7 The energy of oscillations – Part 2

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	**Write it 3 times** (English)
equilibrium position	_____ _____ _____
amplitude	_____ _____ _____

Recall

In Part A you met simple harmonic motion and its period. Now follow the **energy** and **speed** through one cycle:

- At the far ends of a swing the object stops for an instant, then turns back.
- At the middle it is moving fastest.
- The energy keeps swapping between two forms while the total stays fixed.

Each idea has a worked example before the Practice.

New ideas

■ 1 Speed and acceleration through the cycle

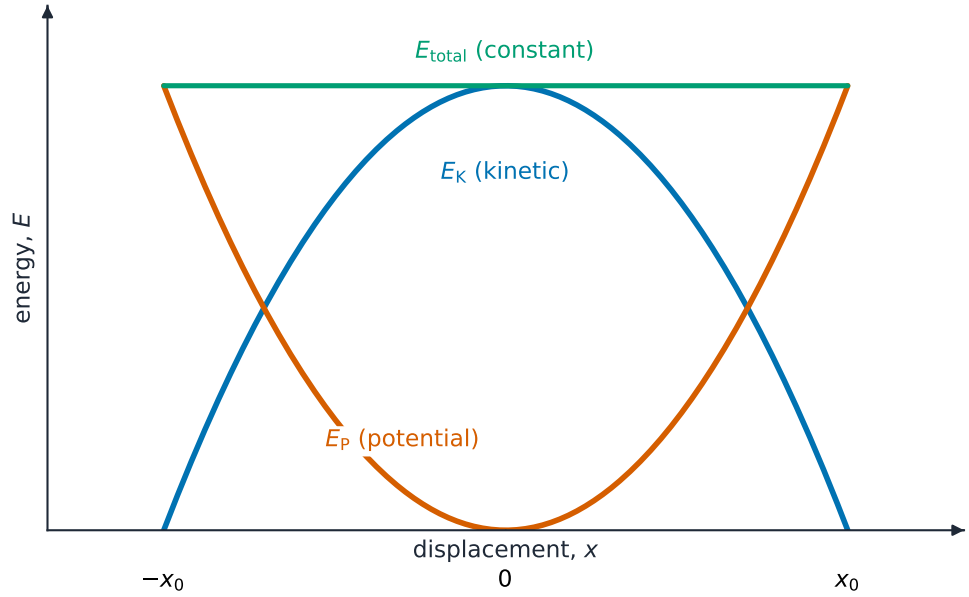
As the object oscillates about its **equilibrium position** (the middle):

- At the **ends** (maximum displacement, called the **amplitude** A): the speed is **zero** and the acceleration is largest.
- At the **middle** ($x = 0$): the acceleration is zero and the **speed is largest**.

■ 2 Energy swaps between two forms

The energy slides back and forth between kinetic and elastic potential, while the **total** stays constant (no friction):

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



- At the ends: all **potential** (stretched spring, not moving).
- At the middle: all **kinetic** (moving fastest, spring relaxed).

Worked example. A 0.50 kg mass on a spring ($k = 200$ N/m) has amplitude $A = 0.10$ m. All the energy is kinetic at the middle, so $\frac{1}{2}kA^2 = \frac{1}{2}mv_{\max}^2$, giving $v_{\max} = A\sqrt{\dfrac{k}{m}} = 0.10 \times \sqrt{\dfrac{200}{0.50}} = 2.0$ m/s.

3 Amplitude and energy

Because $E = \frac{1}{2}kA^2$, the energy depends on the **square** of the amplitude – double the amplitude and the energy becomes **four times** larger.

Watch out: the fastest point is the **middle**, not the ends. At the ends the object is momentarily at rest, even though the force on it is largest there.

Practice

Try these in order. The methods are all above.

2.1 State where in its swing an oscillating mass has (a) maximum speed, (b) zero speed. [2]

2.2 At which point of the motion is all the energy kinetic? [1]

2.3 A spring ($k = 300$ N/m) oscillates with amplitude $A = 0.20$ m. Find the total energy $E = \frac{1}{2}kA^2$. [2]

2.4 A 0.20 kg mass on a spring ($k = 80$ N/m) has amplitude 0.15 m. Find its maximum speed. [3]

2.5 The amplitude of an oscillation is doubled. State the factor by which the total energy changes. [1]

2.6 Explain why the acceleration is largest at the ends of the swing, even though the speed there is zero. [2]