

Physics Paper 1 (Combined Foundation)

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1. Energy stores and systems

Energy System

System:

An object or group of objects.

When a system changes there are changes in the way energy is stored within it.

Closed system:

Where neither matter nor energy enters or leaves.

Conservation of energy:

Energy is not created or destroyed but may be transferred between different energy stores.

The energy in a system can be transferred between different stores when work is done by:

- Heating
- Forces
- Current flowing

Energy Store	Example
Thermal	Cup of hot tea
Kinetic	Moving car
Gravitational Potential	Water in a reservoir at the top of a mountain
Elastic Potential	Stretched bungee cord
Chemical	Battery, food
Magnetic	Two opposing north poles on bar magnet
Electrostatic	Two electrons repelling each other
Nuclear	The energy available to be released by fission when splitting an atom

2. Kinetic Energy and Elastic Potential Energy

Kinetic Energy

Kinetic energy of an object depends on the:

- mass
- speed

Kinetic energy (J) = 0.5 x mass (kg) x velocity² (m/s)

$$E_k = 0.5mv^2$$

Unit conversions:

kJ to J: x 1000
g to kg: ÷ 1000

Elastic Potential Energy

A force acting on an object may cause the shape of an object to change.

Elastic objects can store elastic potential energy if they are stretched or squashed. For example, this happens when a catapult is used or a spring is stretched.

Objects can also store elastic potential energy when they are squashed.

Elastic potential energy (J) = 0.5 x spring constant (N/m) x extension² (m)

Unit conversions:

kJ to J: x 1000
cm to m: ÷ 100

3. Work Done

A car braking to slow down

The friction force from the brakes does work. Energy is transferred from the car's kinetic store to the thermal store of its brakes, the brakes then transfer heat to the surroundings.

Energy transferred = work done

work done (J) = force (N) x distance (m)

W = Fs

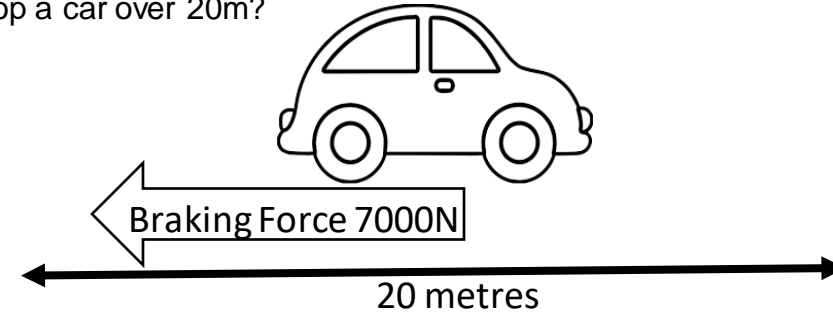
Unit conversions:

kJ to J: x 1000

cm to m: ÷ 100

km to m: x 1000

Example: How much work is done by the brakes if a 7000N braking force is used to stop a car over 20m?



Use the EVERY model to complete calculations:

E = equation

V = values

E = enter results

R = result

Y = units

E $W = F \times s$

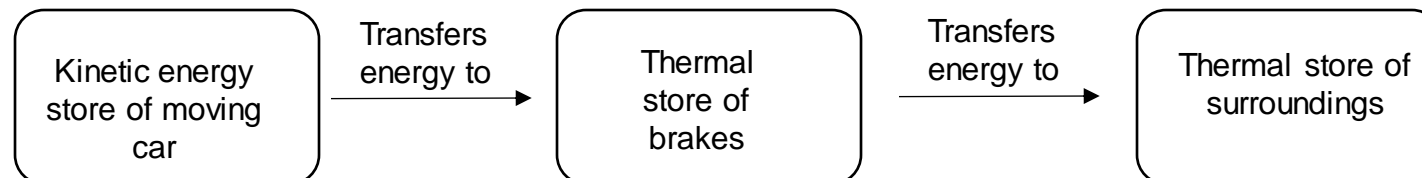
V $F = 7000 \text{ N and } s = 20 \text{ m}$

E $W = 7000 \times 20$

R $W = 140\,000$

Y J

$W = 140000\text{J or } 140 \text{ kJ}$



4. Gravitational Potential Store (E_p)

Raising an object off the ground increases its gravitational potential energy store.

The amount of energy depends on the mass and height of the object and strength of the gravitational field it is in.

Gravitational potential energy store (J) = mass (kg) x gravitational field strength (N/kg) x change in height (m)

$$E_p = mgh$$

Unit conversions:

kJ to J: $\times 1000$

cm to m: $\div 100$

km to m: $\times 1000$

g to kg: $\div 1000$

Note: weight = mass x gravitational field strength

$$W = m \times g$$

Therefore, we have a second formula for E_p

$$E_p = \text{Weight} \times \text{change in height}$$

$$E_p = W \times \Delta h$$

Example: What is the gravitational energy required to lift a 100 kg mass up by 100 m?

Gravitational field strength = 9.81 N/kg

Use the EVERY model to complete calculations:

E = equation

V = values

E = enter results

R = result

Y = units

E $E_p = m \times g \times h$

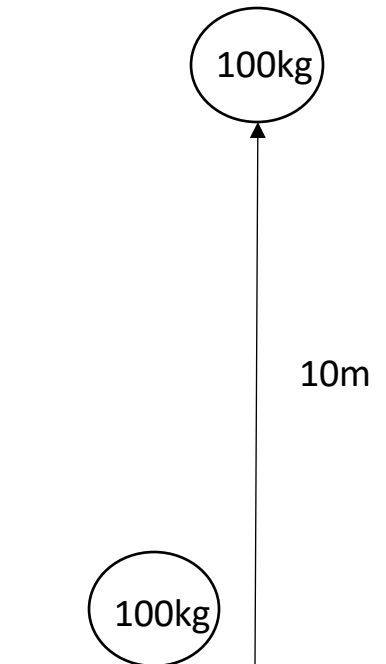
V $m = 100 \text{ kg}; g = 9.81; h = 100 \text{ m}$

E $E_p = 100 \times 9.81 \times 100$

R $E_p = 98100$

Y J

$$E_p = 98100 \text{ J}$$



5. Specific Heat Capacity (c) and Power

The amount of energy needed to raise the temperature of 1 kg of a substance by 1 °C.

$$\begin{array}{l} \text{Change in} \\ \text{thermal} \\ \text{energy (J)} \end{array} = \text{mass (kg)} \times \begin{array}{l} \text{specific} \\ \text{heat} \\ \text{capacity} \\ \text{(J/kg}^\circ\text{C)} \end{array} \times \begin{array}{l} \text{change} \\ \text{in} \\ \text{temperature} \\ \text{(}^\circ\text{C)} \end{array}$$

$$\Delta E = mc\Delta T$$

Unit conversions:

kJ to J: x 1000
g to kg: ÷ 1000

Example: How much energy is released into the surroundings when a cup of tea holding 250g of fluid cools from 90°C to 20°C? $c = 4200 \text{ J/kg}^\circ\text{C}$

Use the EVERY model to complete calculations:

E = equation

V = values

E = enter results

R = result

Y = units

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

V $m = 250 \text{ g} = 0.25 \text{ kg}; c = 4200; \Delta\theta = 90 - 20 = 70$

E $\Delta E = 0.25 \times 4200 \times 70$

R 73 500

Y J

$$\Delta E = 73500\text{J or } 73.5 \text{ kJ}$$

Power

Power is the rate at which energy is transferred and is measured in watts.

1 watt = 1 joule of energy transferred per second.

$$\text{Power (W)} = \text{energy transferred (J)} \div \text{time (s)}$$

$$\text{Power (W)} = \text{work done (J)} \div \text{time (s)}$$

$$P = E \div t$$

Unit conversions:

kJ to J: x 1000
minutes to seconds: x 60
hours to seconds: x 3600
W to kW: ÷ 1000

Example. Calculate the power of a motor that uses 60,000 J of energy to lift an object in 20 seconds. Give your answer in kW.

E $P = E \div t$

V $E = 60\,000\text{J}; t = 20 \text{ s}$

E $P = 60\,000 \div 20$

R 3000

Y W

$$P = 3000\text{W or } 3\text{kW}$$

A more powerful device can transfer more energy in a given time or will transfer the same amount of energy in a faster time.

6. Conservation of Energy

Dissipation of energy	<p>Wasting energy.</p> <p>More energy needs to be put into appliance to account for dissipated energy.</p> <p>Useful dissipation of energy example: back of a fridge</p> <p>Example of dissipation of energy is bad: light bulbs, engines and TV's as heat</p>
Conservation of energy	Energy can be transferred usefully, stored or dissipated, but it cannot be created or destroyed
Heat	When an object is heated, thermal energy is being transferred to it
Temperature	A measure of hot or cold something is

Reducing Wasted Energy (dissipated energy)

Friction	Between two moving objects causes thermal energy to be dissipated. It can be reduced by lubrication.
Lubrication	<ul style="list-style-type: none"> Friction between two moving objects causes energy to be dissipated as sound and to the thermal store.
Insulation	Reduces energy transfer by heating
Cavity wall insulation	Fills the air gap between the inner and outer wall reducing heat loss by convection.
Loft insulation	Reduces heat loss by convection.
Double glazing	<ul style="list-style-type: none"> Creates an air gap between the two panes of glass to reduce energy loss by conduction. Gases are good insulators
Draught excluders	Reduce energy loss by convection when placed around windows and doors.

7. Efficiency

Appliance	Useful Energy	Dissipated (wasted) Energy
Light bulb	Light	<ul style="list-style-type: none"> • Heating the bulb and surroundings
Hair Dryer	<ul style="list-style-type: none"> • Kinetic energy of the fan to push air • Heating of the air 	<ul style="list-style-type: none"> • Sound of the motor. • Heating of the dryer and surroundings
Electric Motor	<ul style="list-style-type: none"> • Kinetic energy of objects driven by motor. • Gravitational potential energy of objects lifted by motor 	<ul style="list-style-type: none"> • Heating of the motor and surroundings. • Sound of the motor turning

Efficiency

An efficient device wastes less energy than a less efficient device. It can be calculated as a decimal or multiplied by 100 to give a percentage.

$$\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy output}}$$

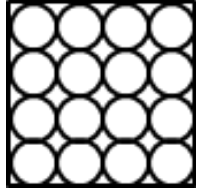
$$\text{Efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

Example: Calculate the wasted power and efficiency of a motor that has a rated power of 500W and transfers 300W usefully.

$$\text{Wasted power} = \text{input power} - \text{output power} = 500 - 300 = 200\text{W}$$

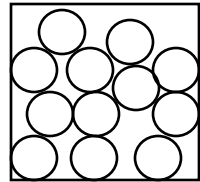
$$\text{Efficiency} = \frac{300}{500} = 0.6 \text{ Or } 60\%$$

8. Methods of Heat Transfer Overview



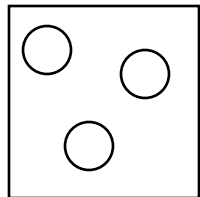
Solids

Have **strong forces** between particles or molecules, holding them close together in a **fixed, regular** arrangement. The particles can only vibrate around fixed positions.



Liquids

Have **weaker forces** between particles so although the particles are close together they can **flow** over each other at low speeds in random directions.



Gases

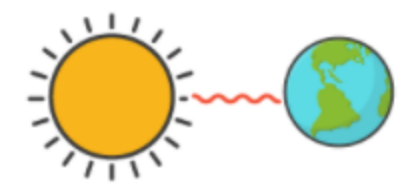
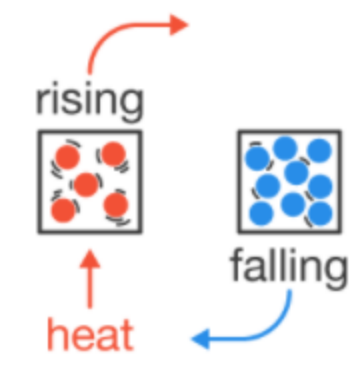
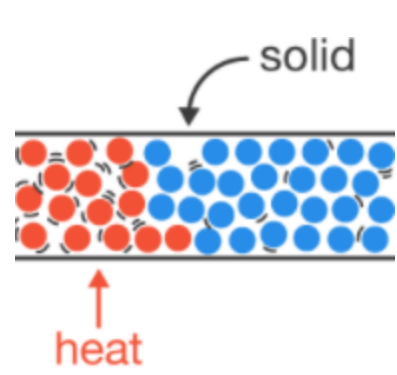
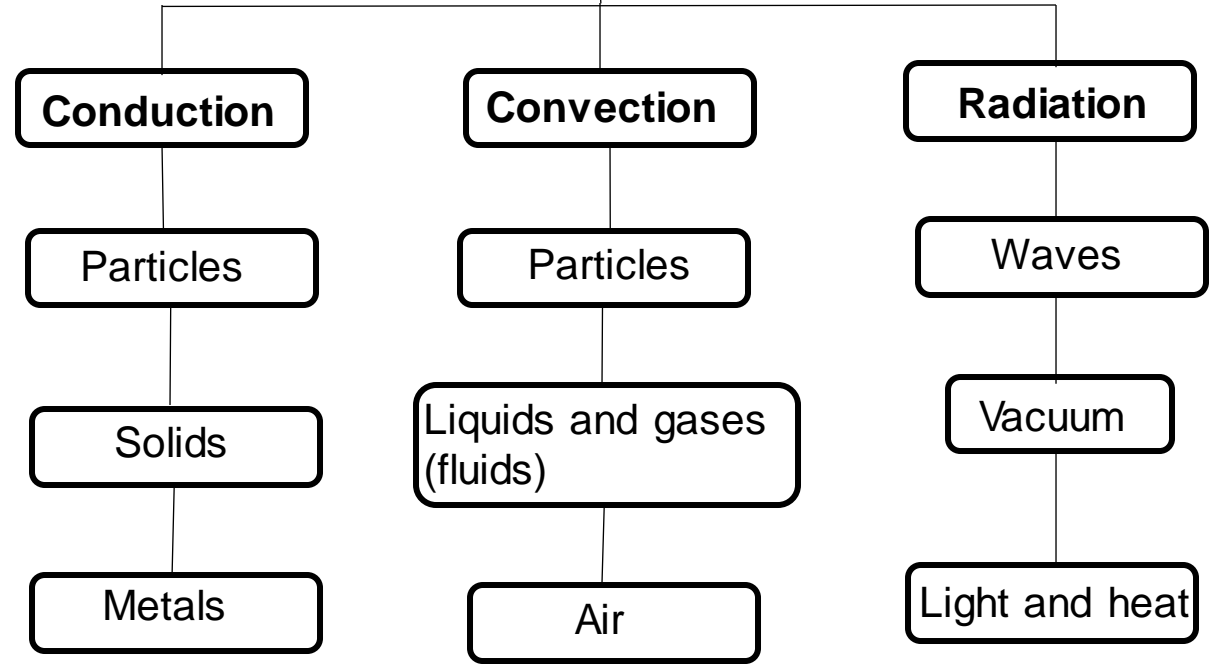
Have almost **no forces** between particles. Have **more energy** and are **free to move** in random directions and speeds.

