

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 5

LEFEL 5

EXAMINATION PERIOD

CYFNOD ARHOLIADAU

MODULE CODE: ACHA5015
STRESS ANALYSIS & CAE

EXAM

TIME: 2 HOURS

ANSWER ALL QUESTIONS

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

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 = 1.53 Mpa

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

A 'formula sheet' is provided for reference.

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

and 1 bar = 10^5 N/m^2 (Pa)

ANSWER ALL QUESTIONS

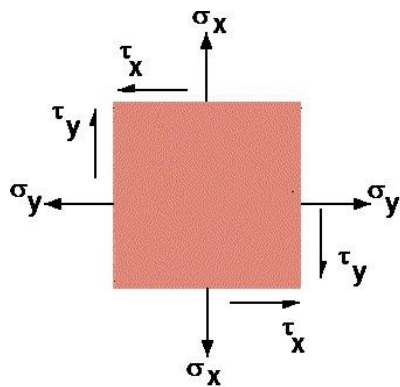
QUESTION ONE



The bracket shown above is part of a mounting for engine ancillaries. At a certain point in the material a strain gauge measures the strain in the 'x' direction of $2\mathbf{G} \times 10^{-6}$ and a strain in the 'y' direction of $-1\mathbf{F} \times 10^{-6}$. The material has a Poisson's ratio of 0.28 and a Modulus of Elasticity of 170 GPa.

- i. Calculate the corresponding stresses in each direction at this point in the material and state whether they are compressive or tensile.
(5 Marks)
- ii. If at a second point on the bracket, the material the stresses are found to be $8\mathbf{F}$ MPa (tensile) in the 'x'direction and $4\mathbf{G}$ MPa (Compressive) in the 'y' direction, calculate the corresponding strains that would be measured at this point.
(5 Marks)

QUESTION TWO



$$\sigma_x = 10 \text{ MPa}$$

$$\sigma_y = 20 \text{ MPa}$$

$$\tau_{xy} = 125 \text{ MPa}$$

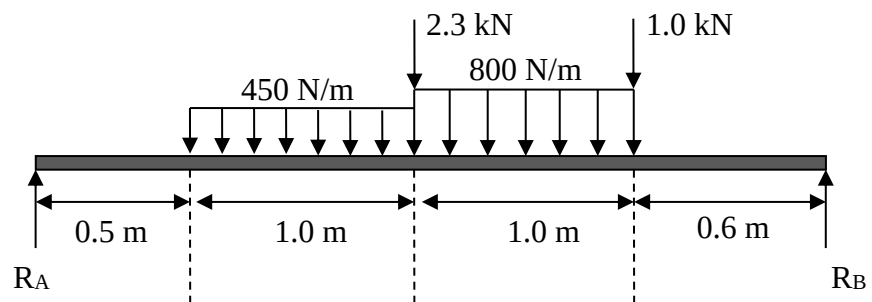
The stresses in a shear panel on a chassis may be defined as shown above.

- i. Calculate the principle stresses σ_1 and σ_2
(4 Marks)
- ii. Calculate the maximum and minimum shear stresses on the plane, τ_{max} and τ_{min}
(3 Marks)
- iii. Sketch Mohr's Circle for this stress case indicating the principle stresses, maximum/minimum shear stress and σ_x, σ_y
(3 Marks)

QUESTION THREE

The diagram below shows a simply supported beam with a single point load and two uniformly distributed loads. If the reaction forces R_A and R_B are 1969.4N and 2580.6N respectively, by applying Macaulay's method

- i. Write down an equation for the bending moment at any point along the beam. (2 marks)
- ii. Write down an equation for the slope at any point along the beam. (2 marks)
- iii. Write down an equation for the deflection at any point along the beam (1 mark)
- iv. Apply boundary conditions and calculate the constants of integration. (3 marks)
- v. Calculate the deflection at the centre on the beam if the flexural stiffness is 1.EFMPa. (2 marks)



QUESTION FOUR



A hydrogen storage tank for a vehicle may be modelled as a thin walled pressure vessel. The cylinder has a diameter of 280mm, is 600mm in length and is made from sheet steel, The longitudinal and circumferential joint efficiencies are 5F% and 6G% respectively. If the cylinder is to withstand an internal pressure of 14.E Bar with the maximum stress within the material not exceeding 150MPa calculate,

- i. Calculate the minimum thickness based on the circumferential stress (4 marks)
- ii. Calculate the minimum thickness based on the longitudinal stress (4 marks)
- iii. The minimum thickness. (2 mark)

