AQA GCSE Physics

# Energy

Student Booklet

Name: ________________________ Teacher: _____________________

## Contents

LESSON 1

# Energy Stores & Gravitational Potential Energy

## Do Now

**1.** What is the unit of energy?

**2.** Name two types of energy store.

**3.** What does "g" represent in physics equations?

**4.** If an object is lifted higher, what happens to its gravitational potential energy?

## Part 1 of 3: Energy Stores

| | |
|---|---|
| Energy is the ability to do work. Whenever something happens anywhere in the universe, energy is transferred. | 1 |
| Energy is stored in objects. The main energy stores are: **gravitational**, **kinetic**, **elastic**, **thermal**, **chemical**, **nuclear**, **electrostatic** and **magnetic**. | 2 |
| Energy cannot be created or destroyed — it is only transferred between stores. This is the **Law of Conservation of Energy**. | 3 |
| The unit of energy is the **Joule (J)**. Larger quantities are expressed in kJ (1 kJ = 1000 J) or MJ. | 4 |

| Questions | |
|---|---|
| **1.** Define energy. | *(1)* |
| **2.** Name four energy stores. | *(2)* |
| **3.** State the Law of Conservation of Energy. | *(2)* |
| **4.** A ball is held above the ground. Which energy store does it have? | *(1)* |
| **5.** Convert 4500 J into kJ. | *(1)* |

## Part 2 of 3: Gravitational Potential Energy

| | |
|---|---|
| Gravitational potential energy (GPE) is stored when an object with mass is raised in a gravitational field. | 1 |
| The formula for GPE is: $E_{GP} = m \times g \times h$ | 2 |
| $E_{GP}$ = gravitational potential energy store (J); m = mass (kg); g = gravitational field strength (N/kg); h = height above the ground (m). | 3 |
| On Earth, g = 9.8 N/kg. GPE increases if mass, height, or g increases. | 4 |
| Example: A rock of mass 75 kg is lifted 4 m. $E_{GP} = 75 \times 9.8 \times 4 =$ **2940 J**. | 5 |

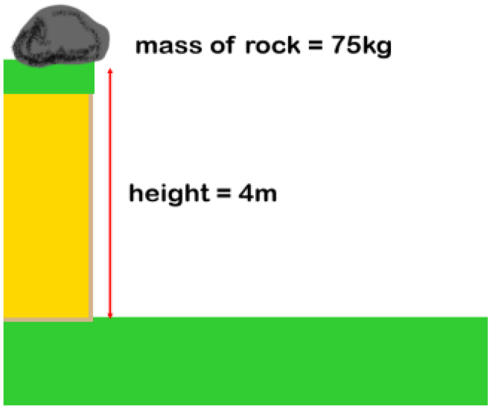


*Fig 1.1 – A rock raised 4 m above the ground storing gravitational potential energy.*

| Questions | |
|---|---|
| **1.** Define gravitational potential energy store. | *(1)* |
| **2.** What does g measure? Give its value on Earth. | *(2)* |
| **3.** A 5 kg book is placed on a shelf 1.5 m high. g = 9.8 N/kg. Calculate its GPE. | *(3)* |
| **4.** If the height of an object doubles, what happens to its GPE? Explain. | *(2)* |
| **5.** A 60 kg person stands on a 3 m diving board. g = 9.8 N/kg. Calculate GPE. | *(3)* |

## Part 3 of 3: Rearranging E = mgh

| | |
|---|---|
| To find mass: $$m = \frac{E_{GP}}{g \times h}$$ | 1 |
| To find height: $$h = \frac{E_{GP}}{m \times g}$$ | 2 |
| To find g: $$g = \frac{E_{GP}}{m \times h}$$ | 3 |
| Use the VESSS method: Values Equation Substitute Solve State units. | 4 |

| Questions | |
|---|---|
| **1.** A ball has a GPE of 196 J and a mass of 2 kg. g = 9.8 N/kg. Find the height. | *(3)* |
| **2.** A buzzard stores 5403 J of GPE at a height of 98 m. g = 9.8 N/kg. Find its mass. | *(3)* |
| **3.** An object of mass 12 kg is at a height of 5 m and stores 588 J of GPE. Find g. | *(3)* |
| **4.** A 3 kg ball is dropped from 10 m. g = 9.8 N/kg. Calculate the GPE lost. | *(3)* |
| **5.** A rock on the Moon (g = 1.6 N/kg) has a mass of 20 kg and is 8 m high. Find its GPE. | *(3)* |

| Exam Question [7 marks] | |
|---|---|
| Figure 1.1 shows a person sliding down a zip wire from height h. | |
| **(a)** The change in GPE is 1.47 kJ. The person's mass is 60 kg, g = 9.8 N/kg. Calculate the change in vertical height. | *(3)* |
| **(b)** As the person moves down the zip wire, the increase in KE is less than the decrease in GPE. Explain why. | *(2)* |
| **(c)** Different people reach different speeds at the bottom. Explain why. | *(2)* |

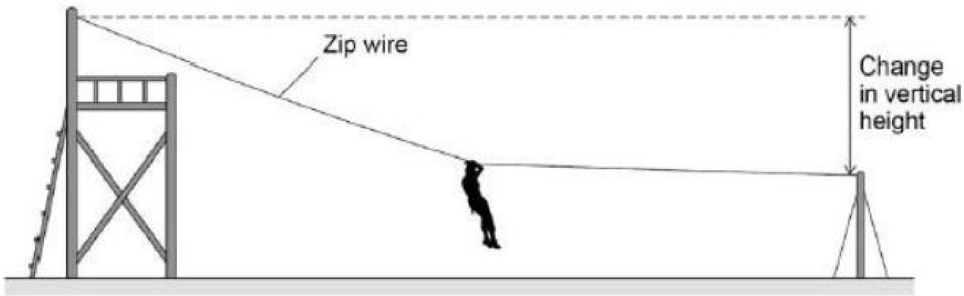


*Fig 1.2 – Zip wire exam figure showing change in vertical height.*

LESSON 2

# Kinetic Energy

## Do Now

**1.** What is the formula for gravitational potential energy?

**2.** What is the unit of energy?

**3.** A 10 kg object is 5 m high. g = 9.8 N/kg. Calculate its GPE.

**4.** What does "velocity" mean and how does it differ from speed?

## Part 1 of 3: Kinetic Energy

| | |
|---|---|
| Kinetic energy (KE) is the energy stored in a moving object. | 1 |
| The formula for KE is: $E_k = ½ × m × v^2$ | 2 |
| $E_k$ = kinetic energy store (J); m = mass (kg); v = velocity (m/s). | 3 |
| Velocity is used (not speed) because KE depends on both magnitude and direction of motion. | 4 |
| Tip: calculate $v^2$ *first*, then multiply by ½m. Using 0.5 for ½ on a calculator avoids errors. | 5 |

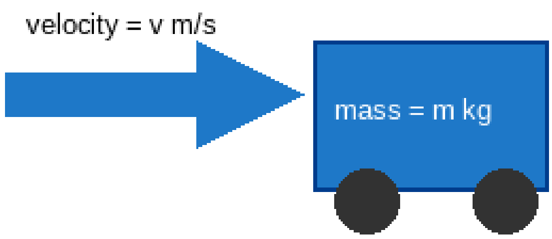


*Fig 2.1 – An object of mass 4 kg moving at velocity 3 m/s.*

| Questions | |
|---|---|
| **1.** Define kinetic energy store. | *(1)* |
| **2.** Write the formula for kinetic energy. | *(1)* |
| **3.** Why does a train waiting at a station have zero kinetic energy store? | *(1)* |
| **4.** A 4 kg object moves at 3 m/s. Calculate its KE. | *(3)* |
| **5.** A 0.2 kg ball moves at 5 m/s. Calculate its KE. | *(3)* |

## Part 2 of 3: Rearranging E_k = ½mv²

| | |
|---|---|
| To find mass: $$m = \frac{2E_k}{v^2}$$ | 1 |
| To find velocity: $v = \sqrt{(2E_k / m)}$ | 2 |
| A lorry moving at 30 mph has more KE than a car at the same speed because its mass is larger — KE ∝ m. | 3 |
| KE increases with the square of velocity — doubling speed quadruples KE. | 4 |

| Questions | |
|---|---|
| **1.** Why does a lorry at 30 mph have more KE than a car at the same speed? | *(1)* |
| **2.** A car of mass 1200 kg travels at 20 m/s. Calculate its KE. | *(3)* |
| **3.** An object has KE = 200 J and mass 25 kg. Find its velocity. | *(3)* |
| **4.** An object has KE = 450 J and velocity = 6 m/s. Find its mass. | *(3)* |
| **5.** How does doubling the velocity of an object affect its KE? Explain. | *(2)* |

