

Springs, wires and the stiffness of materials

Physics grades 11-12 (A Level · IB · Class 11-12) · Lab answers

Model answers use the sample results above. Your values will differ slightly, but the graph should be a straight line through the origin and your Young modulus should lie near 200 GPa for steel.

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

Question 1 Area of the wire

Mean $d = (0.50 + 0.51 + 0.49) \div 3 = 0.50$ mm. $A = \pi(0.25 \times 10^{-3})^2 = \mathbf{0.000\text{ m}^2}$.

Question 2 Forces

$F = 2.00 \times 9.81 = \mathbf{19.62\text{ N}}$. Hooke's law and E are defined with force, which is what stretches the wire.

Question 3 Stress and strain at the largest load

$\sigma = 29.43 \div 0.000 = \mathbf{149885759.206\text{ Pa}}$. $\epsilon = 1.88 \times 10^{-3} \div 2.50 = \mathbf{0.000752}$.

Question 4 Gradient

Gradient $= (29.43 - 4.91) \div ((1.88 - 0.31) \times 10^{-3} \text{ m}) = 24.52 \div 0.00157 = \mathbf{15621.019\text{ N/m}}$.

Question 5 Young modulus

$E = 15621.019 \times 2.50 \div 0.000 = \mathbf{198892992577.260\text{ Pa}}$ (199 GPa), close to the accepted value for steel.

Question 6 Uncertainty

Diameter: $0.01 \div 0.50 = 2\%$. Area uncertainty $= 2 \times 2 = \mathbf{4\%}$, so E has an uncertainty of about 4 % from this source, the largest in the experiment.

Question 7 Stored energy

$E = \frac{1}{2}Fx = \frac{1}{2} \times 29.43 \times 1.88 \times 10^{-3} = \mathbf{0.0277\text{ J}}$.

Question 8 Improvements

Both give a larger extension for the same load, so the percentage error in the small length x is reduced. A reference wire carrying a constant load next to the test wire cancels the effect of temperature changes and sagging of the support. **Take readings on unloading as well, to check the elastic limit has not been passed.**