Exercise walk-through

Energy of Simple Harmonic Oscillators ▪ 7.4

eXercise

You must be able to

- describe the continuous exchange between **kinetic energy** and **potential energy** during SHM
- state that the **total mechanical energy 总机械能** of an ideal oscillator is constant
- relate the total energy of a mass-spring oscillator to its amplitude, $E = \frac{1}{2}kA^2$

Method — Energy is traded, not lost

During SHM, kinetic and potential energy convert back and forth while the **total stays constant** (no friction).

Method — Total energy from the amplitude

$$E = \tfrac{1}{2}kA^2.$$

At the amplitude all the energy is potential; at equilibrium all of it is kinetic (so the speed is greatest there).

Method — Example

A spring with $k = 100$ N m^{-1} and amplitude 0.20 m: $E = \frac{1}{2}(100)(0.20)^2 = 2.0$ J.

Practice 2.1 ▪ 2 marks

A spring of constant 100 N m^{-1} oscillates with amplitude 0.20 m. Find the total energy.

Solution 2.1

Worked steps

$E = \frac{1}{2}kA^2 = \frac{1}{2}(100)(0.20)^2 = 2.0$ J M1 A1.

Practice 2.2 ▪ 1 mark

State where in the motion the kinetic energy is greatest.

Solution 2.2

Method: Total energy from the amplitude

Worked steps

at the equilibrium position B1.

Practice 2.3 ▪ 1 mark

State the potential energy at the amplitude, in terms of the total energy E.

Solution 2.3

Method: Total energy from the amplitude

Worked steps

all of it — E B1.

Exam-style 3.1 ▪ 1 mark

The total energy of a mass-spring oscillator is

A $\frac{1}{2}kA$

B $\frac{1}{2}kA^2$

C kA^2

D $\frac{1}{2}mA^2$

Solution 3.1

A $\frac{1}{2}kA$

B $\frac{1}{2}kA^2$ ✓

C kA^2

D $\frac{1}{2}mA^2$

Worked steps

B.

Exam-style 3.2 ▪ 1 mark

At the amplitude of SHM, the energy is entirely

A kinetic

B potential

C thermal

D zero

Solution 3.2

Method: Total energy from the amplitude

A kinetic

B potential ✓

C thermal

D zero

Worked steps

B.

Exam-style 3.3 ▪ 2 marks

A 0.50 kg mass on a spring of constant 200 N m^{-1} oscillates with amplitude 0.10 m.
(a) Find the total energy.
(b) Find the maximum speed.

Solution 3.3

Method: Total energy from the amplitude

Worked steps

(a) $E = \frac{1}{2}(200)(0.10)^2 = 1.0$ J M1 A1. (b) at equilibrium all energy is kinetic: $\frac{1}{2}mv^2 = 1.0 \Rightarrow v = \sqrt{\dfrac{2(1.0)}{0.50}} = 2.0$ m s^{-1} M1 A1.