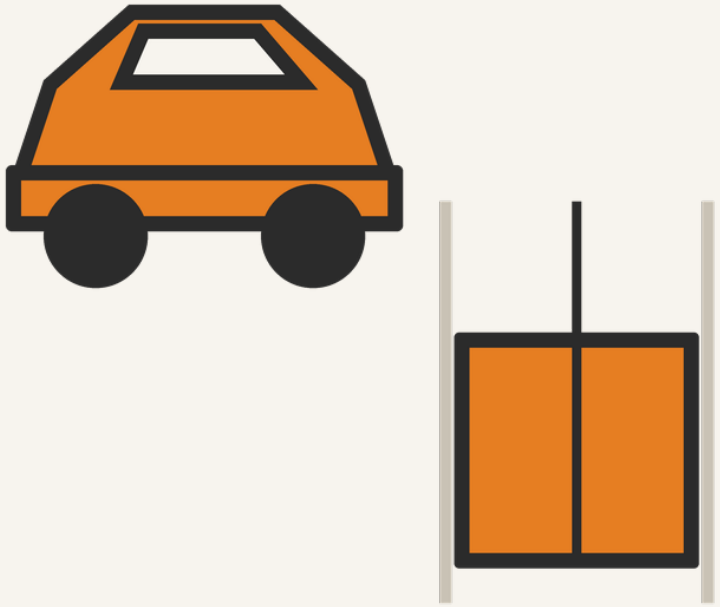
BOOKLET 2 · ENERGY AND EFFICIENCY

Kinetic and Potential Energy



One formula for things that move, one for things that are lifted.

National 5 Engineering Science

LEARNING INTENTION

To calculate kinetic energy using $E_k = \frac{1}{2} m v^2$ and potential energy using $E_p = m g h$.

Daily Review

SHOW ME BOARDS

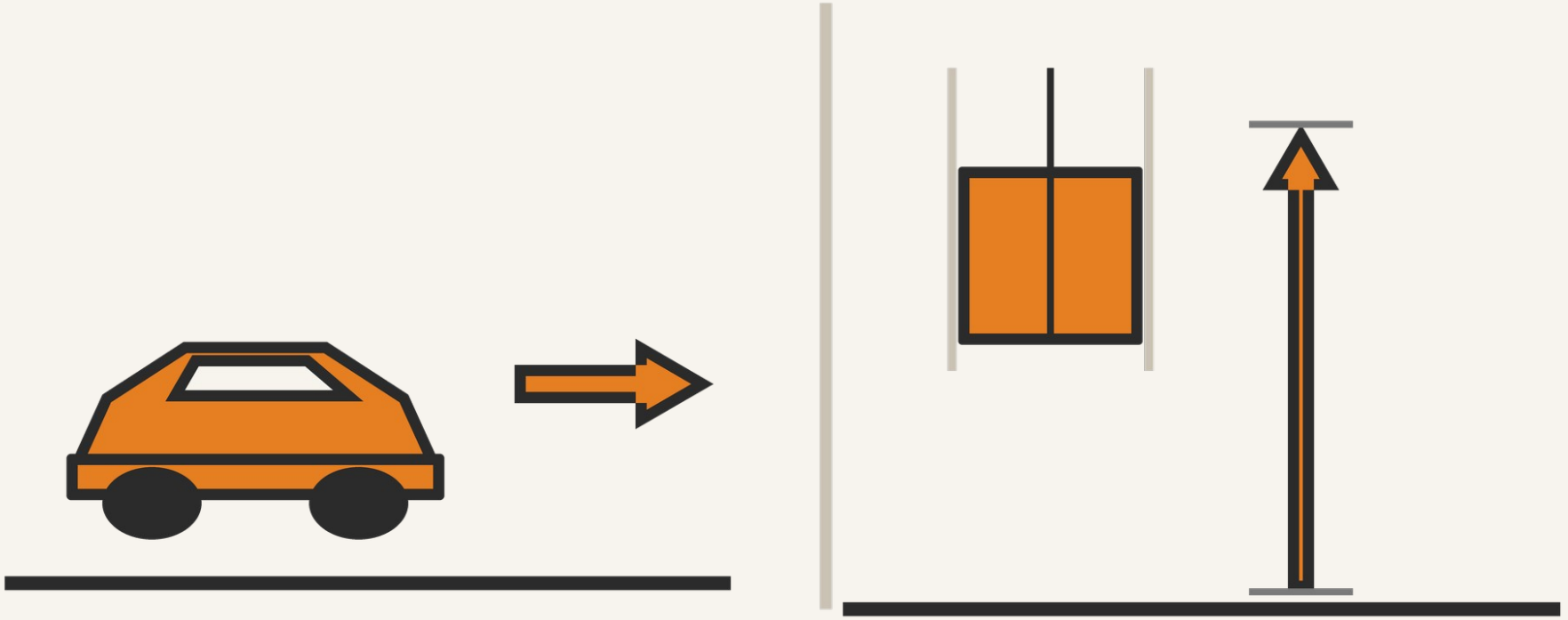
1. Write the formula for work done.
2. A force of 60 N moves a crate 3 m. Calculate the work done.
3. State the unit of work done.
4. State the law of conservation of energy.
5. Name the three things the SQA gives marks for in a calculation.

By the end of this lesson…

1. I can state both formulae with their symbols and units.
2. I can calculate E_k, remembering to square the speed.
3. I can calculate E_p using $g = 9.8\ N/kg$.
4. I can change a mass into kilograms before I substitute.

Moving, or Lifted?

