

LOCATION: SWANSEA

LLEOLIAD: ABERTAWE

LEVEL 6

LEFEL 6

EXAMINATION PERIOD
JULY 2022

CYFNOD ARHOLIADAU
GORFFENAF 2022

MODULE CODE: ACHA6012
AUTOMOTIVE MATERIALS AND SUSTAINABILITY

TIME: 2 HOURS

ANSWER ALL OF SECTION A

ANSWER TWO OUT OF THREE IN SECTION B

Equipment or materials required – None

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SECTION A

ANSWER ALL QUESTIONS IN SECTION A

1. Road vehicles already struggle to meet present emission legislation, and proposed Euro vii emissions standards due for release in 2025 are likely to be even more stringent than those current set.

Critically review 2 possible alternative types of fuel, **using case studies** to illustrate points with specific attention to:

- a. How these fuels might help to meet this new set of regulations, [5 marks]
- b. How they might impact on the end user in terms of practicalities, and [8 marks]
- c. What developments and infrastructure needs to be in place in order for these fuels to be environmentally and economically successful. [12 marks]

SECTION B
ANSWER TWO OUT OF THREE QUESTIONS IN SECTION B

QUESTION 2

- a) Explain what makes up an atom and how the valency of an atom is calculated. If an atom has a complete outer shell what does that mean.

[4 marks]

- b) Atoms can be arranged in either body-centred cubic, face-centred cubic or hexagonal close packed arrangements within a material structure. If you consider a unit cell of Iron, which has a total of 2 atoms per unit cell. Using the correct equation from the formula sheet, calculate the unit cell dimension, a , of Iron, if the $R = 0.1241\text{nm}$.

[3 marks]

- c) It is hard to get an ideal alignment in a materials lattice structure and there can be imperfections and deformations occurring. There are three main types of defects; Point, Area and Line. Give details of the different types of Point defects that can occur.

[6 marks]

- a) In the automotive industry forging and casting are two common production methods used. Analyse the advantages and disadvantages of each production method when considering automotive components manufacturing.

[12 marks]

QUESTION 3

- a) For a fibre reinforced composite, being loaded in the longitudinal direction (along fibre axis), using the material properties listed in the below table, calculate;

Variable	Value	Units
Modulus of Elasticity Fibre	200	GPa
Modulus of Elasticity Matrix	3.2	GPa
Percentage Volume of Fibre	55	%
Cross Sectional Width of Composite	100	cm
Cross Sectional Height of Composite	2	cm
Length of Composite	1.1	m

- i. The Modulus of Elasticity of the Composite
[4 marks]
 - ii. Calculate the force on the fibre and matrix elements of the composite when a stress of 30 MPa is applied evenly across the cross sectional area of the composite.
[5 marks]
 - iii. Determine the strain experienced by the fibre and matrix elements when the stress from part ii) is applied
[8 marks]
- b) When there are geometric features within a component, the stress concentration factor can have a significant impact on the stress value around the feature.

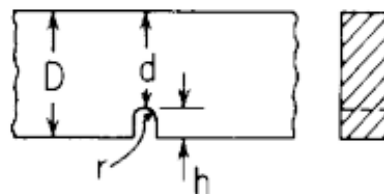


Figure 1 – U notch in a member of rectangular section

Rectangular width (D)	Notch Height (h)	Notch fillet radius (r)	Applied Axial Stress (P)
20 mm	1mm	0.5mm	65MPa

Using the 'Roark's Equation for Stress and Strain' information given in the formula sheet and the geometric conditions provided above for rectangular section with a u-notch, calculate;

- i. The appropriate stress concentration factor (K_t) when loaded in tension.

[6 marks]

- ii. The peak stress experienced in the component in this condition due to the stress concentration.

[2 marks]

QUESTION 4

- a) Engineers ideally want to minimise or eliminate corrosion from occurring, explain the different ways in which corrosion can be prevented.

[7 marks]

- b) Given that fatigue is a serious concern within the automotive sector, suggest 4 approaches that could be taken to reduce the likelihood of experiencing a fatigue failure, giving a brief explanation of each.

[10 marks]

- c) When conducting an Life Cycle Analysis of a car, outline the 4 stages discussing the considerations at each stage.

[8 marks]

Formula Sheet

Composites

$$E_c A_c = E_m A_m + E_f A_f$$

$$\frac{F_f}{F_m} = \frac{E_f V_f}{E_m V_m}$$

$$F_c = F_f + F_m$$

Crystalline Structure

Body Centred Cubic Dimension

$$a = \frac{4R}{\sqrt{3}}$$

Face Centred Cubic Dimension

$$a = 2\sqrt{2}R$$

Fracture Toughness

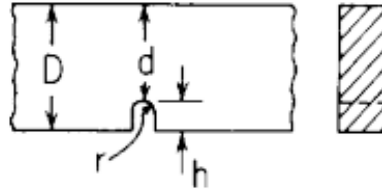
$$K = \sigma \sqrt{\pi a}$$

$$K_c = \sqrt{G_c E}$$

Formula sheet continues on the next page

Stress Concentration

3. One U-notch in a member of rectangular section



3a. Elastic stress, axial tension	$K_t = C_1 + C_2 \left(\frac{h}{D} \right) + C_3 \left(\frac{h}{D} \right)^2 + C_4 \left(\frac{h}{D} \right)^3$ where for $0.5 \leq h/r \leq 4.0$ $C_1 = 0.721 + 2.394\sqrt{h/r} - 0.127h/r$ $C_2 = 1.978 - 11.489\sqrt{h/r} + 2.211h/r$ $C_3 = -4.413 + 18.751\sqrt{h/r} - 4.596h/r$ $C_4 = 2.714 - 9.655\sqrt{h/r} + 2.512h/r$ For the semicircular notch ($h/r = 1$) $K_t = 2.988 - 7.300 \left(\frac{h}{D} \right) + 9.742 \left(\frac{h}{D} \right)^2 - 4.429 \left(\frac{h}{D} \right)^3$ Axial Tension (Refs. 16 and 17)
3b. Elastic stress, in-plane bending	$K_t = C_1 + C_2 \left(\frac{h}{D} \right) + C_3 \left(\frac{h}{D} \right)^2 + C_4 \left(\frac{h}{D} \right)^3$ where for $0.5 \leq h/r \leq 4.0$ $C_1 = 0.721 + 2.394\sqrt{h/r} - 0.127h/r$ $C_2 = -0.426 - 8.827\sqrt{h/r} + 1.518h/r$ $C_3 = 2.161 + 10.968\sqrt{h/r} - 2.455h/r$ $C_4 = -1.456 - 4.535\sqrt{h/r} + 1.064h/r$ For the semicircular notch ($h/r = 1$) $K_t = 2.988 - 7.735 \left(\frac{h}{D} \right) + 10.674 \left(\frac{h}{D} \right)^2 - 4.927 \left(\frac{h}{D} \right)^3$ Bending (Refs. 17 and 18)

$$\sigma_{max} = PK_t$$

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