Topic 4: Energy resources and energy transfers

Edexcel International GCSE Physics 4PH1 · Section 4 · statements 4.1–4.19P · sheets 4.1–4.2

Energy is never used up

Your turn

A phone battery goes flat after a day of use.

A. Has its energy been destroyed?

B. Which store did the energy leave, and where did most of it end up?

C. Why can we not easily use that energy again?

Eight stores, four pathways

Stores

chemical, kinetic, gravitational, elastic

thermal, magnetic, electrostatic, nuclear

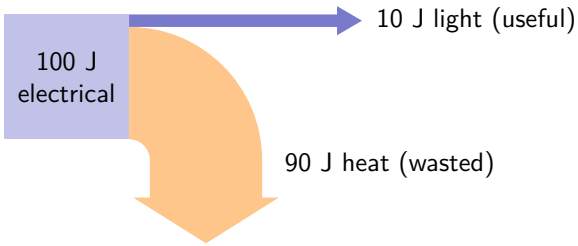
Transfer pathways

mechanically (a force moves), electrically (a current flows)

by heating, by **radiation** (light and sound)

> Conservation of energy: total energy before = total energy after.

Sankey diagrams show where energy goes



Lamp: 100 J in, 10 J light out. Efficiency $= 10/100 \times 100\% = 10\%$.

- Arrow width is proportional to energy.
- Useful output goes straight on; waste bends away.

Efficiency forwards and backwards

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy output}} \times 100\%$$

1. **Kettle** 2000 J in, 1800 J heats the water: $1800/2000 \times 100\% = 90\%$.
2. **Lamp known** 25% efficient, 15 J of light each second; find the input.
3. **Rearrange** input $=$ useful $\div$ efficiency $= 15\ \text{J} \div 0.25 = 60$ J each second, a 60 W lamp.
4. **Waste** $60 - 15 = 45$ J each second heats the surroundings.

Conduction, convection, radiation

Method	How it works	Reduce it with
conduction	particle vibrations pass along a solid; metals fast (free electrons)	insulating materials, trapped air
convection	warm fluid expands, becomes less dense and rises; cool fluid sinks	stop air moving (loft, cavity wall)
radiation	infrared waves; need no medium	shiny foil reflects infrared

Which surface emits best?

Your turn

Two identical cans hold the same hot water. One is matt black, one is shiny silver.

A. Which can cools faster, and why?
B. Which would warm faster standing in sunlight?
C. Why are kettles and some flasks shiny?

Work, energy and power equations

$$W = F \times d \qquad GPE = m \times g \times h \qquad KE = \tfrac{1}{2} \times m \times v^2 \qquad P = \frac{W}{t}$$

m in kg, v in m/s, h in m, $g = 10$ N/kg, P in W

1. **Known** A 2.0 kg book is lifted 1.5 m, then dropped.
2. **GPE** $GPE = mgh = 2.0\ \text{kg} \times 10\ \text{N/kg} \times 1.5\ \text{m} = 30\ \text{J}$.
3. **KE at the ground** All 30 J becomes KE: $v = \sqrt{2KE/m} = \sqrt{2 \times 30/2.0} \approx 5.5$ m/s.
4. **Power** A 60 W lamp for 10 s: $W = Pt = 60 \times 10 = 600$ J.

Worked example: KE becomes GPE

1. **Known** 0.50 kg ball thrown up at 8.0 m/s; ignore air resistance.
2. **KE** $KE = \frac{1}{2}mv^2 = \frac{1}{2} \times 0.50 \times 8.0^2 = 16$ J.
3. **At the top** All 16 J is GPE: $h = GPE/(mg) = 16/(0.50 \times 10) = 3.2$ m.
4. **Check** A 1.0 kg ball at 8.0 m/s also reaches 3.2 m: $h = v^2/(2g)$.

Your turn: the motor

Your turn

A motor lifts a 20 kg load through 3.0 m in 5.0 s. It takes 1000 J of electrical energy in that time.

A. Calculate the useful work done.

B. Calculate the useful power output.

C. Calculate the efficiency of the motor.

(P) Seven ways to generate electricity

Method	**Transfer**	**For / against**
wind	kinetic → electrical	renewable, no fuel / unreliable, noise
hydroelectric	gravitational → electrical	instant supply / floods valleys
geothermal	thermal → electrical	steady / few sites
solar heating, cells	thermal; light → electrical	no running cost / weather, cost
fossil fuels	chemical → thermal → electrical	reliable / CO_2, non-renewable
nuclear	nuclear → thermal → electrical	no CO_2 / radioactive waste

Six mistakes that cost marks

Mistake	**Correct idea**
Efficiency above 100%	Useful output never exceeds input
Energy is used up	It spreads into thermal stores
KE with v unsquared or grams	Use kg and square v first
Shiny surfaces emit best	Dark, dull surfaces emit and absorb best
Heat rises	Hot fluid rises; no **convection** in solids
Renewable means reliable	Wind and solar depend on the weather

Check yourself

Your turn

Answer without notes, then check.

A. A motor uses 500 J and delivers 350 J of useful work. Efficiency?

B. Which thermal transfer method needs no medium?

C. KE of an 800 kg car at 20 m/s?

D. A heater transfers 12 000 J in 30 s. Power?

E. (P) One advantage and one disadvantage of nuclear power?