## Part 3 of 3: Applying Kinetic Energy

| | |
|---|---|
| KE and GPE are linked by conservation of energy. When an object falls, GPE converts to KE (ignoring air resistance). | 1 |
| If a 3 kg ball falls from 5 m: GPE lost = mgh = 3 × 9.8 × 5 = 147 J = KE gained. | 2 |
| The maximum KE at the bottom equals the GPE at the top (in a closed system). | 3 |

| Questions | |
|---|---|
| **1.** A trampolinist has KE = 8500 J and mass 65 kg. Find their velocity. | *(3)* |
| **2.** A 0.05 kg pancake is tossed with initial KE = 0.6 J. Calculate its initial velocity. | *(3)* |
| **3.** A 2 kg ball is dropped from 10 m. g = 9.8 N/kg. What is its KE just before hitting the ground? | *(3)* |
| **4.** A cyclist of mass 70 kg (including bike) reaches 15 m/s. Calculate their KE. | *(3)* |

## Exam Question [6 marks]

A ball of mass 0.5 kg is dropped from a height of 8 m. g = 9.8 N/kg. Ignore air resistance.

| | |
|---|---|
| **(a)** Calculate the gravitational potential energy of the ball before it is dropped. | *(2)* |
| **(b)** State the kinetic energy of the ball just before it hits the ground. | *(1)* |
| **(c)** Calculate the velocity of the ball just before it hits the ground. | *(3)* |

LESSON 3

# Conservation of Energy & Dissipation

## Do Now

**1.** State the Law of Conservation of Energy.

**2.** What is a closed system?

**3.** A 2 kg ball moves at 4 m/s. Calculate its KE.

**4.** A 3 kg ball is dropped from 5 m. g = 9.8 N/kg. What is its KE just before hitting the ground?

## Part 1 of 3: Conservation of Energy

| | |
|---|---|
| In a **closed system**, the total energy remains constant. Energy is transferred between stores but the total never changes. | 1 |
| Example: A ball thrown upward — KE converts to GPE as it rises; GPE converts back to KE as it falls. | 2 |
| In reality, no system is perfectly closed. Some energy is always transferred to the surroundings as thermal energy. | 3 |
| When a ball hits the ground, KE is transferred to sound and thermal energy stores — both are dissipated. | 4 |

### Questions

| | |
|---|---|
| **1.** What is a closed system? | *(1)* |
| **2.** State the law of conservation of energy. | *(2)* |
| **3.** A 1 kg ball is thrown upward with KE = 20 J. What is its maximum GPE? Explain. | *(2)* |
| **4.** Why is no real system truly closed? | *(2)* |
| **5.** A 25 kg cannonball is fired upward at 8 m/s. g = 9.8 N/kg. Find its maximum height. | *(3)* |

## Part 2 of 3: Dissipation

| | |
|---|---|
| **Dissipation** is when energy is transferred to the surroundings in a less useful form, usually thermal or sound. | 1 |
| Dissipated energy is "wasted" — it spreads into the surroundings and cannot be recovered easily. | 2 |
| Examples: friction in a car engine (thermal), air resistance on a cyclist (thermal), sound from brakes. | 3 |
| Reducing dissipation: lubrication reduces friction; streamlining reduces air resistance; insulation reduces thermal loss. | 4 |

| Questions | |
|---|---|
| **1.** What does "dissipation" mean in physics? | *(2)* |
| **2.** Give two examples of energy dissipation in everyday life. | *(2)* |
| **3.** A bullet is shot upward with KE = 32 J. At its highest point its GPE = 31.8 J. Explain why the values differ. | *(2)* |
| **4.** Name two ways to reduce energy dissipation in machines. | *(2)* |
| **5.** Why is dissipated energy considered "wasted"? | *(2)* |

## Part 3 of 3: Energy Transfers in Scenarios

| | |
|---|---|
| When describing energy transfers, state the **initial store mechanism of transfer final store(s)**. | 1 |
| Zip wire: GPE (mechanically) KE + thermal (friction). | 2 |
| Bouncing ball: GPE KE (falling) elastic PE (squash) KE + thermal + sound (bounce). | 3 |
| The total energy at the end equals the total at the start; only the distribution changes. | 4 |

| Questions | |
|---|---|
| **1.** Describe the energy transfer as a ball falls from a height (ignore air resistance). | *(2)* |
| **2.** Describe the energy transfers for a person braking on a bicycle. | *(3)* |
| **3.** A 60 kg person slides down a zip wire. GPE decreases by 1470 J but KE increases by only 1100 J. How much energy was dissipated? | *(2)* |
| **4.** Explain why a bouncing ball never bounces back to its original height. | *(2)* |

### Exam Question [6 marks]

A person of mass 60 kg slides down a zip wire. The change in vertical height is 2.5 m. g = 9.8 N/kg.

| | |
|---|---|
| **(a)** Calculate the decrease in GPE. | *(2)* |
| **(b)** The increase in KE is 1100 J. Calculate the energy transferred to thermal energy. | *(2)* |
| **(c)** Explain why different people reach different speeds at the bottom. | *(2)* |

LESSON 4

# Elastic Potential Energy

## Do Now

**1.** What is meant by the term "energy store"?

**2.** What is the unit of the spring constant?

**3.** What is the difference between compression and extension?

**4.** If a spring with k = 5 N/m is stretched 2 m, what is its elastic potential energy?

## Part 1 of 3: Elastic Potential Energy

| | |
|---|---|
| Elastic potential energy (EPE) is stored when an elastic object (e.g. a spring) is stretched or compressed. | 1 |
| The formula is: $E_e = \frac{1}{2} \times k \times e^2$ | 2 |
| $E_e$ = elastic potential energy (J); k = spring constant (N/m); e = extension (m). | 3 |
| The **extension** is the extra length stretched — not the total length. | 4 |
| The spring constant k measures the stiffness of the spring. A higher k means a stiffer spring. | 5 |
| This formula is on the AQA formula sheet — you do not need to memorise it. | 6 |

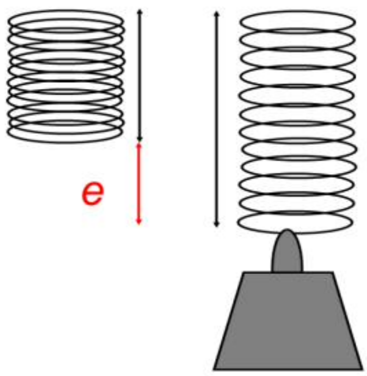


*Fig 4.1 – A spring showing natural length and extension e.*

## Questions

| | |
|---|---|
| **1.** Define elastic potential energy store. | *(1)* |
| **2.** What two factors affect the elastic potential energy stored in a spring? | *(2)* |
| **3.** Do you need the total length of a spring to calculate its EPE? Explain. | *(2)* |
| **4.** A spring (k = 2 N/m) is stretched 3 m. Calculate its EPE. | *(3)* |
| **5.** Which spring is easier to stretch: k = 0.5 N/m or k = 40 N/m? Why? | *(2)* |

## Part 2 of 3: Rearranging E = ½ke²

| | |
|---|---|
| To find spring constant: $$k = \frac{2E_e}{e^2}$$ | 1 |
| To find extension: $e = \sqrt{(2E_e / k)}$ | 2 |
| Example: A spring stores 18 J with k = 4 N/m. Find the extension. | 3 |
| $e = \sqrt{(2 \times 18/4)} = \sqrt{9} = 3$ m. | 4 |

| Questions | |
|---|---|
| **1.** A spring (k = 75 N/m) is extended 40 cm. Calculate its EPE. | *(3)* |
| **2.** A spring stores 400 J with k = 12 N/m. Find the extension. | *(3)* |
| **3.** A spring stores 50 J when extended 5 m. Calculate the spring constant. | *(3)* |
| **4.** A spring (k = 200 N/m) has 180 J of EPE. Find the extension. | *(3)* |

## Part 3 of 3: Elastic Energy in Context

| | |
|---|---|
| When a spring is released, elastic PE converts to KE (and some thermal). | 1 |
| A bungee cord stores elastic PE when stretched; when it pulls the jumper back, EPE converts to KE then GPE. | 2 |
| Elastic PE  KE conversions occur in trampolines, bows, catapults and musical instruments. | 3 |

| Questions | |
|---|---|
| **1.** Describe the energy transfers in a bow-and-arrow as the arrow is fired. | *(3)* |
| **2.** A 0.1 kg ball is fired by a spring (k = 50 N/m, e = 0.2 m). Assuming all EPE converts to KE, find the ball's velocity. | *(4)* |
| **3.** Give two examples of objects that store elastic potential energy. | *(2)* |

| Exam Question [6 marks] | |
|---|---|
| A bungee cord has spring constant k = 15 N/m. A student of mass 70 kg jumps from a bridge. The unstretched cord length is 20 m. | |
| **(a)** Give two reasons why the cord must be appropriate for the student's weight. | *(2)* |
| **(b)** The cord stretches 18 m. Calculate the elastic PE stored. | *(3)* |
| **(c)** The student's KE at the lowest point is zero. Explain why. | *(1)* |

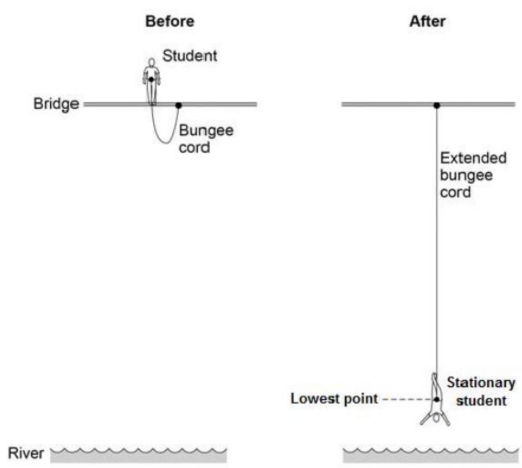


*Fig 4.2 – Bungee jumper before and after jump: student at bridge level (Before) and at lowest point (After).*

LESSON 5

# Specific Heat Capacity

## Do Now

**1.** What is thermal energy?

**2.** What is the difference between temperature and thermal energy?

**3.** If 500 J is added to two objects of different materials but equal mass, will they heat up equally?

**4.** What unit is temperature measured in?

## Part 1 of 3: Temperature and Thermal Energy

| | |
|---|---|
| **Temperature** is the average kinetic energy store of the particles in a system. | 1 |
| Two blocks of equal mass but different materials will heat up by different amounts when given the same energy. | 2 |
| Copper has SHC = 386 J/kg°C; gold has SHC = 126 J/kg°C. Gold heats up faster with the same energy input. | 3 |
| The material that is "easier to heat up" has the lower specific heat capacity. | 4 |

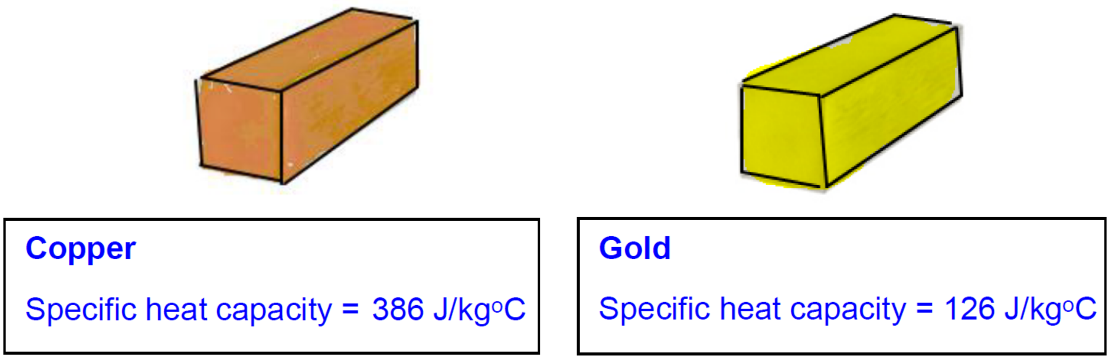


*Fig 5.1 – Copper (SHC = 386 J/kg°C) and gold (SHC = 126 J/kg°C) blocks of equal mass. Adding 500 J raises gold's temperature more.*

| Questions | |
|---|---|
| **1.** What does temperature measure at a particle level? | *(1)* |
| **2.** Two blocks of equal mass are given the same energy. One heats up more than the other. What can you conclude? | *(2)* |
| **3.** Which metal requires more energy to raise its temperature by 1°C per kg: copper or gold? Why? | *(2)* |
| **4.** Define the term "specific heat capacity". | *(2)* |

## Part 2 of 3: The SHC Equation

| | |
|---|---|
| The formula for thermal energy transfer is: $\Delta E = m \times c \times \Delta T$ | 1 |
| $\Delta E$ = change in thermal energy (J); m = mass (kg); c = specific heat capacity (J/kg°C); $\Delta T$ = change in temperature (°C). | 2 |
| Example: Water (c = 4200 J/kg°C), mass 2 kg, heated by 10°C. $\Delta E = 2 \times 4200 \times 10 = 84\,000$ J. | 3 |
| The higher the SHC, the more energy needed to raise the temperature — water has one of the highest SHCs. | 4 |
| This equation is on the AQA formula sheet. | 5 |

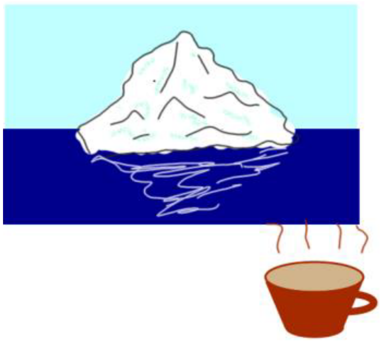

*Fig 5.2 – Water has a very high SHC, which is why oceans moderate the climate.*

| Questions | |
|---|---|
| **1.** Write the equation for specific heat capacity. | *(1)* |
| **2.** A 1 kg block of iron (c = 450 J/kg°C) is heated from 20°C to 70°C. Calculate the energy transferred. | *(3)* |
| **3.** A block of silver (m = 12.5 kg) is heated by 37°C. c = 233 J/kg°C. Calculate the thermal energy. | *(3)* |
| **4.** A 3 kg copper block absorbs 5790 J. c = 386 J/kg°C. Find the temperature change. | *(3)* |

## Part 3 of 3: Rearranging E = mcT

| | |
|---|---|
| To find mass: $$m = \frac{\Delta E}{c \times \Delta T}$$ | 1 |
| To find SHC: $$c = \frac{\Delta E}{m \times \Delta T}$$ | 2 |
| To find temperature change: $$\Delta T = \frac{\Delta E}{m \times c}$$ | 3 |
| Water has c = 4200 J/kg°C — this is why it is used in central heating systems (stores a lot of energy). | 4 |

## Questions

| | |
|---|---|
| **1.** Find the mass of zinc needed to absorb 2300 J heated from 50°C to 61°C. c = 387 J/kg°C. | *(4)* |
| **2.** A 3.4 kg mass of water (c = 4186 J/kg°C) gains 6800 J. Find the temperature change. | *(3)* |
| **3.** Water in a kettle (c = 4200 J/kg°C, m = 0.5 kg) is heated by 80°C. Calculate the energy used. | *(3)* |
| **4.** A material with c = 500 J/kg°C absorbs 12 500 J with a 5°C rise. Find the mass. | *(3)* |

## Exam Question [6 marks]

A student heats 0.5 kg of water using a 100 W immersion heater for 5 minutes. The specific heat capacity of water is 4200 J/kg°C.

| | |
|---|---|
| **(a)** Calculate the energy supplied by the heater in 5 minutes. | *(2)* |
| **(b)** Calculate the expected temperature rise of the water. | *(3)* |
| **(c)** The actual temperature rise is less than calculated. Give one reason why. | *(1)* |

LESSON 6

# Investigating Specific Heat Capacity

## Do Now

**1.** Write the equation for specific heat capacity.

**2.** What does the specific heat capacity of a substance tell us?

**3.** A 2 kg block is heated by 20°C. c = 400 J/kg°C. Calculate the energy transferred.

**4.** Why is water used in central heating systems?

## Part 1 of 3: The SHC Investigation

| | |
|---|---|
| Aim: to find the specific heat capacity of a metal block by measuring energy transferred and temperature change. | 1 |
| Equipment: metal block, immersion heater, thermometer, joulemeter (or ammeter + voltmeter + stopwatch), digital scales. | 2 |
| Method step 1: Measure the mass of the block using digital scales. | 3 |
| Method step 2: Apply glycerine to the immersion heater and thermometer to ensure good thermal contact with the block. Insert both. | 4 |
| Method step 3: Record the starting temperature and joulemeter reading. | 5 |
| Method step 4: Switch on the heater. Record temperature and energy at regular intervals for 10 minutes. | 6 |
| Method step 5: Use $\Delta E = mc\Delta T$ to calculate c. | 7 |

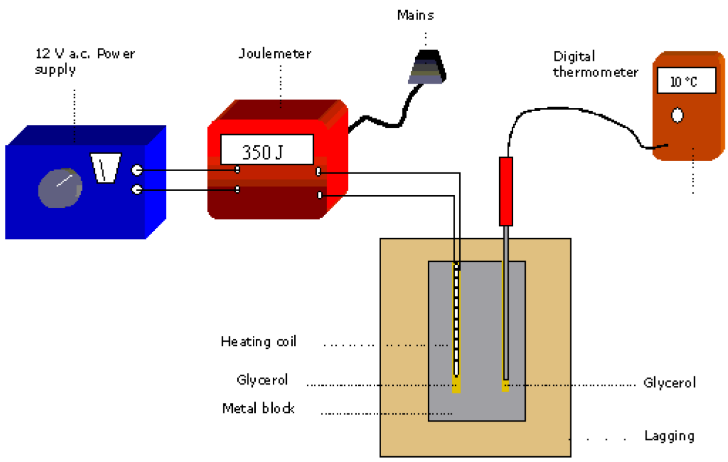


*Fig 6.1 – SHC apparatus: 12V power supply, joulemeter, immersion heater and thermometer in a lagged metal block.*

| Questions | |
|---|---|
| **1.** Name the key pieces of equipment for the SHC investigation. | *(3)* |
| **2.** Why is glycerine applied to the heater and thermometer? | *(2)* |
| **3.** What measurements must be taken during the experiment? | *(3)* |
| **4.** Why is it important to insulate (lag) the metal block? | *(2)* |

## Part 2 of 3: Analysing Results

| | |
|---|---|
| Calculate c using: $$c = \frac{\Delta E}{m \times \Delta T}$$ | 1 |
| Plot a graph of temperature (y-axis) against energy supplied (x-axis). The gradient = 1/(mc). | 2 |
| Possible errors: heat loss to surroundings (c appears too high); poor thermal contact (uneven heating). | 3 |
| To improve: use lagging; allow system to reach thermal equilibrium; repeat and average. | 4 |
| Compare calculated c with the known value (e.g. aluminium: 900 J/kg°C). Discuss percentage error. | 5 |

| Questions | |
|---|---|
| **1.** A student heats a 0.5 kg aluminium block. Energy supplied = 4500 J; ΔT = 10°C. Calculate c. | *(3)* |
| **2.** The known SHC of aluminium is 900 J/kg°C. Calculate the percentage error. | *(2)* |
| **3.** A student carried out an experiment with 100 g (0.1 kg) of water in sunlight for 30 minutes. The temperature rose by 3°C. c = 4200 J/kg°C. Find the energy absorbed. | *(2)* |
| **4.** Suggest one improvement to increase the accuracy of the SHC experiment. | *(2)* |

## Part 3 of 3: Evaluating the SHC Investigation

| | |
|---|---|
| Sources of error: heat loss to surroundings; thermal lag (thermometer not reaching equilibrium); poor contact. | 1 |
| Systematic errors: if the joulemeter is not zeroed; if mass measurement is incorrect. | 2 |
| Reliability: repeat the experiment and average values; use a data logger for precision. | 3 |
| Variables: independent = energy supplied; dependent = temperature change; controlled = mass, material, insulation. | 4 |

| Questions | |
|---|---|
| **1.** What is the independent variable in the SHC investigation? | *(1)* |
| **2.** What is the dependent variable? | *(1)* |
| **3.** Give two sources of error that could make the calculated c too high. | *(2)* |
| **4.** How could you check if your result is repeatable? | *(1)* |
| **5.** Why should you record temperature over time rather than just at the end? | *(2)* |

**Exam Question [5 marks]**

A student investigates the specific heat capacity of a metal block of mass 0.8 kg. The immersion heater supplies 3600 J of energy. The temperature rises from 20°C to 25°C.

| | |
|---|---|
| **(a)** Calculate the specific heat capacity of the metal. | *(3)* |
| **(b)** The student's value is higher than the accepted value. Give one reason why. | *(1)* |
| **(c)** Suggest one way to reduce this source of error. | *(1)* |

LESSON 7

# Power

## Do Now

*Gravitational Potential Energy:* $E_{GP} = m \times g \times h$ *Kinetic Energy:* $E_k = ½ \times m \times v^2$

**1.** What is the unit of energy?

**2.** Calculate the GPE of a 3 kg object at a height of 5 m. g = 9.8 N/kg.

**3.** A 20 kg object is 8 m high. g = 9.8 N/kg. Calculate its GPE.

**4.** A 4 kg ball moves at 6 m/s. Calculate its kinetic energy.

**5.** A ball has a kinetic energy of 72 J and a mass of 4 kg. Calculate its speed.

## Part 1 – Watt is Power?

| | |
|---|---|
| Work done is energy transferred. | 1 |
| Rate means how much each second. | 2 |
| Power is the rate at which energy is transferred. | 3 |
| Watt is the unit of power. | 4 |

| Questions | |
|---|---|
| **1.** What is work done? | *(1)* |
| **2.** What does rate mean? | *(1)* |
| **3.** Define power. | *(1)* |
| **4.** What is the unit of power? | *(1)* |

## Part 2 – Calculating Power

| | |
|---|---|
| Formula 1: $$P = \frac{E}{t}$$ | 1 |
| Formula 2: $$P = \frac{W}{t}$$ | 2 |
| P = power (W) | 3 |
| E = Energy Transferred (J) | 4 |
| t = time (s) | 5 |

| **Example 1** | |
|---|---|
| **Values** | $P = ?$ $E = 600$ J $t = 12$ s |
| **Equation** | $P = \frac{E}{t}$ |
| **Substitute** | $P = \frac{600}{12}$ |
| **Solve** | $P = 50$ |
| **Units** | *Watts (W)* |

| **Questions** | |
|---|---|
| **5.** A lamp transfers 200 J in 4 s. Calculate its power. | *(2)* |
| **6.** A heater transfers 6000 J in 60 s. Calculate its power. | *(2)* |
| **7.** An electric motor transfers 2400 J in 8 s. Calculate its power. | *(2)* |
| **8.** A car engine transfers 84 000 J in 60 s. Calculate its power. | *(3)* |

| | |
|---|---|
| 1 Watt means 1 Joule per second. | 1 |
| 1 kJ = 1000 J | 2 |
| 1 min = 60 s | 3 |

| **Example 2: a machine transfers 1.2 kJ in 2 minutes, calculate its power** | |
|---|---|
| **V** | $P = ?$ $E = 1.2 \times 1000 = 1200$ J $t = 2 \times 60 = 120$ s |
| **E** | $P = \frac{E}{t}$ |
| **S** | $P = \frac{1200}{120}$ |
| **S** | $P = 10$ |
| **U** | *Watts (W)* |

| **Questions** | |
|---|---|
| **9.** A device transfers 3 kJ of energy in 30 s. Calculate its power. | *(3)* |
| **10.** An appliance transfers 1800 J of energy in 3 minutes. Calculate its power. | *(3)* |
| **11.** A motor transfers 4.8 kJ of energy in 60 s. Calculate its power. | *(3)* |
| **12.** A lamp transfers 3.6 kJ of energy in 3 minutes. Calculate its power. | *(3)* |
| **13.** Two motors both lift the same weight the same height. Motor A takes 5 s; Motor B takes 20 s. Which is more powerful? Explain. | *(2)* |

## Part 3 – Finding Energy or Time

| Example 3 (finding energy) | |
|---|---|
| V | $E = ?$ $P = 250$ W $t = 2$ min $= 120$ s |
| E | $P = \frac{E}{t}$ |
| S | $250 = \frac{E}{120}$ |
| S | $250 \times 120 = E = 30\,000$ |
| U | Joules (J) |

| Example 4 (finding time) | |
|---|---|
| V | $t = ?$ $P = 500$ W $E = 15\,000$ J |
| E | $P = \frac{E}{t}$ |
| S | $500 = \frac{15\,000}{t}$ |
| S | $500t = 15\,000$ |
| S | $t = \frac{15\,000}{500} = 30$ |
| U | Seconds (s) |

| Questions | |
|---|---|
| **14.** A 40 W fan runs for 5 s. How much energy does it transfer? | *(2)* |
| **15.** A 250 W lamp runs for 2 minutes. Calculate the energy transferred. | *(3)* |
| **16.** A 3 kW kettle heats water for 4 minutes. Calculate the energy transferred in kJ. | *(3)* |
| **17.** A 60 W electric fan runs for 30 minutes. Calculate the energy transferred in kJ. | *(3)* |

| Questions | |
|---|---|
| **18.** A device transfers 18 000 J at a power of 300 W. How long does it run for? | *(3)* |
| **19.** A battery stores 900 000 J. A 50 W lamp is connected. How many hours will it run? | *(3)* |
| **20.** A 2 kW motor transfers 480 000 J. How long does it take? Give your answer in minutes. | *(3)* |

## Part 4 – 2 Step Calculations

A motor lifts a 50 kg rock through a height of 4 m in 8 s. g = 9.8 N/kg. Calculate the power of the motor.

| Step 1 – Calculate GPE | |
|---|---|
| V | $E = ?$ $m = 50$ kg $h = 4$ m $g = 9.8$ N/kg |
| E | $E = m \times g \times h$ |
| S | $E = 50 \times 9.8 \times 4$ |
| S | $E = 1960$ |
| U | Joules (J) |

| Step 2 – Calculate Power | |
|---|---|
| V | $P = ?$ $E = 1960$ J $t = 8$ s |
| E | $P = \frac{E}{t}$ |
| S | $P = \frac{1960}{8}$ |
| S | $P = 245$ |
| U | Watts (W) |

| **Two-Step Question [5 marks]** | |
|---|---|
| A crane lifts a 150 kg load through a height of 8 m in 12 s. g = 9.8 N/kg. | |
| **(a)** Calculate the gravitational potential energy gained by the load. | *(2)* |
| **(b)** Using your answer to (a), calculate the power of the crane. | *(2)* |
| **(c)** State the unit of power. | *(1)* |

| **Two-Step Question [5 marks]** | |
|---|---|
| A pump raises 60 kg of water through a height of 5 m in 6 s. g = 9.8 N/kg. | |
| **(a)** Calculate the gravitational potential energy gained by the water. | *(2)* |
| **(b)** Calculate the power of the pump. | *(2)* |
| **(c)** State the unit of power. | *(1)* |

| **Questions** | |
|---|---|
| **21.** A 75 kg person climbs stairs of height 4 m in 8 s. g = 9.8 N/kg. Calculate power. | *(3)* |
| **22.** A 90 kg weightlifter raises a bar 1.8 m in 2 s. g = 9.8 N/kg. Calculate power. | *(3)* |
| **23.** A motor transfers 540 000 J in 15 minutes. Calculate its power in W and in kW. | *(3)* |

| **Exam Question [6 marks]** | |
|---|---|
| A crane lifts a 400 kg steel beam through a height of 15 m. g = 9.8 N/kg. | |
| **(a)** Calculate the gravitational potential energy gained by the steel beam. | *(2)* |
| **(b)** The crane takes 40 seconds to lift the beam. Calculate the power of the crane. | *(2)* |
| **(c)** A second crane lifts the same beam through the same height but takes only 25 seconds. Calculate the power of the second crane. | *(2)* |

LESSON 8

# Energy Stores & Transfers

## Do Now

**1.** Name four energy stores.

**2.** Name four ways energy can be transferred.

**3.** Describe the energy transfer when a candle burns.

**4.** What is meant by the "rate" of energy transfer?

## Part 1 of 3: Energy Stores Recap

| | |
|---|---|
| The four main stores studied so far: **Gravitational** (E=mgh), **Kinetic** ($E=\frac{1}{2}mv^2$), **Elastic** ($E=\frac{1}{2}ke^2$), **Thermal** ($E=mc\Delta T$). | 1 |
| Other stores: **Chemical** (food, fuel, batteries), **Nuclear** (uranium), **Electrostatic** (charged objects), **Magnetic** (magnets). | 2 |
| Energy is transferred when something happens. Transfers can be shown as bar models or Sankey diagrams. | 3 |
| In a bar model, the total height of bars stays constant (conservation) while the energy distributes between stores. | 4 |

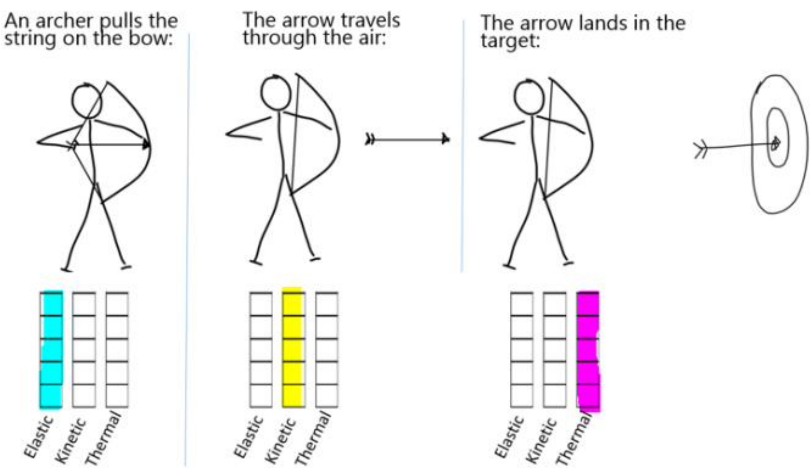


*Fig 8.1 – Energy store bar models for an archer firing an arrow: elastic  kinetic as the arrow travels.*

## Questions

| | |
|---|---|
| **1.** Name the eight energy stores. | *(4)* |
| **2.** What energy store does a charged capacitor have? | *(1)* |
| **3.** Describe the energy stores at each stage as an archer fires an arrow and it lands in a target. | *(4)* |
| **4.** Why do the bars in a bar model always add up to the same total? | *(2)* |

## Part 2 of 3: Energy Transfer Mechanisms

| | |
|---|---|
| Energy is transferred between stores by: **Mechanical working** (forces), **Electrical working** (current), **Heating** (conduction/convection/radiation), **Radiation** (light, sound, etc.). | 1 |
| The rate of energy transfer is **power** (Watts). | 2 |
| Example — electric motor: electrical  (electrical working)  kinetic + thermal. | 3 |
| Example — burning fuel: chemical  (heating)  thermal + (radiation)  light. | 4 |

### Questions

| | |
|---|---|
| **1.** Name the four mechanisms by which energy can be transferred. | *(2)* |
| **2.** A boy falls on a trampoline. Describe the energy transfers. | *(4)* |
| **3.** A jack-in-the-box pops open. Describe the energy transfers. | *(3)* |
| **4.** A weight hangs on a spring and oscillates. Describe the energy transfers. | *(3)* |

## Part 3 of 3: Energy Transfer Diagrams

| | |
|---|---|
| A **Sankey diagram** shows energy transfers with arrow widths proportional to energy values. | 1 |
| Useful energy goes forwards (horizontal); wasted energy goes downward (usually thermal). | 2 |
| For a car engine: 1000 J input  250 J kinetic (forward) + 750 J thermal (down). | 3 |
| Efficiency can be read from a Sankey diagram: *useful output* ——— *total input.* | 4 |

### Questions

| | |
|---|---|
| **1.** What does the width of an arrow in a Sankey diagram represent? | *(1)* |
| **2.** Which direction does wasted energy usually point in a Sankey diagram? | *(1)* |
| **3.** A light bulb uses 100 J and emits 10 J as light. Sketch/describe its Sankey diagram. | *(3)* |
| **4.** Describe the energy transfers in a bungee jumper from jump to lowest point. | *(4)* |

### Exam Question [7 marks]

A student jumps off a bridge on a bungee cord. The cord has an unstretched length of 20 m.

| | |
|---|---|
| **(a)** Give two reasons why it is important that the cord is appropriate for the student's weight. | *(2)* |
| **(b)** The student falls. Describe the energy transfers before the cord starts to stretch. | *(2)* |
| **(c)** When the cord is stretched, state the energy store in the cord. | *(1)* |
| **(d)** The student's GPE decreases by 29 400 J. KE increases by 18 000 J. What has happened to the rest of the energy? | *(2)* |

LESSON 9

# Reducing Wasted Energy

## Do Now

**1.** What is dissipation?

**2.** Give two examples of wasted energy in a car engine.

**3.** What is thermal conductivity?

**4.** Why does a metal spoon feel colder than a wooden spoon at the same temperature?

## Part 1 of 3: Thermal Insulation

| | |
|---|---|
| Thermal insulation reduces the rate of energy transfer to the surroundings. | 1 |
| Methods: cavity wall insulation, loft insulation (foil or foam), double glazing, draught excluders. | 2 |
| Best insulating materials have **low thermal conductivity** (e.g. foam, wool, air gaps). | 3 |
| High thermal conductivity = faster energy transfer. Low thermal conductivity = slower transfer. | 4 |
| Metal has high thermal conductivity; foam has low thermal conductivity. | 5 |

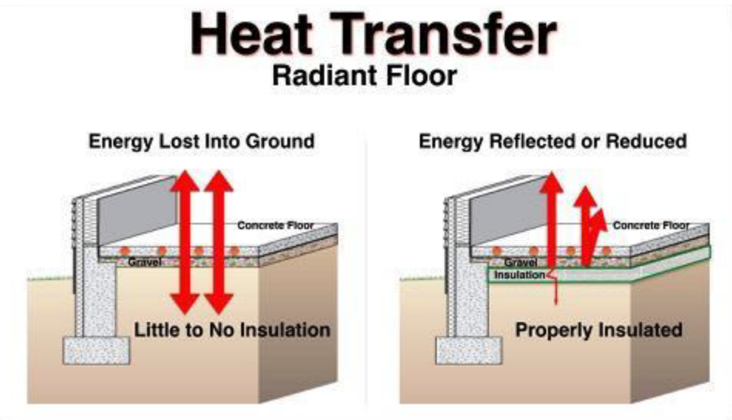


*Fig 9.1 – Heat transfer through an uninsulated floor (energy lost downward) vs. insulated floor (energy reflected/reduced).*

| Questions | |
|---|---|
| **1.** Why do people want to reduce unwanted energy transfers? | *(2)* |
| **2.** Give an example of an unwanted energy transfer in a sewing machine. | *(1)* |
| **3.** Explain how unwanted energy transfer is reduced in heated buildings. | *(2)* |
| **4.** Relate thermal conductivity to rate of energy transfer. | *(2)* |
| **5.** How does the thickness of a wall affect a building's rate of cooling? | *(2)* |
| **6.** How does the thermal conductivity of walls affect a building's rate of cooling? | *(2)* |

