

Energy – forces doing work

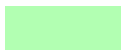
Specification 1PH0 · Pearson Edexcel

Free edition

Revision notes for one topic, free to download.

These are the summary notes only. The full edition of this booklet also carries the worked examples, the required practicals and the formula sheets, with every topic in one place.

Colour Codes



Definitions



Notes and warnings



Sub-topic headings

This booklet is a study aid written from the published specification.
It is not affiliated with, endorsed by or approved by Pearson Edexcel.

Free to download and share for personal study.
Please do not sell or republish it as your own.
For enquiries, please email pcfgyrdi@gmail.com

Topic 8 statement	Identical Topic 3 statement
8.2 energy transfer diagrams	3.3
8.3 closed systems, no net change	3.6
8.8 change in gravitational PE	3.1
8.9 kinetic energy	3.2
8.10 dissipation into less useful stores	3.8
8.11 mechanical processes and temperature rise	3.7
8.15 efficiency	3.11

Define Energy transfer

- energy moving between stores: by forces doing work, electrically, by heating, by radiation.

Define Joule (J)

- the energy transferred when a force of 1 N moves an object 1 m; $1 \text{ J} = 1 \text{ N m}$.

Define Conservation of energy

- energy cannot be created or destroyed, only transferred, stored or dissipated.

Define Gravitational potential energy (GPE)

- energy stored because of an object's position in a gravitational field.

Define Power

- the rate at which energy is transferred, or the rate of doing work.

Define Efficiency

- the fraction of the energy supplied to a device that is usefully transferred.

NOTE

TOPIC 8 OVERLAPS TOPIC 3 — READ THIS FIRST

Topic 8 repeats several Topic 3 (Conservation of energy) statements word for word, because Topic 3 is examined on **Paper 1** and Topic 8 on **Paper 2** — you need this content for both papers.

Appendix 2 confirms this: the GPE, KE and efficiency equations are listed against "3.1 and 8.8", "3.2 and 8.9" and "3.11 and 8.15". Content that appears **only** in Topic 3 — reducing unwanted energy transfer (3.9), thermal conductivity and wall thickness (3.10) and increasing efficiency (3.12) — is cross-referenced at the end of this topic.

Define Energy store

- a way energy is held in a system (kinetic, gravitational, elastic, thermal, chemical, nuclear, magnetic, electrostatic).

Define Work done

- the energy transferred when a force moves an object a distance in the direction of the force.

Define Closed system

- a system in which no energy enters or leaves, so the total energy is constant.

Define Dissipation

- energy spreading out into the surroundings, stored in less useful ways.

Define Kinetic energy (KE)

- energy stored in a moving object because of its speed.

Define Watt (W)

- one joule per second (J/s).

Define Lubrication

- reducing friction between surfaces so less energy is dissipated by heating.

Define Thermal conductivity

- how readily a material transfers energy by conduction.

8.1 Energy stores and how they change (8.1, 8.4)

Describe the changes involved in the way energy is stored when systems change (8.1). Always name the store the energy came *from* and the store it went *to*.

The stores you need are **kinetic, gravitational, elastic (strain), thermal (internal), chemical, nuclear, magnetic and electrostatic.**

Identify the different ways that the energy of a system can be changed (8.4): **a through work done by forces** (a push, a pull, friction, lifting against gravity); **b in electrical equipment** (a current transferring energy through a component); **c in heating** (energy transferred because of a temperature difference).

Examples in the style Edexcel expects:

- Book lifted onto a shelf: **chemical store (muscles) → gravitational store**, by a force doing work.
- Ball falling: **gravitational store → kinetic store**, by gravity doing work.
- Car braking: **kinetic store → thermal store of brakes and surroundings**, by friction doing work.
- Kettle boiling water: **electrical working → thermal store of the water**.
- Catapult released: **elastic store → kinetic store**.

8.2 Energy transfer diagrams (8.2)

Draw and interpret diagrams to represent energy transfers.

Two types are used:

- **Flow (transfer) diagrams** — labelled boxes for each store, joined by arrows labelled with the *transfer pathway* (working, heating, electrically, by radiation).
- **Sankey diagrams** — arrows whose **width is proportional to the energy**. Useful output is drawn straight on; wasted output branches downwards. The input width equals the total of the output widths, because energy is conserved.

