inkMaths

ANSWER BOOK

Hooke's law and elastic strings

Further Mechanics 1 · Year FM

6 questions · 20 marks

NAVY EDITION

SECTION A · Warm-up

A1 $T = \lambda x/l$, where T is the tension, x the extension beyond the natural length, l the natural length and λ the modulus of elasticity. The modulus is measured in newtons, since x/l is a ratio. [2]

A2 Extension = 2.5 - 2 = 0.5 m. $T = 80 \times 0.5/2$ = 20 N. Using the length 2.5 in place of the extension would give 100 N, which is the standard error. [3]

SECTION B · Standard

B1 In equilibrium the tension equals the weight: $T = 3(9.8)$ = 29.4 N. Hooke's law gives $147x/1.2 = 29.4$, so $122.5x = 29.4$ and x = 0.24 m. The string is therefore 1.44 m long. [4]

B2 The two natural lengths total 2.4 m, so the extensions add to 3 - 2.4 = 0.6 m. In equilibrium the tensions are equal: $24x_1/1.2 = 36x_2/1.2$, so $24x_1 = 36x_2$ and $x_1 = 1.5x_2$. Then $2.5x_2 = 0.6$, giving x_2 = 0.24 m and x_1 = 0.36 m. The tension is $24(0.36)/1.2$ = 7.2 N, and the other string gives the same. [4]

B3 A spring can be compressed as well as stretched, giving a thrust with the same formula and the compression in place of the extension, whereas a string goes slack and exerts nothing when its ends come closer than the natural length. A spring also stays straight in compression, so it can hold a particle away from a support, which a string cannot. [3]

SECTION C · Stretch

C1 Resolving along the slope, the tension balances the component of weight down it: $T = 2(9.8)\sin 30°$ = 9.8 N. The normal reaction is perpendicular to the slope and does not enter this equation. Then $49x/1 = 9.8$, so x = 0.2 m. On a smooth plane no friction term appears; on a rough one the extension would depend on which way the particle was about to slip. [4]