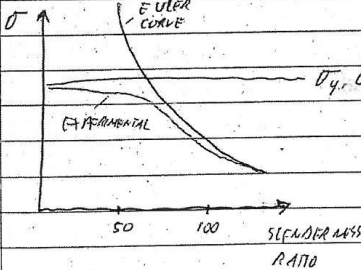
Continuation Sheet

Module/Unit:	ADVANCED STRESS	Page:	3 of
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Question No.	Question	Marks
(16)	RADIUS OF GYRATION $k = \sqrt{\frac{I_{zz}}{A}}$	
	$AREA = 2(4600 + 300 \times 10)$	
	$= 14800 \text{ mm}^2$	
	$k = \sqrt{\frac{98.97 \times 10^6}{14800}} = 81.8 \text{ mm}$	2
(C)	SLENDerness RATIO $= \frac{L}{k}$	
	$= \frac{8}{81.8 \times 10^{-3}}$	
	$= 97.9$	2
(d)	EULER, PINNED ENDS : $P_0 = \frac{\pi^2 EI}{L^2}$	
	$= \frac{\pi^2 \times 200 \times 10^9 \times 98.97 \times 10^{-6}}{8^2}$	
	$= 3.05 \times 10^6 \text{ N}$	3

Continuation Sheet

Module/Unit:	ADVANCED STRESS	Page:	6 of
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Question No	Question	Marks
(1e)	RAANKINE LOADEN: $P_R = \frac{\sigma_y A}{1 + a \left(\frac{L}{\pi}\right)^2}$ $= \frac{320 \times 10^6 \times 0.0148}{1 + \frac{1}{7500} \times 97.9^2}$ $= \frac{4736 \times 10^3}{2.2779}$ $= 2.08 \times 10^6 \text{ N}$	3
(f)	FOR THIS STRUT, WHICH IS APPROACHING THE VALIDITY LIMIT FOR EULER'S THEORY, THERE IS AN APPRECIABLE DIFFERENCE BETWEEN THE RESULTS GIVEN BY THE TWO THEORIES	2
		3
		20

Continuation Sheet

Module/Unit:	ADVANCED STRESS	Page:	5 of
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Question No.	Question	Marks
(2) 10		
①	$\sigma = \frac{F}{A} \quad \therefore F = \sigma \times A$ $= 400 \times 10^6 \times (10 \times 10) \times 10^{-6}$ $= \underline{\underline{40 \text{ kN}}}$	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

Continuation Sheet

Module/Unit:	ADVANCED STRICS	Page:	6 of
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Question No.	Question	Marks
(2)		
(ii)	P.E. WHEN WEIGHT IS DROPPED. $P.E. = mgh$	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

Continuation Sheet

Module/Unit:	ADVANCED STRESS	Page:	7 of
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Continuation Sheet

Module/Unit:	ADVANCED STRESS	Page:	8 of
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Question No.	Question	Marks
2 (b) (i)	$V_{\text{solid}} = V_{\text{hollow}}$ $\pi D_A^2 L = \pi (D_B^2 - d_B^2) L$ $D_A^2 = D_B^2 - d_B^2$ $(100 \times 10^{-3})^2 = D_B^2 - d_B^2$ $0.01 \text{ m}^2 = D_B^2 - d_B^2$	2
(ii)	MAX SHEAR STRESS IS SAME $\frac{T}{J} = \frac{\tau}{r}$ $\tau = \frac{T r}{J}$ $\frac{T_A D_A}{2 J_A} = \frac{T_B D_B}{2 J_B}$ $T_A D_A J_B = T_B D_B J_A$ $\frac{T_A}{T_B} = \frac{D_B J_A}{D_A J_B}$	2

Continuation Sheet

Module/Unit:	ADVANCED STRESS	Page:	9 of
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Question No	Question	Marks
(iii)	$U = T^2 L$ $2 G J$	
	HOLLOW SHAFT STRENGTH 25% MORE ENERGY.	
	$\frac{T_B^2 L_B}{2 G J_B} = \frac{1.25 T_A^2 L_A}{2 G J_A}$	
	SINCE $L_A = L_B$ & $G_A = G_B$	
	$\frac{T_B^2}{J_B} = \frac{1.25 T_A^2}{J_A}$	
	$\frac{J_A}{1.25 J_B} = \frac{T_A^2}{T_B^2}$	2
(iv)	FROM (iii)	
	$\frac{J_A}{1.25 J_B} = \frac{D_B^4 T_A^2}{D_A^4 T_B^2}$	1
	$\frac{1}{1.25 J_B} = \frac{D_B^4 T_A}{D_A^4 T_B^2}$	
	$\frac{1}{1.25} = \frac{D_B^4 T_A}{D_A^4 T_B}$	

Continuation Sheet

Module/Unit:	ADVANCED STRESS	Page:	10 of
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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)	
	$D_B^2 - d_B^2 = 0.01$	
	$(D_B^2 - 0.01)^2 = d_B^4$	
	$\frac{D_B^2}{D_A^2} = \frac{D_B^4 - (D_B^2 - 0.01)^2}{1.25 \times (0.01)^4}$	
	$\therefore 1.25 \times 10^{-4} D_B^4 = D_A^2 \times (D_B^4 - (D_B^2 - 0.01)^2)$	
	$= 0.01 \times (D_B^4 - (D_B^2 - 0.01)^2)$	
	$= 0.01 (D_B^4 - (D_B^4 - 0.02 D_B^2 + 1 \times 10^{-4}))$	
	$= 0.01 (0.02 D_B^2 - 1 \times 10^{-4})$	
	$= 2 \times 10^{-4} D_B^2 - 1 \times 10^{-6}$	

Continuation Sheet

Module/Unit:	ADVANCED STRESS	Page:	11 of
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Question No	Question	Marks
	$1.25 \times 10^{-4} D_3^4 = 2 \times 10^{-4} D_3^2 - 1 \times 10^{-6}$ $7.5 \times 10^{-5} D_3^2 = 1 \times 10^{-6}$ $D_3 = 0.11547 \text{ m}$ $D_3 = \underline{\underline{115.47 \text{ mm}}} \quad (\text{ATFANAL } \checkmark)$	1
	From (i) $D_3^2 + d_3^2 = 0.01$ $D_3^2 - 0.01 = d_3^2$ $0.11547^2 - 0.01 = d_3^2$ $0.05774 = d_3^2$ $\underline{\underline{57.74 \text{ mm}}} = d_3$	1
		20