

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 6

LEFEL 6

EXAMINATION PERIOD

FEB 2019

CYFNOD ARHOLIADAU

CHWEFROR 2019

MODULE CODE:

M6X00420: Advanced Stress & FEA (PART TIME)

TIME: 2 HOURS

ANSWER THREE OUT OF FOUR QUESTIONS

Equipment or materials required – None

Adnoddau neu ddefnyddiau sydd eu hangen – Dim

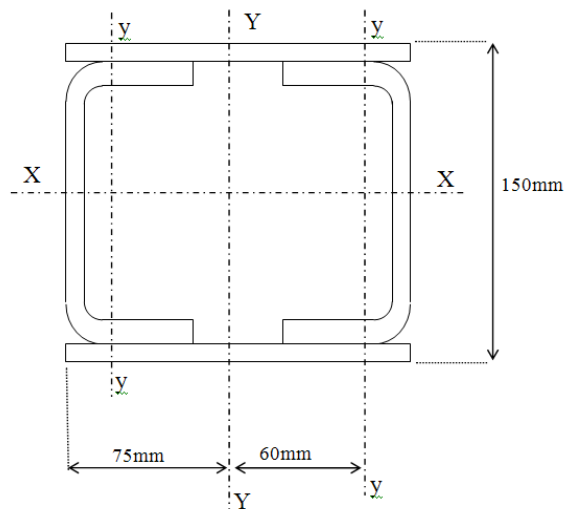
A formula sheet is provided for reference.

University approved calculators are permitted.

Assume 'g' = 9.81 m/s².

Question 1

- a) Given the fact that Aluminium is approximately one third the density of steel but also one third the stiffness, briefly discuss why, in terms of vehicle stiffness, structural panels made from Aluminium can be beneficial over steel panels.
- [2 Marks]
- b) The engine longitudinal of an integral vehicle chassis is fabricated from steel and is 1m long. The fabrication is symmetrical about the YY axis and is constructed from two flat 2mm plates and two 'C section' folded steel sheets as shown below. Given that the Young's Modulus, E , is 200GPa the compressive yield stress, σ_c , is 320MPa and a constant a of 1/7500, assuming the longitudinal is fixed at one end and free at the other, determine the following;



Properties of ONE
folded sheet steel
section;

$$I_{xx} = 1.5 \times 10^6 \text{ mm}^4$$

$$I_{yy} = 5.5 \times 10^5 \text{ mm}^4$$

$$A = 384 \text{ mm}^2$$

- i. Which axis will the longitudinal buckle about? [5 Marks]
- ii. What is the radius of gyration about this axis? [1 Mark]
- iii. What is the slenderness ratio of this longitudinal? [1 Mark]
- iv. According to Euler theory, what load will this longitudinal buckle at? [3 Marks]
- v. According to Rankine-Gordon theory, what load will this longitudinal buckle at? [3 Marks]
- vi. Comment on the results of (iv) and (v), and with the use of a diagram explain the difference between experimental results and buckling loads according to Euler theory. [5 Marks]

Question 2

- a) A mild steel shaft of 50mm diameter is subjected to a bending moment of 1.9kNm. Using $\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$ calculate the maximum bending stress.

[3 marks]

- b) In addition to this bending stress, this shaft is to carry a torque. Using $\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$ show that the relationship between the shear stress, τ , and the torque, T, when carrying a torque alone, is given by $\tau = 40700T$

[3 marks]

- c) If the yield point of the steel in a simple tension test is 200MPa, find the maximum torque that can be applied according to,

- i) The maximum shear stress theory of yielding

[7 marks]

- ii) The Von-Mises theory of yielding

[7 marks]

Question 3

a.

During FEA, meshing your part is an important step in the Pre-Processing stage. Your mesh will significantly influence your results. Discuss this, stating checks that you should perform, why these are important and why the errors that the checks are looking for, may be present.

[15 Marks]

b.

