

# 7 The energy of oscillations – Part 2

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

## Vocabulary 词汇

Write each word three times. 把每个单词抄写三遍。

| English              | 中文   | Write it 3 times (English) |
|----------------------|------|----------------------------|
| equilibrium position | 平衡位置 | _____                      |
| amplitude            | 振幅   | _____                      |

## 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

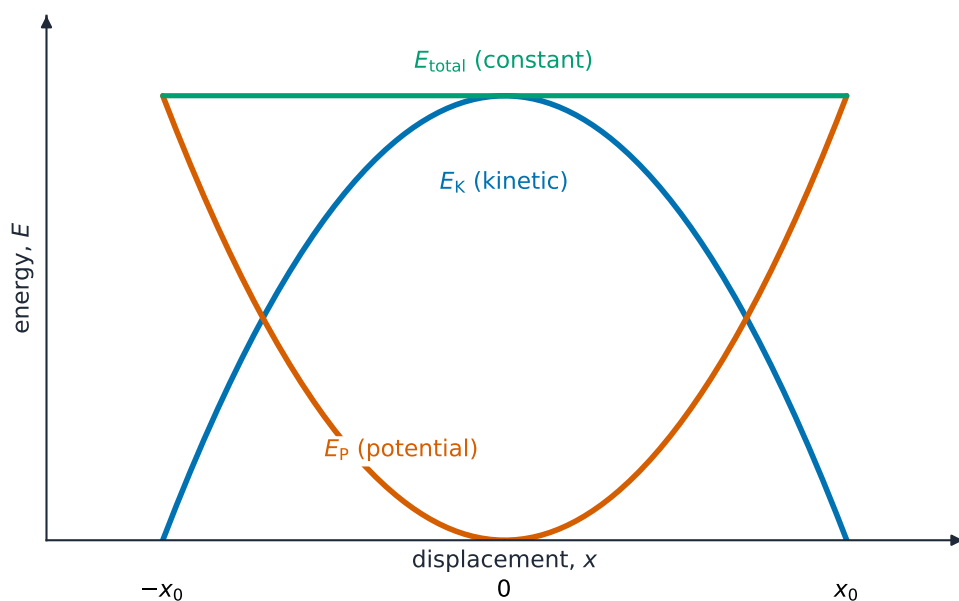
As the object oscillates about its **equilibrium position** 平衡位置 (the middle):

- At the **ends** (maximum displacement, called the **amplitude** 振幅  $A$ ): 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):

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



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

### ■ 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]

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

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**2.3** A spring ( $k = 300 \text{ N/m}$ ) oscillates with amplitude  $A = 0.20 \text{ m}$ . Find the total energy

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

**2.4** A 0.20 kg mass on a spring ( $k = 80 \text{ N/m}$ ) 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]