## Part 2 of 3: Reducing Friction & Other Losses

| | |
|---|---|
| **Lubrication** (oil/grease) reduces friction between moving surfaces, reducing thermal energy waste. | 1 |
| **Streamlining** reduces air resistance, reducing thermal energy wasted in vehicles. | 2 |
| **Insulation** around pipes and tanks reduces thermal energy loss by conduction. | 3 |
| In electrical devices, thicker wires reduce resistance and therefore reduce heating losses. | 4 |

| Questions | |
|---|---|
| **1.** Explain how lubrication reduces energy waste in engines. | *(2)* |
| **2.** Why are racing cars designed to be streamlined? | *(2)* |
| **3.** How does insulating a hot water pipe reduce energy waste? | *(2)* |
| **4.** A house loses 20% of heat through the roof. Suggest one way to reduce this. | *(1)* |

## Part 3 of 3: Reducing Energy Waste — Hot Water Tanks

| | |
|---|---|
| A copper hot water tank loses energy quickly because copper has high thermal conductivity. | 1 |
| Insulation (foam jacket) around the tank reduces the rate of energy transfer to the room. | 2 |
| An insulated tank keeps water hot for longer, reducing the need to reheat it. | 3 |
| The electric immersion heater inside the tank converts electrical energy to thermal energy. | 4 |

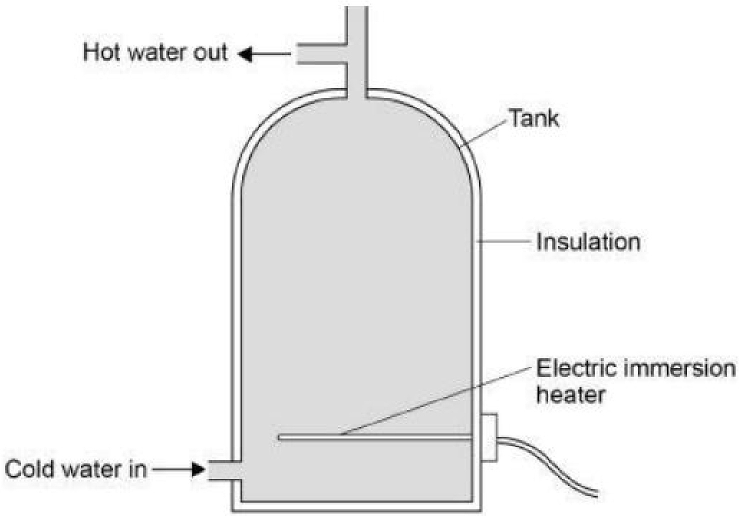


*Fig 9.2 – Insulated hot water tank showing tank, insulation layer and electric immersion heater.*

| Questions | |
|---|---|
| **1.** Why does a copper hot water tank lose heat quickly? | *(1)* |
| **2.** How does a foam jacket reduce heat loss from the tank? | *(2)* |
| **3.** Compared to an uninsulated tank, how does the rate of energy transfer change? | *(1)* |
| **4.** Explain why insulating a hot water tank saves money. | *(2)* |

| Exam Question [5 marks] | |
|---|---|
| Figure 9.2 shows a copper hot water tank with insulation. | |
| **(a)** Copper has higher thermal conductivity than most metals. How does the rate of energy transfer compare to most metals? Tick one box: Higher / Lower / The same. | *(1)* |
| **(b)** The tank is insulated. The water is heated, then the heater switches off. Compare the rate of cooling with and without insulation. | *(2)* |
| **(c)** During one morning, 4 070 000 J is transferred from the heater. 4 030 000 J goes to the water. Calculate the proportion of energy transferred to the water. | *(2)* |

LESSON 10

# Efficiency

## Do Now

**1.** What is meant by "wasted" energy?

**2.** Give two examples of useful energy outputs from a car engine.

**3.** What is the formula for power?

**4.** A 500 W machine runs for 20 s. How much energy does it transfer?

## Part 1 of 3: What is Efficiency?

| | |
|---|---|
| **Efficiency** is the fraction of input energy that is transferred to a useful output. | 1 |
| Formula 1: $$\text{Efficiency} = \frac{\text{useful output energy}}{\text{total input energy}}$$ | 2 |
| Formula 2: $$\text{Efficiency} = \frac{\text{useful output power}}{\text{total input power}}$$ | 3 |
| Efficiency has no units. It is between 0 and 1 (or expressed as a percentage 0–100%). | 4 |
| No machine is 100% efficient — some energy is always dissipated as thermal or sound. | 5 |

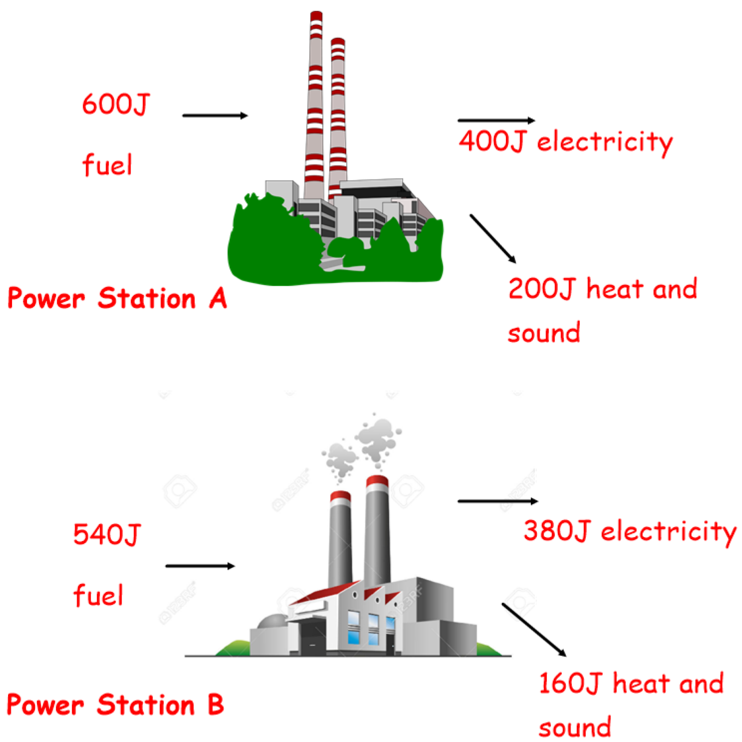


*Fig 10.1 – Power Station A (efficiency = 400÷600 = 0.67) vs Power Station B (efficiency = 380÷540 = 0.70). Station B is more efficient.*

| Questions | |
|---|---|
| **1.** What does the efficiency of an appliance tell us? | *(2)* |
| **2.** Write both equations for efficiency. | *(2)* |
| **3.** Why would a more efficient motor give a car a higher top speed? | *(2)* |
| **4.** A loudspeaker uses 400 W and produces 325 W of sound. Find its efficiency. | *(3)* |
| **5.** A car uses 3890 J of fuel to generate 2650 J of KE. Find its efficiency. | *(3)* |

## Part 2 of 3: Calculating and Applying Efficiency

| | |
|---|---|
| Example: A lightbulb uses 470 J, emits 180 J as heat and 290 J as light. Efficiency = 290/470 = 0.617. | 1 |
| To find wasted energy: wasted = input – useful output. | 2 |
| Increasing efficiency: lubrication, streamlining, better insulation, using waste heat (CHP). | 3 |
| **CHP (Combined Heat and Power)** stations recapture waste steam to heat homes, greatly increasing overall efficiency. | 4 |

| Questions | |
|---|---|
| **1.** A lightbulb uses 470 J; 180 J is heat and 290 J is light. Find the efficiency. | *(3)* |
| **2.** A power station uses 2000 J of fuel to generate 600 J of electricity. How much energy is wasted? | *(2)* |
| **3.** An electric motor uses 2.4×10 J to give a weight 1.8×10 J of GPE. Find efficiency. | *(3)* |
| **4.** A lightbulb (efficiency 0.4) emits 3000 J of light in 20 s. Find the power input. | *(3)* |

