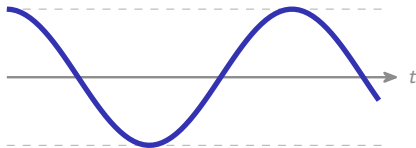


Oscillations

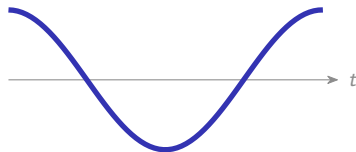
AP Physics 1 ■ Unit 7

AP Physics 1



What we will cover

- 1 Defining simple harmonic motion
- 2 Frequency and period
- 3 Representing and analyzing SHM
- 4 Energy of an oscillator



Simple harmonic motion

Simple harmonic motion 简谐运动 happens when the **restoring force** 回复力 is proportional to the displacement:

The defining law

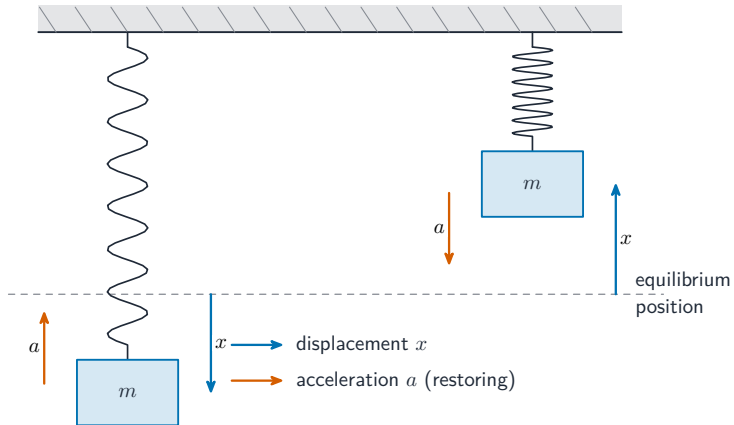
$$F = -kx$$

Pull it **twice** as far, and it pulls back **twice** as hard – always toward the middle.



*SHM restores
toward equilibrium*

Simple harmonic motion



Frequency and period

An oscillation repeats every **period** 周期 T ;
the **frequency** 频率 $f = 1/T$.

Period depends on the system, not the swing

$$T_{\text{spring}} = 2\pi\sqrt{\frac{m}{k}}$$

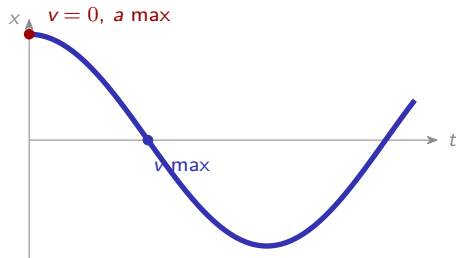
$$T_{\text{pendulum}} = 2\pi\sqrt{\frac{L}{g}}$$

The period does **not** depend on the **amplitude** 振幅 – a big swing and a small swing take the same time.

0.5 kg on $k = 50 \text{ N/m}$: $T \approx 0.63 \text{ s}$, whether you pull it 2 or 10 cm.

A pendulum's period ignores mass entirely.

Reading an oscillation

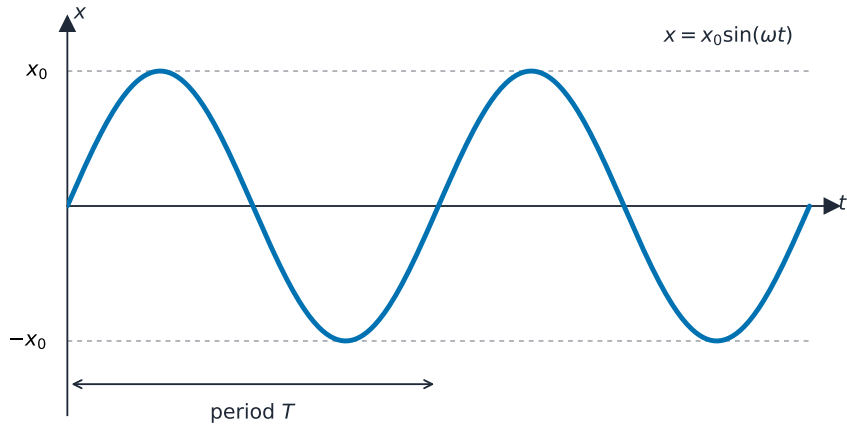


Displacement, velocity and acceleration trace smooth sine curves:

- **velocity** greatest at the **equilibrium** 平衡位置 (middle)
- **acceleration** greatest at the extremes

The **phase** 相位 sets where in the cycle it is: v peaks a quarter-cycle before x .

Reading an oscillation



Energy of an oscillator

Energy sloshes between two forms, but the total is constant:

Set by the amplitude

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

- **kinetic energy** 动能 greatest in the middle
- **potential energy** 势能 greatest at the extremes

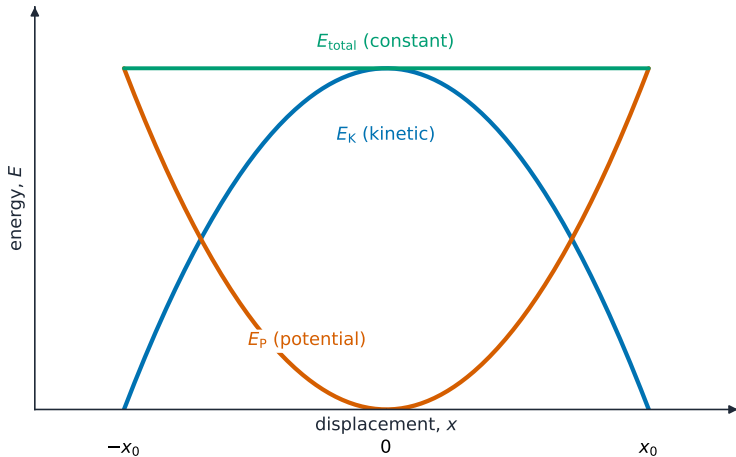


Oscillators store and exchange energy

Energy of an oscillator

Energy of an oscillator

Energy of an oscillator



Unit 7 – key takeaways

1 SHM

$F = -kx$: restoring force proportional to displacement

2 Period

$2\pi\sqrt{m/k}$ or $2\pi\sqrt{L/g}$; independent of amplitude

3 Motion

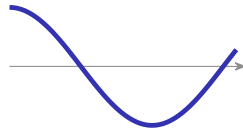
v max in the middle; a max at the extremes

4 Energy

$E = \frac{1}{2}kA^2$; trades between KE and PE

Check yourself

- 1 Double the amplitude – does the period change?
- 2 Where in the swing is the velocity greatest?
- 3 Where is the acceleration greatest?
- 4 Does a pendulum's period depend on the mass?



Answers 1. no 2. in the middle (equilibrium) 3. at the extremes 4. no