Topic 1: Energy

AQA GCSE Physics 8463 · spec 4.1 · sheets 1.1–1.7

Energy: stores, transfers and resources

- describe how energy is stored and transferred when a **system** changes;
- calculate kinetic, elastic potential and **gravitational potential energy**, and energy changes from **heating**;
- calculate power and efficiency, and explain how to reduce wasted energy;
- compare the energy resources used for transport, electricity and heating.

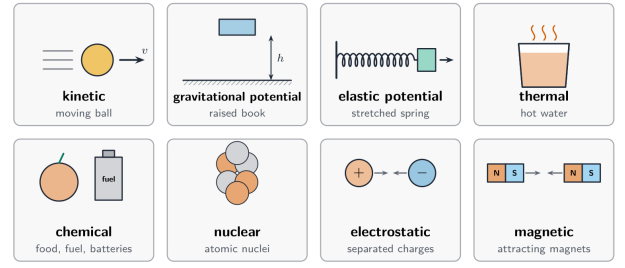
Energy stores and systems

- A ball thrown upwards: its kinetic store empties and the gravitational potential store fills. At the top, it stops for an instant.
- A car hitting a wall: the kinetic store empties; the thermal stores of the car and wall fill, and some energy is carried away by sound.
- A battery-powered toy car speeding up: the chemical store of the battery empties; the kinetic store of the car fills.

Energy stores and systems (2)

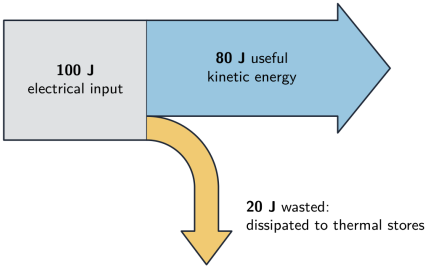
- A car braking: the kinetic store empties; the thermal store of the brakes fills.
- An electric kettle boiling water: energy is transferred electrically from the mains to the thermal store of the water.

Figure: Energy stores and systems



- The eight **energy stores**, with an example of each.
- Match each part of the diagram to the text.

Figure: Energy stores and systems (2)



widths add up: 80 J + 20 J = 100 J; efficiency = 0.80

- The width of each arrow, not its length, shows the energy.
- Match each part of the diagram to the text.

Calculating energy changes

- E_k is **kinetic energy** in J; m is mass in kg; v is speed in m/s.
- E_p is **gravitational potential energy** in J; h is the change in height in m; g is the **gravitational field strength** in N/kg (9.8 N/kg on Earth).
- E_e is **elastic potential energy** in J; k is the **spring constant** in N/m; e is the **extension** in m.

$$E_k = \frac{1}{2}mv^2 \qquad E_p = mgh \qquad E_e = \frac{1}{2}ke^2$$

Calculating energy changes (2)

- Energy in one cord: $E_e = \frac{1}{2} \times 735 \times 8.0^2 = 23\,520$ J.
- Two cords: $2 \times 23\,520 = 47\,040$ J.
- If all of this becomes **gravitational potential energy**: $h = \dfrac{E_p}{mg} = \dfrac{47\,040}{240 \times 9.8} = 20$ m.

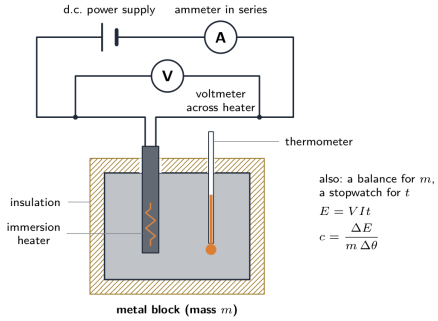
$$v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2 \times 0.36}{0.020}} = \sqrt{36} = 6.0 \text{ m/s}$$

Specific heat capacity

- When a substance is heated, the energy in its thermal store increases and its temperature rises:
- ΔE is the change in thermal energy in J, m the mass in kg and $\Delta\theta$ the temperature change in °C.
- The **specific heat capacity** c is the energy needed to raise the temperature of 1 kg of a substance by 1 °C, in J/kg °C.
- This equation is on the equations sheet.

$$\Delta E = m\,c\,\Delta\theta$$

Figure: Specific heat capacity



- Required practical 1: ammeter in series with the heater, voltmeter across it; insulation reduces energy transfer to the surroundings.
- Match each part of the diagram to the text.

