A-LEVEL PHYSICS • EXERCISE SHEET

5.1 Energy conservation

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

Objective

Build the skills to answer exam questions on **energy conservation** —work, the conservation principle, efficiency and power.

You must be able to:

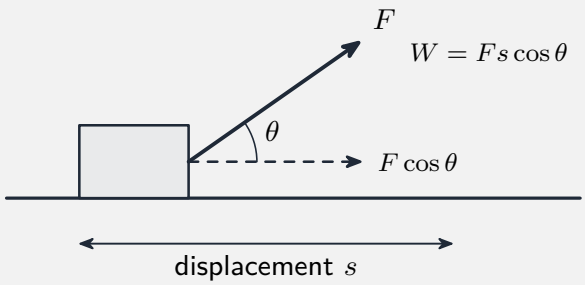
- use **work done** $= Fs\cos\theta$
- apply **conservation of energy** (e.g. GPE → KE)
- use **efficiency** and **power** ($P = W/t$ and $P = Fv$)

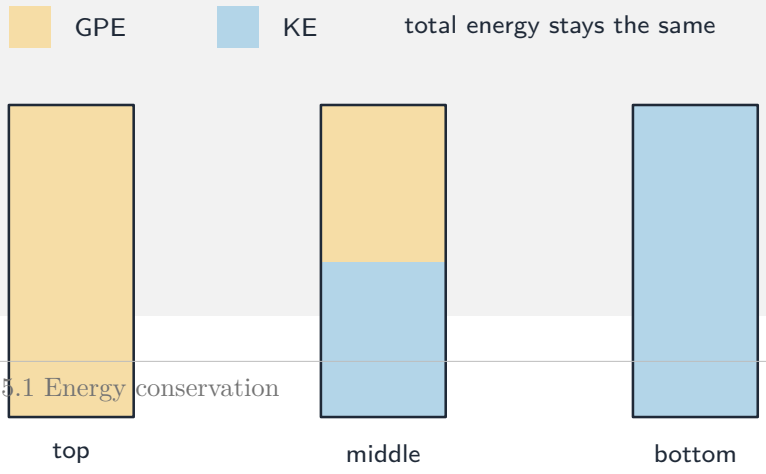
1 Worked examples

Study these first. Each one shows the method for a question type used later —follow the steps and you can do the Practice and Exam-style questions yourself.

■ Work done

Work is done when a force moves along its own line: $W = Fs\cos\theta$. Only the component **along** the displacement does work:





- $\theta = 0$: $W = Fs$ (max); $\theta = 90°$: $W = 0$ (e.g. the normal force on a flat road); $\theta = 180°$: $W = -Fs$ (e.g. friction).

■ **Conservation of energy**

Energy is never made or destroyed. On a **smooth** ramp, GPE → KE:

$$mgh = \tfrac{1}{2}mv^2 \Rightarrow v = \sqrt{2gh}.$$

■ **Efficiency and power**

$$\text{efficiency} = \frac{\text{useful energy out}}{\text{total energy in}}, \qquad P = \frac{W}{t}, \qquad P = Fv.$$

$P = Fv$ comes from $P = W/t = Fs/t = F(s/t) = Fv$.

2 Practice

Now apply the methods above.

2.1 Define the **work done** by a force. [1]

2.2 A child pulls a sledge 5.0 m with a 20 N force at 60° to the ground. Find the **work done**. [2]

2.3 Define **power** and give its unit. [1]

2.4 State the **principle of conservation of energy**. [1]

3 Exam-style questions

3.1 A force acts at 90° to the direction of motion. The work it does is: [1]

- **A** maximum
- **B** Fs
- **C** zero

- **D** negative

3.2 A ball is released from rest at the top of a **smooth** ramp 1.2 m high. Calculate its speed at the bottom. ($g = 9.81$ m s^{-2}.) [3]

3.3 A motor lifts a 50 kg load through 8.0 m in 10 s.

(a) Calculate the **useful power** output. [2]

(b) If the input power is 500 W, calculate the **efficiency**. [2]

3.4 Derive $P = Fv$ from $P = W/t$. [2]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **5.1 Energy conservation** past-paper sheet in the Library, or try these in **Practice mode**:

- 9702/22 J25 —Q1 (work, energy and power)
- 9702/21 N25 —Q1 (energy conservation)
- 9702/11 J25 —Q20 (power and P = Fv)
- 9702/21 N24 —Q3 (efficiency)

Solutions

2.1 Work = force × displacement **in the direction of the force** ($W = Fs\cos\theta$).

2.2 $W = Fs\cos\theta = 20 \times 5.0 \times \cos 60° = 50$ J.

2.3 Power is the **work done (energy transferred) per unit time**, unit **watt** (W = J s^{-1}).

2.4 Energy cannot be **created or destroyed**, only **transferred** from one form to another; the total energy of a closed system is constant.

3.1 C —zero.

3.2 $mgh = \frac{1}{2}mv^2$; $v = \sqrt{2gh} = \sqrt{2 \times 9.81 \times 1.2} = \sqrt{23.5} = 4.9$ m s^{-1}.

3.3 (a) useful work = $mgh = 50 \times 9.81 \times 8.0 = 3924$ J; $P = W/t = 3924/10 = 392$ W. (b) efficiency = $392/500 = 0.78 = 78\%$.

3.4 $P = W/t = Fs/t$; since $s/t = v$, $P = Fv$.