

AS Physics 9702

Unit 6 · Deformation of solids

Worked answers

Try the separate worksheet first. These worked answers explain methods as well as results. Equivalent valid reasoning and sensible rounding may also be correct. Suggested marks are RevisionTown practice guidance, not Cambridge marking instructions.

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) Load is the applied force, here 4.0 N (not the sum 8.0 N of equal opposite end forces). Extension = $0.205 - 0.180 = 0.025$ m. (b) The forces act on opposite ends and stretch the spring even while the whole spring is in equilibrium. (c) Compressive forces shorten it along its axis. The limit of proportionality marks the end of the region in which force is directly proportional to deformation.

U6-Q2 · 5 marks

(a) Extension is directly proportional to load within the proportional region. $k = F/x = 2.0/0.0080 = 250 \text{ N m}^{-1}$; the other pairs give the same value. (b) $x = 7.0/250 = 0.028 \text{ m} = 28 \text{ mm}$. (c) The 12 N load is outside the stated Hooke's-law range, so constant k cannot be assumed.

U6-Q3 · 6 marks

(a) $A = \pi d^2/4 = \pi(5.0 \times 10^{-4})^2/4 = 1.9635 \times 10^{-7} \text{ m}^2$. Stress = $F/A = 1.2223 \times 10^8 \text{ Pa}$. (b) Strain = $x/L = 0.00120/2.00 = 6.00 \times 10^{-4}$, with no unit. $E = \text{stress/strain} = 2.037 \times 10^{11} \text{ Pa} \approx 2.0 \times 10^{11} \text{ Pa}$ to match the diameter precision.

U6-Q4 · 5 marks

(a) $E = (F/A)/(x/L) = FL/(Ax)$. Therefore $F/x = EA/L$, and $k = F/x$ gives $k = EA/L$. (b) Doubling diameter quadruples area. With twice the length and unchanged E , $k_B/k_A = 4/2 = 2$. (c) Since $x = F/k$ for the same force, $x_B/x_A = 1/2$.

U6-Q5 · 8 marks

(a) Measure original test length L using a metre rule/tape, diameter d using a micrometer at several positions and orientations, and small extensions using a travelling microscope or displacement sensor. Known added masses give force increments mg . (b) Fix the wire securely, apply a small preload to straighten it, take a reference reading, and add loads in steps while measuring settled extension relative to that reference. Plot added force F against extension x , fit the proportional region and calculate $E = (L/A) \times \text{gradient}$, with $A = \pi d^2/4$. Unload to check reversibility. (c) Use eye protection and a tray just below the masses in case of breakage. A longer wire gives larger extensions and smaller fractional extension uncertainty; a reference wire can instead reduce common support/temperature movement.

U6-Q6 · 6 marks

(a) $A = \pi(0.000400)^2/4 = 1.2566 \times 10^{-7} \text{ m}^2$. $E = FL/(Ax) = (15.0 \times 1.50)/(1.2566 \times 10^{-7} \times 0.00090) = 1.989 \times 10^{11} \text{ Pa}$. (b) Maximum percentage uncertainty = $100(0.01/1.50 + 2 \times 0.005/0.400 + 0.03/0.90) = 6.50\%$. Thus $E \approx (1.99 \pm 0.13) \times 10^{11} \text{ Pa}$. (c) The extension contributes 3.33%; diameter contributes 2.50% after its factor of two, so extension contributes more.

U6-Q7 · 5 marks

(a) The limit of proportionality is at 18 N. (b) Full recovery from 22 N means deformation at that load is elastic despite nonlinearity. The elastic-limit load is at least 22 N but below 27 N, assuming the tests describe the same initially unaltered response. (c) The remaining 0.8 mm is plastic, or permanent, deformation: the original length is not recovered after removal of load.

U6-Q8 · 6 marks

(a) A small extension Δx under approximately constant force F requires work $F\Delta x$; summing the narrow graph strips gives the area under the curve. (b) $k = 12/0.030 = 400 \text{ N m}^{-1}$. Energy = triangular area = $(1/2) \times 12 \times 0.030 = 0.180 \text{ J}$, also $(1/2)kx^2$. (c) Energy is proportional to x^2 , so doubling extension gives $4 \times 0.180 = 0.720 \text{ J}$.

U6-Q9 · 5 marks

(a) Initial energy = $(1/2) \times 180 \times 0.020^2 = 0.036 \text{ J}$. Final energy = $(1/2) \times 180 \times 0.050^2 = 0.225 \text{ J}$. (b) Additional work = $0.225 - 0.036 = 0.189 \text{ J}$. (c) Forces are 3.6 N and 9.0 N, so mean force = 6.3 N. Work = $6.3 \times 0.030 = 0.189 \text{ J}$. The incorrect expression assumes force starts at zero during the extra 30 mm, whereas it starts at 3.6 N.

U6-Q10 · 6 marks

(a) The first triangle gives $(1/2) \times 0.004 \times 8 = 0.016 \text{ J}$. The second trapezium gives $(1/2)(8 + 10) \times 0.004 = 0.036 \text{ J}$. Total supplied work = 0.052 J . (b) Unloading area = $(1/2) \times 10 \times (0.008 - 0.002) = 0.030 \text{ J}$. (c) Energy not returned mechanically = $0.052 - 0.030 = 0.022 \text{ J}$, appearing in internal energy and irreversible changes. Permanent extension = 2 mm .

U6-Q11 · 2 marks

Correct option: B. $G = \Delta x / \Delta F = 1/k$, so $k = 1/G$ in N m^{-1} . A reverses the graph axes when interpreting the gradient. C additionally confuses spring stiffness with Young modulus. D correctly inverts the gradient but incorrectly removes its dimensions.

U6-Q12 · 2 marks

Correct option: C. Curvature means force is no longer directly proportional to extension; full recovery means the deformation is elastic. A and B incorrectly identify the proportional limit with the elastic limit or assume nonlinearity proves permanence. D has no basis: a non-proportional graph does not imply zero stiffness or zero Young modulus.

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