



**(to accompany the examination paper sent to the external examiner
but NOT to be seen by students)**

Programme:	BSc/HND Motorsport/Automotive Engineering	Level:	5
Module:	Mechanical Principles		
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Q	Question	Marks
Q1	$E_x = -12 \times 10^{-6}$ $E_y = +16 \times 10^{-6}$ $\nu = 0.25$ $E = 163 \times 10^9 \text{ N/m}^2$ <i>i)</i> $\sigma_1 = \frac{E}{1-\nu^2} (E_1 + \nu E_2) = \frac{163 \times 10^9}{1-0.25^2} (-12 \times 10^{-6} + (0.25 \times 16 \times 10^{-6}))$ $\sigma_1 = -1.3 \text{ MPa}$ $\sigma_2 = \frac{E}{1-\nu^2} (E_2 + \nu E_1) = \frac{163 \times 10^9}{1-0.25^2} (16 \times 10^{-6} + (0.25 \times -12 \times 10^{-6}))$ $\sigma_2 = 2.26 \text{ MPa}$ <i>ii)</i> $\sigma_1 = 25 \times 10^6 \text{ N/m}^2$ $\sigma_2 = -20 \times 10^6 \text{ N/m}^2$ $E_1 = \frac{1}{E} (\sigma_1 - \nu \sigma_2) = \frac{1}{163 \times 10^9} (25 \times 10^6 - (0.25 \times -20 \times 10^6))$ $E_1 = 184 \times 10^{-6}$ $E_2 = \frac{1}{E} (\sigma_2 - \nu \sigma_1) = \frac{1}{163 \times 10^9} (-20 \times 10^6 - (0.25 \times 25 \times 10^6))$ $E_2 = -161 \times 10^{-6}$	5



Q	Question	Marks
Q2	$L = 0.3\text{m}$ $P = 55 \times 10^6 \text{ N/m}^2$ $E = 163.2 \times 10^9 \text{ N/m}^2$ $\nu = 0.3$ i) $K = \frac{E}{3(1-2\nu)} = \frac{163.2 \times 10^9}{3(1-2(0.3))} = 136 \times 10^9$ ii) $K = \frac{\sigma}{E_v}$ $\sigma = -P$ $K = \frac{-P}{E_v}$ $E_v = \frac{-P}{K} = \frac{-55 \times 10^6}{136 \times 10^9} = -404.4 \times 10^{-6}$ iii) $E_v = \frac{\Delta V}{V}$ $\Delta V = E_v V = E_v L^3 = -404.4 \times 10^{-6} \times 0.3^3$ $\Delta V = -1.09 \times 10^{-5} \text{ m}^3$ iv) An orthotropic material has different material properties in different directions. Carbon Fibre or wood may be considered to be orthotropic.	3 3 2 2



Q	Question	Marks
Q3	i) $EI \frac{d^2 y}{dx^2} = 1312.9[x] - \frac{100[x-0.5]^2}{2} + \frac{100[x-1.5]^2}{2} - 2000[x-1.5] - \frac{600[x-1.5]^2}{2} + \frac{600[x-2.5]^2}{2}$ ✓ ii) $EI \frac{dy}{dx} = \frac{1312.9[x]^2}{2} - \frac{100[x-0.5]^3}{6} + \frac{100[x-1.5]^3}{6} + \frac{2000[x-1.5]^2}{2} - \frac{600[x-1.5]^3}{6} + \frac{600[x-2.5]^3}{6} + A$ ✓ iii) $EI y = \frac{1312.9[x]^3}{6} - \frac{100[x-0.5]^4}{24} + \frac{100[x-1.5]^4}{24} - \frac{2000[x-1.5]^3}{6} + \frac{600[x-1.5]^4}{24} + \frac{600[x-2.5]^4}{24} + Ax + B$ ✓ iv) @ $x=0$ $y=0$ Sub into eqn iii) $B=0$ ✓ @ $x=3.1m$ $y=0$ Sub into eqn iii) workings ✓ $A = 1557.984$ v) Substitute $x=1.55m$ into eqn 3. workings ✓ $y = -1.61 \times 10^{-3}m$ ✓	2 2 1 1 2



Q	Question	Marks
Q4.	$d = 0.28\text{m}$ $L = 0.6\text{m}$ $n_L = 0.55$ $n_C = 0.65$ $P = 14.6 \times 10^5 \text{ N/m}^2$ $\sigma = 150 \times 10^6 \text{ N/m}^2$ i) $\sigma_C = \frac{PD}{2Ln_L}$ $\epsilon = \frac{PD}{2\sigma_C n_L} = \frac{14.6 \times 10^5 \times 0.28}{2 \times 150 \times 10^6 \times 0.65} = 2.48 \times 10^{-3} \text{ m}$ ii) $\sigma_L = \frac{PD}{4Ln_C}$ $\epsilon = \frac{PD}{4\sigma_L n_C} = \frac{14.6 \times 10^5 \times 0.28}{4 \times 150 \times 10^6 \times 0.65} = 1.048 \times 10^{-3} \text{ m}$ iii) $\epsilon_{\min} = 2.48 \times 10^{-3} \text{ m}$	1 4 4 1

