

How moving and lifted objects store energy

Grade 7 science (Year 8 · Class 7) · Lesson

Quick answer: Kinetic energy is the energy an object has because it is moving, and it grows with both mass and speed. Gravitational potential energy is the energy stored by an object because of its height above the ground. When an object falls or rolls downhill, stored energy changes into kinetic energy and the total stays the same.

Level: Grade 7 science (Year 8 · Class 7) · **Curriculum:** MS-PS3-1, MS-PS3-2

What is kinetic energy?

Everything that moves has energy because of its motion. A rolling football, a cyclist and a falling raindrop all have it.

Definition

Kinetic energy (KE) is the energy an object has because it is moving. It is measured in joules (J).

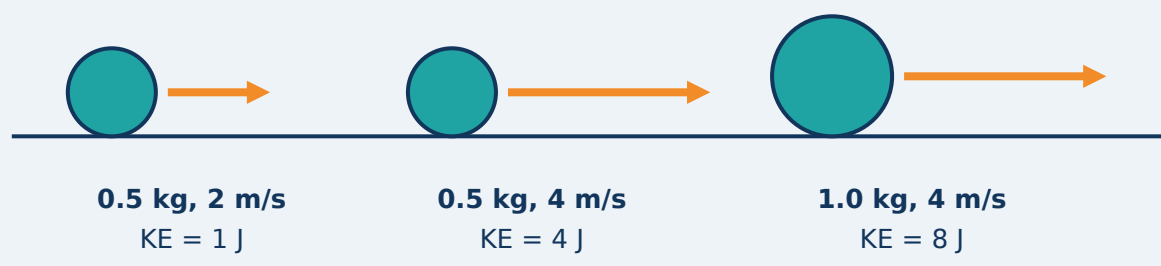
Kinetic energy depends on two things: the mass of the object and its speed. A heavier object moving at the same speed has more kinetic energy. A faster object of the same mass also has more.

Formula

$$KE = \frac{1}{2} \times m \times v^2$$

KE is the kinetic energy in joules (J), m is the mass in kilograms (kg) and v is the speed in metres per second (m/s).

Longer arrow = greater speed. Bigger ball = greater mass.



Kinetic energy for three moving balls. Doubling the speed gives four times the energy; doubling the mass gives twice the energy.

How do mass and speed change kinetic energy?

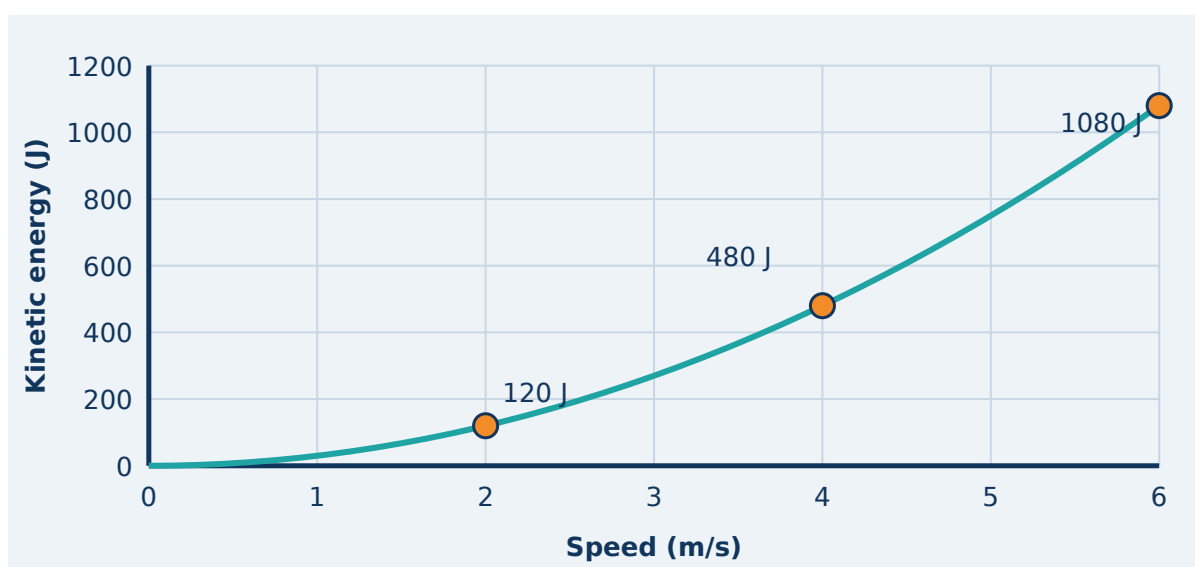
Compare the first two balls in the figure. They have the same mass, but the second one moves twice as fast, and its energy goes from 1 J to 4 J. That is four times more, because speed is squared in the formula. Now compare the last two balls. They have the same speed, but the mass doubles, so the energy only doubles from 4 J to 8 J.

Speed of a 60 kg cyclist	Kinetic energy	Compared with 2 m/s
2 m/s	120 J	1 time
4 m/s	480 J	4 times
6 m/s	1080 J	9 times

Worked example 1

Aarav in Pune bowls a cricket ball of mass 0.16 kg at 25 m/s. Calculate its kinetic energy.

$$KE = \frac{1}{2} \times m \times v^2 = \frac{1}{2} \times 0.16 \text{ kg} \times (25 \text{ m/s})^2 = 0.08 \times 625 = \mathbf{50 \text{ J.}}$$



The kinetic energy of a cyclist rises faster and faster as the speed increases. The graph is a curve, not a straight line.

