

AS Physics 9702

# Unit 6 · Deformation of solids

## Original worksheet

Name: \_\_\_\_\_ Date: \_\_\_\_\_

Suggested marks: 61. Work through the questions over more than one study session if needed. Use additional paper for extended working and graph paper where requested.

Show equations, substitutions, units and reasoning. Use the constants specified in each question. The questions are original practice, not an official Cambridge examination or mark scheme.

Scope: Cambridge International AS Physics 9702, 2025–2027 learning outcomes. The published 2028–2030 AS scope has been checked separately and is substantively unchanged. Version: 11 October 2026.

### U6-Q1 · 5 marks

A straight spring has unloaded length 0.180 m. Opposite tensile forces of 4.0 N act at its ends, giving length 0.205 m. (a) Define load and find the extension. [2] (b) Explain why zero resultant force does not mean zero deformation. [1] (c) Explain how the deformation differs if the end forces are compressive and state what the limit of proportionality identifies. [2]

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### U6-Q2 · 5 marks

A spring obeys Hooke's law for loads up to 8 N. Loads 2.0, 4.0 and 6.0 N give extensions 8.0, 16.0 and 24.0 mm. (a) State Hooke's law and calculate  $k$ . [3] (b) Predict the extension at 7.0 N. [1] (c) Explain why the same prediction method is not justified for 12 N. [1]

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### U6-Q3 · 6 marks

A 2.00 m wire of diameter 0.50 mm extends by 1.20 mm under a tensile force of 24 N. (a) Calculate its cross-sectional area and tensile stress. [3] (b) Calculate strain and Young modulus. [3]

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**U6-Q4 · 5 marks**

Two uniform wires are made of the same material and remain in the proportional region. Wire B has twice the length and twice the diameter of wire A. (a) Derive  $k = EA/L$  from the definitions of stress and strain. [2] (b) Find  $k_B/k_A$ . [2] (c) Under the same load, state the ratio of their extensions  $x_B/x_A$ . [1]

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**U6-Q5 · 8 marks**

Design an experiment to determine the Young modulus of a metal wire. (a) State the measurements and instruments required. [3] (b) Describe load and extension measurements, including a method of obtaining  $E$  from a graph. [3] (c) Give one safety measure and one improvement reducing a significant measurement uncertainty. [2]

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**U6-Q6 · 6 marks**

A wire has diameter  $0.400 \pm 0.005$  mm and test length  $1.50 \pm 0.01$  m. At a force of 15.0 N, known with negligible uncertainty, its extension is  $0.90 \pm 0.03$  mm. (a) Calculate Young modulus. [3] (b) Estimate its maximum percentage uncertainty. [2] (c) Identify the larger of the diameter and extension percentage contributions. [1]

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**U6-Q7 · 5 marks**

A specimen's force-extension graph is straight up to 18 N, then curves. If unloaded from 22 N, it returns to its initial length. If unloaded from 27 N, 0.8 mm of extension remains. (a) Identify the limit of proportionality. [1] (b) Explain why 22 N has not exceeded the elastic limit, and give a bounded statement about that limit. [2] (c) Name and explain the deformation remaining after the 27 N test. [2]

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**U6-Q8 · 6 marks**

A spring's force-extension graph is a straight line from the origin to 12 N at 30 mm. (a) Explain why area under the graph is work done. [2] (b) Calculate its spring constant and stored elastic energy at 30 mm. [3] (c) State the energy if extension doubles while the spring remains proportional. [1]

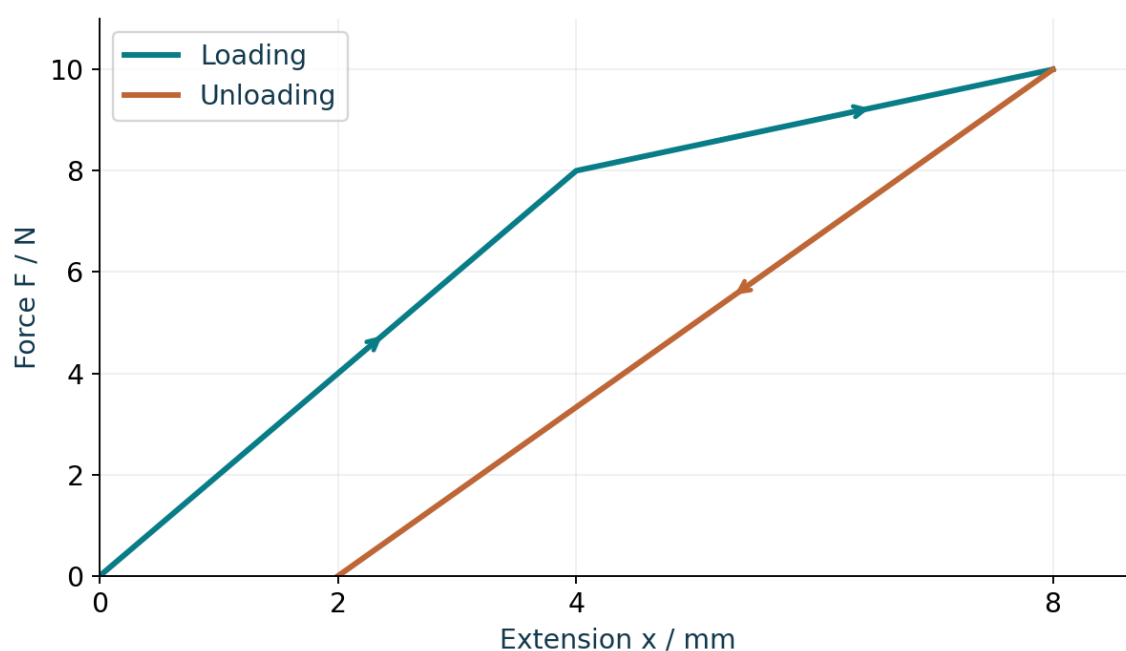
**U6-Q9 · 5 marks**

A spring of stiffness  $180 \text{ N m}^{-1}$  is stretched from 20 mm to 50 mm, remaining within its proportional range. (a) Calculate stored energy at each extension. [2] (b) Find the additional work done. [1] (c) Check your result using the mean force during this additional extension and explain why  $(1/2)k(0.030)^2$  is wrong here. [2]

**U6-Q10 · 6 marks**

A specimen is loaded along straight graph segments joining (extension/mm, force/N): (0,0), (4,8), (8,10). It unloads along a straight line from (8,10) to (2,0). (a) Calculate loading work. [2] (b) Calculate the energy returned during unloading. [2] (c) Find energy not returned mechanically and state the permanent extension. [2]

Figure for U6-Q10



**U6-Q11 · 2 marks**

Diagnostic multiple choice. A graph plots extension  $x$  in metres vertically against force  $F$  in newtons horizontally, in the Hooke's-law region. Its gradient is  $G$ . What is spring constant  $k$ ? Choose one option and explain. [2]

- A.  $k = G$ , with unit  $\text{N m}^{-1}$
  - B.  $k = 1/G$ , with unit  $\text{N m}^{-1}$
  - C.  $k = G$ , with unit Pa
  - D.  $k = 1/G$ , with no unit
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**U6-Q12 · 2 marks**

Diagnostic multiple choice. A material's loading graph becomes curved at high load, but on unloading it returns completely to its original length. Which conclusion is supported? Choose one option and explain. [2]

- A. Its elastic limit has definitely been exceeded.
  - B. It shows plastic deformation whenever the graph is curved.
  - C. It has passed the limit of proportionality but the deformation remains elastic.
  - D. Its Young modulus must be zero.
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