FEA models are normally correlated to physical tests in order to gain confidence in the model. Discuss tools that may be used in order to do this.

[5 Marks]

Question 4

a.

In terms of FEA, Stress analysis is generally split into linear static analysis and non-linear analysis.

i.

State the two conditions that must be met for the analysis to be considered static.

[4 Marks]

ii.

Discuss three reasons why analysis may be considered to be non-linear.

[8 Marks]

b.

Other than linear static analysis and nonlinear analysis, discuss 8 types of analysis that may be carried out.

[8 Marks]

Formula Sheet

$$I_{NA} = \frac{BD^3}{12} \quad \text{Second moment of area of a rectangle}$$

$$I = \frac{\pi d^4}{64} \quad \text{Second moment of area of a circle}$$

$$I_{NA} = I_G + Ah^2 \quad \text{Parallel axis theorem}$$

$$\text{P.E.} = mgh \quad \text{Potential energy}$$

$$\text{K.E.} = \frac{1}{2} mv^2 \quad \text{Kinetic energy}$$

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R} \quad \text{The simple theory of elastic bending}$$

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L} \quad \text{The simple theory of elastic torsion}$$

$$J = \frac{2\pi R^4}{4} = \frac{\pi D^4}{32} \quad \text{Polar second moment of area for a solid circular shaft}$$

$$\text{slenderness ratio} = \frac{L}{k}$$

$$k = \sqrt{\frac{I}{A}} \quad \text{Radius of gyration}$$

$$P_e = \frac{\pi^2 EI}{L^2} \quad \text{Buckling: pinned-pinned}$$

$$P_e = \frac{\pi^2 EI}{4L^2} \quad \text{Buckling: fixed-free}$$

$$P_e = \frac{4\pi^2 EI}{L^2} \quad \text{Buckling: fixed-fixed}$$

$$P_e = \frac{2\pi^2 EI}{L^2} \quad \text{Buckling: fixed-pinned}$$

$$P_R = \frac{\sigma_y A}{1 + a(L/k)^2} \quad \text{Rankine Load}$$

Theory	Value in tension test at failure	Value in complex stress system	Criterion for failure
Maximum principal stress (<i>Rankine</i>)	σ_y	σ_1	$\sigma_1 = \sigma_y$
Maximum shear stress (<i>Guest-Tresca</i>)	$\frac{1}{2}\sigma_y$	$\frac{1}{2}(\sigma_1 - \sigma_3)$	$\sigma_1 - \sigma_3 = \sigma_y$
Maximum principal strain (<i>Saint-Venant</i>)	$\frac{\sigma_y}{E}$	$\frac{\sigma_1}{E} - \nu \frac{\sigma_2}{E} - \nu \frac{\sigma_3}{E}$	$\sigma_1 - \nu \sigma_2 - \nu \sigma_3 = \sigma_y$
Total strain energy per unit volume (<i>Haigh</i>)	$\frac{\sigma_y^2}{2E}$	$\frac{1}{2}[\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\nu(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1)]$	$\sigma_1^2 + \sigma_2^2 + \sigma_3^2 - 2\nu(\sigma_1\sigma_2 + \sigma_2\sigma_3 + \sigma_3\sigma_1) = \sigma_y^2$
Shear strain energy per unit volume Distortion energy theory (<i>Maxwell-Huber-von Mises</i>)	$\frac{\sigma_y^2}{6G}$	$\frac{1}{12G}[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2]$	$\frac{1}{2}[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2] = \sigma_y^2$
Modified shear Stress/Internal friction theory (<i>Mohr</i>)			$\frac{\sigma_2 + \sigma_3}{\sigma_{yt} \sigma_{yc}} = 1$

$$\sigma_{1,2} = \frac{1}{2} \left[(\sigma_x + \sigma_y) \pm \sqrt{(\sigma_x - \sigma_y)^2 + 4\tau_{xy}^2} \right]$$

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