

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD

CYFNOD ARHOLIADAU

MODULE CODE: ACHA5015
STRESS ANALYSIS & CAE

RESIT EXAM

TIME: 2 HOURS

ANSWER ALL QUESTIONS

SOME VALUES USED IN QUESTIONS ARE DEPENDANT ON YOUR STUDENT NUMBER (ABCDEFG)

e.g If your student number is 1806532 then A=1, B=8. C=0, D=6, E=5, F=3, G=2
so a value of 1.**EF**Mpa = 1.53Mpa

*Equipment or materials required – **Calculator***

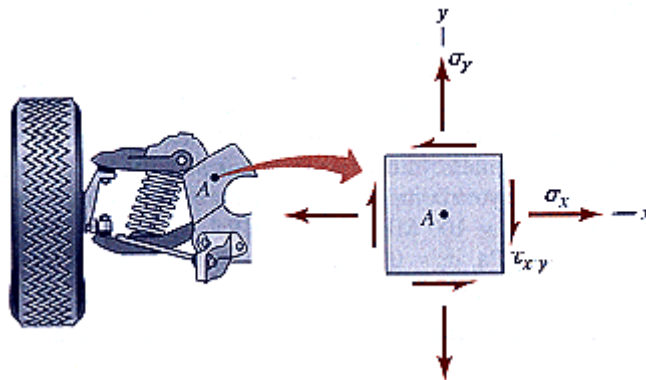
A 'formula sheet' is provided for reference.

Assume 'g' = 9.81 m/s^2 .

and $1 \text{ bar} = 10^5 \text{ N/m}^2 (\text{Pa})$

ANSWER ALL QUESTIONS

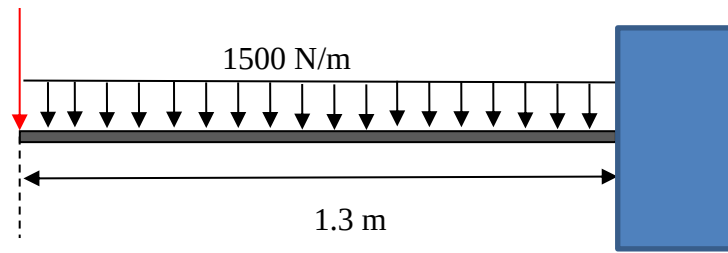
QUESTION ONE



- a) A pressed steel section of a suspension component has stresses of 1FG MPa in the x direction and -1EF MPa in the y direction. Given that the material has a Young's Modulus of 205 GPa and a Poisson's ratio of 0.25, calculate the resulting strains in both directions and state whether they are tensile or compressive.
- b) At a different section of the component, the strain is measured using a strain gauge and is found to be $+10\text{FG} \times 10^{-6}$ in the x direction and $-3\text{DE} \times 10^{-6}$ in the y direction. Calculate the stresses at this point within the component.
- c) If the yield strength of the material is 250 MPa, calculate the minimum safety factor of the component, based on the stresses above.

(10 marks)

QUESTION TWO



A 1.3 m long cantilever beam carries a uniformly distributed load of 1500 N/m along its entire length. A point load of 5.1 kN also acts at the free end of the beam. The beam has a flexural stiffness of $2.2 \times 10^6 \text{ Nm}^2$.

Calculate;

- i) The deflection at the free end of the beam due to the uniformly distributed load (3 Marks)
- ii) The deflection at the free end of the beam due to the point load (3 Marks)
- iii) The corresponding total deflection at the free end of the beam (1 Mark)
- iv) How much the point load may be increased before the deflection exceeds 3.5mm (3 Marks)

QUESTION THREE



A pneumatic gear shift system reservoir for a vehicle, as shown above, may be modelled as a thin walled cylinder with a diameter of 0.26m, and a length of 0.52m.

The reservoir must withstand 10.**E** bar of pressure.

Assuming longitudinal and circumferential joint efficiencies of 83% and 91% respectively, calculate the minimum wall thickness before the material stress exceeds 1**FG** MPa

(10 Marks)

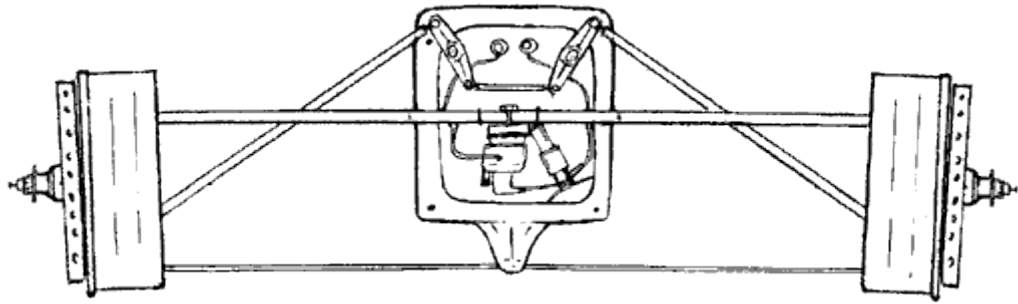
QUESTION FOUR



A hydraulic actuator for a super car rear wing may be modelled as a cylinder having an external diameter of 32 mm and an internal diameter of 26 mm. If it is pressurised internally to 80 Bar gauge,

- a) State the boundary conditions to be applied
(3 Marks)
- b) Calculate the constants, a and b , in Lamé's Equations for this application
(5 Marks)
- c) Calculate the corresponding circumferential stresses at the inner and outer radii
(2 marks)

