AP PHYSICS 1 • EXERCISE SHEET

7.4 Energy of Simple Harmonic Oscillators

Name: ______________ Class: __________ Date: ____________ **Total: 10 marks**

Objective

Build the skills to answer exam questions on **the energy of simple harmonic oscillators**.

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, $E = \frac{1}{2}kA^2$

1 Worked examples

Study these first. Each one shows the method for a question type used later.

■ Energy is traded, not lost

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

■ Total energy from the amplitude

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

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

■ 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.

2 Practice

2.1 A spring of constant 100 N m^{-1} oscillates with amplitude 0.20 m. Find the total energy. [2]

2.2 State where in the motion the kinetic energy is greatest. [1]

2.3 State the potential energy at the amplitude, in terms of the total energy E. [1]

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3 Exam-style questions

3.1 The total energy of a mass-spring oscillator is [1]

- **A** $\frac{1}{2}kA$
- **B** $\frac{1}{2}kA^2$
- **C** kA^2
- **D** $\frac{1}{2}mA^2$

3.2 At the amplitude of SHM, the energy is entirely [1]

- **A** kinetic
- **B** potential
- **C** thermal
- **D** zero

3.3 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. [2]

(b) Find the maximum speed. [2]

4 Go further

- work through the **7.4 Energy of Simple Harmonic Oscillators** lesson on the **Learn** page;
- read the **Oscillations** section of the AP Physics 1 handout on the **Know** page.

Solutions

2.1 $E = \frac{1}{2}kA^2 = \frac{1}{2}(100)(0.20)^2 = 2.0$ J.

2.2 at the equilibrium position.

2.3 all of it —E.

3.1 **B**.

3.2 **B**.

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