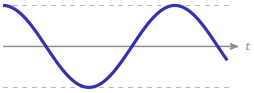
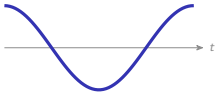
Oscillations

AP Physics 1 ▪ Unit 7

AP Physics 1



What we will cover



1 Defining SHM

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

2 Period

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

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

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

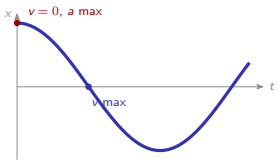
The period does not depend on the **amplitude** 振幅 – a big swing and a small swing take the same time.

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

A pendulum's period ignores mass entirely.

3 Analyzing SHM

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.

4 Energy

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

Oscillations
└Energy

Energy of an oscillator

5 Recap

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

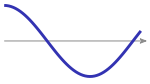
v max in the middle; a max at the extremes

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