Exercise walk-through

Hooke's law ▪ 3.4

eXercise

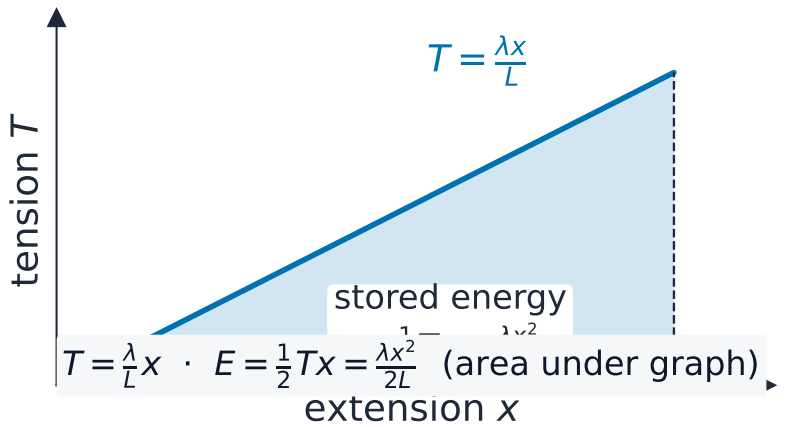
You must be able to

- use $T = \dfrac{\lambda x}{L}$ to find tension, extension, or λ
- find the stored energy $E = \dfrac{\lambda x^2}{2L}$
- combine Hooke's law with equilibrium or energy conservation

Method — Tension and energy

Natural length 2 **m, modulus** 50 **N, extension** 0.5 **m:** $T = \dfrac{50 \times 0.5}{2} = 12.5$ N; $E = \dfrac{50 \times 0.5^2}{2 \times 2} = 3.125$ J.

Method — Tension and energy



A straight tension–extension line with the triangle beneath shaded as energy

Practice 2.1 ▪ 2 marks

A spring of natural length 1 m and modulus 30 N is stretched by 0.2 m. Find the tension.

Solution 2.1

Method: Tension and energy

Worked steps

$$T = \frac{30 \times 0.2}{1} = 6 \text{ N} \quad \text{M1 A1}.$$

Practice 2.2 ▪ 2 marks

Find the energy stored in the spring in 2.1.

Solution 2.2

Method: Tension and energy

Worked steps

$$E = \frac{30 \times 0.2^2}{2 \times 1} = 0.6 \text{ J}$$ M1 A1.

Exam-style 3.1 ▪ 1 mark

Doubling the extension of an elastic string multiplies the stored energy by:

A 2

B 4

C $\frac{1}{2}$

D 1

Solution 3.1

Method: Tension and energy

A 2

B 4 ✓

C $\frac{1}{2}$

D 1

Worked steps

B. $E \propto x^2$, so doubling x multiplies E by 4.

Exam-style 3.2 ▪ 3 marks

A particle of mass 2 kg hangs in equilibrium on an elastic string of natural length 1.5 m and modulus 60 N.

(a) Find the extension of the string.

(b) Find the elastic energy stored.

Solution 3.2

Method: Tension and energy

Worked steps

(a) equilibrium $T = mg = 20$ N; $\dfrac{60x}{1.5} = 20 \Rightarrow 40x = 20 \Rightarrow x = 0.5$ m M1 M1 A1.

(b) $E = \dfrac{60 \times 0.5^2}{2 \times 1.5} = \dfrac{15}{3} = 5$ J M1 A1.

Exam-style 3.3 ▪ 5 marks

A particle of mass 0.5 kg is attached to one end of an elastic string of natural length 2 m and modulus 40 N, the other end fixed at O. The particle is released from rest at O and falls vertically. Using energy, find its speed when the string has extension 0.5 m.

Solution 3.3

Method: Tension and energy

Worked steps

the particle falls $2+0.5=2.5$ m to reach extension 0.5 m M1; energy: $mg(2.5)=\frac{1}{2}mv^2+\frac{\lambda x^2}{2L}$ M1; $0.5(10)(2.5)=\frac{1}{2}(0.5)v^2+\frac{40(0.25)}{2(2)}$ M1; $12.5=0.25v^2+2.5\Rightarrow v^2=40$ M1; $v=6.32$ m s^{-1} A1.