Power

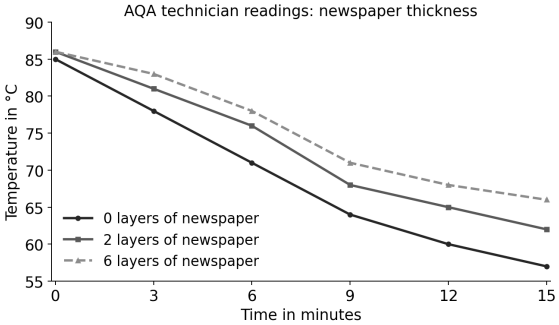
- **Power** is the rate at which energy is transferred, or the rate at which work is done.
- A more **powerful** motor lifts the same load through the same height in less time.
- P is **power** in watts, E energy transferred in J, W the **work done** in J and t the time in s.
- A transfer of 1 J per second is a power of 1 **watt** (W).

$$P = \frac{E}{t} \qquad P = \frac{W}{t}$$

Conservation and dissipation of energy

- **Lubrication** with oil or grease reduces friction between moving parts, so less energy is **dissipated** by **heating**.
- **Thermal insulation** reduces energy transfer by heating. A material with a lower **thermal conductivity** transfers energy more slowly. For a house, the rate of cooling is lower if the walls are thicker and if they are made of a material with a lower **thermal conductivity**.

Figure: Conservation and dissipation of energy



- Cooling curves for zero, two and six layers of newspaper (AQA GCSE Physics Required Practical Handbook, sample results).
- Read the axes and units first.

Efficiency

- **Efficiency** tells you what fraction of the input energy is transferred usefully:
- You must learn both.
- **Efficiency** can be a decimal or a percentage, and it can never be more than 1 (100%).
- It has no unit.

$$\text{efficiency} = \frac{\text{useful output energy transfer}}{\text{total input energy transfer}} \qquad \text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

National and global energy resources

- The main energy resources are **fossil fuels** (coal, oil and gas), **nuclear fuel**, bio-fuel, wind, hydroelectricity, geothermal, the tides, the Sun and water waves.
- We use them for transport, electricity generation and **heating**.
- A **renewable** resource is one that is being, or can be, replaced as it is used.
- **Fossil fuels** and **nuclear fuel** are **non-renewable**: they will run out.

Sources for this lesson

- AQA, *GCSE Physics (8463) specification*, section 4.1 Energy, and the *Required practical handbook* (sample results for practical 2).
- J. P. Joule, "On the mechanical equivalent of heat", *Philosophical Transactions of the Royal Society*, 140 (1850), read 21 June 1849.
- AQA, *GCSE Physics* Paper 1 Higher, June 2024, questions 1, 2, 6 and 8 (adapted).

Common errors

- Calling "electrical" a store. It is a way of transferring energy.
- Using the stretched length instead of the **extension** in $E_e = \frac{1}{2}ke^2$.
- Forgetting to square the speed or the extension.

Common errors (2)

- Using the final temperature instead of the temperature change in $\Delta E = mc\Delta\theta$.
- Leaving time in minutes, mass in grams or energy in kJ.
- Saying energy is "lost" or "used up" without saying where it goes.

Common errors (3)

- Giving an **efficiency** greater than 1 or 100%.
- Saying **renewable** resources are always available.

Key terms

- **Energy store**: a way energy is held, such as kinetic, thermal or chemical.
- **System**: the object or group of objects being studied.
- **Specific heat capacity**: the energy needed to raise 1 kg of a substance by 1 °C.

Key terms (2)

- **Power**: the rate of energy transfer, in watts.
- **Dissipated energy**: energy stored in less useful ways, usually thermal.
- **Efficiency**: useful output divided by total input.
- **Renewable resource**: an energy resource that is replaced as it is used.

Check yourself

- 1.
- Name the store that empties and the store that fills when a car brakes. 2.
- A 0.50 kg cart moves at 4.0 m/s.
- Calculate its **kinetic energy**. 3.