

3 Work, kinetic energy, and potential energy – Part 1

Name: _____ Class: _____ Date: _____

Vocabulary

Write each word three times.

English	Write it 3 times (English)		
Energy	_____	_____	_____
joules	_____	_____	_____
kinetic energy	_____	_____	_____
Work	_____	_____	_____
work–energy theorem	_____	_____	_____
Potential energy	_____	_____	_____
Gravitational potential energy	_____	_____	_____
Elastic potential energy	_____	_____	_____

Recall

You already know a lot about energy:

- Energy comes in forms – movement, height, heat, light – and can change from one form to another.
- You cannot make energy from nothing or destroy it; it is only moved around.
- You met the idea that a fast or heavy object carries more energy. At AP we make this exact with formulas.

Each idea below has a worked example. Then do the Practice.

New ideas

■ 1 Kinetic energy

Energy is the capacity to do work, measured in **joules** (J). A moving object has **kinetic energy** :

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

It depends on the **square** of the speed, so doubling the speed makes the kinetic energy **four times** larger.

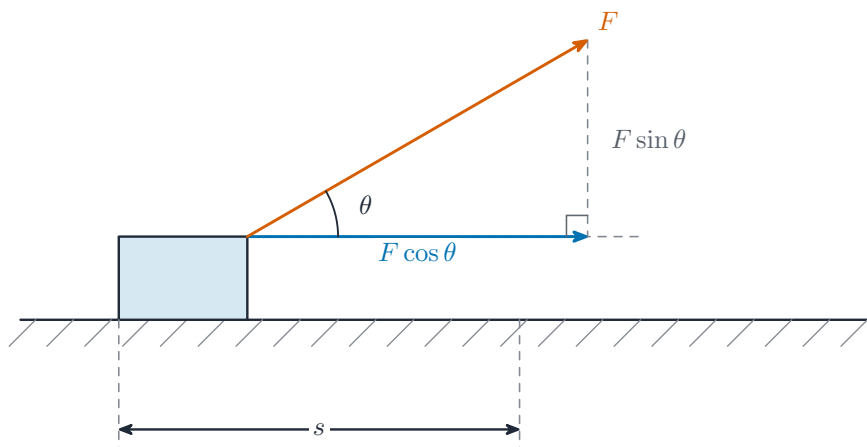
Worked example. A 1500 kg car at 20 m/s has $K = \frac{1}{2} \times 1500 \times 20^2 = 3.0 \times 10^5$ J. At 40 m/s it is four times as much.

■ 2 Work

Work is energy transferred when a force pushes something through a distance:

$$W = Fd \cos \theta,$$

where θ is the angle between the force and the movement. Work is **positive** if the force helps the motion, **negative** if it opposes it, and **zero** if the force is at right angles to the motion.



Worked example. A 20 N force pushes a box 3.0 m in its own direction: $W = Fd = 20 \times 3.0 = 60$ J.

■ 3 The work–energy theorem

The net work done on an object equals the change in its kinetic energy – the **work–energy theorem** :

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

Worked example. If 60 J of net work is done on a resting 3.0 kg trolley, then $60 = \frac{1}{2} \times 3.0 \times v^2$, giving $v^2 = 40$ and $v = 6.3$ m/s.

■ 4 Potential energy

Potential energy is stored energy that depends on position:

- **Gravitational potential energy** (from height h): $U_g = mgh$.
- **Elastic potential energy** (in a stretched spring): $U_s = \frac{1}{2}kx^2$.

Worked example. Lifting a 2.0 kg book 1.5 m stores $U_g = mgh = 2.0 \times 9.8 \times 1.5 = 29.4$ J.

Watch out: carrying a bag horizontally at steady height does **no** work on the bag – the lifting force is vertical but the movement is horizontal, so $\cos 90^\circ = 0$.

Practice

Try these in order. The methods are all above.

2.1 Find the kinetic energy of a 0.50 kg ball moving at 6.0 m/s. [2]

2.2 A 40 N force pushes a crate 5.0 m in its own direction. Find the work done. [2]

2.3 State whether the work is positive, negative, or zero when (a) friction acts on a sliding box, (b) you carry a box horizontally at constant height. [2]

2.4 A 3.0 kg mass is lifted 2.0 m. Find the gain in gravitational potential energy ($g = 9.8 \text{ m/s}^2$). [2]

2.5 A 2.0 kg trolley starts at rest. A net work of 36 J is done on it. Use the work–energy theorem to find its final speed. [3]

2.6 A car's speed triples. By what factor does its kinetic energy increase? [1]
