

HND/C PHASE TEST SPECIFICATION

Programme:	HND Automotive Engineering / Motorsport Engineering				
Unit:	Mechanical Principles				
Phase Test No:	1	Lecturer:	E Williams	Internal Verifier:	A Gibson

Time and Date:	Friday 5 th February 2010	Duration:	110 mins	Contribution to Overall Unit Assessment (%):	25%
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Outcomes being Assessed (from Unit Syllabus):	
Number	Description
Learning Outcome 1:	Investigate complex loading systems
Learning Outcome 2:	{Deflection of beams ('standard cases') { 'Stresses in pressure vessels'

For Attention of Students:

Answer **ALL** questions.

The mark allocation is as indicated – total 50 marks.

A 'formula sheet' is provided for reference.

Assume 'g' = 9.81 m/s².

and 1 bar = 10⁵ N/m² (P_a)

1. Mutually perpendicular stresses of 80 N/mm^2 (tensile) and 50 N/mm^2 (compressive) act at a point in a material. Calculate the magnitude and sense of the strains in the directions of the stresses, given that Poisson's ratio (ν) is 0.25 and the Modulus of Elasticity (E) is 200 kN/mm^2 .
(8 marks)
2. A 100 mm cube is subjected to a compressive force of 200 kN across one pair of opposite faces, a compressive force of 300 kN across a second pair of opposite faces, with no force applied across the third pair of faces. Calculate the change in volume of the cube. (Assume ' E ' = 200 kN/mm^2 and ' ν ' = 0.25)
(10 marks)
3. A 3 m long cantilever carries a uniformly distributed load of 20 kN/m. What upward 'prop' force must be applied at the free end to restrict the deflection at this point to 1.5 mm? Assume ' EI ' = $70 \times 10^3 \text{ kNm}^2$.
(10 marks)
4. An air receiver takes the form of a thin walled cylinder with a diameter of 0.8 m and length of 1.5 m, with a steel plate thickness of 12 mm. If the longitudinal and circumferential joint efficiencies are 80% and 30% respectively, and the maximum allowable stress is 80 N/mm^2 , what is the corresponding maximum allowable air pressure?
(Assume ' E ' = 210 GN/m^2 and ' ν ' = 0.27)
(10 marks)
5. A hydraulic cylinder has an internal diameter of 80 mm and a wall thickness of 20 mm, and is to withstand a maximum internal pressure of 120 bar. Determine the circumferential (hoop stress) at the inner diameter of the cylinder
(12 marks)

Q1/

$$\nu = 0.25$$

$$E = 200 \times 10^9 \text{ Pa}$$

$$\sigma_x = 80 \times 10^6 \text{ Pa}$$

$$\sigma_y = -50 \times 10^6 \text{ Pa}$$

$$\epsilon_x = \frac{1}{E} (\sigma_x - \nu \sigma_y)$$

$$= \frac{1}{200 \times 10^9} (80 \times 10^6 - (0.25 \times -50 \times 10^6))$$

$$= \underline{\underline{+4.63 \times 10^{-4}}}$$

$$\epsilon_y = \frac{1}{E} (\sigma_y - \nu \sigma_x)$$

$$= \frac{1}{200 \times 10^9} (-50 \times 10^6 - (0.25 \times 80 \times 10^6))$$

$$= \underline{\underline{-3.5 \times 10^{-4}}}$$

Q2/

$$\sigma_x = \frac{-200 \times 10^3}{\cancel{100^2}} = -20 \text{ N/mm}^2$$

$$\frac{100^2}{100^2}$$

$$= -20 \text{ MN/m}^2$$

$$\sigma_y = \frac{-300 \times 10^3}{100^2} = -30 \text{ N/mm}^2$$

$$= -30 \text{ MN/m}^2$$

$$\epsilon_v = \frac{\sigma_x + \sigma_y + \sigma_z (1 - 2\nu)}{E}$$

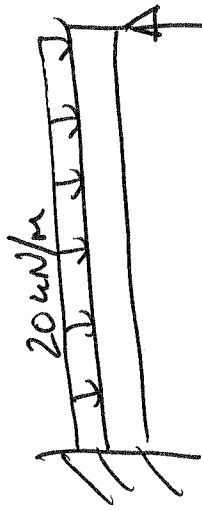
$$= \frac{-20 \times 10^6 - 30 \times 10^6 + 0 (1 - (2 \times 0.25))}{200 \times 10^9}$$

$$= -1.25 \times 10^{-4}$$

$$\epsilon_v = \frac{\delta V}{V}$$

$$\delta V = \epsilon_v \times V = -1.25 \times 10^{-4} \times 100^3 = \underline{\underline{-125 \text{ mm}^3}}$$