TRAVELS VIA

MEDIUM

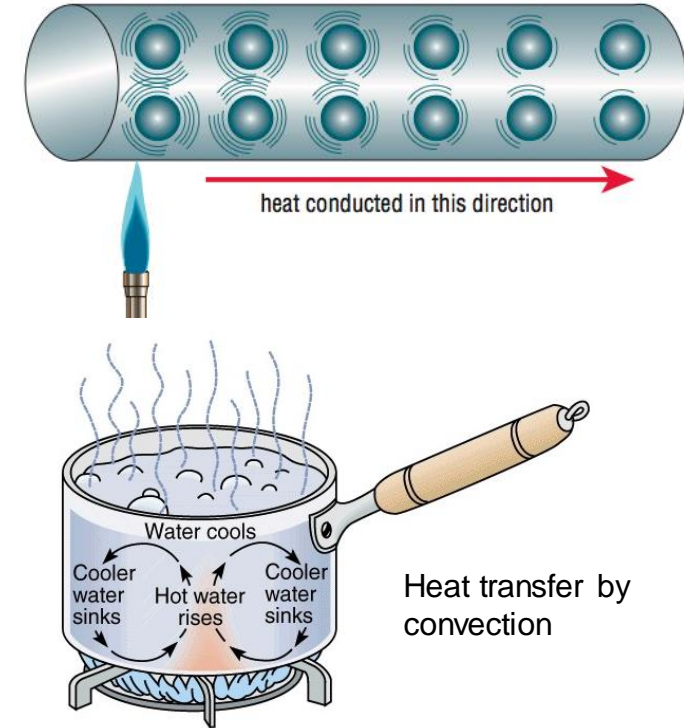
EXAMPLE

Methods of heat transfer



9. Methods of Heat Transfer

Heat Transfer Method	Description
Conduction (Occurs in solids)	<p>When heated particles vibrate more with an increase in their kinetic energy.</p> <p>They collide more with surrounding particles transferring the heat</p>
Convection (Occurs in liquids and gases)	<p>Particles are free to move (in a liquid and gas). Increase in their kinetic store. Particles move faster.</p> <p>The space between the particles increases, so the density decreases.</p> <p>The warmer less dense region rises and the cooler, denser regions sink.</p>
Infrared Radiation (Occurs in all objects)	<p>The hotter an object the more infrared radiation it emits in a given time.</p> <p>An object at constant temperature emits and absorbs infrared radiation at the same rate</p> <p>A perfect black body absorbs all the infrared radiation that falls upon it and then emits it back at the same rate as it absorbs it.</p>



10. Non-Renewable Energy Resources

Renewable energy resources will never run out. It is an energy resource that can be replenished quickly.

Non-renewable resources will one day run out (fossil fuels). Fossil fuels are coal, oil and natural gas.

Energy Resource	Uses	Advantages	Disadvantages
Coal	Electricity generation, heating, steam trains in some countries	<ul style="list-style-type: none">• Reliable energy resource• Low extraction costs• High energy per kg	All fossil fuels are running out. Burning fossil fuels releases carbon dioxide a greenhouse gas which causes global warming. SO ₂ found in coal leads to acid rain when burned.
Oil	Electricity generation, heating, basis for petrol and diesel	<ul style="list-style-type: none">• Reliable energy resource• Low extraction costs• High energy per kg	Burning fossil fuels releases carbon dioxide a greenhouse gas which causes global warming.
Gas	Electricity generation, heating, cooking	<ul style="list-style-type: none">• Reliable energy resource• Gas fired power stations can be started quickly to meet changing energy demands	Burning fossil fuels releases carbon dioxide a greenhouse gas which causes global warming.
Nuclear	Electricity generation Fuel: Uranium or plutonium	<ul style="list-style-type: none">• Reliable energy resource• It has the highest energy density per kg of any fuel.• Does not require combustion and therefore does not release carbon dioxide into the atmosphere	The waste products from nuclear plants is dangerous radioactive waste which needs to be stored safely for hundreds of years.

11. Renewable Energy Resources 1

Energy Resource	Uses	Advantages	Disadvantages
Solar Energy	<ul style="list-style-type: none"> • Heating domestic hot water. • Photovoltaic cells can create electricity to charge batteries. • Electricity generation in large scale solar power plants 	<ul style="list-style-type: none"> • No atmospheric pollution due to burning of fossil fuels • In sunny countries it is more reliable (during the day) • Useful for remote places not supplied by the national grid. • No fuel costs and minimal running costs 	<ul style="list-style-type: none"> • Cannot increase supply to match demand • High initial costs • Unreliable
Wind Power	Electricity generation	<ul style="list-style-type: none"> • No atmospheric pollution due to burning of fossil fuels • No fuel costs and minimal running costs • No permanent damage to the landscape when removed. • Fast start-up 	<ul style="list-style-type: none"> • Visual and noise pollution • Cannot increase supply to match demand • High initial costs • Cannot generate electricity if there is too little wind • Unreliable
Geothermal	<ul style="list-style-type: none"> • Electricity generation • Heating 	<ul style="list-style-type: none"> • Reliable • No atmospheric pollution due to burning of fossil fuels 	<ul style="list-style-type: none"> • Few suitable locations (only possible in volcanic areas) • High cost to build power station
Bio-fuels	<ul style="list-style-type: none"> • Electricity generation • Heating • Fuel for transport 	<ul style="list-style-type: none"> • Carbon neutral (if plants are grown at the same rate as being burned). • Reliable as crops grow quickly 	<ul style="list-style-type: none"> • High costs to refine the fuel • Space for growing food taken up • Forests cleared to make space – decay and burned vegetation release CO₂ and methane.

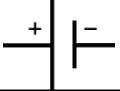
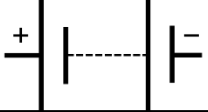
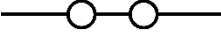
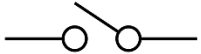
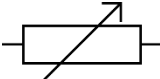
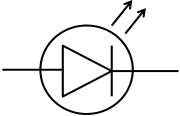

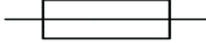

12. Renewable Energy Resources 2

Energy Resource	Uses	Advantages	Disadvantages
Hydro-Electric	Electricity generation	<ul style="list-style-type: none"> • Can respond immediately to increased demand, fast start-up. • Reliable (except if there is a drought) • No fuel costs and minimal running costs • Potential to be used as part of pumped storage scheme 	<ul style="list-style-type: none"> • Requires land to be flooded to create a dammed reservoir • Loss of animal habitats • Relies on rainfall to keep reservoir full unless part of pumped storage system
Tidal barrage	Electricity generation	<ul style="list-style-type: none"> • No atmospheric pollution due to burning of fossil fuels • No fuel costs and minimal running costs 	<ul style="list-style-type: none"> • Visual pollution • Difficulty providing access for boats / wildlife • Initial costs are high • Environmental impact during building phase due to multiple vehicles and large amounts of concrete being used
Wave power	Electricity generation	<ul style="list-style-type: none"> • No atmospheric pollution due to burning of fossil fuels • Smaller solution for limited populations 	<ul style="list-style-type: none"> • Unreliable • Few suitable locations

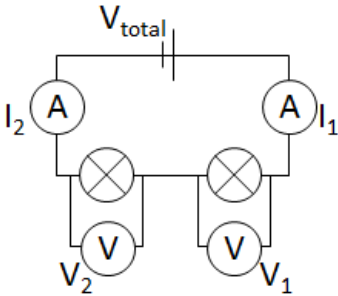
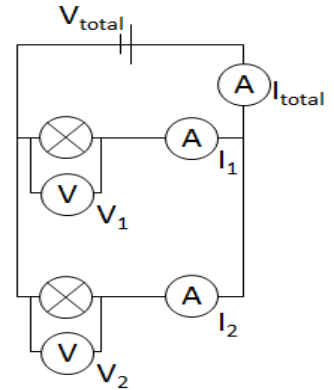
13. Electrical Terms

Keyword	Definition
Ampere (A)	Unit of electric current.
Current (I)	The flow of electrical charge. Measured in Amps (A)
Direct potential difference	Potential difference in one direction
Electric circuit	A collection of electronic components connected by a conductive wire that allows for electric current to flow.
Ohm (Ω)	Unit for resistance.
Potential difference (V)	The force that pushes the charge around. Measured in volts (V).
Resistance (R)	Reduces the flow of current. Measured in ohms (Ω).
Resistor	Component that prevents the flow of electric current.
Volt (V)	The standard unit of measure for electric potential (voltage).
Watt (W)	The standard unit of measure used for electric power.

14. Electrical Components

Component	Circuit symbol	Function
Cell		'Pushes' the electrons around a complete circuit.
Battery		
Closed switch		Break and complete a circuit, so turn on and off.
Open switch		
Variable resistor		Allows the current in a circuit to be varied. Placed in series within the circuit.
Light emitting diode (LED)		Emits light when current passes through it. Placed in series within the circuit.
Ammeter		Used to measure current through a circuit. Placed in series within the circuit.
Fuse		A glass or ceramic canister containing a thin wire that melts if the current gets too high. Placed in series within the circuit.
Voltmeter		Used to measure potential difference (voltage) across a component. Placed in parallel within the circuit.

15. Series and Parallel Circuit Rules

	Series Circuit	Parallel Circuit
Number of loops	1	2+
Current	Same all the way round	Shared across the components $I_{total} = I_1 + I_2 + \dots$
Potential difference	Shared across the components $V_{total} = V_1 + V_2 + \dots$	Same across the components $V_1 = V_2 = \dots$
Resistance	Add together $R_{total} = R_1 + R_2 + \dots$	Total resistance will decrease if two or more resistors are added in parallel. Resistors in parallel have the same pd across them as the power supply. Adding another loop to the circuit means the current has more than one way it has to go. The total current around the circuit increases . An increase in current means a decrease in resistance ($V = IR$)
	$V_{total} = IR_{total}$	$R_1 = V_{total} / I_1$ $I_1 =$ current flowing through R_1 $R_1 =$ Resistance of lamp 1
Example of a circuit		

16. Current, potential difference and resistance

The current (I) through a component depends on both the resistance (R) of the component and the potential difference (V) across the component.

The resistance of an electrical component can be found by measuring the electric current flowing through it and the potential difference across it.

Ohm's Law, shows the relationship between potential difference, current and resistance:

Potential difference (V) = Current (A) x Resistance (Ω)

$$V = IR$$

Resistance is the opposite to current:

The higher the resistance of a circuit, the lower the current

Good conductors have a **low** resistance and insulators have a **high** resistance

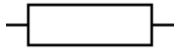
The current through a component depends on both the resistance R of the component **and** the potential difference V across the component

The **greater** the resistance R of the component, the **lower** the current for a given potential difference V across the component

The **lower** the resistance R of the component, the **greater** the current for a given potential difference V across the component

17. I-V Characteristics and Circuit Devices 1

Fixed Resistor



Purpose: Limits the current in a circuit.

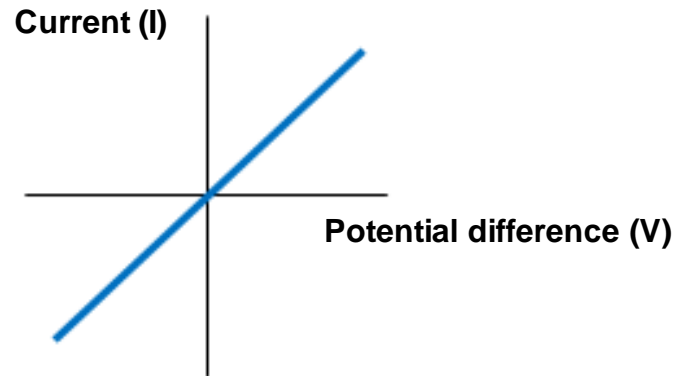
At a constant temperature, the potential difference is **directly proportional** to the current.

If the potential difference increases, the current increases.

The resistance doesn't change when the current changes.

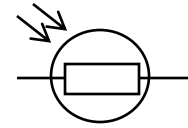
Obeys Ohm's law. It is an ohmic conductor.

Obeys $V = IR$



If the temperature changes, the resistance will change.

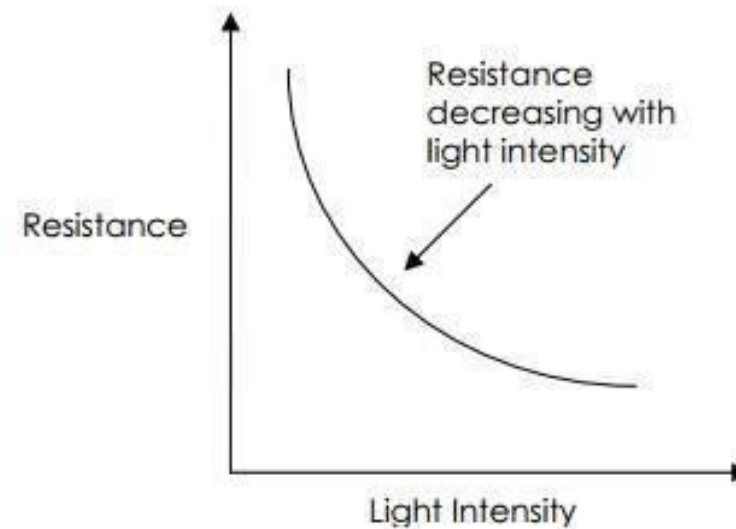
Light Dependent Resistor (LDR)



Used for: Automatic night lights

Bright light – low resistance

Darkness – high resistance



18. I-V Characteristics and Circuit Devices 2

Filament bulb



Property: Emits light when current flows through it.

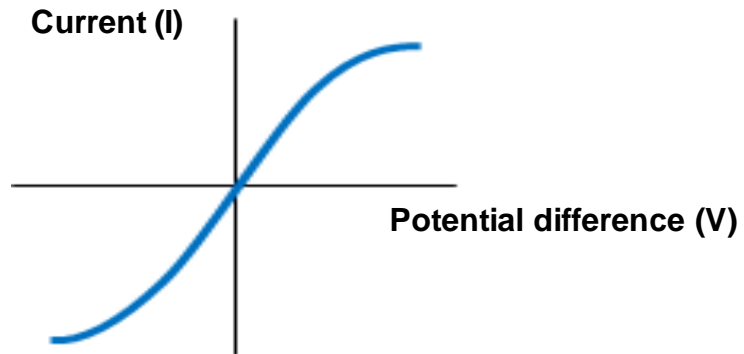
As the current increases, the filament wire gets hotter. The higher the current, the higher the temperature.

Resistance increases.

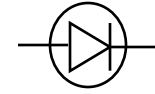
Harder for current to flow.

Graph gets less steep.

