

Springs, wires and the stiffness of materials

Physics grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

Model answers with a marking guide. Award method marks for correct use of formulas even if a later number is wrong, and check powers of ten when areas are converted from millimetres.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.4.2

Question 1 Stress and strain (3 marks)

- a. $A = \pi(0.6 \times 10^{-3})^2 = \mathbf{0.000 \text{ m}^2}$.
- b. $\sigma = 90 \div 0.000 = \mathbf{79577471.546 \text{ Pa}}$.
- c. $\epsilon = \sigma/E = 79577471.546 \div 2.0 \times 10^{11} = \mathbf{0.000398}$.

Marking: 1 mark for each part.

Question 2 Spring energy (3 marks)

- a. $k = 25 \div 0.080 = \mathbf{312.5 \text{ N/m}}$.
- b. $E = \frac{1}{2}Fx = \frac{1}{2} \times 25 \times 0.080 = \mathbf{1 \text{ J}}$.

Marking: (a) 1; (b) 1 for formula, 1 for answer.

Question 3 Reading a stress-strain graph (3 marks)

- a. $E = \sigma/\epsilon = 280 \times 10^6 \div 1.4 \times 10^{-3} = \mathbf{200000000000.000 \text{ Pa}}$ (200 GPa).
- b. The **ultimate tensile stress** (the greatest stress the wire withstands, 450 MPa).

Marking: (a) 1 for substitution, 1 for answer; (b) 1.

Question 4 Aluminium wire (3 marks)

- a. $A = \pi(0.5 \times 10^{-3})^2 = 0.000 \text{ m}^2$. $\sigma = 40 \div 0.000 = \mathbf{50929581.789 \text{ Pa}}$.
- b. $\epsilon = 50929581.789 \div 7.0 \times 10^{10} = \mathbf{0.000728}$.
- c. $x = \epsilon L = 0.000728 \times 3.00 = \mathbf{2.18 \text{ mm}}$.

Marking: 1 mark for each part.

Question 5 Elastic and plastic (2 marks)

The wire does not return to its original length, because beyond the elastic limit the atomic layers have slipped and the deformation is **plastic**. A permanent extension remains.

Marking: 1 for permanent extension; 1 for explanation of plastic deformation.

Question 6 Brittle fracture (2 marks)

The graph is a steep straight line that ends suddenly at fracture. Glass has no plastic region: it obeys Hooke's law up to the point at which it breaks, **so it is brittle**, and it fractures with very little strain.

Marking: 1 for straight line with no plastic region; 1 for breaks suddenly.

Question 7 Extra energy (2 marks)

$$E = \frac{1}{2}k(x_2^2 - x_1^2) = \frac{1}{2} \times 400 \times (0.050^2 - 0.020^2) = \frac{1}{2} \times 400 \times 0.0021 = \mathbf{0.42 \text{ J}}.$$

Marking: 1 for the difference of energies; 1 for the answer.

Question 8 Area under a graph (2 marks)

The area represents the **work done** in stretching, which is the energy stored. Within the elastic limit all of it can be recovered, but beyond that, plastic deformation converts some of it to thermal energy, so it cannot be recovered.

Marking: 1 for work done or energy stored; 1 for explanation of loss beyond elastic limit.