Kinetic and gravitational potential energy

$E_k = \frac{1}{2} m v^2$ · $E_p = m g h$

sansara academy
Summary sheet

1 Kinetic energy

Example $E_k = \frac{1}{2} m v^2$

A 60 kg runner runs at 5 m/s. Find the kinetic energy.

$m = 60$ kg
$v = 5$ m/s

$v^2 = 5^2 = 25$
$E_k = \frac{1}{2} \times 60 \times 25$
$E_k = 750$ J

- Anything that moves has energy in its **kinetic store**. More mass or more speed means more energy.
- $E_k = \frac{1}{2} m v^2$: energy in joules (J), mass in kilograms (kg), speed in metres per second (m/s).

2 Why speed matters so much

$v = 5$ m/s
$\frac{1}{2} \times 60 \times 5^2 = 750$ J

$v = 10$ m/s
$10^2 = 100$
$\frac{1}{2} \times 60 \times 100 = 3000$ J
× not × 2 × 4

5 m/s
10 m/s

2 × speed → 4 × energy

- Speed is **squared**, so doubling the speed gives **four times** the kinetic energy.
- Square the speed first, then multiply.

3 Gravitational potential energy

Exam-style $E_p = m g h$

A 500 g ball is lifted 80 cm. $g = 9.8$ N/kg.

convert first

500 g ÷ 1000 = 0.5 kg
80 cm ÷ 100 = 0.8 m

$E_p = 0.5 \times 9.8 \times 0.8$
$E_p = 3.92$ J

× all three: m, g and h

0.5 × 9.8 = 4.9 don't forget h!

- Lifting an object moves energy into its **gravitational potential store**.
- $E_p = m g h$. g is in N/kg (about 9.8 on Earth) and is given in the question.
- Convert first: grams ÷ 1000 = kg, and cm ÷ 100 = m. Multiply by all three: m, g **and** h.

4 Linking the two

Find the speed just before it lands $E_k = \frac{1}{2} m v^2$

$E_k = 3.92$ J (m = 0.5 kg)
$\frac{1}{2} \times 0.5 \times v^2 = 3.92$
$v^2 = 3.92 \div 0.25 = 15.68$
$v = \sqrt{15.68} = 3.96...$

a little less in real life: air resistance transfers some energy to the surroundings

$v \approx 4.0$ m/s

- As an object falls, energy lost from the gravitational store is gained by the kinetic store (ignoring air resistance).
- Set $\frac{1}{2} m v^2$ equal to the lost E_p, then take the square root to find the speed.

$E_k = \frac{1}{2} m v^2$

kinetic energy = ½ × mass × speed²

E	energy	joule (J)
m	mass	kilogram (kg)
v	speed	metre per second (m/s)
g	gravitational field strength	newton per kilogram (N/kg)
h	height	metre (m)

Also $E_p = m g h$. Both are on the equation sheet; know them by heart.

Exam tip
Always end with the unit, joules (J).

Check yourself

1. A 2 kg ball moves at 3 m/s. What is its kinetic energy?
2. A 3 kg box is lifted 2 m (g = 10 N/kg). How much gravitational potential energy does it gain?

Answers: 1. $E_k = \frac{1}{2} \times 2 \times 3^2 = \frac{1}{2} \times 2 \times 9 = 9$ J 2. $E_p = 3 \times 10 \times 2 = 60$ J