inkPhysics

QUESTION WORKBOOK

Stress, strain and the Young modulus

Materials · Year 12

AQA 3.4.2.2 · CIE 6.1.5, 6.1.6 · OCR A 3.4.2(c), 3.4.2(d)(i), 3.4.2(d)(ii), 3.4.2(e)

18 questions · 54 marks

NAVY SCREEN EDITION

SECTION A · Warm-up

A1 Define tensile stress and tensile strain, stating the unit of each. [2]

A2 A wire of cross-sectional area 2.0×10^{-6} m^2 carries a tension of 40 N. Calculate the tensile stress. [2]

A3 A wire of original length 2.5 m extends by 1.0 mm. Calculate the tensile strain. [2]

A4 State what is meant by a brittle material, and describe how its stress–strain graph shows this behaviour. [2]

A5 The straight initial region of a material's stress–strain graph passes through a stress of 8.0×10^{7} Pa at a strain of 4.0×10^{-4}. Determine the Young modulus of the material. [2]

SECTION B · Standard

B1 A wire of length 2.0 m and cross-sectional area 1.5×10^{-6} m^2 extends by 0.80 mm when a force of 60 N is applied. Calculate (a) the stress, (b) the strain and (c) the Young modulus of the wire. [4]

B2 A steel wire ($E = 2.0 \times 10^{11}$ Pa) has length 3.0 m and cross-sectional area 1.0×10^{-6} m^2. Calculate its extension under a tension of 50 N. [3]

B3 Sketch a typical stress–strain graph for a ductile metal wire and mark the limit of proportionality and the elastic limit. State how the Young modulus is found from the graph. [3]

B4 A wire of length 2.0 m and cross-sectional area 1.5×10^{-6} m^2 extends by 0.80 mm under a tension of 60 N. Calculate (a) the elastic strain energy stored in the wire and (b) the energy stored per unit volume. [3]

B5 Wires P and Q are made of the same material and carry the same load. P has twice the original length and twice the diameter of Q. Determine the ratio of the extension of P to the extension of Q. [3]

B6 Explain why the wire used in an experiment to measure the Young modulus should be long and thin. [2]

B7 A steel wire of density ρ and length L hangs vertically from a fixed clamp. Show that the stress at the top of the wire due to its own weight is ρgL, and go on to calculate this stress for a 120 m wire. (Density of steel = 7800 kg m^{-3}; g = 9.81 m s^{-2}.) [3]

SECTION C · Stretch

C1 A wire supporting a hanging sign has a breaking stress of 4.0×10^8 Pa and a diameter of 0.50 mm. Calculate the maximum tension the wire can support before breaking. [3]

C2 A steel wire ($E = 2.0 \times 10^{11}$ Pa) of length 1.5 m must support a 100 N load while extending by no more than 0.50 mm. Calculate the minimum cross-sectional area required and the corresponding minimum diameter. [4]

C3 Describe a simple laboratory method for measuring the Young modulus of a metal in the form of a wire, naming the measurements you would take. [3]

C4 A stage rigging cable of diameter 6.0 mm must carry a load of 8.0 kN. The breaking stress of the cable material is 5.0×10^8 Pa, and safety rules require the working stress to be no more than half the breaking stress. Deduce whether this cable may be used. [4]

C5 A composite wire is made by joining a 1.0 m steel wire ($E = 2.0 \times 10^{11}$ Pa) end to end with a 1.0 m brass wire ($E = 1.0 \times 10^{11}$ Pa). Both have cross-sectional area 2.0×10^{-7} m^2. The composite wire hangs vertically and supports a load of 40 N. Ignoring the weight of the wire itself, calculate the total extension. [4]

C6 Compare the behaviour of a ductile metal and a brittle material as each is stretched to fracture, with reference to the features of their stress–strain graphs.

[5]