InkPhysics

QUESTION WORKBOOK

Density and Hooke's law

Materials · Year 12

AQA 3.4.2.1 · CIE 4.3.1, 6.1.1, 6.1.2, 6.1.3, 6.1.4, 6.2.1, 6.2.2, 6.2.3, 6.2.4
OCR A 3.2.4(a), 3.4.1(a), 3.4.1(b), 3.4.1(c), 3.4.1(d)(i), 3.4.2(a), 3.4.2(b), 3.4.2(f)

18 questions · 57 marks

NAVY SCREEN EDITION

SECTION A · Warm-up

A1 Define density and state its SI unit. [2]

A2 A block has a mass of 540 g and a volume of 200 cm^3. Calculate its density in g cm^{-3} and in kg m^{-3}. [2]

A3 State Hooke's law for a spring. [2]

A4 Distinguish between the limit of proportionality and the elastic limit of a wire. [2]

A5 State how the energy stored in a stretched cord is found from its force–extension graph when the graph is curved. [1]

SECTION B · Standard

B1 A spring extends by 4.0 cm when a force of 2.0 N is applied. Calculate (a) its spring constant and (b) the force needed to extend it by 6.0 cm (within its limit of proportionality). [3]

B2 Steel has a density of 7800 kg m^{-3}. Express this in g cm^{-3} and calculate the mass of a 50 cm^3 steel component. [3]

B3 A spring of spring constant 200 N m^{-1} is stretched by 0.10 m within its limit of proportionality. Calculate the energy stored, and confirm your value using ½FΔL. [4]

B4 An irregular metal object of mass 0.50 kg is lowered into a measuring cylinder and displaces 62.5 cm^3 of water. Calculate the density of the metal in kg m^{-3}. [3]

B5 A foundry casts a brass component by mixing 60 cm^3 of copper (density 8900 kg m^{-3}) with 40 cm^3 of zinc (density 7100 kg m^{-3}). Assuming the total volume is unchanged on mixing, calculate the density of the brass. [4]

B6 A metal cube of side 3.0 cm has a mass of 216 g. Use the table to determine which metal the cube is most likely made of.
aluminium 2700 kg m^{-3}; titanium 4500 kg m^{-3}; steel 8000 kg m^{-3}; lead 11300 kg m^{-3} [3]

B7 The force–extension graph for a rubber cord is curved. A student counts 34 whole squares under the curve up to an extension of 0.30 m, on a grid where each square represents 0.5 N by 0.02 m. Calculate the energy stored, and explain why the student counted squares rather than using ½FΔL. [3]

SECTION C · Stretch

C1 Two springs have spring constants 50 N m^{-1} and 100 N m^{-1}. Calculate the effective spring constant when they are combined (a) in series and (b) in parallel, and find the extension of each combination under a 3.0 N load. [4]

C2 A spring of spring constant 800 N m^{-1} is compressed by 5.0 cm and used to launch a 0.20 kg ball horizontally. Assuming all the stored energy is transferred to the ball, calculate the launch speed. [4]

C3 Explain what happens to a spring stretched beyond its limit of proportionality, and how this appears on a force–extension graph. [3]

C4 A jumping toy contains a spring of spring constant 450 N m^{-1} that is compressed by 3.0 cm before release. The toy has a mass of 12 g. Assuming all the stored energy is transferred to gravitational potential energy, calculate the maximum height the toy reaches. (g = 9.81 m s^{-2}.) [4]

C5 A supplier advertises springs with a spring constant of 25.0 N m^{-1}, accurate to within 5%. A student hangs a load of 6.6 N from one of the springs and measures its extension as 0.240 m, within the limit of proportionality. Deduce whether this spring meets the advertised claim. [4]

C6 A copper wire is loaded steadily until it is stretched beyond its elastic limit, and the load is then removed. Describe fully the behaviour of the wire during loading and unloading, with reference to its force–extension graph and to the energy transfers involved. [6]