Q3/



$$EI = 70 \times 10^3 \text{ kN/m}^2$$

$$l = 3\text{m}$$

without prop.

$$y = \frac{wl^4}{8EI}$$

$$y = \frac{-20 \times 10^3 \times 3^4}{8 \times 70 \times 10^6} = \underline{\underline{-2.893 \times 10^{-3} \text{ m}}}$$

$\therefore$ Prop must produce effective upward deflection of $(2.89 - 1.5) \times 10^{-3} = +1.39 \times 10^{-3}$

$$y = \frac{Pl^3}{3EI}$$

$$\therefore P = \frac{y \times 3EI}{l^3} = \frac{1.39 \times 10^{-3} \times 3 \times 70 \times 10^6}{3^3} = \underline{\underline{10.8 \text{ kN}}}$$

Q3

Q4/

$$n_L = 0.8$$

$$n_C = 0.3$$

$$d = 0.8 \text{ m}$$

$$t = 12 \text{ mm} = 12 \times 10^{-3} \text{ m}$$

$$l = 1.5 \text{ m}$$

$$\begin{aligned}\sigma_{\max} &= 80 \text{ MPa} \\ &= 80 \times 10^6 \text{ Pa}\end{aligned}$$

$$\sigma_C = \frac{p d}{2 t n_L}$$

$$P = \frac{\sigma_C \times 2 t n_L}{d}$$

$$P_{\max} = \frac{80 \times 10^6 \times 2 \times 12 \times 10^{-3} \times 0.8}{0.8}$$

$$= 19.2 \times 10^5 \text{ N/m}^2$$

$$\sigma_L = \frac{p d}{4 t n_C}$$

$$P = \frac{\sigma_L \times 4 t n_C}{d}$$

$$P_{\max} = \frac{80 \times 10^6 \times 4 \times 12 \times 10^{-3} \times 0.3}{0.8}$$

$$= 14.4 \times 10^5 \text{ N/m}^2$$

$$\begin{aligned}\text{hence } P_{\max} &= 14.4 \times 10^5 \text{ N/m}^2 \\ &= 14.4 \text{ Bar}\end{aligned}$$

$$\sigma_r = a - \frac{b}{r^2}$$

$$d_i = 80 \times 10^{-3} \text{ m.}$$

$$d_o = 120 \times 10^{-3} \text{ m.}$$

$$P = 120 \text{ bar} \rightarrow 120 \times 10^5 \text{ Pa.}$$

$$\textcircled{a} \quad r_o = 0.06.$$

$$\sigma_r =$$

$$0 = a - \frac{b}{0.06^2}$$

$$0 = \frac{b}{0.06^2} - a$$

$$0 = b - (0.06)^2 a. \quad \textcircled{1}$$

$$\textcircled{2} - \textcircled{1}$$

$$\sigma_c = a + \frac{b}{r^2}$$

$$\rightarrow r_i = 40 \times 10^{-3} \text{ m}$$

$$r_o = 60 \times 10^{-3} \text{ m.}$$

$$\textcircled{a} \quad r_i = 0.04$$

$$\sigma_r = -120 \times 10^5 \text{ N/m}^2 \text{ (compressive)}$$

$$-120 \times 10^5 = a - \frac{b}{0.04^2}$$

$$120 \times 10^5 = \frac{b}{0.04^2} - a.$$

$$1.92 \times 10^4 = b - 0.04^2 a. \quad \textcircled{2}$$

$$1.92 \times 10^4 = -(0.04)^2 a + (0.06)^2 a$$

$$a = \frac{19200}{0.06^2 - 0.04^2} = 9.6 \times 10^6 \text{ N/m}^2$$