QUESTION FIVE



A steel rear wing strut is 1.3 m long and has a tubular cross section of diameter 19.05 mm and wall thickness of 1.2 mm. The bottom of the strut is built into a fully restrained socket on the suspension upright and the top is completely unrestrained. Given $E = 200$ GPa,

- i) Calculate the second moment of area for the strut (2 Marks)
- ii) Identify type the case and value for 'n' (2 Marks)
- iii) Calculate Euler's critical buckling load for the strut. (3 Marks)
- iv) Calculate the Slenderness Ratio to confirm the strut classification is correct. (3 Marks)

Diwedd/End

Stress Analysis & CAE Formula Sheet

Two-dimensional stress and strain equations:

$$\begin{aligned}\varepsilon_1 &= \frac{1}{E}(\sigma_1 - \nu\sigma_2) & \sigma_1 &= \frac{E}{1-\nu^2}(\varepsilon_1 + \nu\varepsilon_2) \\ \varepsilon_2 &= \frac{1}{E}(\sigma_2 - \nu\sigma_1) & \sigma_2 &= \frac{E}{1-\nu^2}(\varepsilon_2 + \nu\varepsilon_1)\end{aligned}$$

Principle Stresses

$$\begin{aligned}\sigma_1 &= \frac{(\sigma_x + \sigma_y)}{2} + \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} & \tau_{\max} &= \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} = \frac{\sigma_1 - \sigma_2}{2} \\ \sigma_2 &= \frac{(\sigma_x + \sigma_y)}{2} - \frac{\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} & \tau_{\min} &= \frac{-\sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2}}{2} = -\left[\frac{\sigma_1 - \sigma_2}{2}\right] & \tan 2\theta &= \frac{2\tau}{\sigma_x - \sigma_y}\end{aligned}$$

Three-dimensional and volumetric strain equations:

$$\begin{aligned}\varepsilon_x &= \frac{1}{E}[\sigma_x - \nu(\sigma_y + \sigma_z)] & \varepsilon_v &= \frac{\delta V}{V} = \varepsilon_x + \varepsilon_y + \varepsilon_z \\ \varepsilon_y &= \frac{1}{E}[\sigma_y - \nu(\sigma_x + \sigma_z)] \\ \varepsilon_z &= \frac{1}{E}[\sigma_z - \nu(\sigma_x + \sigma_y)] & \varepsilon_v &= \frac{\sigma_x + \sigma_y + \sigma_z}{E}(1 - 2\nu)\end{aligned}$$

Relationships between elastic constants:

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

Stress and strains in thin walled pressure vessels:

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

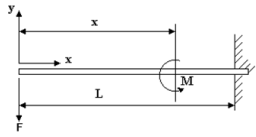
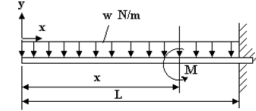
Stresses in thick walled cylinders: (Lame's Equations)

Loaded beams : Standard Cases

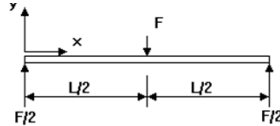
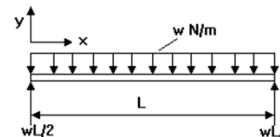
$$\sigma_R = a - \frac{b}{r^2} \quad \sigma_C = a + \frac{b}{r^2}$$

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:

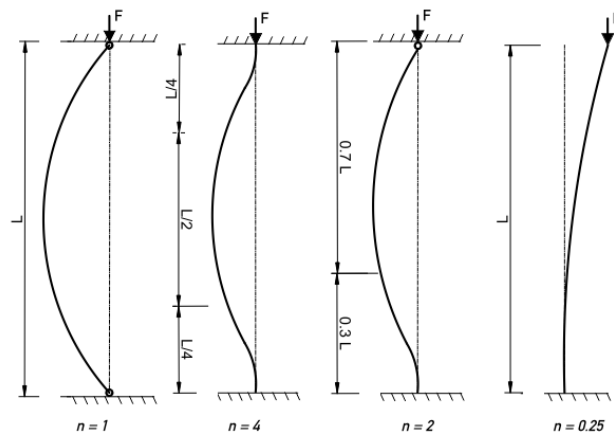
	$\frac{FL^2}{16EI}$	$\frac{FL^3}{48EI}$
	$\frac{wL^3}{24EI}$	$\frac{5wL^4}{384EI}$

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:

