Physics Paper 1 (Triple)

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3. Work done
4. Gravitational potential energy
5. Specific heat capacity and power
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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 velocity^2 (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 extension^2 (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.

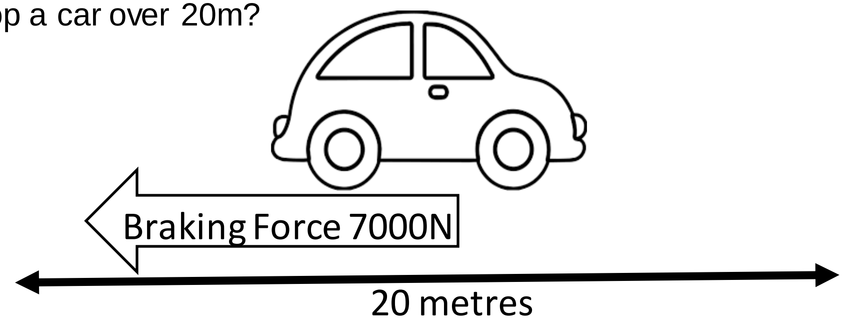
Energy transferred = work done

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 x s
V	F = 7000 N and s = 20 m
E	W = 7000 x 20
R	W = 140 000
Y	J

W = 140000J or 140 kJ

Kinetic energy store of moving car → Transfers energy to → Thermal store of brakes → Transfers energy to → Thermal store of surroundings

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: x 1000
cm to m: ÷ 100
km to m: x 1000
g to kg: ÷ 1000

Note: weight = mass x gravitational field strength

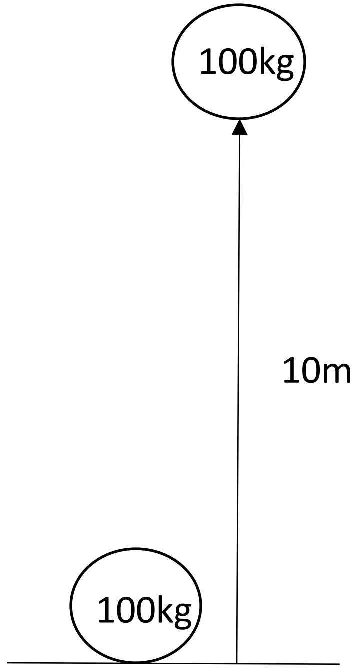
W = m x g

Therefore, we have a second formula for E_p

E_p = Weight x 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 = 9.81N/kg



Use the EVERY model to complete calculations:
E = equation
V = values
E = enter results
R = result
Y = units

E	E_p = m x g x h
V	m = 100 kg; g = 9.81; h = 100 m
E	E_p = 100 x 9.81 x 100
R	E_p = 98100
Y	J

E_p = 98100 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.

Change in thermal energy (J)	**=**	**mass (kg)**	**x**	**specific heat capacity (J/kg°C)**	**x**	**change in temperature (°C)**

$\Delta E = mc\Delta T$

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 J/kg°C

Use the EVERY model to complete calculations:

E = equation

V = values

E = enter results

R = result

Y = units

E	ΔE = m x c x $\Delta\theta$
V	m = 250 g = 0.25 kg; c = 4200; $\Delta\theta$ = 90-20 = 70
E	ΔE = 0.25 x 4200 x 70
R	73 500
Y	J

ΔE = 73500J or 73.5 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.

Power (W) = energy transferred (J) ÷ time (s)

Power (W) = work done (J) ÷ time (s)

P = E ÷ 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 ÷ t
V	E = 60 000J; t = 20 s
E	P = 60 000 ÷ 20
R	3000
Y	W

P = 3000W or 3kW

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	Wasting energy. More energy needs to be put into appliance to account for dissipated energy. Useful dissipation of energy example: back of a fridge Example of dissipation of energy is bad: light bulbs, engines and TV’s as heat
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	• 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	• 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	• Heating the bulb and surroundings
Hair Dryer	• Kinetic energy of the fan to push air • Heating of the air	• Sound of the motor. • Heating of the dryer and surroundings
Electric Motor	• Kinetic energy of objects driven by motor. • Gravitational potential energy of objects lifted by motor	• 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.

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

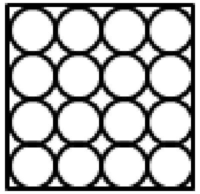
$$\textbf{Efficiency} = \frac{\textbf{useful power output}}{\textbf{total power input}}$$

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

Wasted power = input power - output power = 500 – 300 = 200W

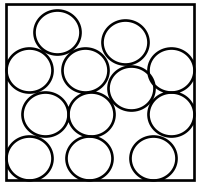
$$\text{Efficiency} = \frac{300}{500} = 0.6 \text{ 0r } 60\ \%$$

8. Methods of Heat Transfer Overview



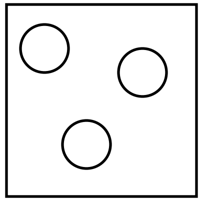
Solids

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.

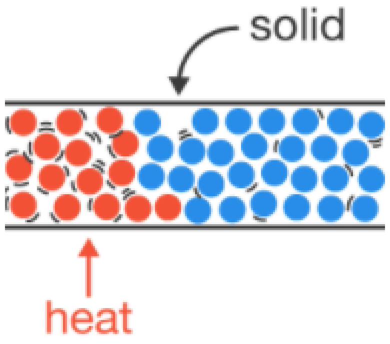


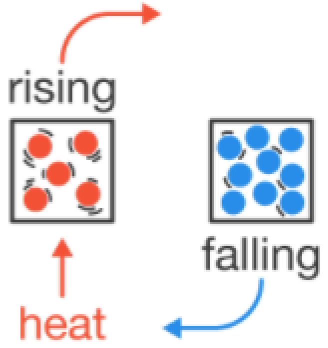
Gases

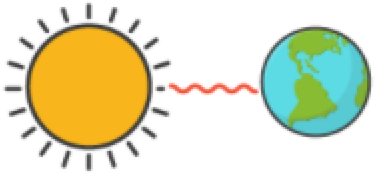
Have almost **no forces** between particles. Have **more energy** and are **free to move** in random directions and speeds.

