

3 Further Mechanics – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English

Write it 3 times (English)

Hooke's law

modulus of elasticity

elastic potential energy

coefficient of restitution

Recall

In **Part 1** you met projectiles and circular motion. Part 2 adds stretchy **elastic strings** (Hooke's law) and **bouncy collisions** (the coefficient of restitution).

New ideas

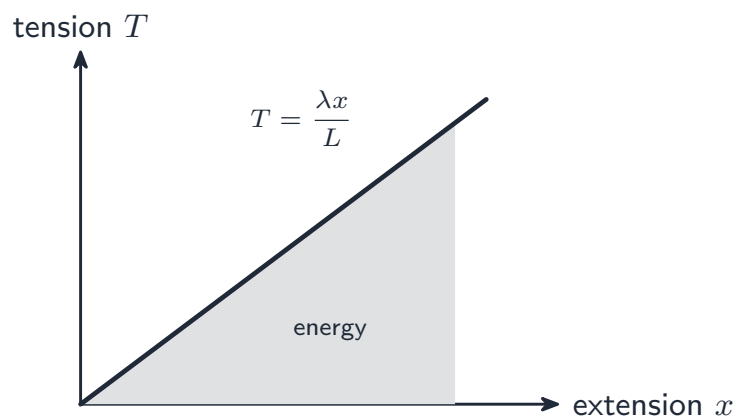
■ 1 Hooke's law

Hooke's law says the tension in an elastic string or spring is proportional to its **extension** x :

$$T = \frac{\lambda x}{L},$$

where L is the natural length and λ is the **modulus of elasticity**. Stretching it stores **elastic potential energy**:

$$E = \frac{\lambda x^2}{2L}.$$



Worked example. $L = 2$ m, $\lambda = 50$ N, $x = 0.5$ m: $T = \frac{50 \times 0.5}{2} = 12.5$ N.

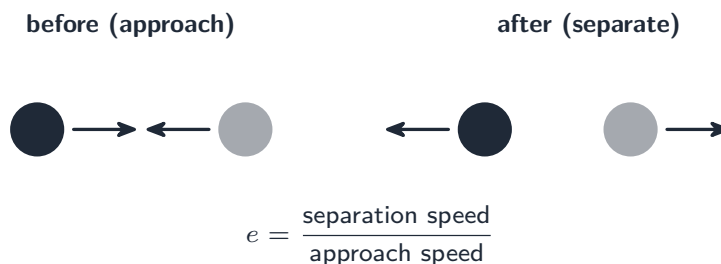
Micro-check. An elastic string has $L = 1$ m, $\lambda = 20$ N and extension $x = 0.2$ m. Find the tension. [1]

■ 2 The coefficient of restitution

In a collision, momentum is conserved. The bounciness is measured by the **coefficient of restitution** e :

$$e = \frac{\text{speed of separation}}{\text{speed of approach}}, \quad 0 \leq e \leq 1.$$

Here $e = 1$ is perfectly elastic (no energy lost) and $e = 0$ is perfectly inelastic (the bodies stay together).



Worked example. Two balls approach at 4 m s^{-1} and separate at 2 m s^{-1} : $e = \frac{2}{4} = 0.5$.

Micro-check. Two bodies approach at 6 m s^{-1} and separate at 3 m s^{-1} . Find e . [1]

Watch out: in $T = \frac{\lambda x}{L}$, x is the **extension** – the extra length, not the total stretched length. The stored energy uses x^2 , so doubling the stretch **quadruples** the energy. The coefficient of restitution is separation $\div$ approach, always between 0 and 1.

Practice

3.1 An elastic string has natural length 2 m, modulus 40 N, and is stretched by 0.5 m. Find the tension. [2]

3.2 For the string in 3.1, find the stored elastic energy ($E = \frac{\lambda x^2}{2L}$). [2]

3.3 Two balls approach at 8 m s^{-1} and separate at 2 m s^{-1} . Find the coefficient of restitution. [2]

3.4 State the value of e for (a) a perfectly elastic collision; (b) a perfectly inelastic one. [2]

3.5 State what is conserved in **every** collision. [1]

3.6 Challenge. An elastic string of natural length 1.5 m and modulus 60 N is stretched to a total length of 2 m. Find the tension and the stored elastic energy. [3]