Common mistake

Do not forget that only the speed is squared, not the mass. A car moving twice as fast has four times, not twice, the kinetic energy. Square the speed first, then multiply.

What is gravitational potential energy?

A book on a high shelf can fall. Because of its height, it has stored energy that can be released.

Definition

Gravitational potential energy (GPE) is the energy stored in an object because of its height above the ground. It is also measured in joules (J).

Formula

$$\text{GPE} = m \times g \times h$$

GPE is in joules (J), m is the mass in kilograms (kg), g is the gravitational field strength (9.8 N/kg on Earth) and h is the height in metres (m).

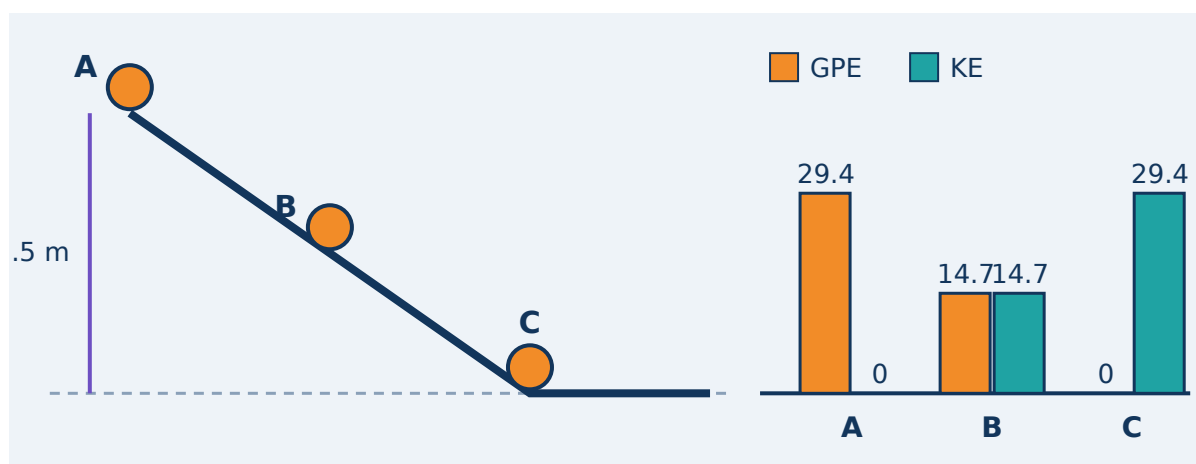
Worked example 2

Chiamaka in Lagos lifts a 3.0 kg bag of rice onto a shelf 1.5 m above the floor. Calculate the gain in gravitational potential energy.

$$\text{GPE} = m \times g \times h = 3.0 \text{ kg} \times 9.8 \text{ N/kg} \times 1.5 \text{ m} = \mathbf{44 \text{ J}}$$
 (44.1 J before rounding).

How does energy change between the two stores?

When an object falls or rolls downhill, it loses height and gains speed. Gravitational potential energy is converted into kinetic energy. If friction and air resistance are small enough to ignore, the total of the two stays constant.



Energy bars for a trolley rolling down a track. As the potential energy bar shrinks, the kinetic energy bar grows by the same amount.

Worked example 3

A 2.0 kg trolley starts from rest at A, 1.5 m above the bottom. Find its kinetic energy at B (0.75 m high) and at C.

GPE at A = $2.0 \times 9.8 \times 1.5 = 29.4 \text{ J}$. At B, GPE = $2.0 \times 9.8 \times 0.75 = 14.7 \text{ J}$, so KE = $29.4 - 14.7 = \mathbf{14.7 \text{ J}}$. At C, all the GPE has become kinetic: KE = $\mathbf{29.4 \text{ J}}$.

Feature	Kinetic energy	Gravitational potential energy
Depends on	Mass and speed	Mass and height
Formula	$\frac{1}{2} \times m \times v^2$	$m \times g \times h$
Zero when	The object is at rest	The object is at ground level
Example	A sprinter running	A kite high in the air

What happens when friction acts?

On a real track the trolley ends with less kinetic energy than the potential energy it started with. The missing energy is not destroyed. Friction transfers it to the surroundings as thermal energy, and a little as sound.

Lina's tip

Before any calculation, ask two questions: how fast is it going, and how high is it? Speed points to kinetic energy and height points to potential energy. Then pick the matching formula.

Key points to remember

- Kinetic energy: $KE = \frac{1}{2} \times m \times v^2$, in joules (J), with m in kg and v in m/s.
- Doubling the speed makes kinetic energy four times bigger; doubling the mass only doubles it.
- Gravitational potential energy: $GPE = m \times g \times h$, with $g = 9.8 \text{ N/kg}$ and h in metres.
- When an object falls, GPE changes into KE; without friction the total stays constant.

How moving and lifted objects store energy: frequently asked questions

What is kinetic energy in simple words?

It is the energy of movement. Anything with mass that is moving has it, and the faster it moves, the more it has.

Why does doubling the speed make kinetic energy four times bigger?

The formula uses the speed squared. Doubling the speed gives $2 \times 2 = 4$ times the energy, and tripling it gives $3 \times 3 = 9$ times.

Does a heavier object always have more potential energy?

Only at the same height. A 1 kg object at 4 m has more GPE than a 2 kg object at 1 m, because GPE depends on mass and height together.

What happens to the energy of a ball when it falls?

Its gravitational potential energy decreases while its kinetic energy increases. Without friction, the two always add up to the same total.

Why is energy measured in joules?

The joule is the SI unit of energy. One joule is about the energy needed to lift a small apple 1 m upwards.