Methods of heat transfer

	Conduction	Convection	Radiation
TRAVELS VIA	Particles	Particles	Waves
MEDIUM	Solids	Liquids and gases (fluids)	Vacuum
EXAMPLE	Metals	Air	Light and heat

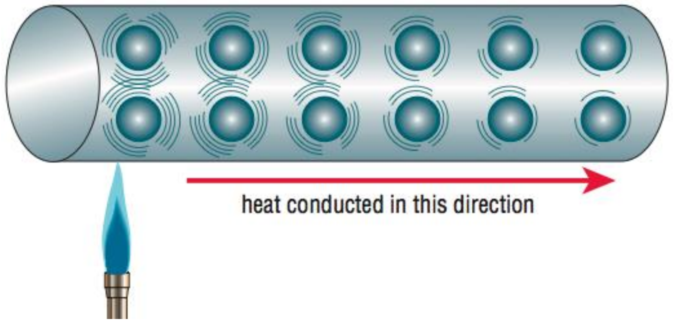


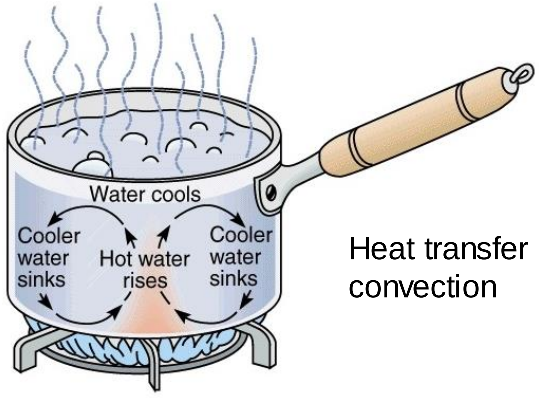




9. Methods of Heat Transfer

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





Heat transfer by convection

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	• 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	• 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	• 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	• 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	• Heating domestic hot water. • Photovoltaic cells can create electricity to charge batteries. • Electricity generation in large scale solar power plants	• 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	• Cannot increase supply to match demand • High initial costs • Unreliable
Wind Power	Electricity generation	• 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	• Visual and noise pollution • Cannot increase supply to match demand • High initial costs • Cannot generate electricity if there is too little wind • Unreliable
Geothermal	• Electricity generation • Heating	• Reliable • No atmospheric pollution due to burning of fossil fuels	• Few suitable locations (only possible in volcanic areas) • High cost to build power station
Bio-fuels	• Electricity generation • Heating • Fuel for transport	• Carbon neutral (if plants are grown at the same rate as being burned). • Reliable as crops grow quickly	• High costs to refine the fuel • Space for growing food taken up • Forests cleared to make space – decay and burned vegetation release CO_2 and methane.

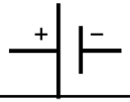
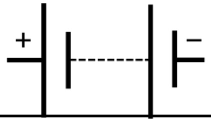
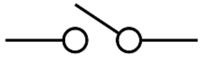
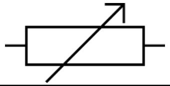
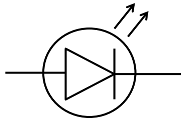
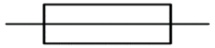
12. Renewable Energy Resources 2

Energy Resource	Uses	Advantages	Disadvantages
Hydro-Electric	Electricity generation	• 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	• 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	• No atmospheric pollution due to burning of fossil fuels • No fuel costs and minimal running costs	• 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	• No atmospheric pollution due to burning of fossil fuels • Smaller solution for limited populations	• Unreliable • Few suitable locations

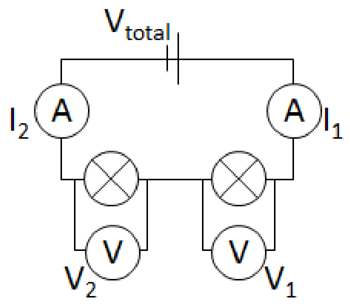
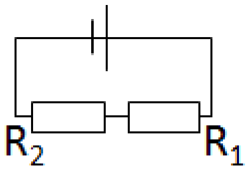
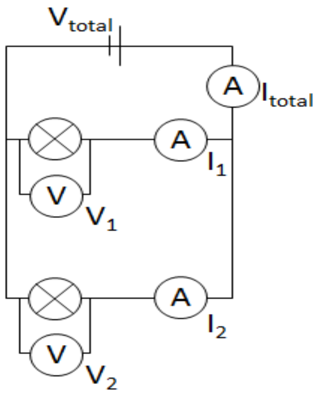
13. Electrical Terms

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

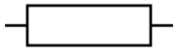
The current through a component depends on both the resistance *R* of the component **and** the potential difference *V* across the component

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.

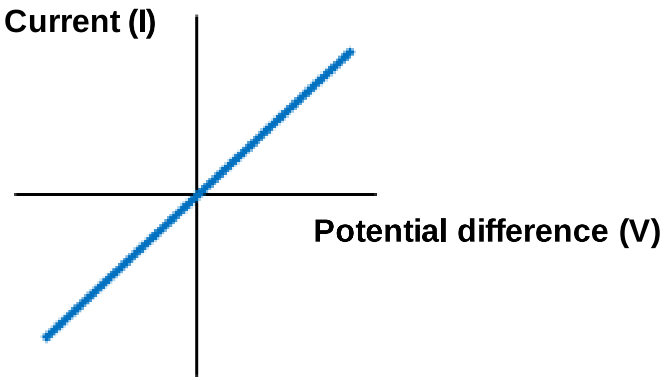
At a constant temperature, the potential difference is **directly proportional** to the current.

If the potential difference increases, the current increases.

The resistance doesn't change when the current changes.

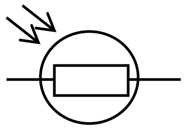
Obeys Ohm's law. It is an <u>ohmic conductor.</u>

Obeys V = IR



If the temperature changes, the resistance will change.

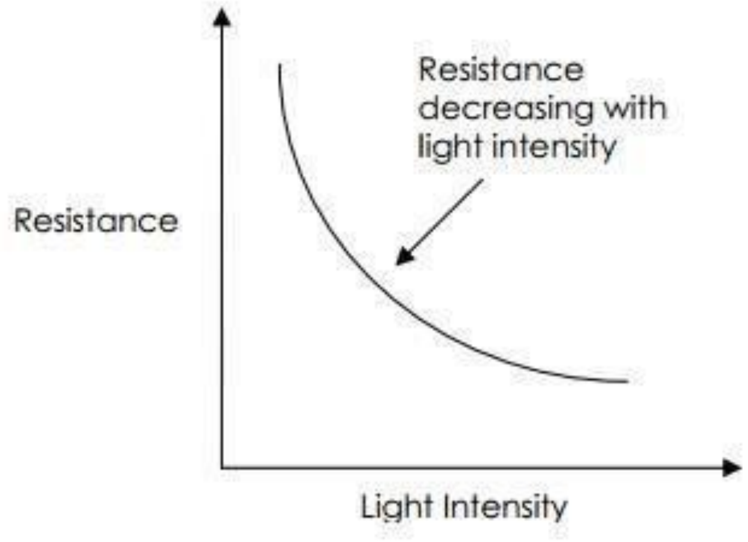
Light Dependent Resistor (LDR)



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.

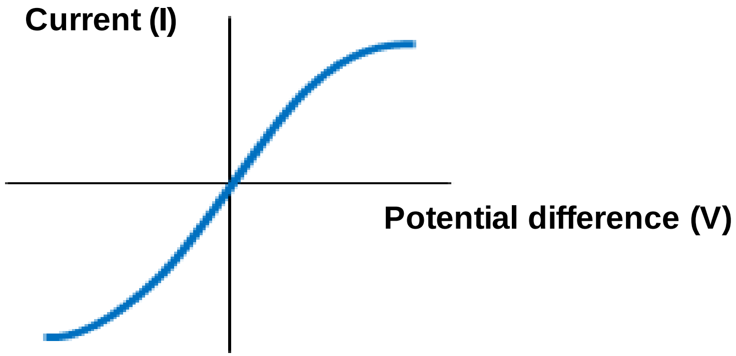
As the current increases, the filament wire gets hotter. The higher the current, the higher the temperature.

Resistance increases.

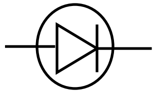
Harder for current to flow.

Graph gets less steep.

It is a non-ohmic conductor



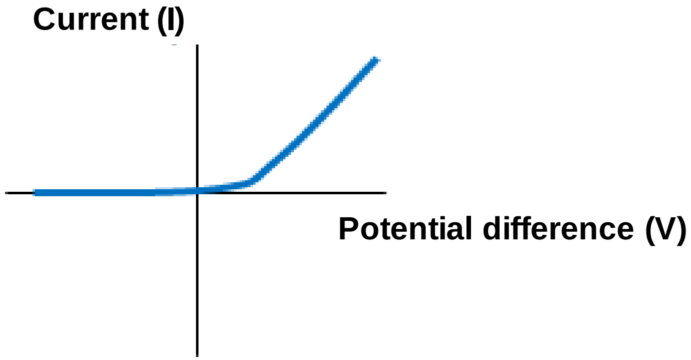
Diode



Property: allows current through in only one direction

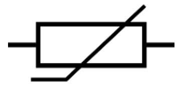
The resistance depends on the direction of the current. As a diode only lets current flow in one direction, it has a very high resistance in the opposite direction, which makes it hard for the current to flow that way.

It is a non-ohmic conductor



19. I-V Characteristics and Circuit Devices 3

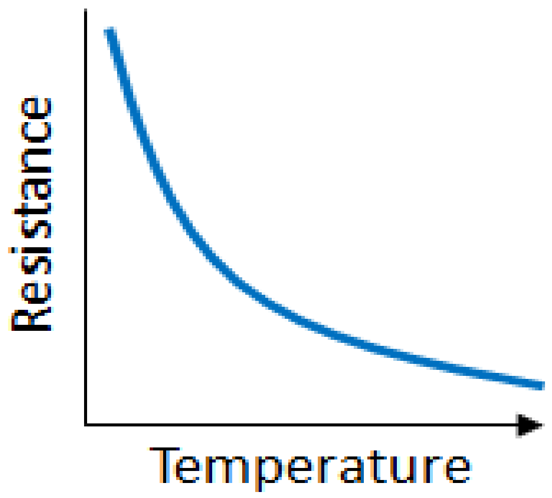
Thermistor



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.

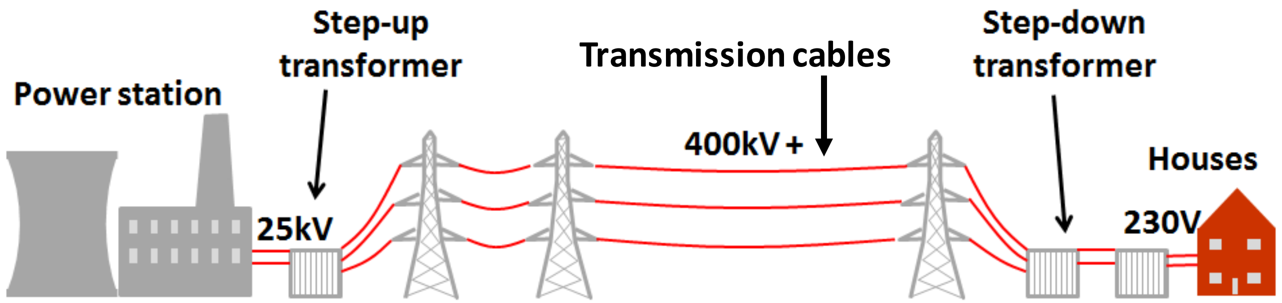
How step up transformers makes the National Grid efficient:

- 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).

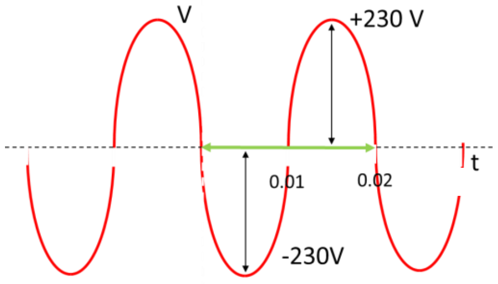


Alternating Current (AC)

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.

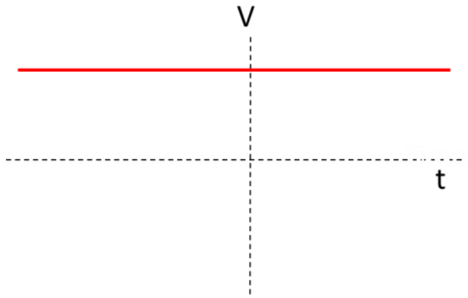
It has a frequency of 50Hz.



Direct Current (DC)

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

Batteries produce a DC voltage.