It is a non-ohmic conductor



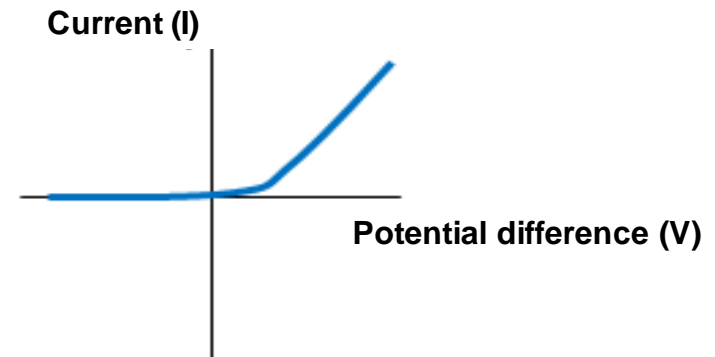
Diode



Property: allows current through in only one direction

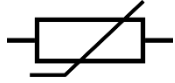
The resistance depends on the direction of the current. As a diode only lets current flow in one direction, it has a very high resistance in the opposite direction, which makes it hard for the current to flow that way.

It is a non-ohmic conductor



19. I-V Characteristics and Circuit Devices 3

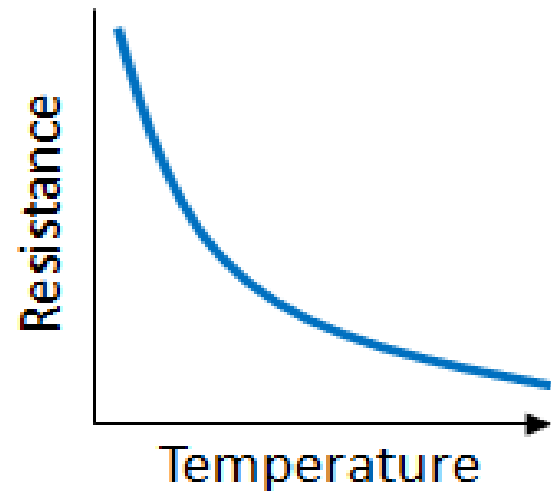
Thermistor



Use: central heating thermostats

High temperature – low resistance

Cold temperature – high resistance



20. National Grid and AC DC supply

National Grid: A network of cables and transformers that connect power stations to consumers.

How step up transformers makes the National Grid efficient:

- Increases the potential difference
- Decreases the current
- Less energy loss

A huge amount of power is needed.

Increase efficiency: Use a high potential difference but a low current.

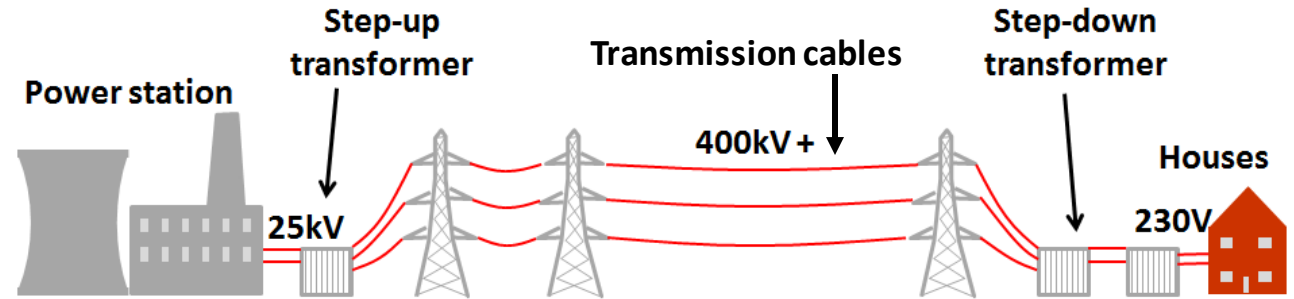
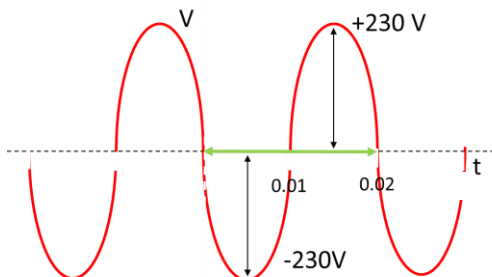
A high current would cause the wires to heat up, wasting a lot of energy (dissipated as heat).

Alternating Current (AC)

The current constantly changes direction. It is produced by an alternating voltage where the positive and negative ends keep alternating.

The UK mains supply is AC at 230V.

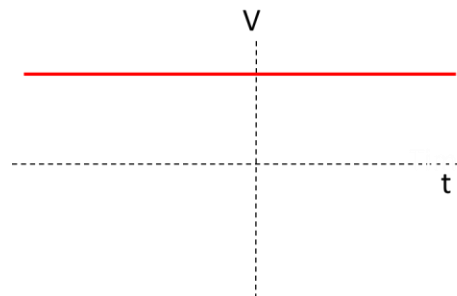
It has a frequency of 50Hz.



Direct Current (DC)

The current always flows in the **same direction**.

Batteries produce a DC voltage.



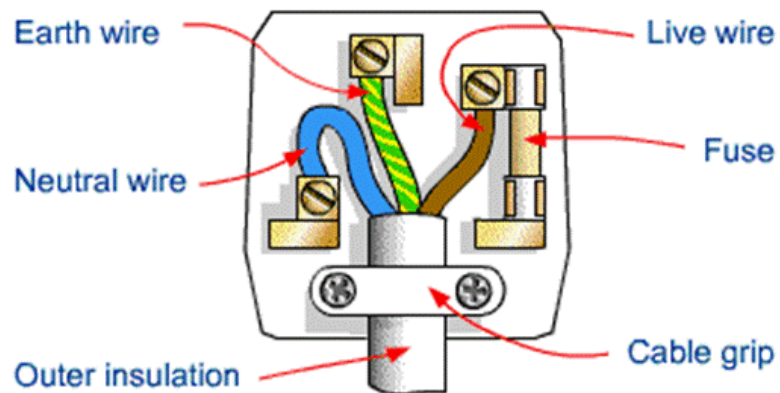
	Underground cables	Overground cables
Advantages	No visual pollution Less affected by the weather	No need to dig up the ground. Easy to repair
Disadvantages	Bigger disturbance to the land Difficult to access to repair	Visual pollution Affected by the weather

21. Electricity in the home

Electrical Wiring

Most electrical appliances are connected to the mains with a three-core cable (3 copper wires coated in insulating plastic).

Wire	Colour	Voltage (V)	Purpose
Live	Brown	230	Provides an alternating potential difference
Neutral	Blue	0	Completes the circuit carrying the current out of the appliance
Earth	Green and yellow	0	A safety feature. Prevents the appliance becoming live if there is a fault so does not normally carry a current.



Live Wire

If you touch the live a large pd is produced across your body and the current flows through you.

This electric shock can injure or kill you.

A connection between the live and earth creates a low resistance path to earth so a large current will flow.

This could cause a fire.

Fuses are placed in series with the live wire to limit the amount of current flowing in a circuit. If a fault occurs the current can be very high, so a fuse is used for safety.

A fuse is a thin piece of wire which all the current flows through, it gets hot and melts if too high a current flows through it, preventing any current flow.

Double Insulated Appliances

Some appliances have no earth wire.

They have a plastic non-conducting outer case and are designed so that the live and neutral wires cannot come into contact with the external casing.

This can be done by placing the wire terminals inside a plastic surrounding box.

22. Electrical power and charge

Power

Energy in an electrical circuit is transferred by a moving charge. The charge has to work against resistance, so work is done. Work done is the same as energy transferred and depends upon power.

$$\text{Energy transferred (J)} = \text{Power (W)} \times \text{Time (s)}$$

$$E = Pt$$

e.g. How much energy is transferred by a 3kW kettle in 2 minutes.

E	$E = Pt$
V	$P = 3 \text{ kW} = 3000\text{W}$ and $t = 2 \text{ min} = 120\text{s}$
E	$E = 3000 \times 120$
R	$E = 360\,000$
Y	J

$E = 360\,000\text{J}$ or 360 kJ .

Power Calculations

$$\text{Power (W)} = \text{Current (A)} \times \text{Potential difference (V)}$$

$$P = IV$$

$$\text{Power (W)} = \text{Current}^2 \text{ (A)} \times \text{Resistance } (\Omega)$$

$$P = I^2R$$

Charge

$$\text{Energy transferred (J)} = \text{Charge (C)} \times \text{Potential difference (V)}$$

$$E = QV$$

$$\text{Charge (C)} = \text{Current (A)} \times \text{Time (s)}$$

$$Q = It$$

An amp is the amount of charge flow per second.
1 amp = 1 coulomb per second.

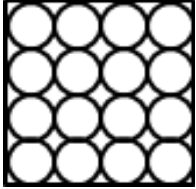
Unit conversions

kJ to J x 1000

minutes to seconds x 60

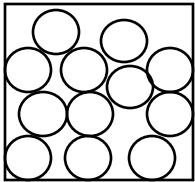
hours to seconds x 3600

23. The particle model



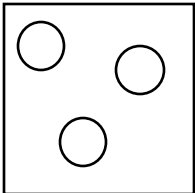
Solids

Have **strong forces** between particles or molecules, holding them close together in a **fixed, regular** arrangement. The particles can only vibrate around fixed positions.



Liquids

Have **weaker forces** between particles so although the particles are close together they can **flow** over each other at low speeds in random directions.



Gases

Have almost **no forces** between particles. Have **more energy** and are **free to move** in random directions and speeds.

Density

Closer the particles, the denser the material

$$\text{Density (kg/m}^3\text{)} = \text{mass (kg)} \div \text{volume (m}^3\text{)}$$

$$\text{Density (g/cm}^3\text{)} = \text{mass (g)} \div \text{volume (cm}^3\text{)}$$

$$\rho = m \div v$$

e.g. What is the density of 1kg of water?

Volume of 1kg of water = 0.001m³.

E $\rho = m \div v$

V $m = 1\text{kg and } v = 0.001\text{m}^3$

E $\text{Density} = 1 \div 0.001$

V 1000

Y kg/m³

24. Internal Energy

If we increase the energy of the particles, it will either:

- Increase the temperature of the substance
- Change its state i.e. change from a solid to a liquid

Internal energy (energy stored by particles in a system) = Kinetic energy of particles (e.g. vibration of atoms) + Potential energy of particles (spacing between the particles)

Temperature is a measure of the average kinetic energy of the particles.

A temperature change depends on the mass of substance, what it is made from and the energy input (see specific heat capacity).

If the substance is heated sufficiently particles have enough energy in their kinetic stores to break the bonds holding them together and so a change in state occurs.

All changes of state do not affect the kinetic energy of the particles so are constant temperature processes.

Evaporation of a liquid: The particles at a liquid's surface sometimes gain enough energy to leave the surface as a gas

Increase rate of evaporation by:

- Increasing the surface area of liquid.
- Increasing the temperature of the liquid.
- Creating a flow of air across the liquid's surface.

Condensation of a gas: The water molecules that are in the air can hit a cool surface, cool down and therefore stay there.

Increase rate of condensation by:

- Increasing surface area
- Reducing surface temperature

25. Specific latent heat

Specific Latent Heat – the energy needed to change the state of 1kg of a substance

Thermal energy (J) = mass (kg) x specific latent heat (J/kg)

$E = ml$

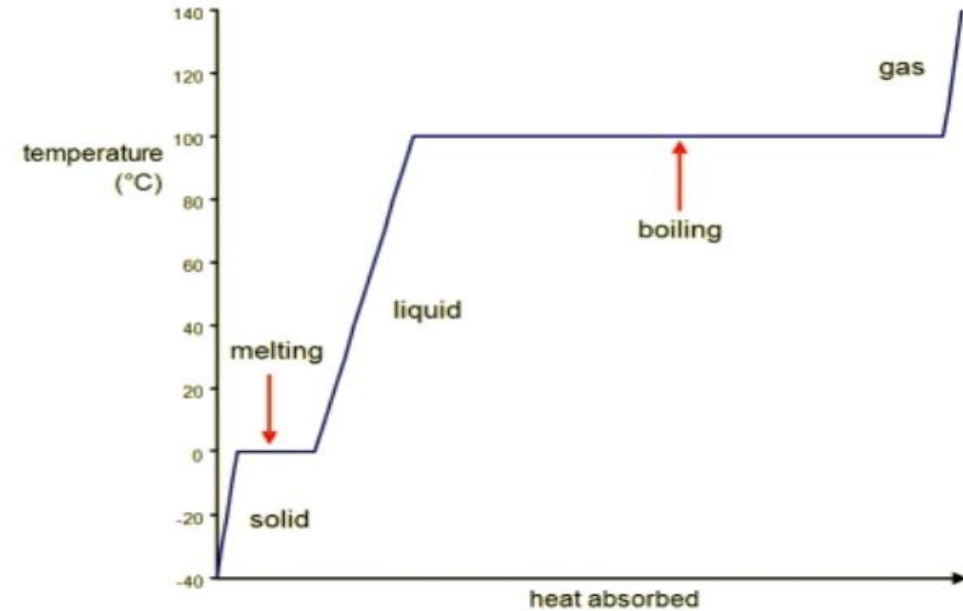
e.g. How much energy is required to melt 1.5kg of ice. L_f water = 334 kJ/kg.

E	$E = ml$
V	mass = 1.5kg and specific latent heat of fusion = 334kJ/kg
E	$E = ml = 1.5 \times 334\ 000$
V	$E = 501\ 000$
Y	J

$E = 501\ 000\text{J}$ or 501 kJ

Specific latent heat of fusion (l_f) = change of state from solid to liquid

Specific latent heat of vaporisation (l_v) = change of state from liquid to vapour



Gradient of the line = specific heat capacity of the substance.

Steeper the line, the higher the specific heat capacity of the substance

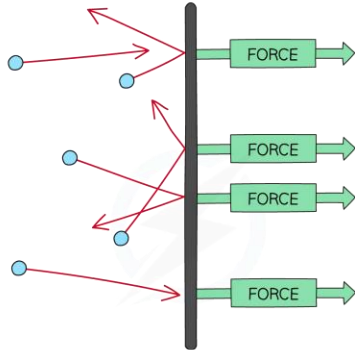
Horizontal line = specific latent heat

Longer the horizontal line = greater the specific latent heat of fusion/vaporisation

26. Particles in gases

Gas Pressure:

When the particles in a gas collide with the side of the container they exert a force on it. This force acts at right angles to the container walls.



In a sealed container, the gas pressure is the total force of all the particles on the area of the container walls.

Increasing the temperature of the gas (whilst keeping the volume constant)

- increases pressure
- Increases the average kinetic energy of the particles. Particles move faster so collide with the sides more often and with more momentum
- A larger total force is exerted
- The pressure increases.

Work Done

Work is done when energy is transferred by applying a force.

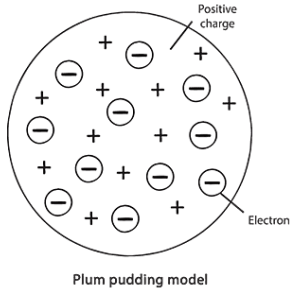
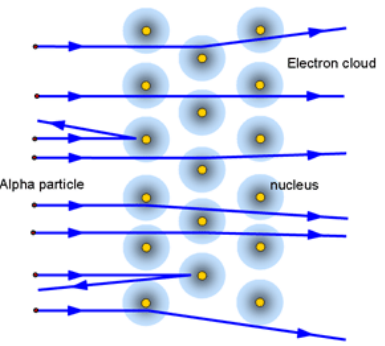
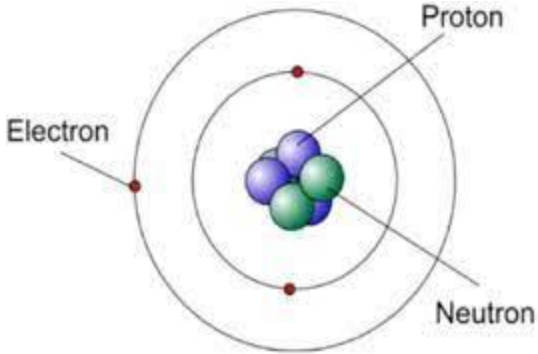
Work done on a gas increases its internal energy. This can increase the temperature of the gas.

Pumping up a bike tyre does work mechanically. The gas exerts a force on the plunger (due to pressure). To push the plunger down against this force, work must be done. Energy is transferred to the kinetic stores of the gas particles, increasing the temperature.

By increasing the volume:

- The particles will bump into the container walls less frequently
- Particles must travel further between each impact with the container
- Reduces the total force per metre of surface area
- Pressure reduces.

27. Atomic models

Atomic model	Plum pudding model		Nuclear model		
Diagram	 <p>Positive charge</p> <p>Electron</p> <p>Plum pudding model</p>	 <p>Electron cloud</p> <p>Alpha particle</p> <p>nucleus</p>	 <p>Proton</p> <p>Neutron</p> <p>Electron</p>		
Discovery	Electron	Positive nucleus in the centre of the atom	Electrons occupy shells	Neutrons	<ul style="list-style-type: none"> • Atomic radius: 1×10^{-10} m • Radius of a nucleus is less than 1/10 000 of the radius of an atom. • Most of the mass of an atom is concentrated in the nucleus. • The electrons are arranged at different distances from the nucleus.
Description	The atom is a ball of positive charge with negative electrons embedded in it.	Positively charged alpha particles were fired at thin gold foil. Most alpha particles went straight through the foil. A few were scattered in different directions by the atoms in the foil. It showed that the mass of an atom was in the centre (the nucleus) and the nucleus was positively charged.		Proved the existence of isotopes	
Discovered by	Thompson	Rutherford	Bohr	Chadwick	

28. Isotopes and Radiation

Isotopes: Atoms of the same element that have different numbers of neutrons but the same number of protons and electrons. They have the same chemical properties but different physical properties.

${}^{16}_8\text{O}$ 8 protons, 8 electrons and 8 neutrons

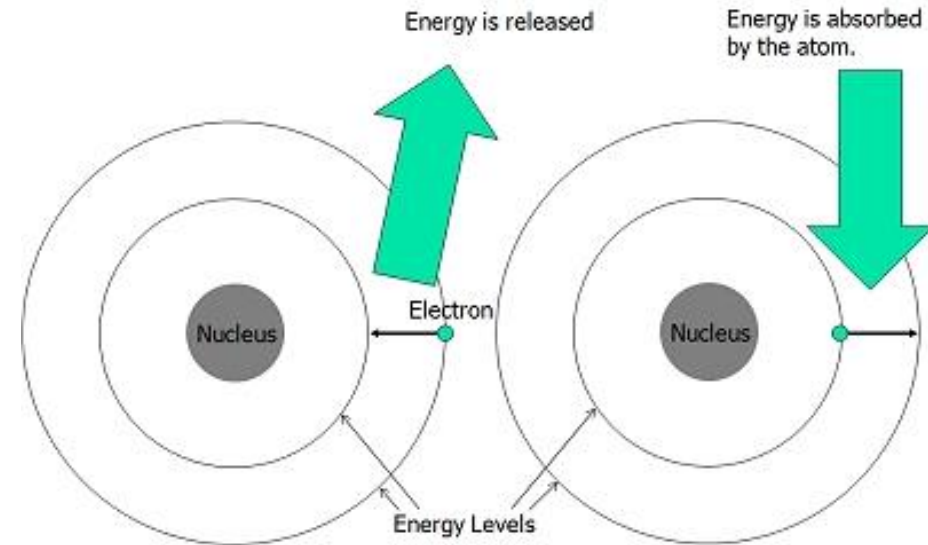
${}^{18}_8\text{O}$ 8 protons, 8 electrons and 10 neutrons

Isotopes that give out nuclear radiation are called radioactive isotopes.

Radioactive atoms have an unstable nucleus.

They give out (emit) radiation from their nucleus.

Doing this makes the atom more stable



When an electron moves to a lower energy level, the electron releases electromagnetic radiation (left hand picture).

When an electron moves to a higher energy level, the electron absorbs electromagnetic radiation (right hand picture).

29. Nuclear Radiation

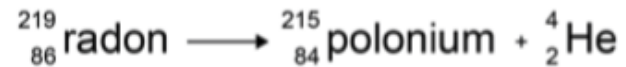
	Alpha	Beta	Gamma
Symbol	${}^4_2\alpha$	${}^0_{-1}e$	${}^0_0\gamma$
What is it?	Helium nuclei	Fast moving electron	Electromagnetic wave
Electrical charge	+2	-1	0
No. of protons	2	0	0
No. of neutrons	2	0	0
Stopped by	Paper, thin sheet of aluminium and lead	Thin sheet of aluminium and lead	Lead
Ionising power (how easy it is to form an ion)	Strong	Weak	Very weak
Penetrating power	Low	Medium	High
Range in air	Few cm	Several metres	Many metres
Uses	Smoke alarms	Monitor thickness of paper and detect leaks in pipes.	Treat cancer. Sterilise medical equipment.
Effect of electromagnetic field	Weakly deflected	Strongly deflected	Not deflected

30. Nuclear equations and half lives

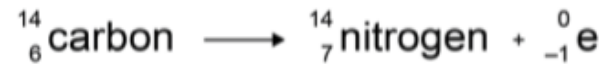
Decay: Radioactive decay is a random event.

Man made source of radiation:

Alpha decay causes the **charge** and **mass** of the nucleus to **decrease** as the nucleus releases the alpha particle



Beta decay causes the **charge** of the nucleus to **increase** but the mass remains the same. Within the nucleus a neutron is changed into a proton and releases an electron (beta particle)



Gamma rays do not change the mass or charge of the atom they are emitted from

Neutrons can also be an emitted form of radiation

Half-Life:

The time taken for the number of radioactive nuclei in an isotope to halve.

Activity (the rate at which a source decays) is measured in Becquerel's Bq (1Bq = 1 decay per second).

e.g. if the initial activity of a sample is 600Bq what will it be after two half-lives?

$$1 \text{ half life} = 600 \div 2 = \mathbf{300Bq}$$

$$2 \text{ half lives} = 300 \div 2 = \mathbf{150Bq}$$

e.g. What fraction remains radioactive after 40 years if the half-life of an isotope is 10 years?

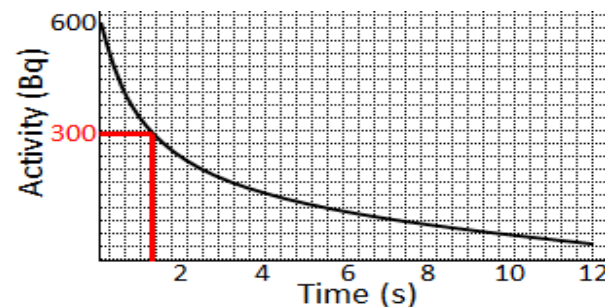
Number of half-lives = $40/10 = 4$ half-lives.

After 1 half life – $\frac{1}{2}$ remains

After 2 half lives - $\frac{1}{4}$ remains

After 3 half lives – $\frac{1}{8}$ remains

After 4 half lives - $\frac{1}{16}$ remains or 6.25%



Finding half-life from a graph:

- Mark where half the activity level is.
- Find the corresponding time (1.8s in this example)

31. Applications of radiation, contamination and irradiation

Applications of radiation	Radioactive contamination	Irradiation
<p>Destruction of unwanted tissue (cancer) or imaging internal organs.</p> <p>Radio-isotopes with a short half-life are used to limit any damage.</p> <p>Alpha radiation cannot be used for imaging because it cannot penetrate body tissue and it is highly ionising.</p> <p>Over exposure to ionising radiation can damage cells and lead to cancer</p>	<p>The unwanted presence of radioactive materials. The level of hazard depends on the type of radiation and the amount of time you are exposed.</p> <p>Nuclear power plant fuel rods and medical equipment with radioactive sources can have sources that we need to store safely for long periods of time at the end of their useful life.</p>	<p>Where an object is deliberately exposed to a radioactive source.</p> <p>Used to sterilise medical equipment and food.</p> <p>The irradiated object does not become radioactive, so it is safe.</p>

Natural background radiation	It comes from either natural sources such as cosmic rays or radioactive rocks.
Man-made radiation	Medical x-rays or radiotherapy Nuclear testing or accidents e.g. Chernobyl
Dose	<p>The amount of radioactivity we are exposed to.</p> <p>Measured in sieverts (Sv). 1000 mSv = 1Sv</p> <p>How big a dose you receive will depend on where you live and what your job is.</p>
Why radioactive waste should have a short half-life	<p>Activity decreases quickly</p> <p>Risk of harm decreases quickly</p>

32. Required practical 1: Specific Heat Capacity

Method

1. Take a 1 kg block of copper.
2. Place an immersion heater in the larger hole in the block.
3. Connect the power supply to the joule meter (reset to read 0 Joules).
4. Connect the joule meter to the 12V immersion heater.
5. Place the thermometer into the other hole in the block.
6. Switch the power pack to 12 V. Turn it on.
7. After 1-minute record the temperature of the block and the reading from the joule meter.
8. Continue taking readings every minute until 10 minutes have passed.

IV - Work done – (energy transferred to block measured by joulemeter)

DV - temperature

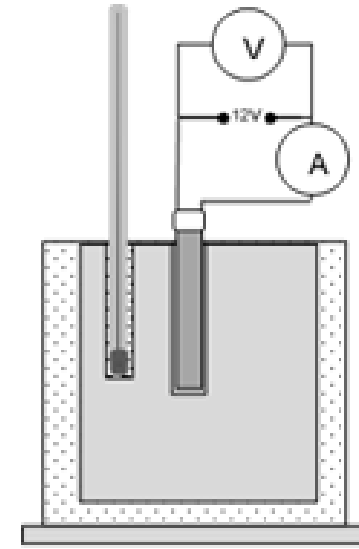
CV – Copper block of 1kg mass

Sources of Error

Heat is lost to the surroundings due to lack of insulation

The immersion heater is not fully immersed into the block

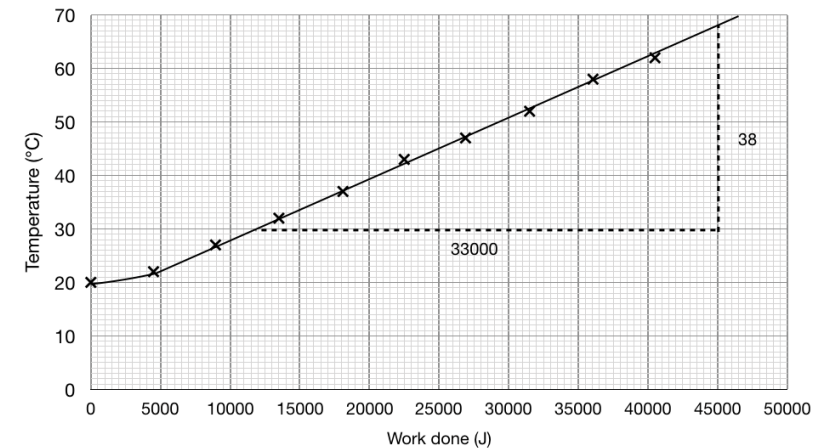
The graph may be curved at the start because it takes time for the heater and block to transfer the energy



Processing data

Plot graph work done against temperature

Specific heat capacity = $1 \div \text{gradient}$



33. Required Practical 2: Thermal Insulation

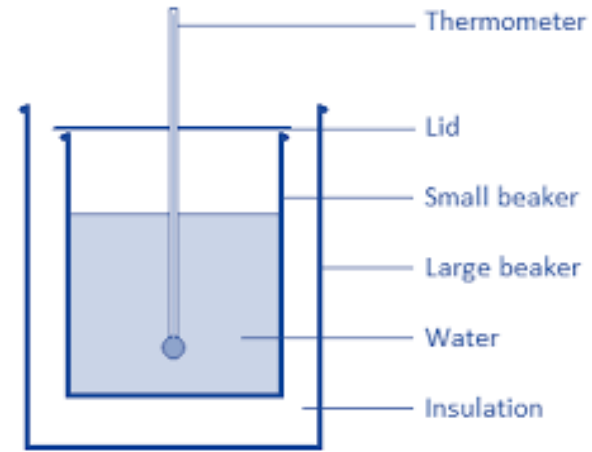
Method

1. Pour 200 cm³ of hot water into a 250 ml beaker with a single layer of insulating material around it.
2. Use a piece of cardboard as a lid for the beaker.
3. Insert the thermometer through the hole in the cardboard lid
4. Record the temperature of the water and start the stopwatch.
5. Record the temperature of the water every 30 seconds for 5 minutes.
6. Repeat steps **1–5** increasing the number of layers of insulating material wrapped around the beaker until you reach 4 layers.
7. Repeat the experiment with no insulation around the beaker.
7. Plot a graph of temperature versus time.

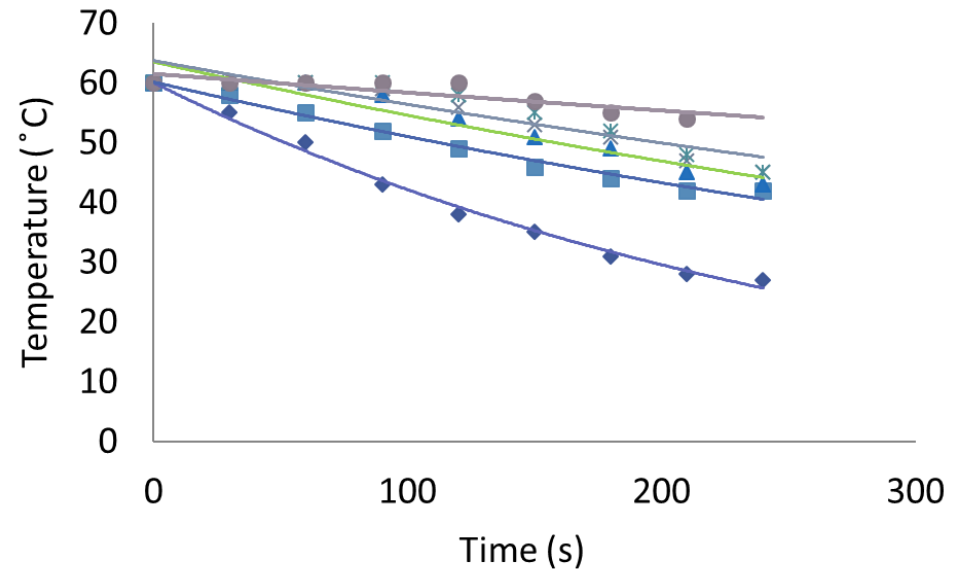
IV – Time (s)

DV – Temperature change

CV – Volume of water, material of insulation, starting temperature.



The more layers of insulation the longer it takes for the temperature to drop, indicating a better insulator.



34. Required Practical 3: Resistance of a wire

Method:

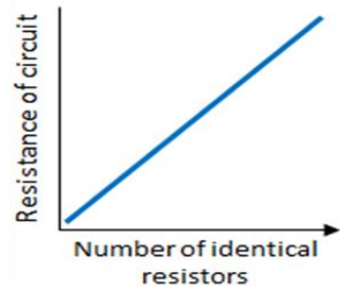
1. Set up equipment as shown in the diagram.
2. Connect the crocodile clips to the resistance wire, 100 cm apart.
3. Record the reading on the ammeter and on the voltmeter.
4. Move one of the crocodile clips closer until they are 90 cm apart.
5. Record the new readings on the ammeter and the voltmeter.
6. Repeat the previous steps reducing the length of the wire by 10 cm each time down to a minimum length of 10 cm.
7. Plot a line graph of length of wire (x axis) against resistance (y axis)

IV: length of the wire

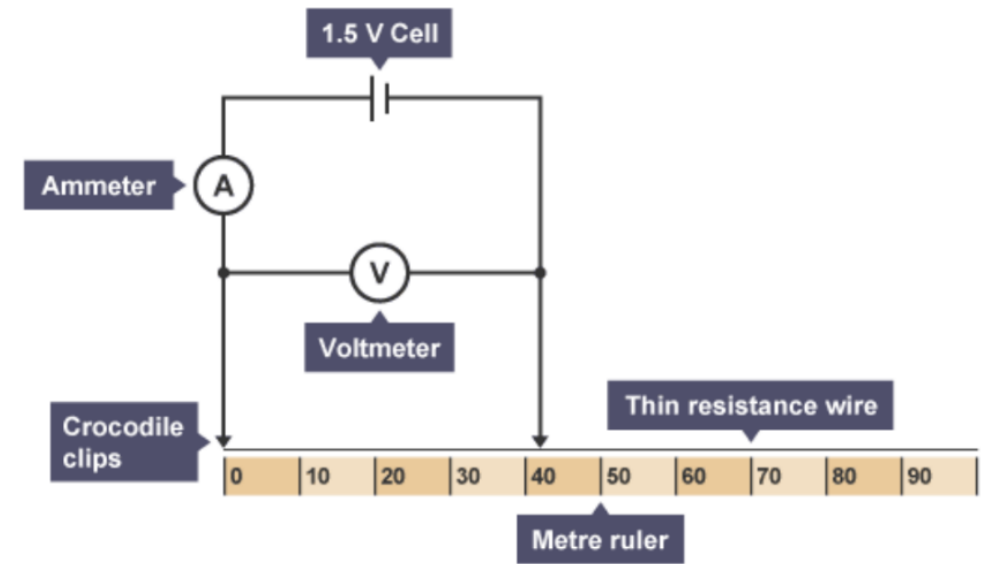
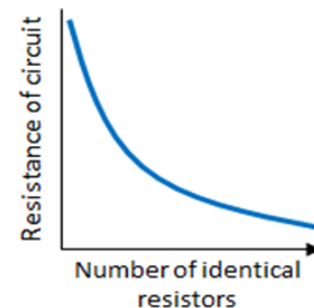
DV: voltage and current

CV: type of wire, diameter of wire and the battery

Resistors in series



Resistors in parallel



Reason for inaccuracy of readings: The resolution of the length of wire is lower due to where the crocodile clips are attached to the wire

Improve accuracy of readings: Turn off the circuit between the readings. This will stop the wire heating up and the temperature changing

Possible errors: Wire heating up and increasing resistance, incorrect reading of ammeter and voltmeter and internal resistance of equipment

Conclusion: The length of the wire is **proportional** to the resistance of the wire.

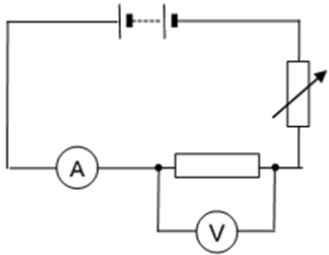
35. Required practical 4: Component IV characteristics

IV—Potential Difference (Volts)

DV—Current (Amps)

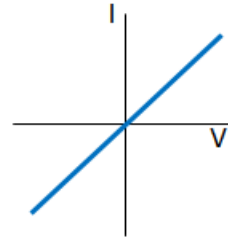
CV— Same components, voltage from power pack, temperature – take the readings, immediately, Repeats to reduce the impact of outliers.

Fixed Resistor

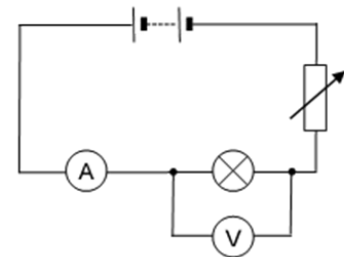


At a constant temperature, the current is **directly proportion** to the voltage.

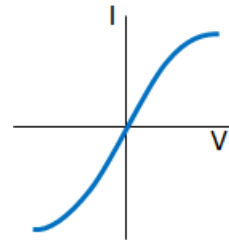
This means it obeys Ohm's Law.



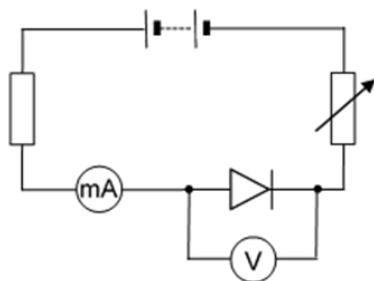
Filament Bulb



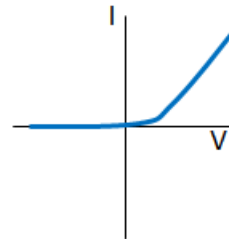
As the voltage increases the current increases. This causes the filament to get hotter, meaning the resistance increases. Therefore as the voltage continues to increase the current levels off.



Diode



The current can only flow in one direction because a diode has a very high resistance in the opposite direction.



Method

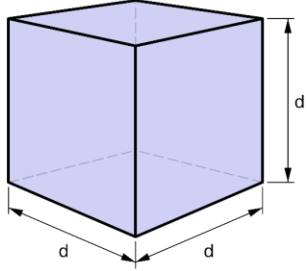
1. Measure the current in the resistor using the ammeter.
2. Measure the potential difference across resistor using the voltmeter.
3. Vary the resistance of the variable resistor
4. Record a range of values of current and potential difference.
5. Ensure current is low to avoid temperature increase.
6. Switch circuit off between readings
7. Reverse connection of the resistor to the power supply.
8. Repeat measurements of I and V in negative direction.
9. Plot a graph of current against potential difference

How to improve accuracy of readings:

- Circuit is switched off between readings
- Temperature does not change

36. Required practical 5: Calculating density

Regular shaped object



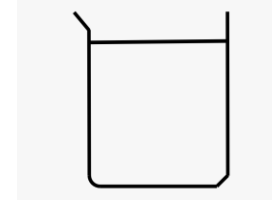
1. Measure the length, width and height using a ruler.
2. Calculate the volume ($l \times w \times h$)
2. Measure the mass using a balance.
3. Use the equation $\text{mass} \div \text{volume}$ to calculate the density.

Irregular shaped object



1. Using a balance, measure the mass of the object.
2. Fill a measuring cylinder with 100 cm^3 of water
3. Put object into measuring cylinder
4. Difference in volume of water is the volume of the object
5. Use the equation $\text{mass} \div \text{volume}$ to calculate the density.

Liquid



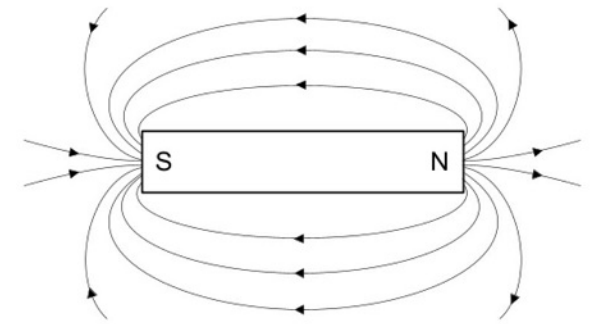
1. Using a balance, record the mass of a beaker
2. Pour 100 cm^3 of liquid into the measuring cylinder.
3. Pour liquid into a beaker and record the mass of the beaker and its contents
4. Difference in mass of (beaker + contents) from the beaker is the mass of the liquid.
5. Use the equation $\text{mass} \div \text{volume}$ to calculate the density.

Physics Paper 2 (Combined Foundation)

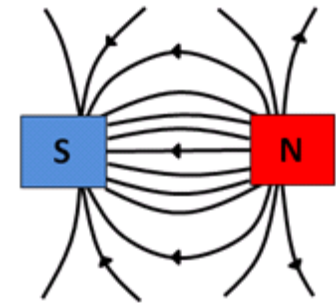
37. Magnets
38. Compasses and magnets
39. Electromagnetism
40. Investigating electromagnetism
41. Uses for electromagnets
42. Wave properties
43. Transverse and longitudinal waves
44. Sound waves and speed of sound experiment
45. Refraction of waves
46. Electromagnetic spectrum
47. Forces - vectors and scalars
48. Resultant Forces
49. Elasticity
50. Newtons laws of motion
51. Speed, velocity and acceleration
52. Graphs of motion
53. Thinking, braking and stopping distance
54. Required practical 6: Force and extension
55. Required practical 7: The effect of force on acceleration
56. Required practical 8: The effect of mass on acceleration
57. Required practical 9: Infrared radiation
58. Required practical 10: The speed of a water wave
59. Maths in science 1
60. Maths in science 2
61. Physics equation sheet

37. Magnets

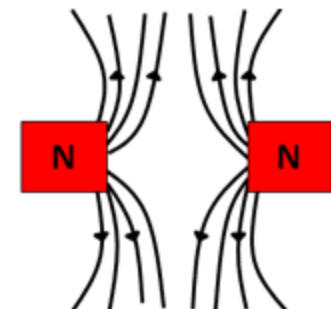
Magnetic metals	Iron (steel), nickel and cobalt
Permanent magnets	Magnetic all the time. Produce their own magnetic field.
Induced magnets	Made from magnetic materials. Only turns into a magnet when held in a magnetic field e.g. core of an electromagnet
North and south pole of a magnet	The part of the magnet where the magnetic field is the strongest
Magnetic field	A region where force is experienced by magnetic materials
Magnetism	A non-contact force from a magnetic to a magnetic field
Field lines	Point away from north and show the direction a north pole would point if it was placed in a field. Closer the field lines in a magnetic field = stronger the magnetic force. Field lines run from north pole to south pole.
Compass	A small bar magnet that is free to move. Always points north in a magnetic field
Evidence that the Earth's core is magnetic	The Earth's iron core creates a magnetic field. The north poles of magnets are attracted to the geographic North Pole of the Earth.



Opposite poles attract



Like poles repel



38. Compasses and magnets

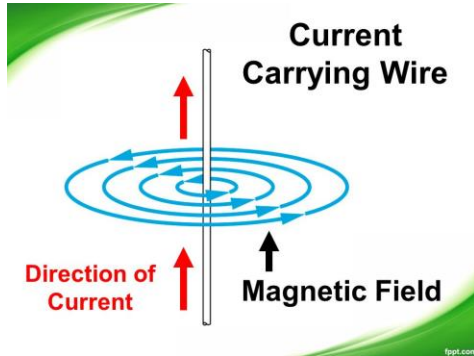
	Iron filings	Plotting compass
Method	Sprinkle iron filings on a piece of paper over the magnet	Use a plotting compass around the magnet with the needle showing the direction.
Advantage	Field lines easily seen	Direction of field lines shown
Disadvantage	Iron filings easily spilt and stick to magnet. Not permanent.	Compasses affected by magnets and do not always work so well. Takes longer.

Using a plotting compass to find the magnetic field of a bar magnet

1. Place magnet on a sheet of (plain) paper
2. Place the compass near the north pole of the magnet
3. Mark the position that the compass needle points to
4. Move the compass so the opposite end of the needle is at this position and mark the new position where the compass tip settles
5. Repeat above until you reach the south pole, then connect the marks together to construct a field line .
6. Add arrows to field lines (pointing north to south).

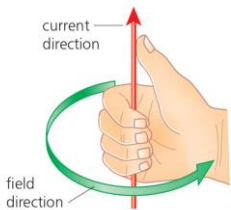
39. Electromagnetism

Magnetic Field around a Wire



- Arrows on the field line show the direction of the magnetic field.
- Reverse the direction of the current, the direction of the magnetic field reverses.
- If the field lines are closer, there is a larger the current.
- Further away from the wire, the weaker the magnetic field

Right Hand Grip Rule



Your thumb points in the direction of the current.

Your fingers point in the direction of the magnetic field.

Solenoid: a coil of wire

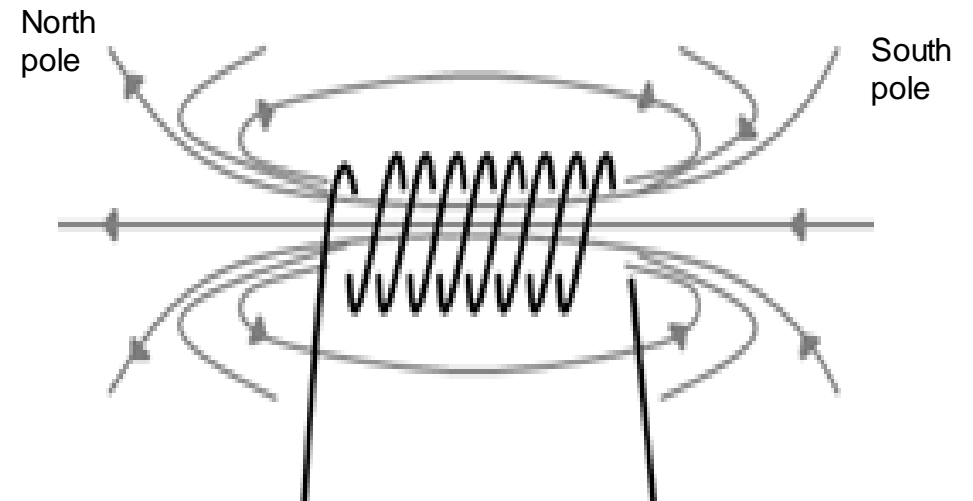
Outside solenoid: Magnetic field lines are like a bar magnet

Inside solenoid Magnetic field is strong. Same strength and direction in all places. Field lines are parallel.

Electromagnet: a solenoid with an iron core

Advantages of an electromagnet:

Can be turned on or off. Strength of magnet can be increased or decreased.