## Part 3 of 3: Efficiency as a Percentage & Increasing It

| | |
|---|---|
| To express as percentage: multiply the decimal by 100 (e.g. 0.67  67%). | 1 |
| Wasted energy is usually thermal. Reducing thermal losses increases efficiency. | 2 |
| Environmental argument: more efficient appliances use less fuel  lower CO emissions. | 3 |
| Economic argument: more efficient appliances cost less to run. | 4 |

| Questions | |
|---|---|
| **1.** Convert efficiency 0.82 to a percentage. | *(1)* |
| **2.** A power station uses 2000 J to produce 600 J electricity. For every 600 J of electricity, how much fuel is used? | *(2)* |
| **3.** State two reasons why improving efficiency is desirable. | *(2)* |
| **4.** A fan uses 180 W and delivers 150 W of useful power to the air. Calculate its efficiency. | *(3)* |

| Exam Question [6 marks] | |
|---|---|
| A fuel burning power station uses 2000 J of fuel energy to generate 600 J of electrical energy. | |
| **(a)** Calculate the efficiency of the power station. | *(2)* |
| **(b)** State where the rest of the energy goes. | *(1)* |
| **(c)** A second power station has efficiency 0.70. For every 1000 J of fuel, how much electricity does it produce? | *(2)* |
| **(d)** Give one way the second power station could increase its efficiency. | *(1)* |

LESSON 11

# Non-Renewable Energy Resources

## Do Now

**1.** What is meant by a "non-renewable" energy resource?

**2.** Name three fossil fuels.

**3.** What gas is released when fossil fuels are burned?

**4.** What is nuclear fission?

## Part 1 of 3: Fossil Fuels

| | |
|---|---|
| Fossil fuels (coal, oil, natural gas) formed from ancient organisms over millions of years. They are **non-renewable**. | 1 |
| Fossil fuels store **chemical energy**. When burned, chemical energy thermal electrical (via turbine/generator). | 2 |
| Advantages: reliable, high energy density, existing infrastructure. | 3 |
| Disadvantages: non-renewable (will run out ~50 years); produce CO (greenhouse gas/climate change); coal also produces SO (acid rain). | 4 |
| They provide a consistent, controllable supply — useful for meeting peak demand. | 5 |

| Questions | |
|---|---|
| **1.** State three things humans use energy resources for. | *(3)* |
| **2.** Define "non-renewable". | *(2)* |
| **3.** Name three common non-renewable energy resources. | *(3)* |
| **4.** What are the benefits of fossil fuels? | *(2)* |
| **5.** When are fossil fuels likely to run out? | *(1)* |
| **6.** Name two things formed when fossil fuels are burned and explain the problems they cause. | *(4)* |

## Part 2 of 3: Nuclear Fuels

| | |
|---|---|
| Nuclear fuels (uranium, plutonium) are **non-renewable** but will last ~80 years. | 1 |
| Nuclear fission: heavy nucleus absorbs a neutron and splits, releasing large amounts of energy as heat. | 2 |
| Advantages: no CO emissions during operation; very high energy density; reliable. | 3 |
| Disadvantages: expensive to build; produces radioactive waste (difficult to dispose of safely); risk of contamination if accident occurs. | 4 |
| Scientists research **nuclear fusion** (joining light nuclei) which would be cleaner but is not yet commercially viable. | 5 |

| Questions | |
|---|---|
| **1.** Explain why nuclear energy is non-renewable. | *(2)* |
| **2.** What are the risks with using nuclear power? | *(3)* |
| **3.** What are the benefits of nuclear power compared to fossil fuels? | *(3)* |
| **4.** What is nuclear fusion and why is it not yet used commercially? | *(3)* |

## Part 3 of 3: UK Energy Mix

| | |
|---|---|
| The UK uses a mix of energy resources. In 2018, gas and nuclear provided the majority of electricity. | 1 |
| The UK government plans to phase out coal-fired power stations to reduce CO emissions. | 2 |
| Electricity demand varies throughout the day — non-renewables are used to meet peak demand because they are controllable. | 3 |
| Renewables are increasingly replacing non-renewables as technology improves and costs fall. | 4 |

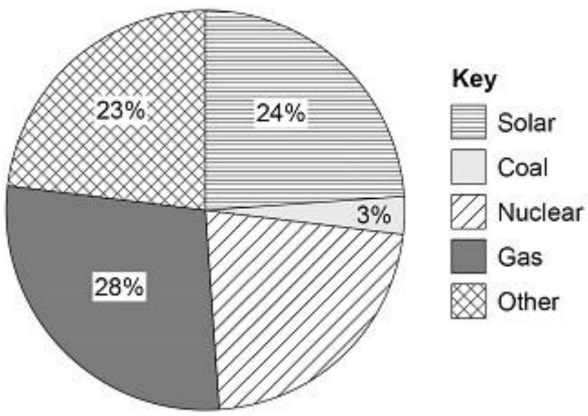


*Fig 11.1 – UK electricity generation by source on one day in June 2018 (solar, coal, nuclear, gas, other).*

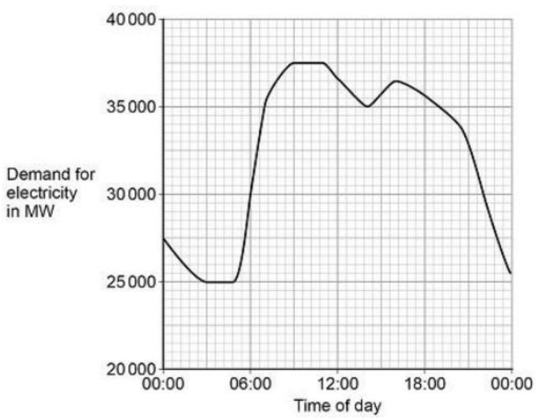


*Fig 11.2 – Electricity demand (MW) varying through the day in the UK.*

| Exam Question [8 marks] | |
|---|---|
| Figure 11.1 shows how different energy resources generated electricity in the UK on one day in June 2018. | |
| **(a)** The UK government plans to stop using coal-fired power stations by 2025. Explain one environmental problem caused when electricity is generated by burning coal. | *(2)* |
| **(b)** Use Figure 11.1 to determine the percentage of electricity generated by nuclear power that day. | *(2)* |
| **(c)** Figure 11.2 shows electricity demand varies with time of day. Identify the maximum and minimum demand and calculate the difference. | *(2)* |
| **(d)** Explain why non-renewable sources are used to meet peak electricity demand. | *(2)* |

LESSON 12

# Renewable Energy Resources

## Do Now

**1.** What is a renewable energy resource?

**2.** Name three renewable energy resources.

**3.** What is one disadvantage of wind power?

**4.** Approximately how long will fossil fuels last at current usage?

## Part 1 of 3: Wind, Solar & Geothermal

| | |
|---|---|
| **Wind power**: Wind turns turbine blades  generator  electricity. Zero emissions, renewable. Disadvantage: intermittent; visual impact; harms birds. | 1 |
| **Solar power**: Photovoltaic cells convert sunlight to electricity. Renewable, no emissions. Disadvantage: no output at night or in cloudy weather; requires large area. | 2 |
| **Geothermal**: Water pumped into hot rocks underground, returns as steam  drives turbine. Renewable, no emissions. Disadvantage: only available in geologically active areas. | 3 |

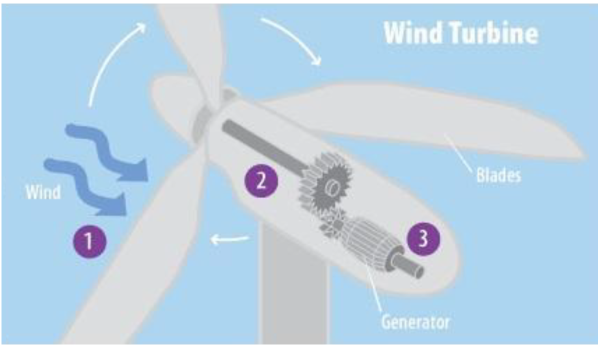


*Fig 12.1 – Wind turbine: (1) wind rotates blades, (2) gearbox speeds up rotation, (3) generator produces electricity.*

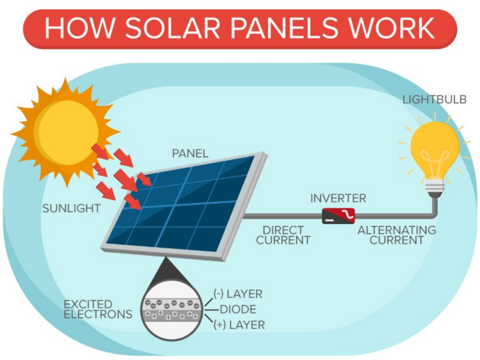


*Fig 12.2 – How a solar panel works: sunlight excites electrons in photovoltaic cells (negative layer  diode positive layer), generating direct current (DC); an inverter converts DC to alternating current (AC) for use in the home.*

