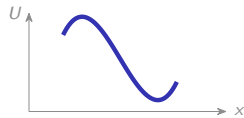


Work, Energy, and Power

AP Physics C: Mechanics ■ Unit 3

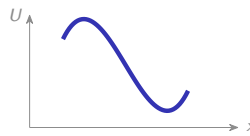
AP Physics C: Mechanics



Work, Energy, and Power

What we will cover

- 1 Kinetic energy and the work-energy theorem
- 2 Work as an integral
- 3 Potential energy and force
- 4 Conservation of energy
- 5 Power



1 Kinetic energy

Kinetic energy and the work-energy theorem

Energy of motion

$$K = \frac{1}{2}mv^2$$

A **scalar** 标量; $\propto v^2$, so double the speed quadruples K .

Work-energy theorem

$$W_{\text{net}} = \Delta K$$



Coaster energy

2 Work

Work as an integral

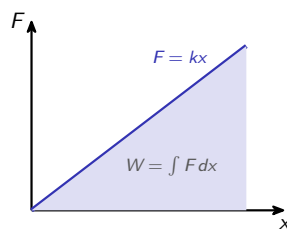
Constant vs variable force

$$W = \vec{F} \cdot \vec{d} = Fd \cos \theta$$

$$W = \int \vec{F} \cdot d\vec{r}$$

The integral is the **area** under an F - x graph.

Stretching a spring: $W = \int_0^x kx' dx' = \frac{1}{2}kx^2$.



3 Potential energy

Work, Energy, and Power
└ Potential energy

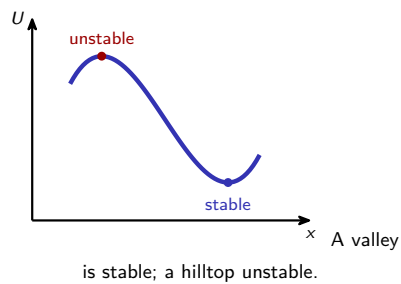
Potential energy and force

A **conservative force** 保守力 stores **potential energy** 势能:

Two stored forms, and the link

$$U_g = mgy, \quad U_s = \frac{1}{2}kx^2$$
$$F_x = -\frac{dU}{dx}$$

For a spring $-\frac{d}{dx}(\frac{1}{2}kx^2) = -kx$ – Hooke's law drops out.



4 Conservation

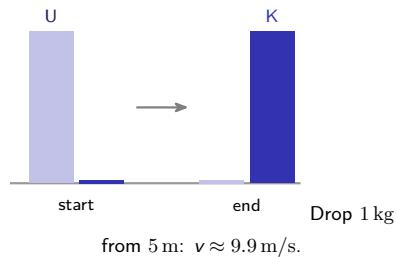
Conservation of energy

With only conservative forces, **mechanical energy is conserved** 机械能守恒:

Before = after

$$K_i + U_i = K_f + U_f$$

A **non-conservative force** 非保守力 like friction removes mechanical energy as heat.



5

Power

Power

Power 功率 is the **rate** of doing work:

Two forms

$$P = \frac{dW}{dt}, \quad P = \vec{F} \cdot \vec{v}$$

Instantaneous power varies as force or speed changes.

Worked example

Lift 50 kg at a steady 2 m/s:

$$P = Fv = (490)(2) = 980 \text{ W}$$

Twice as fast $\Rightarrow$ 1960 W – same work per metre, half the time.

6

Recap

Work, Energy, and Power

└ Recap

Unit 3 – key takeaways

1 Work

$W = \int \vec{F} \cdot d\vec{r}$; the area under an F - x graph

2 Energy

$K = \frac{1}{2}mv^2$; net work equals ΔK

3 Potential

$F_x = -dU/dx$; valley stable, hill-top unstable

4 Conservation

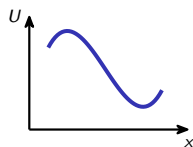
$K + U$ constant; $P = dW/dt = \vec{F} \cdot \vec{v}$

Work, Energy, and Power

└ Recap

Check yourself

- 1 What integral gives the work done by a variable force?
- 2 How do you get the force from a potential-energy function?
- 3 Is a potential-energy valley stable or unstable equilibrium?
- 4 Write instantaneous power as a dot product.



Answers 1. $\int \vec{F} \cdot d\vec{r}$ 2. $F_x = -dU/dx$ 3. stable 4. $P = \vec{F} \cdot \vec{v}$