QUESTION FIVE



A steel pushrod is 0.8 m long and has a tubular cross section of diameter 19.05 mm and wall thickness of 1.0 mm. Both ends of the pushrod are pin jointed. Given $E = 207$ GPa,

- i) Calculate the second moment of area for the pushrod
(2 Marks)
- ii) Calculate the Slenderness Ratio to confirm the pushrod may be classed as a strut.
(3 Marks)
- iii) Identify the load case and value for 'n' for this strut.
(2 Marks)
- iv) Calculate Euler's critical buckling load for the pushrod.
(3 Marks)

Diwedd/End

Stress Analysis & CAE Formula Sheet

Two-dimensional stress and strain equations:

$$\varepsilon_1 = \frac{1}{E}(\sigma_1 - \nu\sigma_2) \qquad \sigma_1 = \frac{E}{1-\nu^2}(\varepsilon_1 + \nu\varepsilon_2)$$

$$\varepsilon_2 = \frac{1}{E}(\sigma_2 - \nu\sigma_1) \qquad \sigma_2 = \frac{E}{1-\nu^2}(\varepsilon_2 + \nu\varepsilon_1)$$

Principle Stresses

$$\sigma_1 = \frac{(\sigma_x + \sigma_y)}{2} + \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} \qquad \tau_{\max} = \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} = \frac{\sigma_1 - \sigma_2}{2}$$

$$\sigma_2 = \frac{(\sigma_x + \sigma_y)}{2} - \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} \qquad \tau_{\min} = \frac{-\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} = -\left[\frac{\sigma_1 - \sigma_2}{2}\right]$$

Three-dimensional and volumetric strain equations:

$$\varepsilon_x = \frac{1}{E}[\sigma_x - \nu(\sigma_y + \sigma_z)] \qquad \varepsilon_v = \frac{\delta V}{V} = \varepsilon_x + \varepsilon_y + \varepsilon_z$$

$$\varepsilon_y = \frac{1}{E}[\sigma_y - \nu(\sigma_x + \sigma_z)]$$

$$\varepsilon_z = \frac{1}{E}[\sigma_z - \nu(\sigma_x + \sigma_y)] \qquad \varepsilon_v = \frac{\sigma_x + \sigma_y + \sigma_z}{E}(1 - 2\nu)$$

Relationships between elastic constants:

$$E = \frac{\sigma}{\varepsilon} \qquad K = \frac{\sigma}{\varepsilon_v} = \frac{E}{3(1-2\nu)} \qquad G = \frac{E}{2(1+\nu)} \qquad K = \frac{2G(1+\nu)}{3(1-2\nu)}$$

Stress and strains in thin walled pressure vessels:

Cylinders		Spheres
$\sigma_c = \frac{pD}{2t\eta_L}$		$\sigma = \frac{pD}{4t\eta}$
$\varepsilon_C = \varepsilon_D = \frac{pD}{4tE}(2 - \nu)$		
$\varepsilon_v = \frac{pD}{4tE}(5 - 4\nu)$		$\varepsilon_v = \frac{3pD}{4tE}(1 - \nu)$

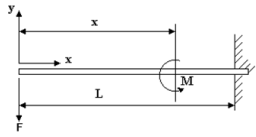
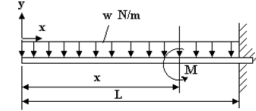
Stresses in thick walled cylinders: (Lame's Equations)

Loaded beams : Standard Cases

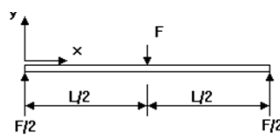
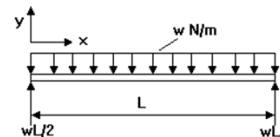
$$\sigma_R = a - \frac{b}{r^2} \qquad \sigma_C = a + \frac{b}{r^2}$$

Where a and b are found by applying boundary conditions

Cantilever Beams:

	Max Slope	Max Deflection
	$\frac{FL^2}{2EI}$	$\frac{FL^3}{3EI}$
	$\frac{wL^3}{6EI}$	$\frac{wL^4}{8EI}$

Simply Supported Beams:

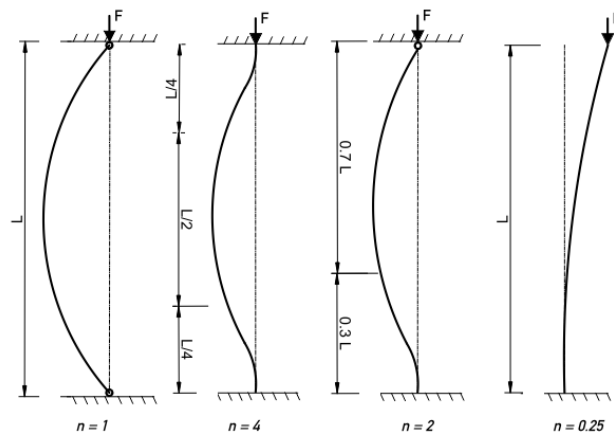
	$\frac{FL^2}{16EI}$	$\frac{FL^3}{48EI}$
	$\frac{wL^3}{24EI}$	$\frac{5wL^4}{384EI}$

Euler's Buckling

$$F_{Cr} = \frac{n\pi^2 EI}{L^2}$$

$$K = \frac{I}{A}$$

$$SR = \frac{L}{K}$$



Area and Second Moment of Area:

