Exercise walk-through

Potential Energy ▪ 3.3

eXercise

You must be able to

- define **potential energy 势能** as energy stored in the configuration of a system
- calculate **gravitational potential energy 重力势能** with $\Delta U_g = mg\Delta h$
- calculate **elastic potential energy 弹性势能** with $U_s = \frac{1}{2}kx^2$
- relate a **conservative force 保守力** to the change in potential energy
- interpret a **potential energy versus position** graph

Method — Gravitational potential energy

$\Delta U_g = mg\Delta h$. Lifting a 2.0 kg book 3.0 m (take $g = 10$ m s^{-2}):
$\Delta U_g = 2.0 \times 10 \times 3.0 = 60$ J.

Method — Elastic potential energy

$U_s = \frac{1}{2}kx^2$. A spring with $k = 200$ N m^{-1} compressed 0.10 m:
$U_s = \frac{1}{2}(200)(0.10)^2 = 1.0$ J.

Method — Reading a potential-energy graph

A **minimum** of U is a point of **stable equilibrium**; the object oscillates about it. The steeper the curve, the larger the force ($F = -\,\text{slope}$).

Practice 2.1 ▪ 2 marks

Find the gravitational potential energy gained by lifting a 5.0 kg box 2.0 m (take $g = 10$ m s^{-2}).

Solution 2.1

Method: Gravitational potential energy

Worked steps

$\Delta U_g = mg\Delta h = 5.0 \times 10 \times 2.0 = 100$ J **M1** **A1**.

Practice 2.2 ▪ 2 marks

A spring of constant 300 N m^{-1} is compressed 0.20 m. Find the elastic potential energy stored.

Solution 2.2

Method: Elastic potential energy

Worked steps

$U_s = \frac{1}{2}(300)(0.20)^2 = 6.0$ J **M1** **A1**.

Practice 2.3 ▪ 1 mark

State what a minimum on a potential-energy versus position graph tells you about the object there.

Solution 2.3

Method: Reading a potential-energy graph

Worked steps

it is a point of stable equilibrium (the object tends to stay or oscillate about it) B1.

Exam-style 3.1 ▪ 1 mark

The elastic potential energy stored in a spring is

A kx

B $\frac{1}{2}kx$

C $\frac{1}{2}kx^2$

D kx^2

Solution 3.1

Method: Elastic potential energy

A kx

B $\frac{1}{2}kx$

C $\frac{1}{2}kx^2$ ✓

D kx^2

Worked steps

C.

Exam-style 3.2 ▪ 1 mark

Doubling the compression of a spring changes its stored potential energy by a factor of

A 2

B 4

C $\frac{1}{2}$

D no change

Solution 3.2

Method: Elastic potential energy

A 2

B 4 ✓

C $\frac{1}{2}$

D no change

Worked steps

B — $U_s \propto x^2$.

Exam-style 3.3 ▪ 2 marks

A 0.30 kg ball is raised 1.5 m and then released from rest (take $g = 10$ m s^{-2}).
(a) Find the gravitational potential energy at the top.
(b) Using energy conservation, find its speed just before it lands.

Solution 3.3

Method: Gravitational potential energy

Worked steps

(a) $U_g = 0.30 \times 10 \times 1.5 = 4.5$ J M1 A1. (b) $\frac{1}{2}mv^2 = U_g \Rightarrow v = \sqrt{2g\Delta h} = \sqrt{30} = 5.5$ m s^{-1} M1 A1.