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WORKSHEETS
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Material behaviour and design worksheet

AQA AS 7407 and first-year A Level 7408 | OCR A AS H156 and A Level H556

35–40 minutes independent practice + 15–20 minutes review | 38 marks

Specification points covered

- AQA 7407 / 7408: 3.4.2.1 selected density, stress, strain, breaking stress, fracture and elastic/plastic behaviour; 3.4.2.2 selected Young modulus and graph analysis.
- OCR A H156 / H556: 3.2.4(a) density; 3.4.2(c), (d)(i), (e), (f) selected stress, strain, strength, modulus and material behaviour. The full experimental method is a separate worksheet.

The Aster warehouse robot sorts fragile parcels. Engineers must choose its inspection window, safety link and impact pad from measured material evidence. Graphs are schematic; crosses indicate fracture. Compare slopes only on the stated common scales.

1. Quantities used in a tensile test [3 marks]

The robot's safety link is tested in tension.

(a) Define tensile stress. [1 mark]

(b) Define tensile strain. [1 mark]

(c) State what is meant by breaking stress. [1 mark]

2. Testing the safety link [5 marks]

A round metal test wire has diameter 0.800 mm and original length 0.600 m. Under a tensile force of 150 N it extends by 0.900 mm, within its proportional region. Its measured breaking stress is 420 MPa.

(a) Calculate its cross-sectional area in m^2. [1 mark]

(b) Calculate its tensile stress. [1 mark]

(c) Calculate its tensile strain. [1 mark]

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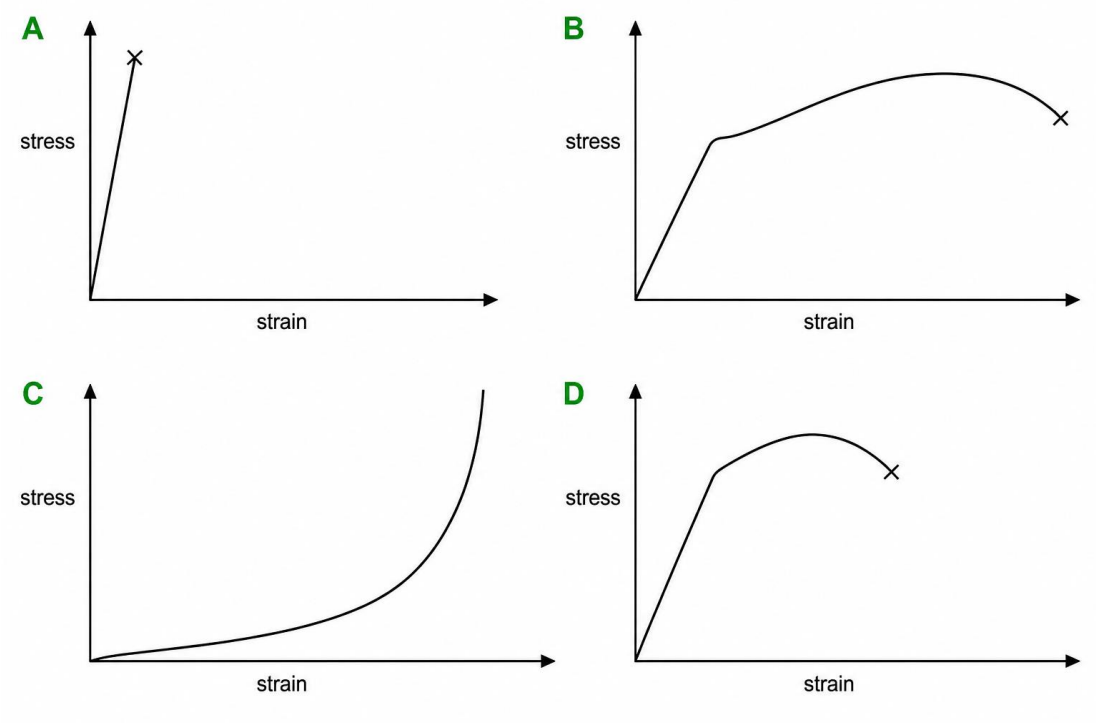
(d) Calculate the Young modulus of the metal. [1 mark]

(e) Decide whether the applied stress is below the measured breaking stress. [1 mark]

3. Reading the material curves [6 marks]

The four panels use common stress and strain scales. They are generic specimens, not numerical plots for the wire in Question 2. Curve C is a supplied model of a polymeric elastomer over its working range; it recovers its length when unloaded.