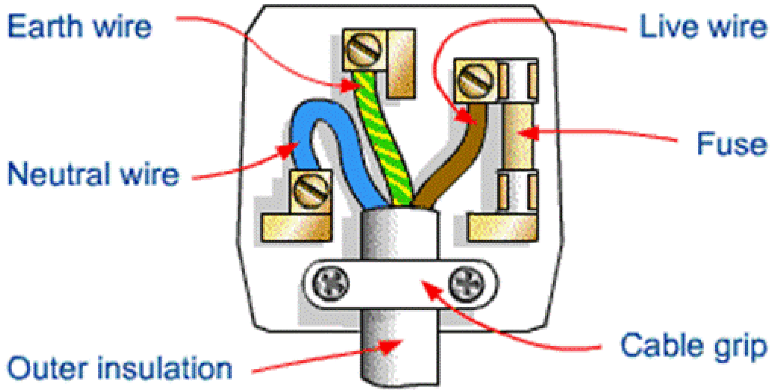
	Underground cables	**Overground cables**
Advantages	No visual pollution Less affected by the weather	No need to dig up the ground. Easy to repair
Disadvantages	Bigger disturbance to the land Difficult to access to repair	Visual pollution Affected by the weather

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.

Energy transferred (J) = Power (W) x Time (s)

$E = Pt$

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

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

$E = 360\ 000$J or 360 kJ.

Power Calculations

Power (W) = Current (A) x Potential difference (V)

$P = IV$

Power (W) = Current^2 (A) x Resistance (Ω)

$P = I^2R$

Charge

Energy transferred (J) = Charge (C) x Potential difference (V)

$E = QV$

Charge (C) = Current (A) x Time (s)

$Q = It$

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

Unit conversions

kJ toJ	x 1000
minutes to seconds	x 60
hours to seconds	x 3600

23. Static electricity and electric fields

Static electricity

- When certain insulating materials are rubbed against each other they become electrically charged. Negatively charged electrons are rubbed off one material and on to the other.
- The material that gains electrons becomes negatively charged.
- The material that loses electrons is left with an equal positive charge.
- Two objects that carry the same type of charge repel.
- Two objects that carry different types of charge attract.

Sparking (electric shock)

- Caused by the build-up of electrostatic charge
- Occurs when two objects which are charged by friction and become oppositely charged and have a surplus of electrons so large that the electrons 'jump' across to an object that is neutral.
- Causes a small current to flow between the objects, called a spark.

Electric Fields

•A charged object creates an electric field around itself

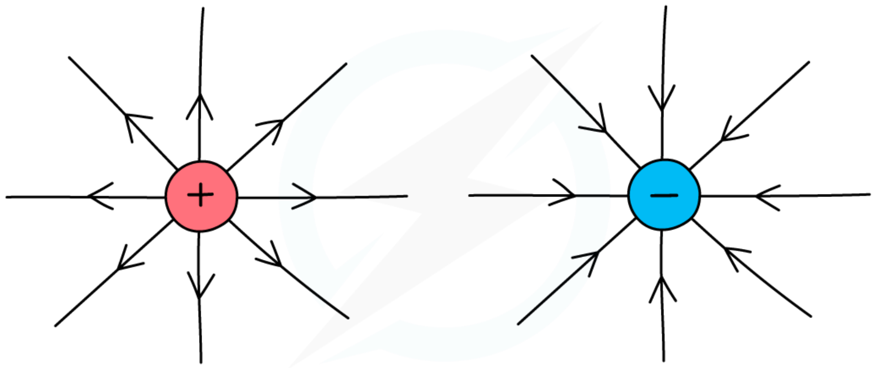
•Shown by electric field lines

•Fields lines always point **away** from **positive** charges and **towards** **negative** charges.

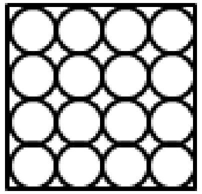
•The strength of an electric field depends on the distance from the object creating the field:

•The field is strongest close to the charged object - this is shown by the field lines being closer together

•The field becomes weaker further away from the charged object - this is shown by the field lines becoming further apart

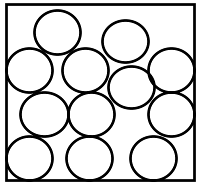


24. The particle model



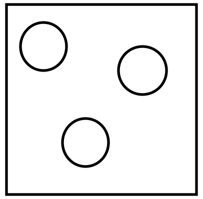
Solids

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

Density (kg/m^3) = mass (kg) ÷ volume (m^3)

Density (g/cm^3) = mass (g) ÷ volume (cm^3)

$\boldsymbol{p = m \div v}$

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

Volume of 1kg of water = $0.001 m^3$.

E	$p = m \div v$
V	m = 1kg and v = $0.001 m^3$
E	Density = 1 ÷ 0.001
V	1000
Y	kg/m^3

25. 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

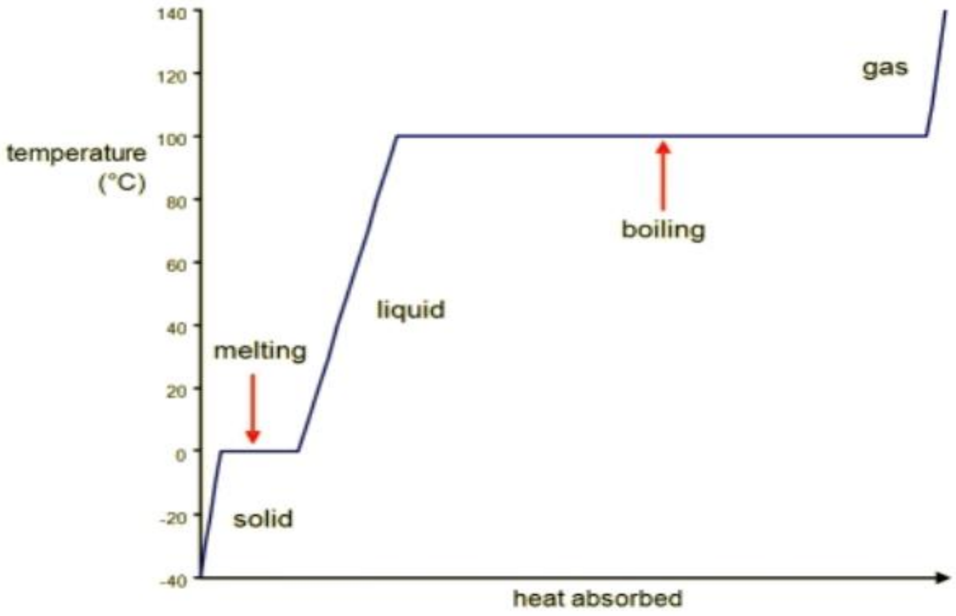
-Reducing surface temperature

26. 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 x 334 000
V E = 501 000
Y J

E = 501 000J 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

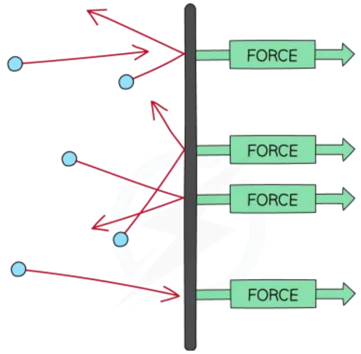
Horizontal line = specific latent heat

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

27. 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.



Pressure = force exerted per unit of area.

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.

For a fixed mass of a gas held at a constant temperature:

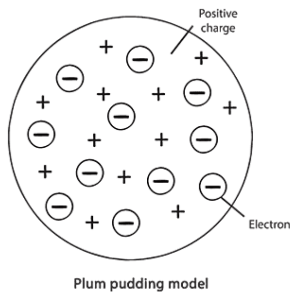
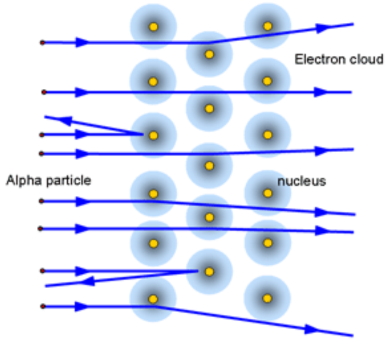
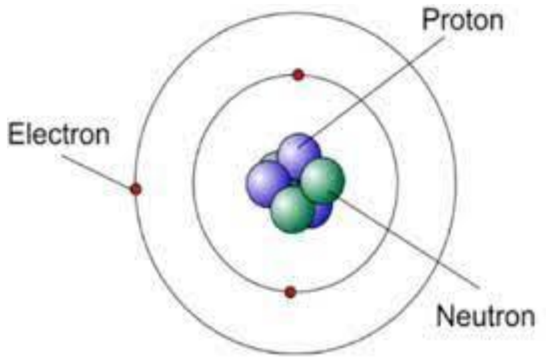
Constant = Pressure (Pa) x volume (m^3)

- When the volume **decreases** (compression), the pressure **increases**
- When the volume **increases** (expansion), the pressure **decreases**
- The key assumption is that the **temperature** and the **mass** (and number) of the particles remains the same

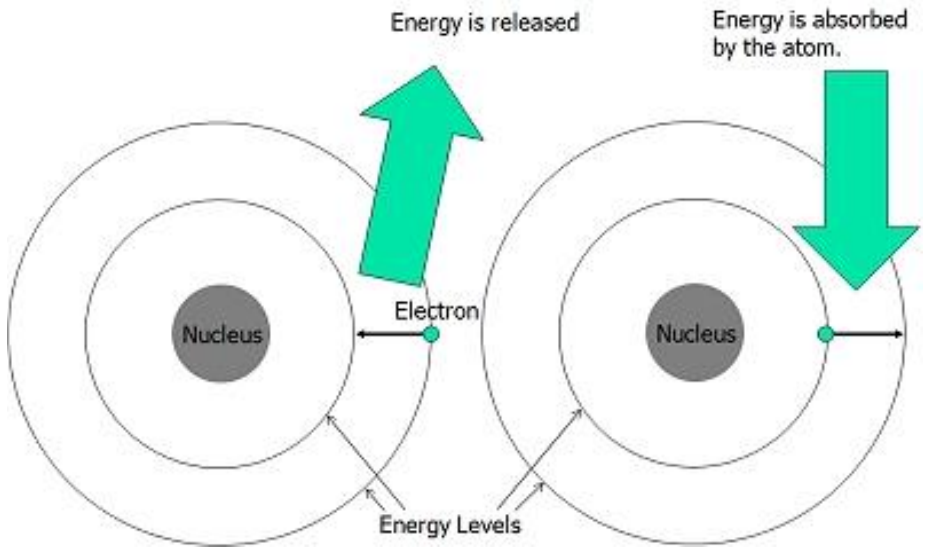
By increasing the volume:

- ➢ 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.

28. Atomic models

Atomic model	Plum pudding model		Nuclear model		
Diagram					
Discovery	Electron	Positive nucleus in the centre of the atom	Electrons occupy shells	Neutrons	• 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	

29. 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.

$^{16}_{8}O$ 8 protons, 8 electrons and 8 neutrons

$^{18}_{8}O$ 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).

30. 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

31. 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

$$^{219}_{86}\text{radon} \longrightarrow {}^{215}_{84}\text{polonium} + {}^{4}_{2}\text{He}$$

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)

$$^{14}_{6}\text{carbon} \longrightarrow {}^{14}_{7}\text{nitrogen} + {}^{0}_{-1}\text{e}$$

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 half life = 600 ÷ 2 = **300Bq**

2 half lives = 300 ÷ 2 **= 150Bq**

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

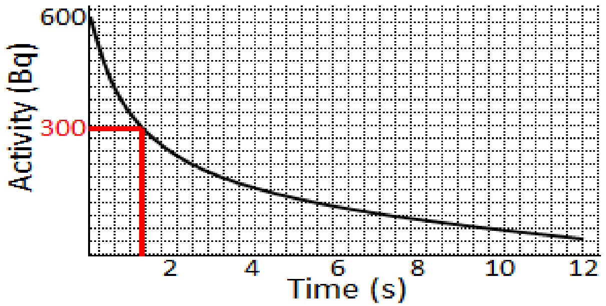
Number of half-lives = 40/10 = 4 half-lives.

After 1 half life – ½ remains

After 2 half lives - ¼ remains

After 3 half lives – ⅛ remains

After 4 half lives - 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)

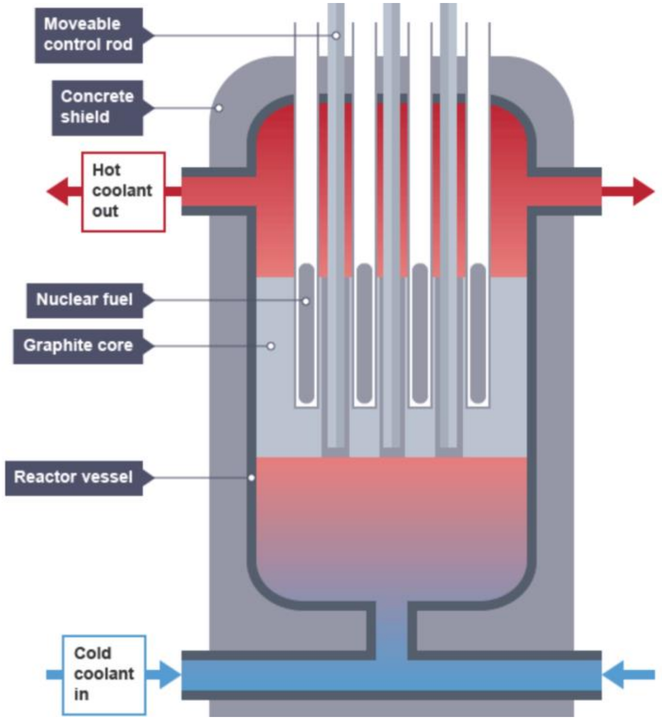
32. Applications of radiation, contamination and irradiation

