Materials: Stress, Strain and the Young Modulus

Materials · 4 questions · step-by-step answers at the end

Name: Date: Score: / 4

USEFUL EQUATIONS

$F = kx$ $\sigma = F / A$ $\varepsilon = x / L$ $E = \sigma / \varepsilon = FL / (Ax)$ $W = \tfrac{1}{2}Fx = \tfrac{1}{2}kx^2$

Questions

Show your working in the space under each question.

1. Two identical springs, each k = 40 N m^{-1}, are joined in series. What is the combined spring constant?

2. A steel wire 2.0 m long and 0.50 mm in diameter stretches by 1.5 mm under a load of 30 N. Find the Young modulus.

3. A wire of diameter 1.0 mm has an ultimate tensile stress of 4.0×10^8 Pa. What is the largest load it can support?

4. Why is a long, thin wire used in a Young modulus experiment?

Step-by-step answers

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1. In series each stretches, so the total extension doubles: k = **20 N m⁻¹**.

2. 1. $A = \pi d^2/4 = \pi(0.50 \times 10^{-3})^2/4 = 1.96 \times 10^{-7}$ m².
2. Stress = $30/1.96 \times 10^{-7}$ = **1.53×10^8 Pa**.
3. Strain = $1.5 \times 10^{-3}/2.0$ = **7.5×10^{-4}**.
4. $E = 1.53 \times 10^8/7.5 \times 10^{-4}$ = **2.0×10^{11} Pa**.

Answer: 2.0×10^{11} Pa

3. $A = \pi(0.5 \times 10^{-3})^2 = 7.85 \times 10^{-7}$ m²; $F = 4.0 \times 10^8 \times 7.85 \times 10^{-7}$ = **314 N**.

4. It gives a **larger extension** for the same load, so the percentage uncertainty in the extension is smaller.