InkPhysics

ANSWER BOOK

Density and Hooke's law

Materials · Year 12

AQA 3.4.2.1 · CIE 4.3, 6.1, 6.2 · OCR A 3.2.4, 3.4.1, 3.4.2

10 questions · 30 marks

NAVY EDITION

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SECTION A · Warm-up

A1 Density is mass per unit volume, $\rho = m/V$. SI unit: kilogram per cubic metre ($kg\ m^{-3}$). [2]

A2 $\rho = m/V = 540/200 = 2.7\ g\ cm^{-3} = 2700\ kg\ m^{-3}$. [2]

A3 The extension of a spring is directly proportional to the force applied, up to the limit of proportionality: $F = k\Delta L$. [2]

SECTION B · Standard

B1 (a) $k = F/\Delta L = 2.0/0.040 = 50\ N\ m^{-1}$. (b) $F = k\Delta L = 50 \times 0.060 = 3.0\ N$. [3]

B2 $7800\ kg\ m^{-3} = 7.8\ g\ cm^{-3}$. $m = \rho V = 7.8 \times 50 = 390\ g = 0.39\ kg$. [3]

B3 $E = \tfrac{1}{2}k\Delta L^2 = \tfrac{1}{2} \times 200 \times 0.10^2 = 1.0\ J$. Check: $F = k\Delta L = 20\ N$, $\tfrac{1}{2}F\Delta L = \tfrac{1}{2} \times 20 \times 0.10 = 1.0\ J$. [4]

B4 $V = 62.5\ cm^3 = 62.5 \times 10^{-6}\ m^3$. $\rho = m/V = 0.50/(62.5 \times 10^{-6}) = 8000\ kg\ m^{-3}$. [3]

SECTION C · Stretch

C1 (a) Series: $1/k = 1/50 + 1/100$, so $k = 33.3\ N\ m^{-1}$; extension $= 3.0/33.3 = 0.090\ m$. (b) Parallel: $k = 50 + 100 = 150\ N\ m^{-1}$; extension $= 3.0/150 = 0.020\ m$. [4]

C2 Stored energy $= \tfrac{1}{2}k\Delta L^2 = \tfrac{1}{2} \times 800 \times 0.050^2 = 1.0\ J$. $\tfrac{1}{2}mv^2 = 1.0$, so $v = \sqrt{(2 \times 1.0/0.20)} = 3.16\ m\ s^{-1}$. [4]

C3 Beyond the limit of proportionality the extension is no longer proportional to the force, so the graph stops being a straight line and curves. Past the elastic limit the spring no longer returns to its original length when unloaded (plastic behaviour). [3]