Exercise walk-through

Conservation of Energy ▪ 3.4

eXercise

You must be able to

- apply **conservation of mechanical energy 机械能守恒** when no friction acts
- convert between kinetic and potential energy
- use $K_i + U_i = K_f + U_f$
- account for energy lost to friction as thermal energy

Method — Mechanical energy is conserved

With no friction, the total of kinetic plus potential energy stays constant:

$$K_i + U_i = K_f + U_f.$$

Method — A falling object

Drop a 2 kg mass from 5 m ($g = 10$ m s^{-2}). All the PE becomes KE:

$$mgh = \tfrac{1}{2}mv^2 \Rightarrow v = \sqrt{2gh} = \sqrt{2(10)(5)} = 10 \text{ m s}^{-1}.$$

Method — When friction acts

Friction removes mechanical energy as heat:

$$K_i + U_i = K_f + U_f + (\text{energy lost to friction}).$$

Practice 2.1 ▪ 1 mark

State the condition under which mechanical energy is conserved.

Solution 2.1

Method: Mechanical energy is conserved

Worked steps

When no friction (or other non-conservative force) acts B1.

Practice 2.2 ▪ 2 marks

A ball is dropped from 2 m ($g = 10$ m s^{-2}). Find its speed just before landing.

Solution 2.2

Worked steps

$v = \sqrt{2gh} = \sqrt{2(10)(2)} = 6.3 \text{ m s}^{-1}$ M1 A1.

Practice 2.3 ▪ 1 mark

At the top of a swing, a pendulum has 6 J of PE and no KE. State its KE at the bottom (no friction).

Solution 2.3

Method: When friction acts

Worked steps

6 J (all PE becomes KE) B1.

Practice 2.4 ▪ 1 mark

Where does mechanical energy go when friction acts?

Solution 2.4

Method: When friction acts

Worked steps

It becomes thermal energy (heat) B1.

Exam-style 3.1 ▪ 1 mark

In the absence of friction, as an object falls its

A total mechanical energy increases

B total mechanical energy stays constant

C kinetic energy decreases

D potential energy increases

Solution 3.1

A total mechanical energy increases

B total mechanical energy stays constant ✅

C kinetic energy decreases

D potential energy increases

Worked steps

B — with no friction, total mechanical energy is constant.

Exam-style 3.2 ▪ 1 mark

A cart at the top of a frictionless track has PE $= 40$ J and KE $= 0$. At the bottom its KE is

A 0

B 20 J

C 40 J

D 80 J

Solution 3.2

A 0

B 20 J

C 40 J ✓

D 80 J

Worked steps

C — all 40 J of PE becomes KE.

Exam-style 3.3 ▪ 2 marks

A 0.5 kg ball is released from rest at height 1.8 m on a frictionless ramp ($g = 10$ m s^{-2}).

(a) Find its speed at the bottom.

(b) State the assumption you made.

Solution 3.3

Worked steps

(a) $v = \sqrt{2gh} = \sqrt{2(10)(1.8)} = 6$ m s^{-1} M1 A1. (b) No friction / energy is conserved B1.

Exam-style 3.4 ▪ 1 mark

A 1 kg block slides down a ramp, starting with 20 J of PE, and reaches the bottom with 14 J of KE.

(a) State how much energy was lost to friction.

(b) Explain where that energy went.

Solution 3.4

Method: When friction acts

Worked steps

(a) $20 - 14 = 6$ J B1. (b) It was converted to thermal energy by friction B1.