Two different stores of energy, two different formulae.



kinetic: it is moving · potential: it has been raised

Kinetic Energy

The faster and the heavier an object is, the more kinetic energy it has.

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

E_k	m	v
kinetic energy (J)	mass (kg)	speed (m/s)

Square the speed first, then multiply. Doubling the speed gives four times the energy.

Worked Example — Car

A car has a mass of 1 200 kg and is travelling at 15 m/s.

Calculate the kinetic energy.

$m = 1\,200\ \text{kg}$

$v = 15\ \text{m/s}$

$E_k = ?$

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

$E_k = \frac{1}{2} \times 1\,200 \times 15^2$

$E_k = \frac{1}{2} \times 1\,200 \times 225$

$\underline{E_k = 135\,000\ \text{J}}$

Watch Out — Square the Speed

THE MISTAKE

- “½ × 1 200 × 15 — that looks right.”
- “The mass is 500 g, so m = 500.”
- “Double the speed, double the energy.”

THE CORRECT ANSWER

- Square the speed first: 15^2 = 225.
- 500 g = 0.5 kg. Kilograms, every time.
- Double the speed and you get four times the energy.

Show Me — Kinetic Energy

SHOW ME BOARDS

1. Write the formula for kinetic energy.
2. m = 4 kg, v = 5 m/s — calculate E_k.
3. What must you do to the speed before you multiply?
4. m = 10 kg, v = 2 m/s — calculate E_k.
5. State the unit of kinetic energy.

Show Me — More Kinetic Energy

SHOW ME BOARDS

EXTRA PRACTICE

1. What does the v stand for in $E_k = \frac{1}{2} m v^2$?

2. m = 2 kg, v = 10 m/s — calculate E_k.

3. m = 50 kg, v = 4 m/s — calculate E_k.

4. A mass is given in grams. What must you do first?

5. m = 8 kg, v = 6 m/s — calculate E_k.

Task 1 — Kinetic Energy

Three calculations in your jotter, SQA layout every time.
Square the speed on its own line so the marker sees it.
3 marks each. One of them is for the unit.

Booklet — “TRY THIS: Kinetic Energy”

Potential Energy

The higher and the heavier an object is, the more potential energy it stores.

$$E_p = m\,g\,h$$

E_p	m	g	h
potential energy (J)	mass (kg)	9.8 N/kg	height (m)

Use $g = 9.8\ \mathrm{N/kg}$ unless the question gives you a different value.

Worked Example — Lift Cage

A lift cage of mass 600 kg is raised 8 m up a lift shaft.

Calculate the gain in potential energy.

$m = 600\ kg$

$g = 9.8\ N/kg$

$h = 8\ m$

$E_p = ?$

$E_p = m\ g\ h$

$E_p = 600 \times 9.8 \times 8$

$E_p = 47\ 040\ J$

Show Me — Potential Energy

SHOW ME BOARDS

1. Write the formula for potential energy.
2. What value of g do we use?
3. m = 10 kg, h = 2 m — calculate E_p.
4. State the unit of height in this formula.
5. m = 50 kg, h = 4 m — calculate E_p.

Show Me — More Potential Energy

SHOW ME BOARDS

EXTRA PRACTICE

1. State the unit of potential energy.
2. m = 20 kg, h = 3 m — calculate E_p.
3. What does the h stand for in $E_p = m\,g\,h$?
4. m = 5 kg, h = 10 m — calculate E_p.
5. m = 100 kg, h = 1.5 m — calculate E_p.

Task 2 — Potential Energy

Three more calculations, same layout every time.
Q3 is a dam holding 5 000 kg of water.
3 marks each. List g with what you know.

Booklet — “TRY THIS: Potential Energy”

Checkpoint

1. Write both formulae from this lesson and give the unit of each answer.

2. A 20 kg robot moves at 3 m/s. Calculate its kinetic energy.

3. What + why: two identical vans, one at twice the speed. How many times the kinetic energy?

Exam Practice — Past Papers

2021 Q11(e) — zip slide rider, E_k (2)
2022 Q13(c) — hoverboard and rider, E_k (2)
SQP Q17(b)(i) — lift cage, E_p (2)
2023 Q11(b) — mass from E_p, then E_k (5)
2025 Q10(c) — height from E_p, rearranged (3)

Find the relationship in the data booklet

LOOKING AHEAD

Electrical and Heat Energy

Electricity delivers energy too. Two more formulae, two new traps.

Plenary — Prove Your I Can… Statements

SHOW ME BOARDS

1. Write the formula for kinetic energy.
2. Write the formula for potential energy.
3. What value of g do we use?
4. m = 6 kg, v = 2 m/s — calculate E_k.
5. m = 2 kg, h = 5 m — calculate E_p.

Plenary — More Quick Checks

SHOW ME BOARDS

EXTRA PRACTICE

1. Which formula needs a speed?
2. Which formula needs a height?
3. Change 2 500 g into kilograms.
4. m = 3 kg, v = 4 m/s — calculate E_k.
5. m = 10 kg, h = 5 m — calculate E_p.

Extension — If You Finish Early

1. A 2 kg part has 100 J of kinetic energy. Calculate its speed.

2. A 50 kg load gains 2 450 J of potential energy. Find the height raised.

3. What + why: which changes E_k more — doubling the mass, or the speed?

Extension — More Challenges

EXTRA PRACTICE

1. A 4 kg robot has 128 J of kinetic energy. Calculate its speed.

2. A crate gains 588 J of potential energy rising 3 m. Find its mass.

3. What + why: a dropped spanner gains E_k as it falls. Where from?