

3.4 Hooke's law

Name: _____ Class: _____ Date: _____

Total: 15 marks

Objective

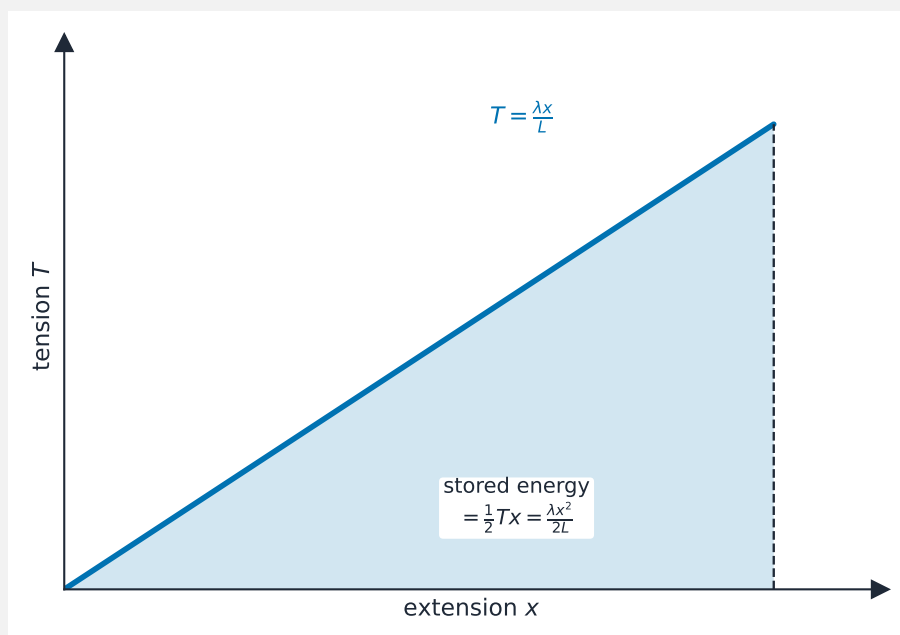
Build the skills to answer exam questions on **Hooke's law** 胡克定律—the tension $T = \frac{\lambda x}{L}$ in an elastic string/spring, and the stored **elastic potential energy** 弹性势能 $E = \frac{\lambda x^2}{2L}$. Take $g = 10 \text{ m s}^{-2}$.

You must be able to:

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

1 Worked examples

■ Tension and energy



Tension rises in proportion to extension; the shaded triangle is the stored elastic energy

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

2 Practice

2.1 A spring of natural length 1 m and modulus 30 N is stretched by 0.2 m. Find the tension. [2]

2.2 Find the energy stored in the spring in 2.1. [2]

3 Exam-style questions

3.1 Doubling the extension of an elastic string multiplies the stored energy by: [1]

- A 2
- B 4
- C $\frac{1}{2}$
- D 1

3.2 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. [3]

(b) Find the elastic energy stored. [2]

3.3 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. [5]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **3.4 Hooke's law** past-paper sheet in the Library, or try these in **Practice mode**:

- 9231/31 N25 —Q4 (Hooke's law)
- 9231/32 N25 —Q2 (elastic energy)
- 9231/34 N25 —Q6 (elastic string)

Solutions

2.1 $T = \frac{30 \times 0.2}{1} = 6 \text{ N}.$

2.2 $E = \frac{30 \times 0.2^2}{2 \times 1} = 0.6 \text{ J}.$

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

3.2 (a) equilibrium $T = mg = 20 \text{ N}; \frac{60x}{1.5} = 20 \Rightarrow 40x = 20 \Rightarrow x = 0.5 \text{ m}.$

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

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