Applications of radiation	Radioactive contamination	Irradiation
Destruction of unwanted tissue (cancer) or imaging internal organs. Radio-isotopes with a short half-life are used to limit any damage. Alpha radiation cannot be used for imaging because it cannot penetrate body tissue and it is highly ionising. Over exposure to ionising radiation can damage cells and lead to cancer	The unwanted presence of radioactive materials. The level of hazard depends on the type of radiation and the amount of time you are exposed. 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.	Where an object is deliberately exposed to a radioactive source. Used to sterilise medical equipment and food. The irradiated object does not become radioactive, so it is safe.

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	The amount of radioactivity we are exposed to. Measured in sieverts (Sv). 1000 mSv = 1Sv How big a dose you receive will depend on where you live and what your job is.
Why radioactive waste should have a short half-life	Activity decreases quickly Risk of harm decreases quickly

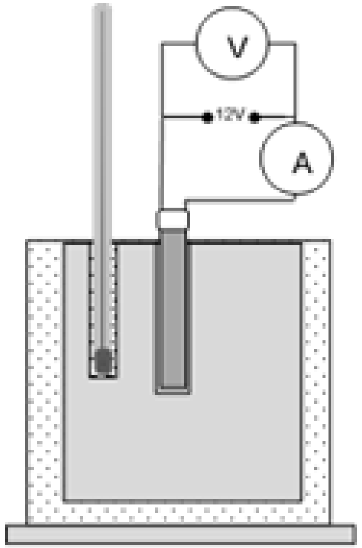
33. Nuclear fission and fusion

	Nuclear Fusion	Nuclear fission
How it occurs	Lighter nuclei join to form heavier nuclei Some of the mass of the nuclei is converted to energy	Neutron absorbed by a uranium nucleus Nucleus splits into two parts. Neutrons are released Gamma rays are emitted.
Requirements for the process to occur	Extremely high temperatures	The unstable nucleus must absorb a neutron. As it splits into two, it emits 2 or 3 neutrons, plus gamma rays. These neutrons then split other unstable atoms creating a chain reaction. All the products of fission have kinetic energy.
Uses	Stars, including the Sun, use nuclear fusion to produce energy	**Nuclear power plants:** reliable source of energy **Nuclear reactor:** The energy released is used to heat water. The chain reaction is controlled to release energy as required. **Nuclear weapons:** The energy is released in an uncontrolled chain reaction. **Generation of electricity:** Fuel is deuterium which can be made from sea water. Does not create radioactive waste that needs to be stored.



Hot coolant out	Used to heat water to create steam and turn a turbine
Graphite core (moderator)	Used to slow down neutrons, so they are more easily absorbed by fuel rods.
Control rods	When lowered, prevent neutrons travelling between fuel rods, slowing down the rate of the chain reaction.

34. 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

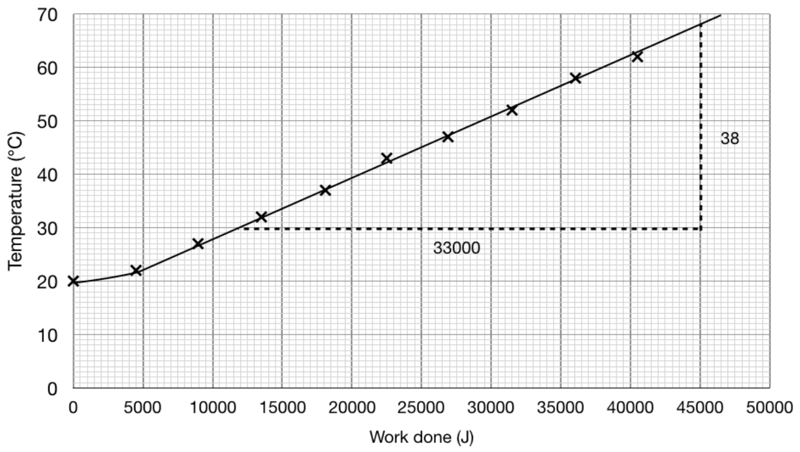
The immersion heater is not fully immersed into the block

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 ÷ gradient



35. Required Practical 2: Thermal Insulation

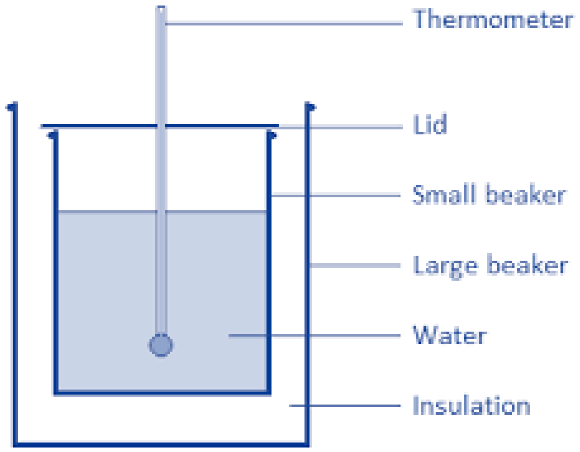
Method

1. Pour 200 cm^3 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.

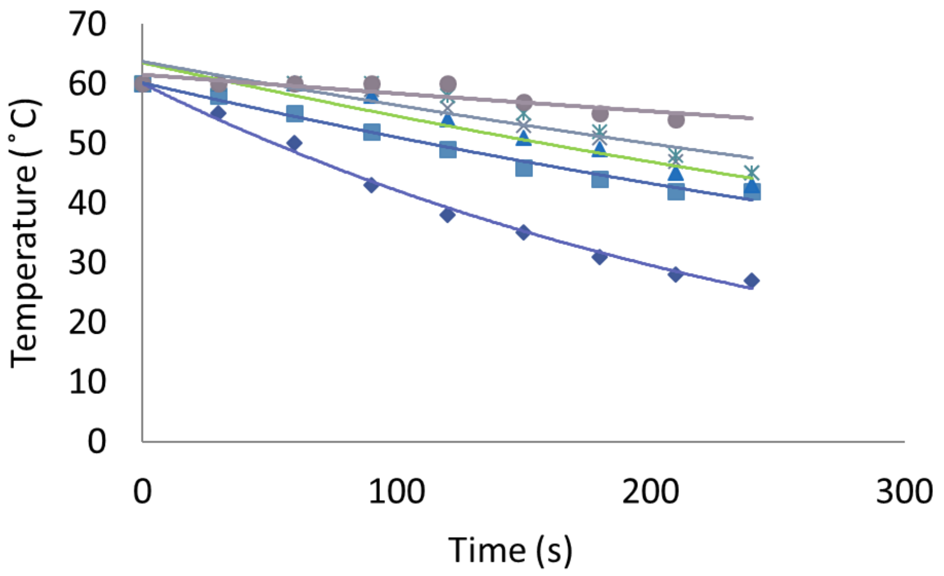
IV – Time (s)

DV – Temperature change

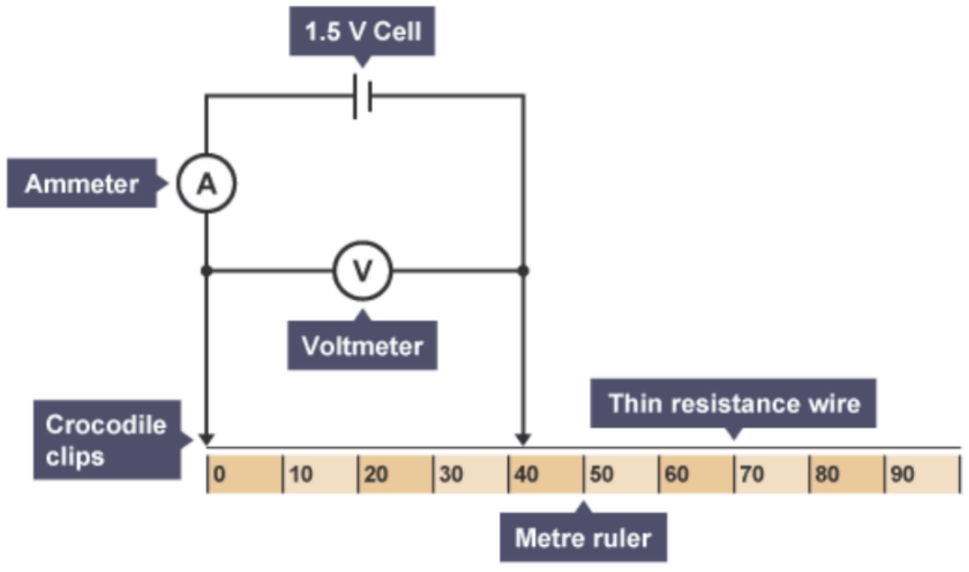
CV – Volume of water, material of insulation, starting temperature.



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



36. Required Practical 3: Resistance of a wire



Method:

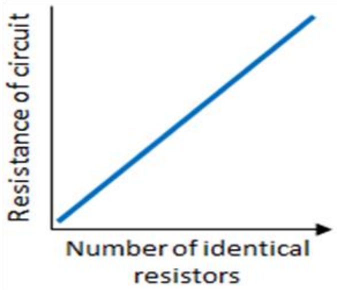
1. Set up equipment as shown in the diagram.
2. Connect the crocodile clips to the resistance wire, 100 cm apart.
3. Record the reading on the ammeter and on the voltmeter.
4. Move one of the crocodile clips closer until they are 90 cm apart.
5. Record the new readings on the ammeter and the voltmeter.
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

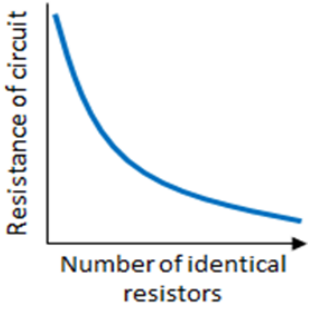
DV: voltage and current

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.

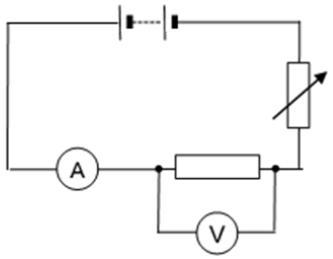
37. Required practical 4: Component IV characteristics

IV—Potential Difference (Volts)

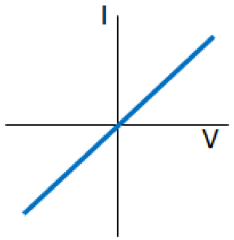
DV—Current (Amps)

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

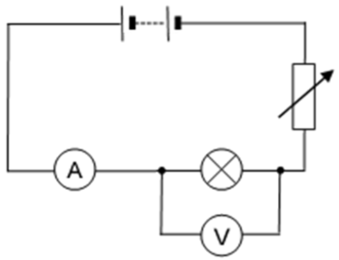
Fixed Resistor



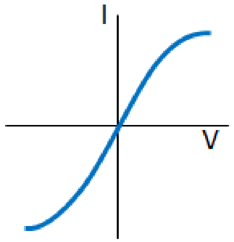
At a constant temperature, the current is **directly proportion** to the voltage. This means it obeys Ohm's Law.



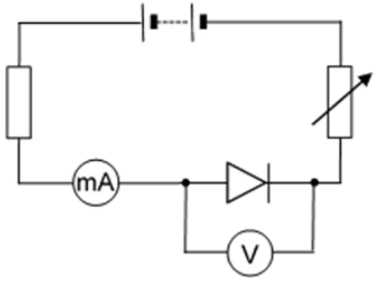
Filament Bulb



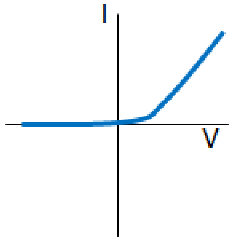
As the voltage increases the current increases. This causes the filament to get hotter, meaning the resistance increases. Therefore as the voltage continues to increase the current levels off.



