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Faculty of Applied Design
and Engineering

EXAMINATION SOLUTIONS: SESSION 2013 2014

School:	LOGISTICS & MANUFACTURING		
Programme:	Mechanical & Manufacturing Engineering	Year:	3
Module/Unit:	ADVANCED STRESS - PART TIME - RESIT		
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Question No	Question	Marks
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Question No.	Question	Marks
(1) (a)	COMPLETE SECTION:	
	$I_{xx} = 2 \times I_{xx} \text{ CHANNEL} + 2 \times I_{xx} \text{ PLATE}$	
	$= 2 \times 26.2 \times 10^6 + 2 \times (I_c + Ah^2)$	
	$= 2 \times 26.2 \times 10^6 + 2 \times \left(\frac{bd^3}{12} + Ah^2 \right)$	
	$= 2 \times 26.2 \times 10^6 + 2 \left(\frac{300 \times 10^3}{12} + 300 \times 10 \times 105^2 \right)$	
	$= 52.4 \times 10^6 + 66.2 \times 10^6$	
	$= 118.6 \times 10^6 \text{ mm}^4$	2
	$I_{zz} = 2 I_{zz} \text{ CHANNEL} + 2 \times I_{zz} \text{ PLATE}$	
	$= 2 (I_{yy} + Ah^2) + 2 \times I_{zz} \text{ PLATE}$	
	$= 2 \times (157 \times 10^6 + 4400 \times 76^2) + 2 \times \frac{10 \times 300^3}{12}$	
	$= 53.97 \times 10^6 + 45 \times 10^6$	
	$= 98.97 \times 10^6 \text{ mm}^4$	2
	IT WILL BUCKLE ABOUT ZZ	1

Continuation Sheet

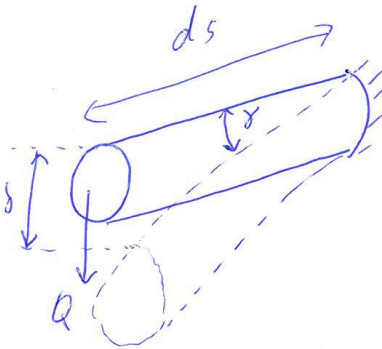
Module/Unit: STRUCTURE & MATERIALS		Page: 3 of
Question No.	Question	Marks
(1b)	RADIUS OF GYRATION $K = \sqrt{\frac{I_{zz}}{A}}$	
	AREA = $2(4600 + 300 \times 10)$	
	$= 14800 \text{ mm}^2$	
	$K = \sqrt{\frac{98.97 \times 10^6}{14800}} = 81.8 \text{ mm}$	2
(c)	SLENDERNESS RATIO $= \frac{L}{K}$	
	$= \frac{8}{81.8 \times 10^{-3}}$	
	$= 97.9$	2
(d)	EULER, PINNED ENDS : $P_e = \frac{\pi^2 EI}{L^2}$	
	$= \frac{\pi^2 \times 200 \times 10^9 \times 98.97 \times 10^{-6}}{8^2}$	
	$= 3.05 \times 10^6 \text{ N}$	3

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STRUCTURE & MATERIALS			
Question No.	Question	Marks	
(12)	RANKINE LOAD : $P_R = \frac{\sigma_y A}{1 + \alpha \left(\frac{L}{H}\right)^2}$ $= \frac{320 \times 10^6 \times 0.0148}{1 + \frac{1}{7500} \times 97.9^2}$ $= \frac{4736 \times 10^3}{2.2779}$ $= 208 \times 10^6 \text{ N}$	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

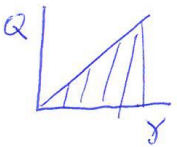
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Question No	Question	Marks
2a i	 SHEAR MODULUS $G = \frac{\text{SHEAR STRESS}}{\text{SHEAR STRAIN}}$ $= \frac{\tau}{\gamma}$ $= \frac{Q}{\gamma A} \quad \left(\text{SINCE } \tau = \frac{Q}{A} \right)$ $\therefore \gamma = \frac{Q}{AG}$	2

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Question No	Question	Marks
2a ii	 STRAIN ENERGY = $\frac{1}{2} Q y$ IN SMALL ELEMENT $= \frac{1}{2} Q \frac{Q}{AL}$ $= \frac{1}{2} \frac{Q^2}{AL}$ ∴ TOTAL STRAIN ENERGY = $\int_0^L \frac{Q^2}{2AL} ds$ $\therefore U = \frac{Q^2 L}{2AL}$	① ② ①

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Question No	Question	Marks
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2a(iii)	RESILANCE = STRAIN PER UNIT VOLUME $U = \frac{P^2 L}{2AE}$ $= \frac{\sigma^2 A^2 L}{2AE}$ $= \frac{\sigma^2 AL}{2E}$	(4)
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Question No	Question	Marks
2b(i)	$\sigma = \frac{F}{A} \quad \therefore F = \sigma \times A = 300 \times 10^6 \times (15 \times 15) \times 10^{-6}$ $= \underline{67.5 \text{ kN}}$ $A_{\text{CEA}} = 15 \times 15 \times 10^{-6} = \underline{2.25 \times 10^{-4} \text{ m}^2}$ $U = \frac{P^2 L}{2AE} = \frac{67500^2 \times 1}{2 \times 2.25 \times 10^{-4} \times 200 \times 10^9} = \underline{50.6 \text{ J}}$	3
2b(ii)	$P.E. = mgh$ $= mg(h + \delta L) \quad (1)$ $E = \frac{\sigma}{\epsilon} = \sigma \div \frac{\delta L}{L} = \frac{\sigma L}{\delta L} \quad \therefore \delta L = \frac{\sigma L}{E}$ $\text{from (1)} \quad P.E. = mg\left(h + \frac{\sigma L}{E}\right) \quad (2)$ TAKE ENERGY IS ASSOCIATED BY SHAFT. $U = \frac{P^2 L}{2AE} = \frac{\sigma^2 A^2 L}{2AE} = \frac{\sigma^2 AL}{2E} = \frac{\sigma^2 V}{2E} \quad (3)$ Equate (2) & (3) $\frac{\sigma^2 V}{2E} = mg\left(h + \frac{\sigma L}{E}\right)$ $\frac{\sigma^2 V}{2Emg} = h + \frac{\sigma L}{E} \quad \therefore h = \frac{\sigma^2 V}{2Emg} - \frac{\sigma L}{E}$	4

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Question No	Question	Marks
2b(iii)	$h = \frac{\sigma^2 V}{2E\pi y} - \frac{\sigma^2 L}{E}$ $= \frac{(75 \times 10^6)^2 \times (225 \times 10^{-4} \times 1)}{2 \times 200 \times 10^9 \times 200 \times 9.81} - \frac{75 \times 10^6 \times 1}{200 \times 10^9}$ $= 1.61 \times 10^{-3} - 3.75 \times 10^{-4}$ $= 1.2 \times 10^{-3}$ $= \underline{\underline{1.2 \text{ mm}}}$	(3)