(a) Identify the brittle curve and support your choice with graph evidence. [2 marks]

(b) Which fractured specimen is most ductile? Support your choice. [2 marks]

(c) Which curve has the greatest initial gradient, and what property does that gradient represent? [1 mark]

(d) On curve B mark U at the maximum tensile stress and F at the fracture point. [1 mark]

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4. What happens after unloading [5 marks]

The steel catch link is loaded first within its elastic region and later beyond its elastic limit.

(a) Compare what remains after removing the load in these two cases. [2 marks]

(b) Explain where a plastic specimen's unloading line meets the strain axis and what that intercept means. [2 marks]

(c) Correct the sentence "The stress has plastically deformed." [1 mark]

5. Choosing the safety components [4 marks]

Use graph evidence and the supplied recovery/energy information.

(a) Recommend a curve for an impact-protected optical window that must show very small strain under normal stress. Justify your choice. [2 marks]

(b) Recommend a curve for a sacrificial catch link that must deform substantially before fracture. Justify your choice. [2 marks]

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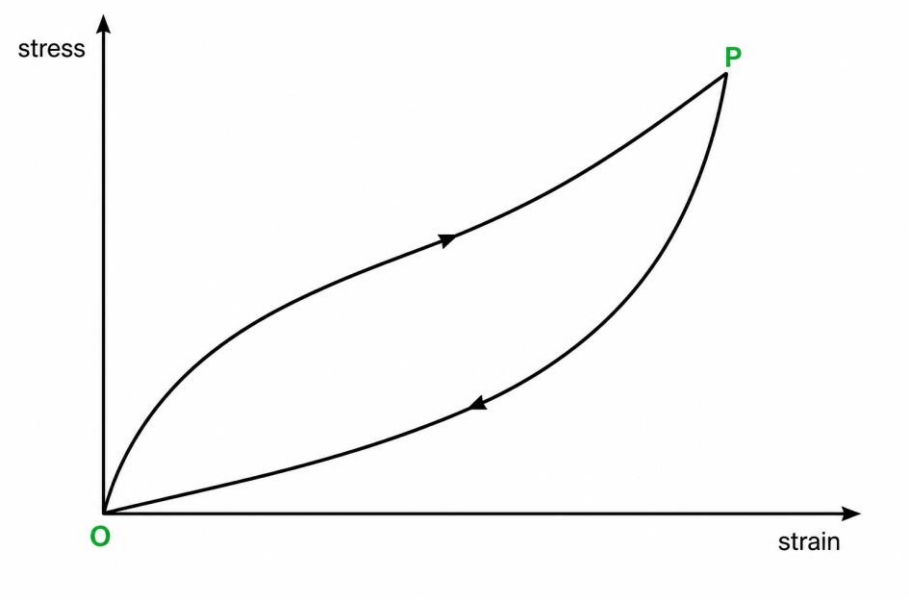
6. The impact pad loading cycle [5 marks]

The supplied elastomer loop returns to O after each cycle. For this test, enclosed stress–strain area equals energy dissipated per unit specimen volume. The measured loop area is 2.50 × 10^5 J m^{-3} and the pad volume is 36.0 cm^3.



(a) Identify the loading and unloading paths using the arrows. [1 mark]

(b) Use the supplied relationship to calculate the energy dissipated per cycle in joules. [2 marks]

(c) Explain why this behaviour reduces rebound. [2 marks]

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7. Checking a material measurement [5 marks]

A technician proposes using one coarse calliper reading and one large load to determine the Young modulus of a thin metal wire.

(a) Improve the diameter measurements and explain how area is obtained. [2 marks]

(b) State a suitable force–extension graph and explain how its gradient gives E. [2 marks]

(c) Give one specific safety precaution for loading the wire. [1 mark]

8. A lighter inspection window [5 marks]

A rectangular window is 0.200 m long, 0.100 m wide and 2.00 mm thick. Candidate glass has density 2500 kg m^{-3} and Young modulus 70 GPa; candidate aluminium has density 2700 kg m^{-3} and Young modulus 69 GPa. Only mass and modulus are considered in this screening test.

(a) Calculate the window volume in m^3. [1 mark]

(b) Calculate its mass if made from the glass. [1 mark]

(c) Calculate its mass if made from the aluminium. [1 mark]

(d) The mass limit is 0.105 kg and the minimum modulus is 60 GPa. Decide which material passes both numerical requirements. [2 marks]

Review: support a material choice with a named graph feature or calculation. Keep Young modulus, breaking stress, maximum stress and permanent strain distinct.

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