For full marks: label every arrow with its energy value where you have one, keep widths to scale, and check that input equals total output.

8.3 Closed systems and conservation of energy (8.3)

Where there are energy transfers in a closed system there is **no net change to the total energy in that system**.

- A **closed system** is one where no energy enters or leaves. Energy can be transferred between stores inside it, and dissipated, but the **total** stays the same.
- Dissipated energy is not "lost" or "used up" — it is still there, spread out in the thermal store of the surroundings where it cannot easily be used again.

WATCH OUT

"Energy is used up." Never write that. Energy is **transferred** and **dissipated**; the total in a closed system is unchanged. Say "energy is transferred to the thermal store of the surroundings", not "energy is lost".

8.4 Work done by a force (8.5, 8.6)

Work is done whenever a force moves an object through a distance in the direction of the force. The energy transferred (joules) is **equal to** the work done (joules) — statement 8.5 — which is why an energy transfer can be measured with a force and a distance.

How to measure the work done by a force (8.5):

1. Measure the force with a **newtonmeter** (or, for a lifting force, calculate the weight from $W = m \times g$).
2. Measure the **distance moved in the direction of the force** with a metre rule or tape measure.
3. Multiply them: work done = force $\times$ distance.

Key points examiners test:

- The distance must be **in the direction of the force**. Carrying a bag horizontally along a corridor means the lifting force is vertical and the movement horizontal, so that force does **no work**.
- If the object does not move, **no work is done**, however hard you push.
- **1 joule = 1 newton-metre**, so work done can be quoted in N m or J; the "use of mathematics" list expects you to convert between them.

ANALOGY

Work done is a shopping bill. Force is the price per item, distance is the number of items, and the work done is what you pay. A big force over a tiny distance can cost the same as a small force over a long distance — which is why a ramp lets you raise a load with a smaller force, provided you push it much further. And if you buy nothing (no movement) you pay nothing, however expensive the item.

8.5 Energy changes when work is done by forces (8.7)

Describe and calculate the changes in energy involved when a system is changed by work done by forces (8.7). The method for every question of this kind:

1. Decide which store loses energy and which gains it.
2. Calculate the work done, $E = F \times d$, or the change in the store using the GPE or KE equations.
3. Apply conservation of energy: in a closed system with nothing dissipated, energy gained = energy lost.

Standard cases (these mirror Topic 3, statement 3.5):

- **Object projected upwards or up a slope** — kinetic store falls, gravitational store rises.
- **Moving object hitting an obstacle** — kinetic store falls; energy goes to elastic, thermal and sound.
- **Object accelerated by a constant force** — the force does work, so the kinetic store rises.
- **Vehicle slowing down** — friction and braking forces do work, so the kinetic store falls and the thermal store of the brakes rises.

8.6 Gravitational potential energy (8.8)

Lifting an object at steady speed means applying an upward force equal to its weight, $m \times g$, through a vertical height Δh . The work done is $m \times g \times \Delta h$, which is exactly the gain in the gravitational store.

WATCH OUT

Δh is the **vertical** height gained, not the distance travelled. A box dragged 5 m up a slope that rises 2 m gains GPE for the **2 m** — although the work done by the pulling force along the slope uses the 5 m.

8.7 Kinetic energy (8.9)

Any moving object has energy in its kinetic store. KE depends on the **square** of the speed: **double the speed gives four times the kinetic energy**, which is why stopping distances grow so fast with speed.

8.8 Dissipation and wasteful mechanical processes (8.10, 8.11)

In all system changes, energy is dissipated so that it is stored in less useful ways (8.10). No real transfer is perfect; some energy always ends up spread out in the thermal store of the surroundings, where it is very hard to use again because it is spread thinly over a huge number of particles.

Mechanical processes become wasteful when they cause a rise in temperature (8.11).

- **Friction** between moving surfaces and **air resistance** do work against the motion, transferring energy to thermal stores.
- The temperature of the machine and the surrounding air rises, so energy is dissipated by heating the surroundings.
- Examples: brake discs becoming hot, a drill bit becoming hot, a bicycle chain warming.

8.9 Power (8.12, 8.13, 8.14)

Power is the rate at which energy is transferred (8.12) — the rate of doing work. Two devices can transfer the same total energy; the more powerful one does it in less time.

- A 2000 W and a 1000 W kettle can both transfer 120 000 J to the water, but the 2000 W kettle does it in half the time.
- Two students of the same weight run up the same staircase: the same work is done against gravity, but the faster one develops the greater power.
- **One watt is equal to one joule per second, J/s (8.14)** — a recall statement.
- Multiples: 1 kW = 1000 W, 1 MW = 1 000 000 W.

8.10 Efficiency (8.15)

Efficiency compares the energy a device transfers **usefully** with the energy it is **supplied** with. It has **no units**, being a ratio of two energies, and can be written as a decimal (0.65) or a percentage (65%).

- Efficiency can never exceed 1 (100%); that would break conservation of energy. An answer above 1 means you divided the wrong way round.
- The energy not usefully transferred is dissipated, usually in heating the surroundings.

8.11 Reducing unwanted energy transfer (cross-reference: 3.9, 3.10, 3.12)

HIGHER TIER

These statements sit in **Topic 3**, but they are the natural partner to the work, power and efficiency material here, and Paper 2 efficiency questions often use the same contexts.

Ways of reducing unwanted energy transfer (3.9):

- **Lubrication** — oil or grease between moving surfaces reduces friction, so less work is done against friction and less energy is dissipated by heating.
- **Thermal insulation** — poor conductors, often trapping air, reduce the rate of energy transfer out of a building or hot object. (Statement 14.10 repeats this in the particle model topic.)
- **Streamlining** reduces air resistance; replacing worn parts reduces unwanted vibration and sound.

Thickness and thermal conductivity of walls (3.10) —

qualitative only: thicker walls and walls of **lower thermal conductivity** both transfer energy more slowly, so the building cools more slowly. Examples: cavity wall insulation (foam and trapped air have very low thermal conductivity), loft insulation, double glazing, thick carpets and draught excluders.

HT ONLY Explain how efficiency can be increased (3.12). *This statement is bold in the specification, so it is Higher Tier only.* Increase efficiency by reducing the wasteful transfers: lubricate moving parts, insulate to cut unwanted heating, streamline to reduce air resistance, and reduce the mass that must be moved.

Conduction, convection and radiation

The specification names **thermal conductivity** (3.10) and, in physics-only Topic 5, the emission and absorption of infrared radiation (5.17P, 5.18P and core practical 5.19P). Convection is not a separate statement, but you need all three mechanisms to explain insulation sensibly.

	Conduction	Convection	Radiation
Where it happens	Mainly solids	Fluids only (liquids and gases)	Anywhere, including a vacuum
How energy moves	Particles vibrate more and pass energy to neighbours; in metals, free electrons carry it quickly	Warmer fluid becomes less dense and rises, cooler fluid sinks, setting up a convection current	Infrared electromagnetic waves emitted by any object
Needs a medium?	Yes	Yes	No
Good/poor	Metals conduct well; gases and trapped air are poor conductors (insulators)	Stopped by trapping the fluid so it cannot circulate	Matt black surfaces emit and absorb best; shiny silver surfaces are poor emitters and absorbers
Reduced by	Thick, low-conductivity materials	Small trapped pockets of air (foam, fibreglass, double glazing)	Shiny reflective foil behind radiators

ANALOGY

Conduction is a bucket chain. People in a line pass buckets of water along: the water (energy) moves but the people (particles) stay put. A longer or slower chain moves less water per second — like a thicker or lower-conductivity wall. In a metal, free electrons are extra runners who carry buckets the whole length themselves, which is why metals conduct so much better. *Convection would be the people walking to the far end carrying the water* — which is why it only happens in a fluid, where particles are free to move.

NOTE

USE OF MATHEMATICS IN THIS TOPIC

Topic 8's list expects you to calculate the energy changes when a system changes, **recalling or selecting** the relevant equations for mechanical, electrical and thermal processes and expressing the redistribution of energy on a common scale; to calculate stored energy and transfers, **converting between newton-metres and joules**; and to use ratios and proportional reasoning to convert units and compute rates. The maths skills tagged are 1a–1d, 2a, 2c, 3a–3d and 4f (area between a curve and the x-axis, tagged on 8.6).