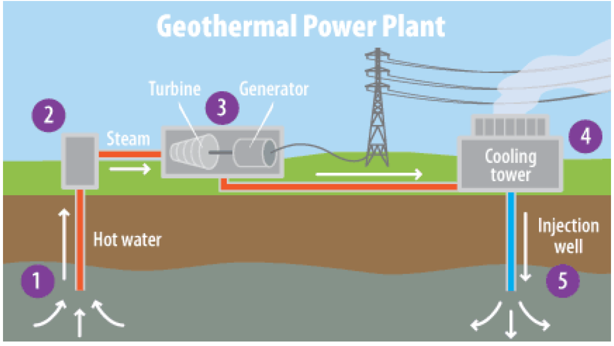


*Fig 12.3 – Geothermal power plant: (1) cold water injected, (2) steam rises, (3) turbine, (4) cooling tower, (5) injection well.*

| Questions | |
|---|---|
| **1.** Explain how wind power generates electricity. | *(3)* |
| **2.** Give one advantage and one disadvantage of solar power. | *(2)* |
| **3.** Why is geothermal power only available in certain locations? | *(2)* |
| **4.** A wind turbine generates 2 MW of power. How much energy does it produce in 1 hour? | *(3)* |

## Part 2 of 3: Hydroelectric, Tidal & Wave

| | |
|---|---|
| **Hydroelectric**: Water in reservoir flows through turbines. Renewable, zero emissions, reliable. Disadvantage: habitat destruction; needs suitable geography. | 1 |
| **Tidal power**: Turbines in sea turn with incoming/outgoing tides. Renewable, predictable. Disadvantage: few suitable sites; affects marine life. | 2 |
| **Wave power**: Floating devices harness wave motion to drive generators. Renewable. Disadvantage: unreliable, easily damaged by storms. | 3 |

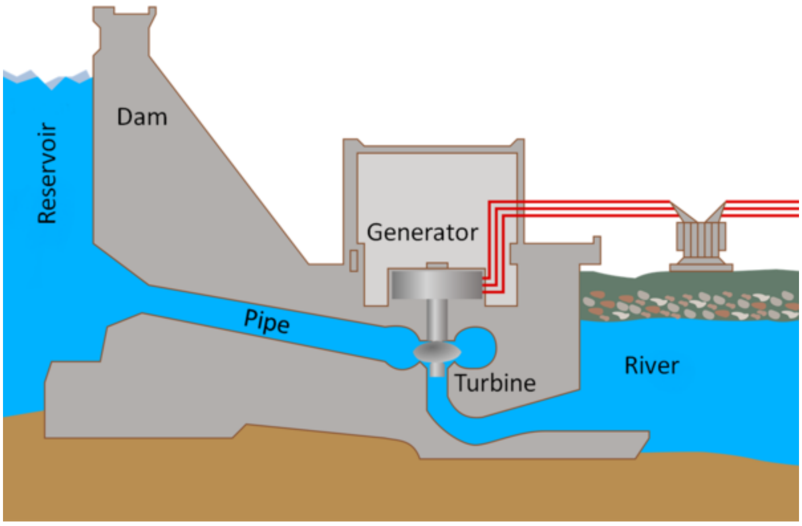


*Fig 12.4 – Hydroelectric dam: reservoir penstock turbine generator power lines.*

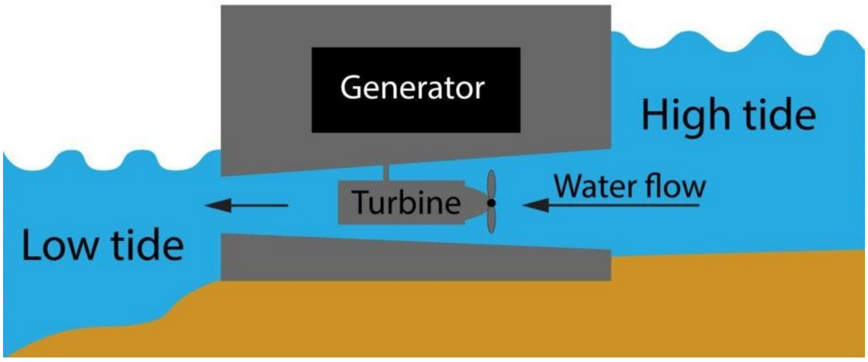


*Fig 12.5 – Tidal power. water flows from high tide to low tide, passing through a turbine connected to a generator; the direction of water flow reverses with each tide, so the turbine generates electricity on both the incoming and outgoing tides.*

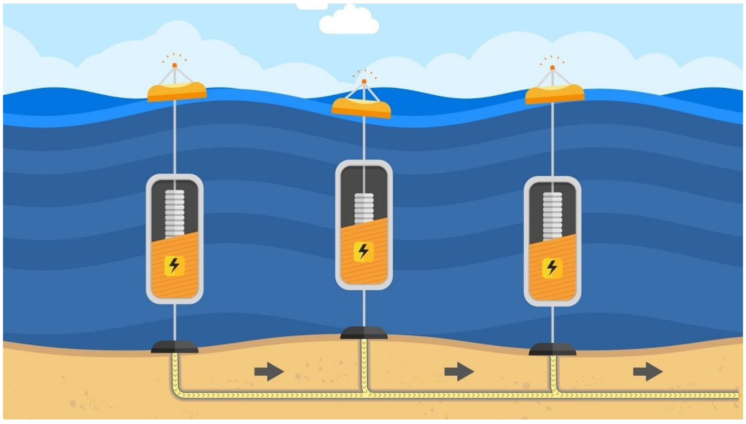

*Fig 12.6 – Wave power. surface buoys rise and fall with ocean waves, driving a linear generator submerged beneath each device; the electricity produced is carried to shore via undersea cables.*

| **Questions** | |
|---|---|
| **1.** Describe how a hydroelectric power station generates electricity. | *(3)* |
| **2.** Give one advantage of tidal power over wind power. | *(1)* |
| **3.** Why might wave power be unreliable? | *(2)* |
| **4.** What environmental problem is associated with hydroelectric dams? | *(2)* |

## Part 3 of 3: Biofuels & Global Energy Trends

| | |
|---|---|
| **Biofuels** (wood, bioethanol, manure) are produced from living things and are considered renewable. | 1 |
| Biofuels are carbon-neutral in theory (CO absorbed growing = CO released burning), but in practice still contribute to climate change. | 2 |
| Disadvantage: land used for biofuel crops cannot grow food — a concern where food shortages exist. | 3 |
| Global primary energy consumption has risen sharply since 1800, driven by industrialisation and population growth. | 4 |
| Renewables are a small but growing fraction; fossil fuels still dominate globally. | 5 |

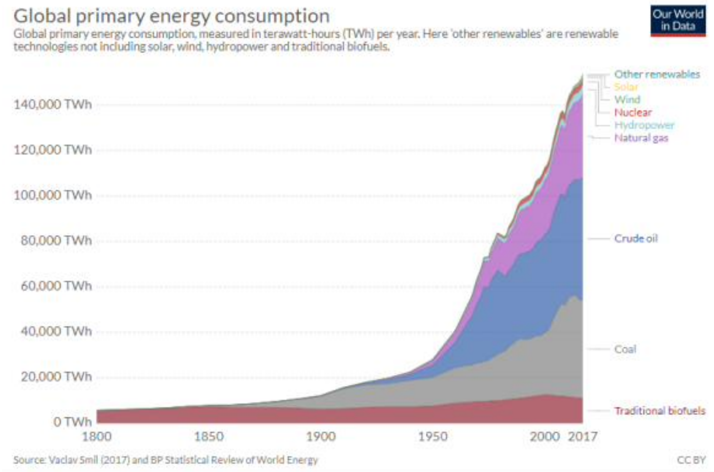


*Fig 12.4 – Global primary energy consumption (TWh/year) since 1800. Coal, crude oil and gas dominate; renewables are rising rapidly.*

| **Questions** | |
|---|---|
| **1.** Why are biofuels considered renewable? | *(2)* |
| **2.** Give one reason why biofuels are not completely carbon-neutral in practice. | *(2)* |
| **3.** From Fig 12.4, when did global energy use begin to increase most rapidly? | *(1)* |
| **4.** What was the main cause of the rapid energy use increase after 1950? | *(2)* |
| **5.** How has the use of renewables compared to non-renewables changed? Give two differences. | *(4)* |

| **Exam Question [6 marks]** | |
|---|---|
| An electric car has a motor powered by a battery. A diesel car has an engine powered by diesel fuel. | |
| **(a)** The table compares the two cars. State one way the electric car is better for the environment. | *(1)* |
| **(b)** Electricity is generated in a gas power station (efficiency 0.35) and transmitted to the electric car (transmission efficiency 0.90). Calculate the overall efficiency of generating and transmitting the electricity. | *(3)* |
| **(c)** Give one reason why renewable energy sources are important for the future. | *(2)* |