inkMaths

ANSWER BOOK

Elastic potential energy

Further Mechanics 1 · Year FM

6 questions · 23 marks

NAVY EDITION

inkphysics.co.uk/maths/ · youtube.com/@InkPhysics

SECTION A · Warm-up

A1 EPE = $\lambda x^2/(2l)$. The tension grows linearly from 0 to $\lambda x/l$ as the string stretches, so the work done stretching it is the area of the triangle under the Hooke's law graph, half the base x times the height $\lambda x/l$. B1 for the formula, B1 for the triangle under the Hooke's law graph. Using the final tension throughout would double the answer. [2]

A2 EPE = $80 \times 0.5^2/(2 \times 2) = 80 \times 0.25/4 =$ **5** J. M1 for substituting into $\lambda x^2/(2l)$, A1 for 5 J. Checking by area: the tension at that extension is 20 N, and $\frac{1}{2} \times 0.5 \times 20 = 5$ J. [2]

SECTION B · Standard

B1 EPE = $20 \times 0.4^2/(2 \times 1) = 20 \times 0.16/2 =$ **1.6** J. The table is smooth and horizontal, so all of it becomes kinetic energy: $\frac{1}{2}(0.2)v^2 = 1.6$ gives $v^2 = 16$ and v = **4** m/s. M1 for the elastic energy, A1 for 1.6 J, M1 for equating it to kinetic energy, A1 for 4 m/s. Beyond the natural length the string goes slack and the particle keeps that speed. [4]

B2 Elastic energy released = $39.2 \times 0.5^2/(2 \times 1) =$ **4.9** J. The particle rises 0.5 m, gaining 0.5(9.8)(0.5) = **2.45** J of potential energy. What remains is kinetic: $\frac{1}{2}(0.5)v^2 = 2.45$, so $v^2 = 9.8$ and v = **3.13** m/s. M1 for the elastic energy, A1 for 4.9 J, B1 for the gain in potential energy, M1 for the energy equation, A1 for 3.13 m/s. Forgetting the height change would give 4.43 m/s. [5]

B3 First, using the total length in place of the extension. Write l and x down separately before substituting anything. Second, measuring heights from different levels at the two instants. Choose one zero level, mark it on the diagram and use it in both energy totals. B1 B1 for the two slips, B1 for the remedies. A third slip, less common, is forgetting that a string stores nothing once it goes slack. [3]

SECTION C · Stretch

C1 Energy stored = $50 \times 0.1^2/(2 \times 0.5)$ = **0.5** J, and the frictional force is $0.2 \times 1 \times 9.8$ = **1.96** N. [7]

The particle leaves the spring at the natural length, after 0.1 m. By then friction has taken 1.96(0.1) = 0.196 J, leaving 0.5 - 0.196 = 0.304 J as kinetic energy, so $\frac{1}{2}(1)v^2 = 0.304$ and v = **0.780** m/s.

For the total distance, all the elastic energy is eventually spent against friction. So $1.96d = 0.5$ and d = **0.255** m, of which the last **0.155** m is travelled clear of the spring. M1 for the stored energy, A1 for 0.5 J, B1 for the frictional force, M1 for the energy equation over the 0.1 m of contact, A1 for 0.780 m/s, M1 for spending all the stored energy against friction, A1 for 0.255 m.

Friction acts over the whole 0.255 m, including the 0.1 m of contact, so it must not be applied only to the free part. A spring is used rather than a string because only a spring can push.