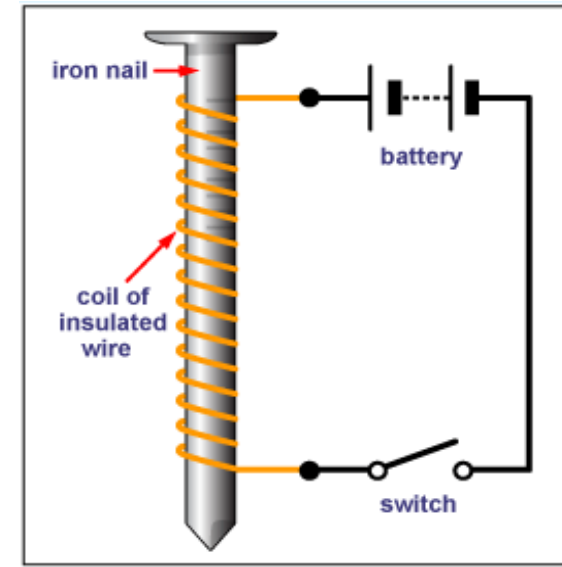
40. Investigating electromagnetism

How to make an electromagnet

1. Set up equipment as shown in diagram
2. Wrap the wire around the nail
3. Connect the wire to the power supply
4. Switch on the power supply

How to test the electromagnet

- the more paperclips suspended, the stronger the electromagnet is
- clamp the electromagnet at different distances from the paperclip(s)
- the further the distance from which paperclips can be attracted the stronger the electromagnet is
- use de-magnetised paper clips



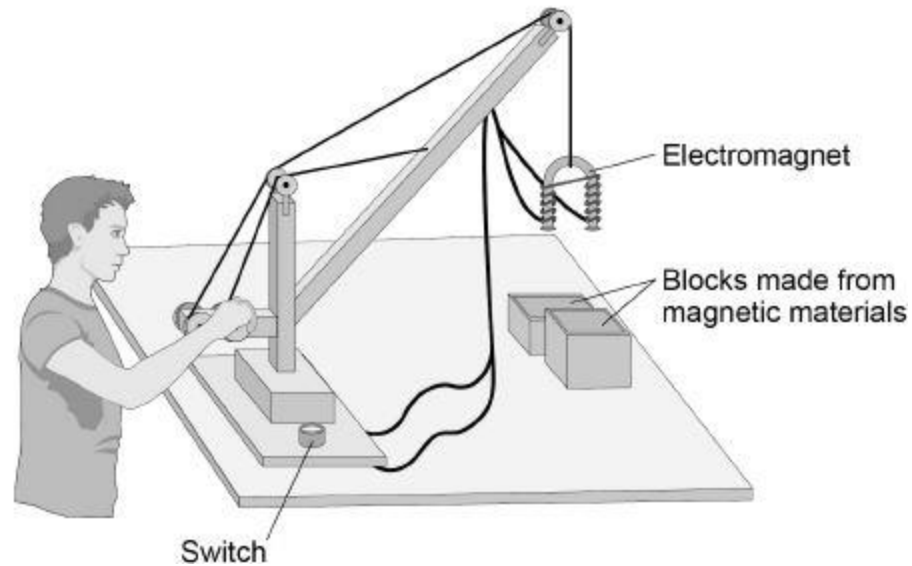
IV: Increase strength of electromagnet by (3 x Cs):

- a) Increase the number of **coils**
- b) Increase the **current**
- c) Change the **core**

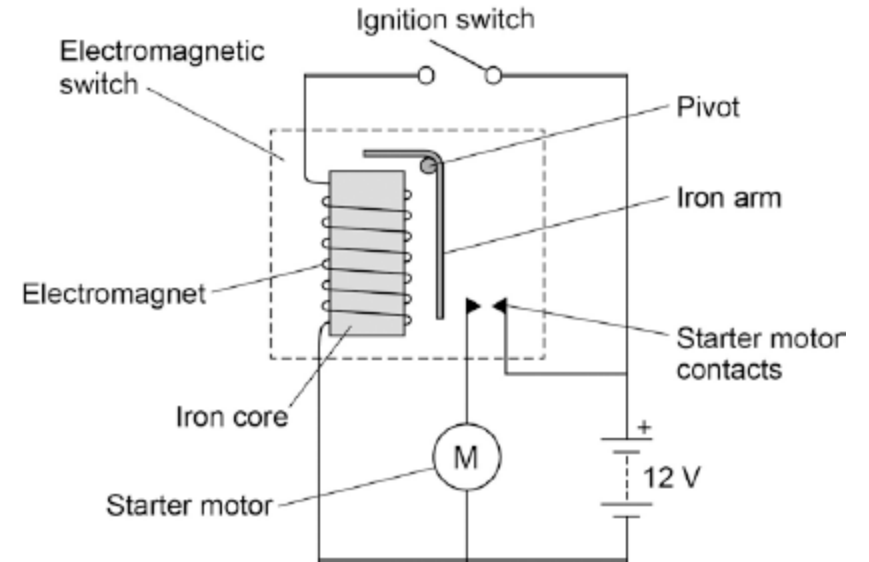
DV: Number of paperclips picked up

CV: Same type of paperclip.

41. Uses for Electromagnets



1. Completing the circuit turns the electromagnet on
2. There is a current in the coil
3. A magnetic field is produced around the coil
4. The iron core becomes magnetised
5. Move electromagnet towards the blocks
6. The block is attracted to the electromagnet
7. Moving the crane moves the block
8. Switching off the current switches off the electromagnet
9. Releasing the block



1. Closing the switch causes a current to pass through the electromagnet
2. The iron core of the electromagnet becomes magnetised
3. The electromagnet attracts the short side of the iron arm
4. The iron arm pushes the starter motor together
5. The starter motor circuit is complete
6. A current flows through the starter motor

42. Wave properties

Mechanical Waves travel through a medium (substance).

The particles oscillate (vibrate) and transfer energy.

The particles do not travel along in the wave.

Frequency (f) - the number of complete waves that pass a point every second.

1 wave per second has a frequency of 1Hz (hertz).

Time period (T) - the time for a complete cycle of a single wave.

Frequency (Hz) = 1 ÷ time period (s)

$$F = 1 \div T$$

Example: What is the frequency for a wave with a time period of 0.2s

E $f = 1 \div T$

V $T = 0.2 \text{ s}$

E $f = 1 \div 0.2$

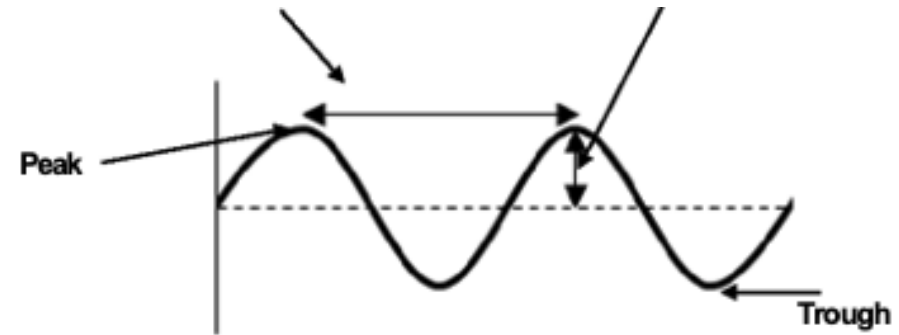
R 5

Y Hz

$$f = 5\text{Hz}$$

Wavelength - the distance between adjacent waves (i.e. from peak to peak or trough to trough)

Amplitude - the maximum displacement from the horizontal mid-line.



Wave speed (m/s) = frequency (Hz) x wavelength (m)

$$V = f \lambda$$

Example: How fast is a wave travelling which has a 3m wavelength and a frequency of 20Hz?

E $V = f \times \lambda$

V $f = 20 \text{ Hz}; \lambda = 3 \text{ m}$

E $V = 20 \times 3$

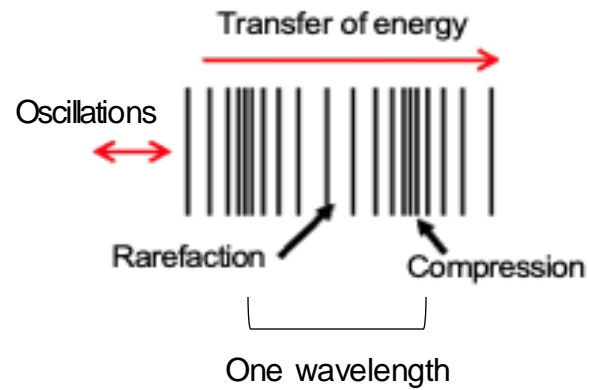
R $V = 60$

Y m/s

43. Transverse and Longitudinal waves

Longitudinal Waves

The **oscillations** (vibrations causing the wave) are **parallel** to the direction of **energy transfer**.



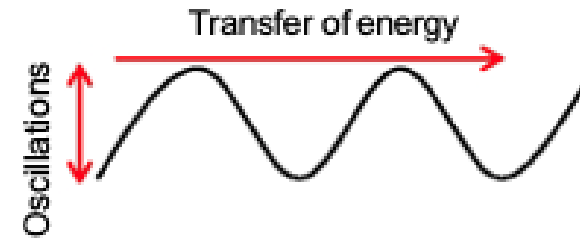
Compression: particles bunch up

Rarefaction: particles spread out

Example: Sound waves

Transverse Waves

The **oscillations** (vibrations causing the wave) are **perpendicular** (90°) to the direction of **energy transfer**.



Example: Light waves, X-rays and water waves (ripples)

All electromagnetic waves

44. Sound Waves and Speed of Sound experiment

Sound waves are mechanical longitudinal waves.

They need a medium to travel through.

The speed of sound can be calculated using:

$$\text{Speed (m/s)} = \text{distance (m)} \div \text{time (s)}$$

Unit conversions:

km to m: x 1000

cm to m: ÷ 100

minutes to seconds: x 60

hours to seconds: x 3600

Speed of sound experiment

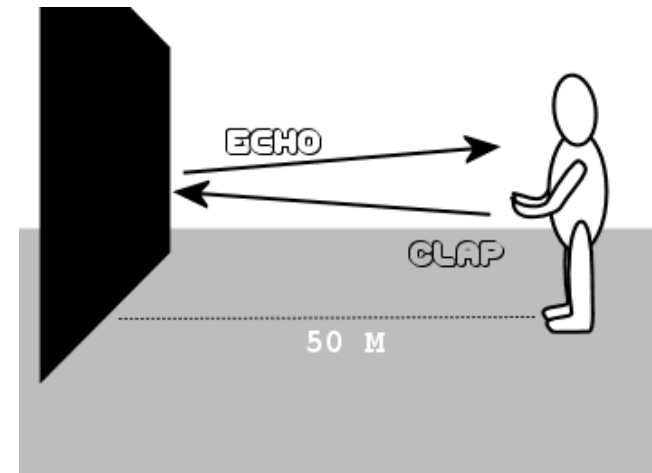
1. Measure the distance between the person and the wall using a metre ruler.
2. Double this distance.
3. Using a stop clock, measure the time taken from the clap being made to hearing its echo.
4. Use the equation,

$$\text{speed} = \text{distance} \div \text{time}.$$

Sound waves

Bigger the amplitude – taller the wave – louder the sound

Higher the frequency – more waves per second – higher pitch



45. Refraction of waves

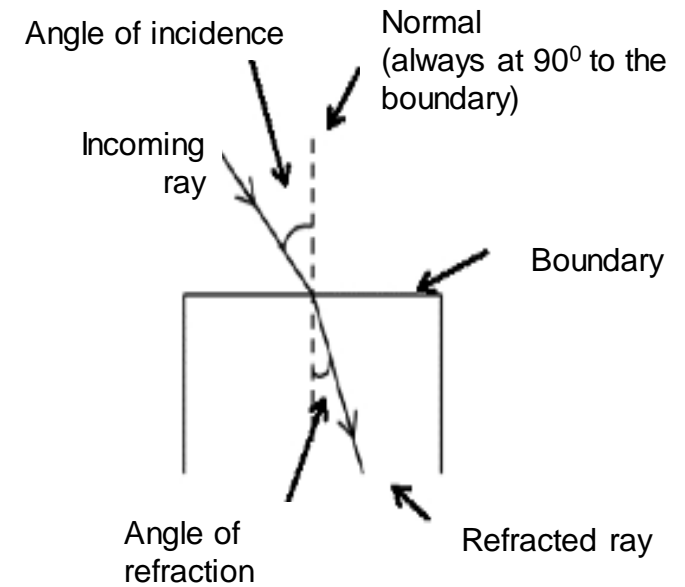
Refraction

Waves change speed when they cross a **boundary** between two materials of different density or a boundary of different depths.

If the wave enters a medium of higher **density** at an **angle** the ray bends towards the normal (see diagram).

If it enters a medium **along the normal** then the wave does not change direction but the **wavelength** and **speed decrease**.

Refraction of Light ray



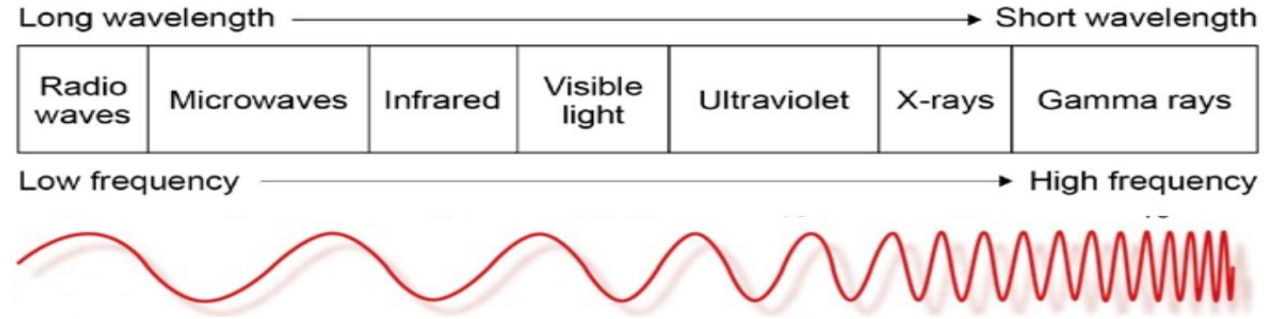
46. Electromagnetic Spectrum

All parts of the EM spectrum travel at the same speed.

They all travel at 300,000,000 m/s.

They are all transverse waves

All parts of the EM spectrum can travel through a vacuum (e.g. space)



Radio Waves	Used for communication. Used for television and radios. Radio waves can be produced by oscillations in electrical circuits. When radio waves are absorbed they may create an alternating current with the same frequency as the radio wave itself, so radio waves can themselves induce oscillations in an electrical circuit.
Microwaves	Used to communicate with satellites (T.V, mobile Phone) Cooking food.
Infra-red Radiation (IR)	Used for electrical heaters, cooking food, infrared cameras
Visible Light	Optical fibres transmit data using light over long distances
Ultra Violet Radiation (UV)	energy efficient lamps, sun tanning UV can damage surface cells, causing sunburn and increasing the risk of skin cancer.
X-Rays	X-Rays pass through flesh but are absorbed by the more dense bone. Ionising, so can cause mutations in DNA, destroy cells and cause cancer
Gamma Rays	Gamma rays can be used as a tracer. A gamma source is injected and its path through the body can be detected. Both are used to treat cancer as they kill cells. Ionising, so can cause mutations in DNA, destroy cells and cause cancer

47. Forces

Scalar	A quantity which has only magnitude	Speed, distance, time, mass...
Vector	A quantity which has both magnitude and direction	Force, velocity, momentum, acceleration..

Mass: Amount of matter in an object

Measured using a balance

Measured in kg

Weight: A force depending on the object's mass and force of gravity

Measured using a Newton meter

Measured in N

Centre of mass: The point through which the weight of an object acts.

- The **wider** base an object has, the **lower** its centre of mass and it is more **stable**
- The **narrower** base an object has, the **higher** its centre of mass and the object is more likely to topple over if pushed

Contact Force	Involves 2 or more objects that must touch to act on each other	Friction, air resistance
Non contact force	Involves 2 or more objects that do not need to be touching for forces to act on each other	Gravitational force, electrostatic force, magnetic force

Weight (N) = mass (kg) x gravitational field strength (N/kg)

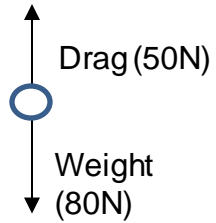
W = mg

e.g. What is the weight of a 2kg mass on earth

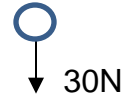
E W=m x g
 V m = 2kg and g = 9.8N/kg
 E W = 2 x 9.8
 R W = 19.6
 Y N

48. Resultant Forces

Found by adding together any forces acting along the same line (direction) and subtracting any that act in the opposite direction:



The resultant force is 30N (80-50) downwards.



The resultant force is a single force which is equivalent to the 2 forces acting together

When a **force** moves an object through a **distance**, **energy is transferred** and **work is done**.

To make something move a force must be applied, which requires energy.

The force does work to move the object and energy is transferred between stores.

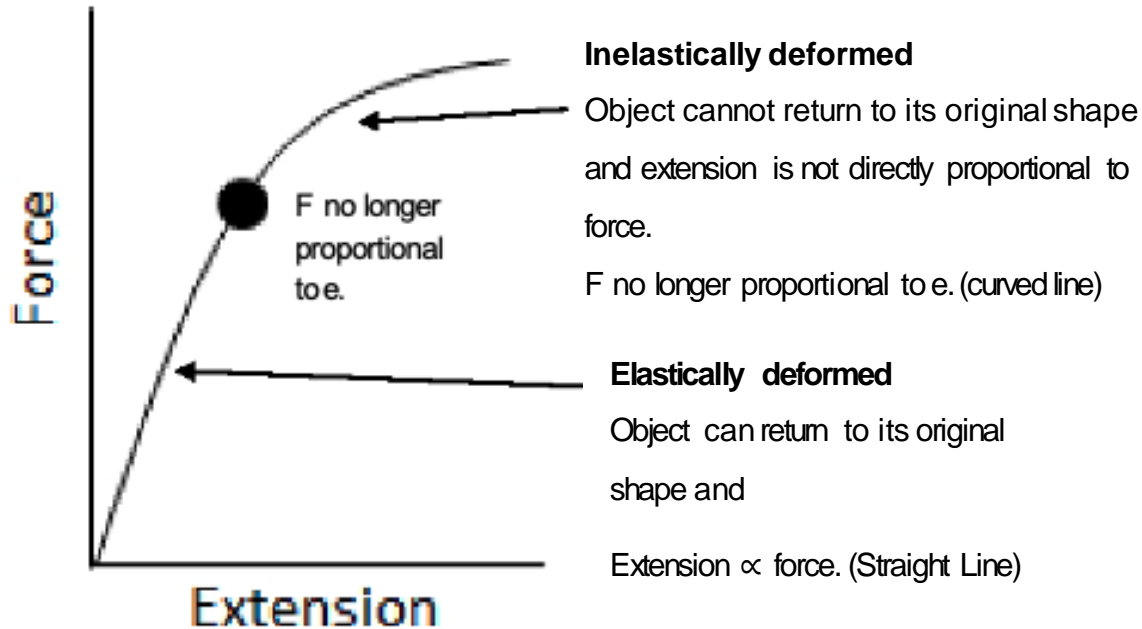
49. Elasticity

To stretch, compress or bend an object more than one force must act on it.

Extension is directly proportional to force:

$$\text{Force (N)} = \text{spring constant (N/m)} \times \text{extension (m)}$$

$$F = ke$$



Elastic Potential Energy

A force acting on an object may cause the shape of an object to change.

Elastic objects can store elastic potential energy if they are stretched or squashed. For example, this happens when a catapult is used or a spring is stretched.

Objects can also store elastic potential energy when they are squashed.

$$\text{Elastic potential energy (J)} = 0.5 \times \text{spring constant (N/m)} \times \text{extension}^2 \text{ (m)}$$

Unit conversions:

kJ to J: $\times 1000$

cm to m: $\div 100$

50. Newton's laws of motion

First Law	<p>A body at rest will remain at rest, and a body in motion will remain in motion, unless it is acted upon by an unbalanced force.</p> <p>Inertia is the tendency of a body to remain in the same state of motion</p>	
Second Law	<p>The amount a body accelerates is directly proportional to the force applied to it and inversely proportional to the mass of the body.</p> <p>$F = ma$</p>	<p>e.g. An aeroplane accelerates from a low speed to a high speed with the engines at maximum power</p> <p>At maximum power the forward force of the engines is constant as it accelerates the air resistance increases</p> <p>resultant force = force from engines – air resistance</p> <p>Therefore resultant force decreases acceleration is directly proportional to resultant force</p>
Third Law	<p>When two objects interact, the forces they exert on each other are equal and opposite.</p> <p>This is an equilibrium situation - neither object moves because the forces are balanced.</p>	

51. Speed, velocity and acceleration

Typical Speed Walking	1.5 m/s
Running	3 m/s
Cycling	6 m/s
Car	25 m/s
Train	55 m/s
Plane	250 m/s

Speed	How fast something is going without reference to a direction. It is a scalar quantity.
Velocity	A speed in a given direction
Acceleration	How quickly something is speeding up, or its rate of change of velocity. Deceleration is how quickly something is slowing down or negative acceleration.

Uniform Acceleration

This can happen due to gravity acting on an object in free fall.

$$v^2 - u^2 = 2 a s$$

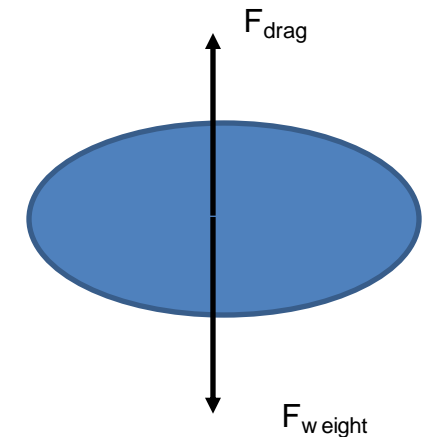
v = final velocity (m/s)
u = initial velocity (m/s)
a = acceleration (m/s²)
s = distance (m)

Terminal Velocity

The maximum speed an object will fall at through a fluid (liquid or gas).

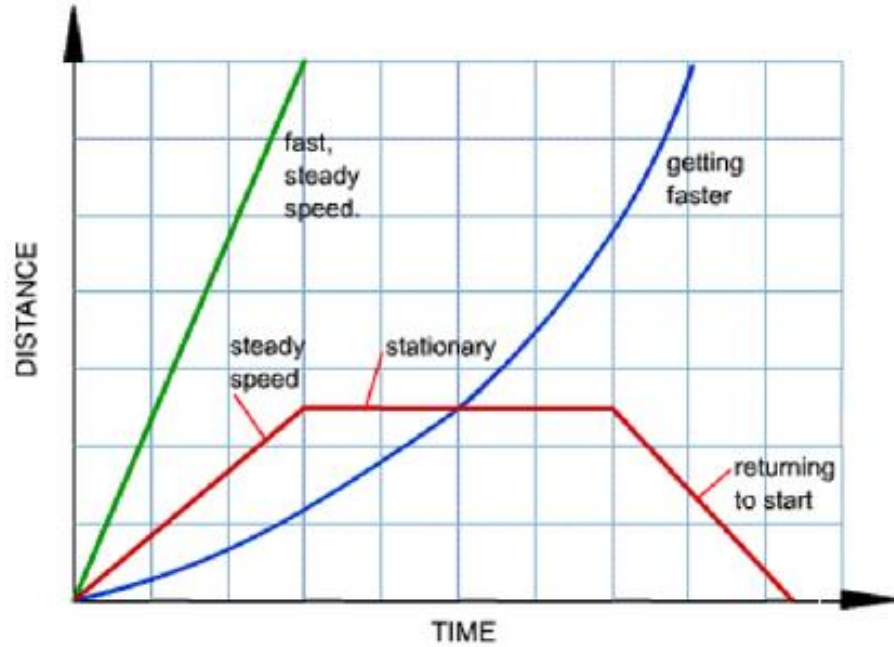
As the speed of a falling object increases so does the frictional force (drag) opposing the objects weight (which doesn't change).

The resultant force is therefore reducing until the drag is equal to the weight. Acceleration is reduced to zero and the terminal velocity is reached.



52. Graphs of Motion

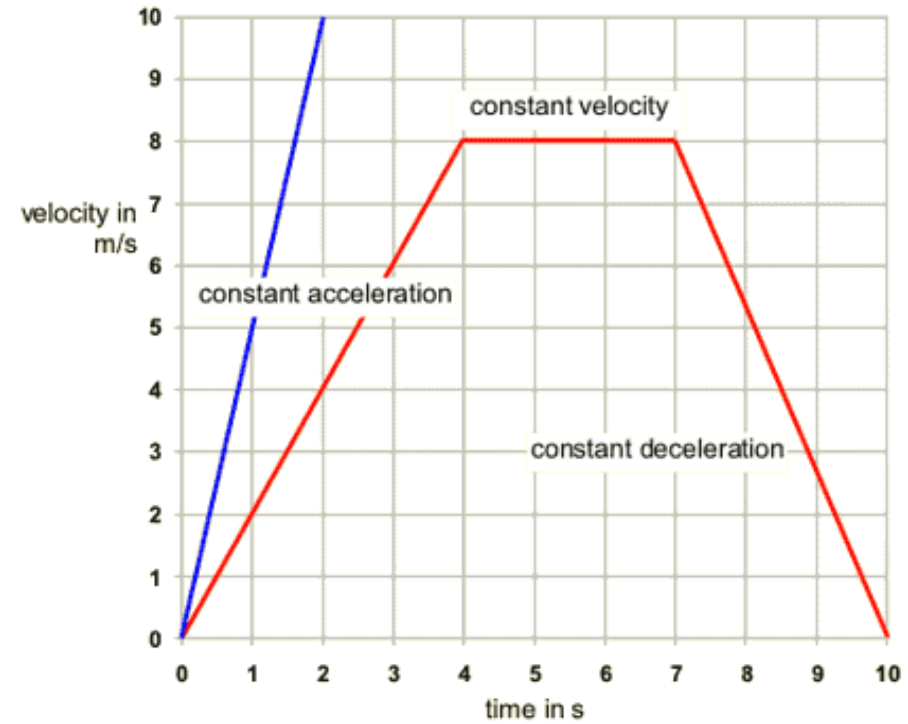
Distance – time graph



Gradient = speed of object

Gradient = $\frac{\text{change in } y}{\text{change in } x}$

Velocity – time graph



Gradient = acceleration of object

Distance travelled = area under the line

53. Thinking, Braking and Stopping Distances

Typical **reaction time** for a person is 0.2-0.9s

Thinking distance – the distance travelled during the reaction time. The distance between the driver seeing the danger and taking action to avoid it.

Braking distance – distance travelled before a car stops after the brakes have been applied. It increases as the speed of the car increases.

Stopping distance= thinking distance + braking distance

Reaction time – the time taken for the driver to react to the stimulus

Thinking distance is affected by:

- Speed
- Your reaction time which is affected by:
 - I. Alcohol
 - II. Drugs
 - III. Sleep deprivation
 - IV. Distractions

Reaction time experiment:

Ruler drop test

Computer based experiments

Braking distance is affected by:

- Speed
- Weather and the road surface e.g. icy
- Condition of tyres e.g. bald tyres cannot get rid of the water in wet conditions leading to skidding
- Quality of brakes

54. Required Practical 6: Force and extension

Force and Extension

The extension of a spring is directly proportional to the force applied, provided its limit of proportionality is not exceeded

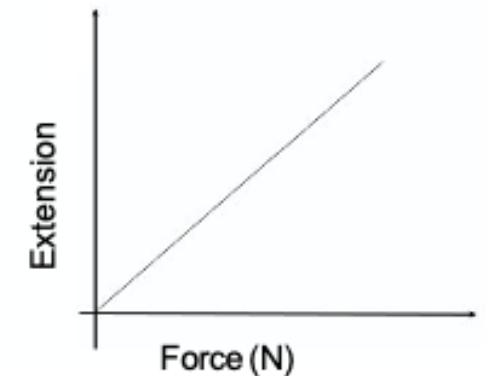
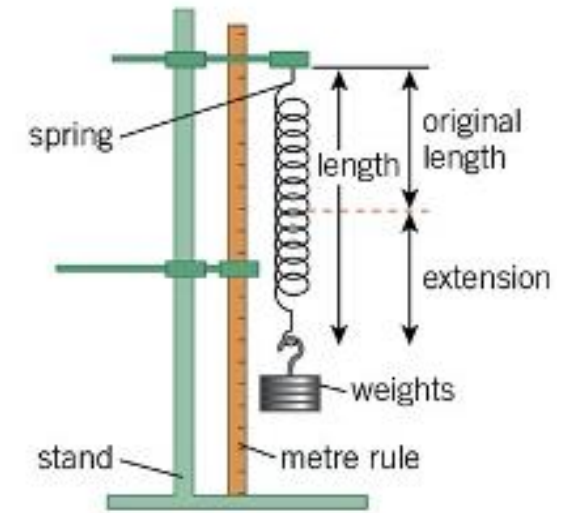
Independent variable - Force applied (N)

Dependent variable - Extension of spring (m)

Control variable - same spring, keep ruler in the same position.

Method

1. Hang the spring on the end of the clamp and gently clamp it to secure it.
2. Measure the original length of the spring and record this length.
3. Add a 100 g (1 Newton) mass holder to the end of the spring.
4. Measure the new length and calculate the extension.
5. Add 100 g masses, one at a time, measuring the length and calculating (and recording) the extension of the spring each time.
6. Stop when you have added a total of 500 g. Be careful not to overstretch the spring.



Spring constant (N/m) = Force (N) ÷ extension (m)
Spring constant = gradient of the line

55. Required Practical 7: The effect of force on acceleration

Independent variable – Force (N) (weight due to mass $W=mg$)

Dependent variable – acceleration (m/s^2)

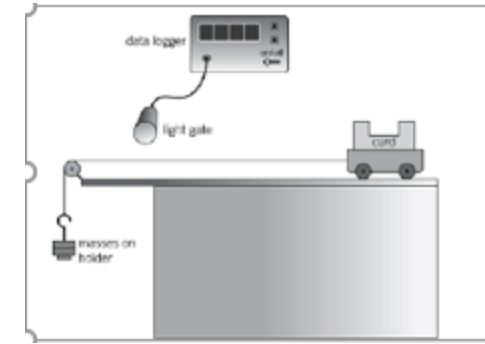
Control variables – mass of trolley, same trolley starts from same position each time

Method

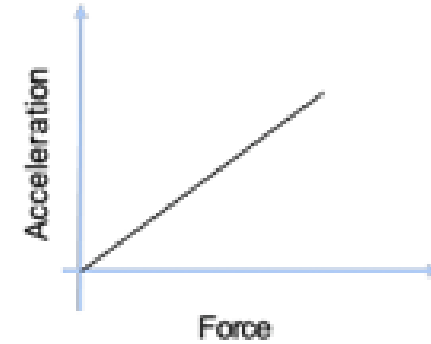
1. Measure the length of each card segment and make a note of this.
2. Set up the apparatus as shown in the diagram below. When the trolley is as close to the pulley as it can get, the bottom of the mass holder should be between 0.5 cm and 1 cm above the floor.
3. During this experiment the trolley will travel towards the pulley.
4. Set up the data logger. You will use its measurements to find the trolley's acceleration.
5. Add mass to the mass holder so that the total mass, including the holder, is 250 g.
6. Pull back the trolley, set the data logger to record, and then let the trolley run to the pulley. Collect the necessary measurements from the data logger.
7. Take 50 g off the mass holder and place it onto the trolley. You may need to use a small amount of tape or sticky tack to hold the mass securely in place. Repeat step 6.
8. Repeat steps 6-7 until there is 200 g on the trolley - this will be the fifth and final run.

How to reduce random errors

Repeat the measurements/investigation
Ignore anomalies and calculate the mean



The acceleration of an object is **proportional** to the resultant force acting on the object.



The acceleration of an object is proportional to the resultant force acting upon it. $F = ma$ or $a = F/m$

m is the mass of the trolley and not the weight being attached to the string

56. Required Practical 8: The effect of mass on acceleration

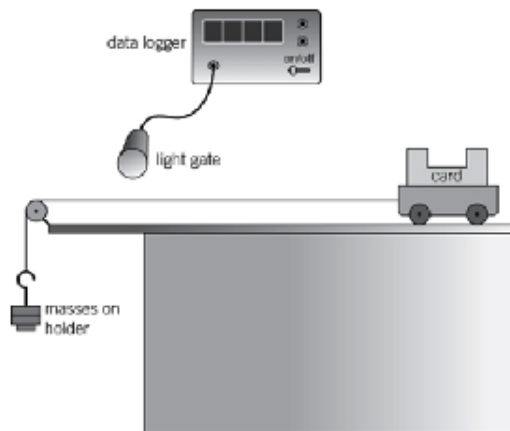
Independent variable – mass of the trolley (N)

Dependent variable – acceleration (m/s^2)

Control variables – Force being applied, trolley starts from same position each time

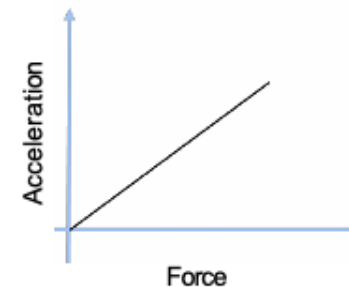
Method

1. Measure the length of each card segment and make a note of this.
2. Set up the apparatus as shown in the diagram below. When the trolley is as close to the pulley as it can get, the bottom of the mass holder should be between 0.5 cm and 1 cm above the floor.
3. During this experiment the trolley will travel towards the pulley. If you need to, place a lump of modelling clay or a block in front of the pulley to protect it from being hit by the trolley.
4. Set up the data logger. You will use its measurements to find the trolley's acceleration. There are different ways of doing this, depending on the data logger and the method your teacher asks you to use.
5. You will be changing the mass (by stacking extra trolleys under the first one) but keeping the applied force the same (by keeping the same number of masses on the mass holder). First, measure the mass of one trolley. (You can assume all trolleys have the same mass.)
6. Each time you change the number of stacked trolleys, measure the acceleration. You may need to change the height of the light gate so that the card still passes through it.



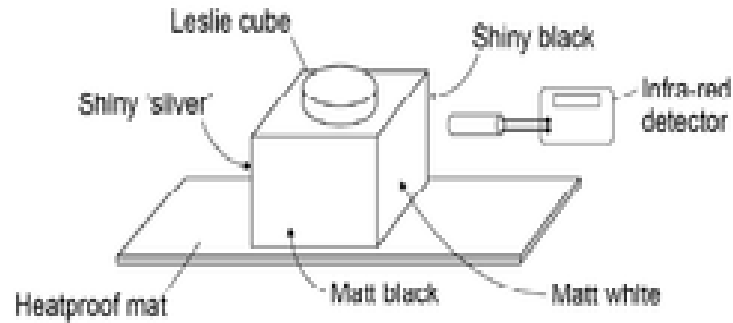
The acceleration of an object is **inversely proportional** to the mass of the object.

$$a = F/m$$



57. Required practical 9: Infra red radiation

Demonstration



Method:

1. Set up equipment as shown in diagram
2. Fill cube with hot water and put on lid
3. Use the detector to measure the amount of radiation from each surface

IV: surface

DV: Amount of IR absorbed or radiated

CV: Distance between surface and IR detector

Advantages of using this cube:

- All surfaces are at the same temperature
- More surfaces are tested
- Volume and temperature of the water does not need to be measured

All bodies (objects) emit and absorb **infrared radiation**.

An object that is good at absorbing radiation is also a good **emitter**, so a perfect black body would be the best possible emitter of radiation.

White and shiny silvery surfaces are the worst absorbers, as they reflect all visible light wavelengths. Poor absorbers are also poor emitters, and do not emit radiation as quickly as darker colours. Radiators in homes are usually painted white so that the infrared radiation is emitted gradually.

Class practical

1. Fill a matt black boiling tube and a shiny boiling tube with equal volumes of hot water.
2. Record temperature of water inside boiling tubes every 30 seconds.
3. Plot results on a graph

IV: surface of boiling tube

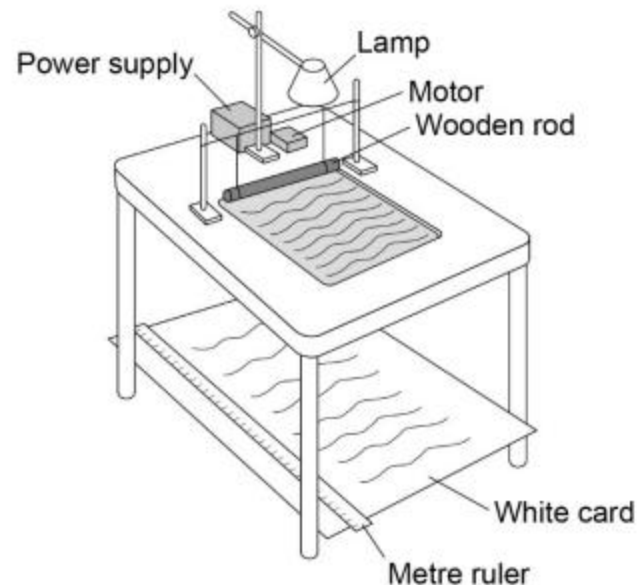
DV: temperature of hot water

CV: volume of hot water, time intervals recording the temperature

Matt black boiling tube: Temperature drops the most and it is the best at it is the best at emitting heat.

58. Required practical 10: Speed of water waves

1. Set up the ripple tank as shown in the diagram.
2. Make sure that there is a large sheet of white card or paper on the floor under the tank.
3. Pour water to a depth of about 5 mm into the tank.
4. Adjust the height of the wooden rod so that it just touches the surface of the water.
5. Switch on the overhead lamp and the electric motor.
6. Adjust the speed of the motor to produce low frequency water waves.
7. Adjust the height of the lamp so that the pattern of the waves can be clearly seen on the white card.



How to find the frequency of a wave using a ripple tank: count the number of ripples that pass a point in 10 seconds. Divide the number of waves by 10.

How to measure the wavelength: measure the distance across 10 gaps between the shadow lines. Divide this distance by 10.

How to calculate the speed of the wave

Wave speed (m/s) = frequency (Hz) x wavelength (m)

How to improve the method of calculating the wavelength:

Take a photo of the shadows and the ruler.

Benefit is that the waves are not being disturbed.

Reasons for using a:

Lamp: create shadows of the ripples

Metre ruler: measure the distance between 10 waves.

Signal generator: The vibration generator can have a built in signal generator so that you can directly set the frequency of paddle oscillation i.e. frequency of the ripple waves.

Deeper water means longer wavelength because velocity increases and frequency is constant

59. Maths in Science 1

Anomalous result	A number that does not fit the pattern
Mean	Adding up a list of numbers and dividing by how many numbers are in the list. Exclude the anomalous result.
Median	The middle value when a list of numbers is put in order from smallest to largest
Mode	The most common value in a list of numbers. If two values are tied then there are two modes. If more than two values are tied then there is no mode.
Range	The largest number take away the smallest value in a set of data or written as X-Y.
Uncertainty	range \div 2
Surface area of a cube	(area of 1 side) x 6 sides
Volume of a cube	Width x height x depth
Area of a circle	$\pi \times (\text{radius})^2$

Prefixes

$$1 \text{ kJ} = 1 \times 10^3 \text{ J} = 1000 \text{ J}$$

$$1 \text{ pm} = 1 \times 10^{-12} \text{ m}$$

$$1 \text{ mm} = 1 \times 10^{-3} \text{ m} = 0.001 \text{ m}$$

kilo	10^3
centi	10^{-2}
milli	10^{-3}
micro	10^{-6}
nano	10^{-9}
pico	10^{-12}

5607.376

Standard form: 5.607×10^3

2 decimal places: 5607.38

3 significant figures: 5610

0.03581

Standard form: 3.581×10^{-2}

2 decimal places: 0.04

3 significant figures: 0.0358

60. Maths in Science 2

Calculating percentage: (part ÷ whole) x 100

e.g. Out of 90 insects, 40 of them were ladybirds. What is the % of ladybirds?

$$(40 \div 90) \times 100 = 44 \%$$

Calculating percentage change:

(difference ÷ starting value) x 100

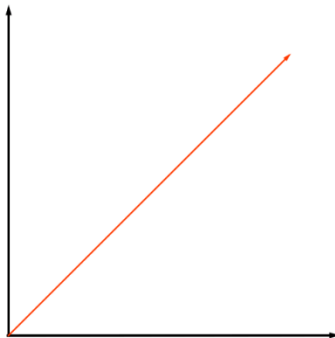
$$(0.59 \div 2.22) \times 100 = 26.6 \%$$

Conc of Sucrose (M)	Mass of potato at start (g)	Mass of potato at end (g)	Change in mass (g)
0	2.22	2.81	0.59

Graphs

Proportional (α)

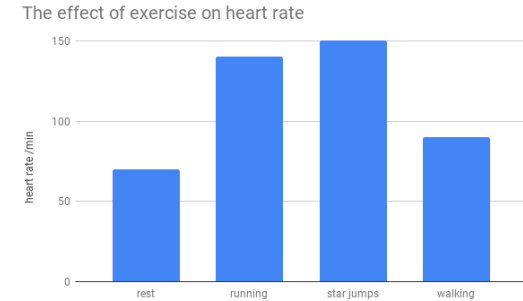
When the line passes through the origin



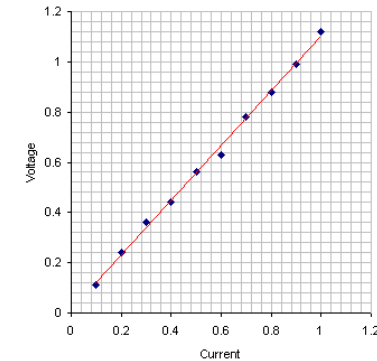
x axis = independent variable = left hand column of results table

y axis = dependent variable = right hand column of results table

Categoric data: data put into groups e.g. colour of eyes
Draw a bar chart

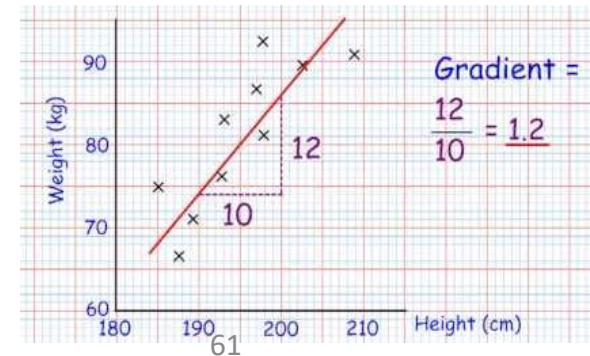


Continuous data: data that can take any value e.g. current
Draw a line graph



Gradient and Graphs

$$\text{Gradient} = \frac{\text{Change in y}}{\text{Change in x}}$$



kinetic energy = $0.5 \times \text{mass} \times (\text{speed})^2$	$E_k = \frac{1}{2} m v^2$
elastic potential energy = $0.5 \times \text{spring constant} \times (\text{extension})^2$	$E_e = \frac{1}{2} k e^2$
gravitational potential energy = $\text{mass} \times \text{gravitational field strength} \times \text{height}$	$E_p = m g h$
change in thermal energy = $\text{mass} \times \text{specific heat capacity} \times \text{temperature change}$	$\Delta E = m c \Delta \theta$
power = $\frac{\text{energy transferred}}{\text{time}}$	$P = \frac{E}{t}$
power = $\frac{\text{work done}}{\text{time}}$	$P = \frac{W}{t}$
efficiency = $\frac{\text{useful output energy transfer}}{\text{total input energy transfer}}$	
efficiency = $\frac{\text{useful power output}}{\text{total power input}}$	
charge flow = $\text{current} \times \text{time}$	$Q = I t$
potential difference = $\text{current} \times \text{resistance}$	$V = I R$
power = $\text{potential difference} \times \text{current}$	$P = V I$
power = $(\text{current})^2 \times \text{resistance}$	$P = I^2 R$
energy transferred = $\text{power} \times \text{time}$	$E = P t$

	energy transferred = charge flow \times potential difference	$E = QV$
HT	potential difference across primary coil \times current in primary coil = potential difference across secondary coil \times current in secondary coil	$V_p I_p = V_s I_s$
	density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$
	thermal energy for a change of state = mass \times specific latent heat	$E = mL$
	weight = mass \times gravitational field strength	$W = mg$
	work done = force \times distance (along the line of action of the force)	$W = Fs$
	force = spring constant \times extension	$F = ke$
	distance travelled = speed \times time	$s = vt$
	acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$	$a = \frac{\Delta v}{t}$
	(final velocity) ² – (initial velocity) ² = 2 \times acceleration \times distance	$v^2 - u^2 = 2as$
	resultant force = mass \times acceleration	$F = ma$
HT	momentum = mass \times velocity	$p = mv$
	period = $\frac{1}{\text{frequency}}$	$T = \frac{1}{f}$
	wave speed = frequency \times wavelength	$v = f\lambda$
HT	force on a conductor (at right angles to a magnetic field) carrying a current = magnetic flux density \times current \times length	$F = BIl$