Diode



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



Method

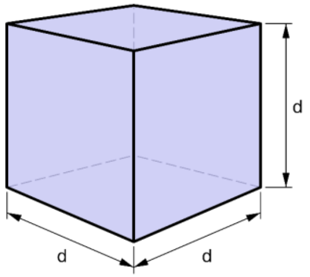
1. Measure the current in the resistor using the ammeter.
2. Measure the potential difference across resistor using the voltmeter.
3. Vary the resistance of the variable resistor
4. Record a range of values of current and potential difference.
5. Ensure current is low to avoid temperature increase.
6. 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

38. Required practical 5: Calculating density

Regular shaped object



1. Measure the length, width and height using a ruler.
2. Calculate the volume (l x w x h)

2. Measure the mass using a balance.

3. Use the equation mass ÷ volume to calculate the density.

Irregular shaped object

1. Using a balance, measure the mass of the object.

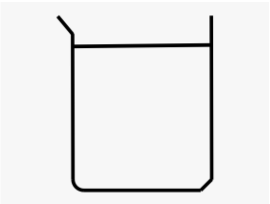
2. Fill a measuring cylinder with 100 cm^3 of water

3. Put object into measuring cylinder

4. Difference in volume of water is the volume of the object

5. Use the equation mass ÷ 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

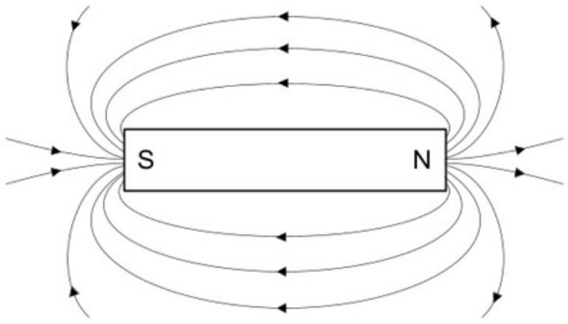
4. Difference in mass of (beaker + contents) from the beaker is the mass of the liquid.

5. Use the equation mass ÷ volume to calculate the density.

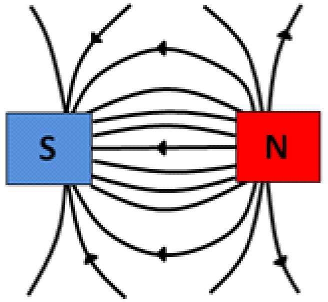
Physics Paper 2 (Triple)

39. Magnets

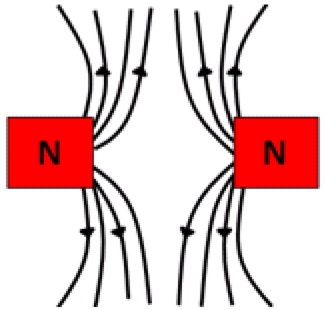
Magnetic metals	Iron (steel), nickel and cobalt
Permanent magnets	Magnetic all the time. Produce their own magnetic field.
Induced magnets	Made from magnetic materials. Only turns into a magnet when held in a magnetic field e.g. core of an electromagnet
North and south pole of a magnet	The part of the 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 of it was placedin 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



40. Compasses and magnets

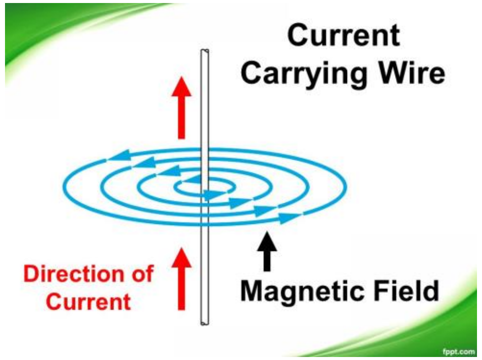
	Iron filings	Plotting compass
Method	Sprinkle iron filings on a piece of paper over the magnet	Use a plotting compass around the magnet with the needle showing the direction.
Advantage	Field lines easily seen	Direction of field lines shown
Disadvantage	Iron filings easily spilt and stick to magnet. Not 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).

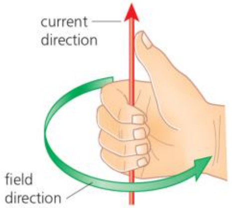
41. Electromagnetism

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

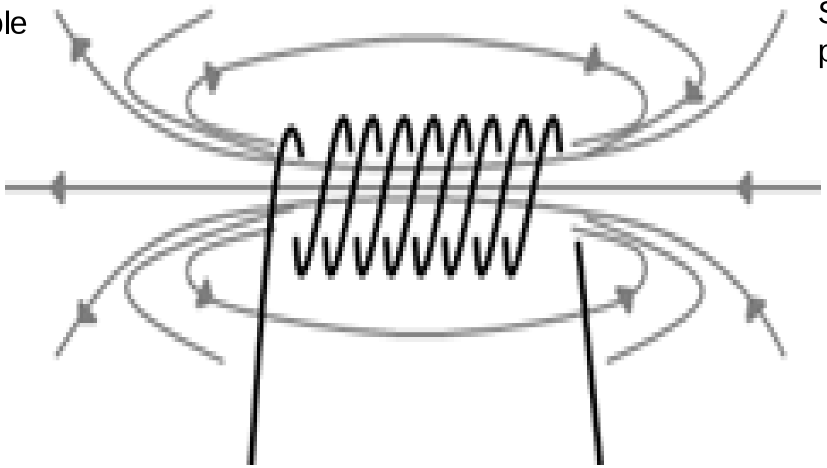
Inside solenoid Magnetic field is strong. Same strength and direction in all places. Field lines are parallel.

Electromagnet: a solenoid with an iron core

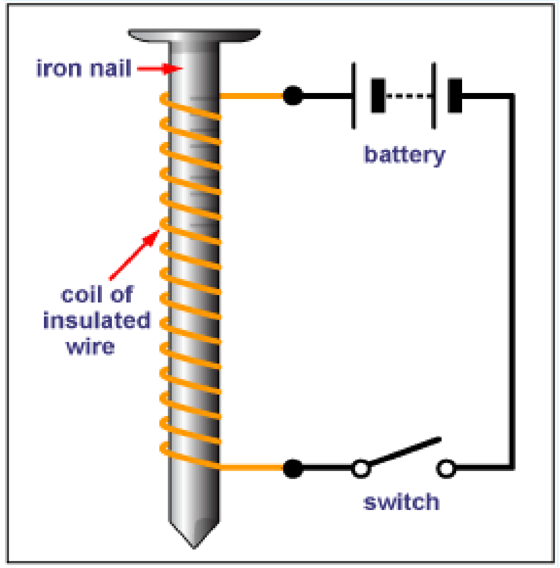
Advantages of an electromagnet:
Can be turned on or off. Strength of magnet can be increased or decreased.

North pole

South pole



42. 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 **<u>coils</u>**

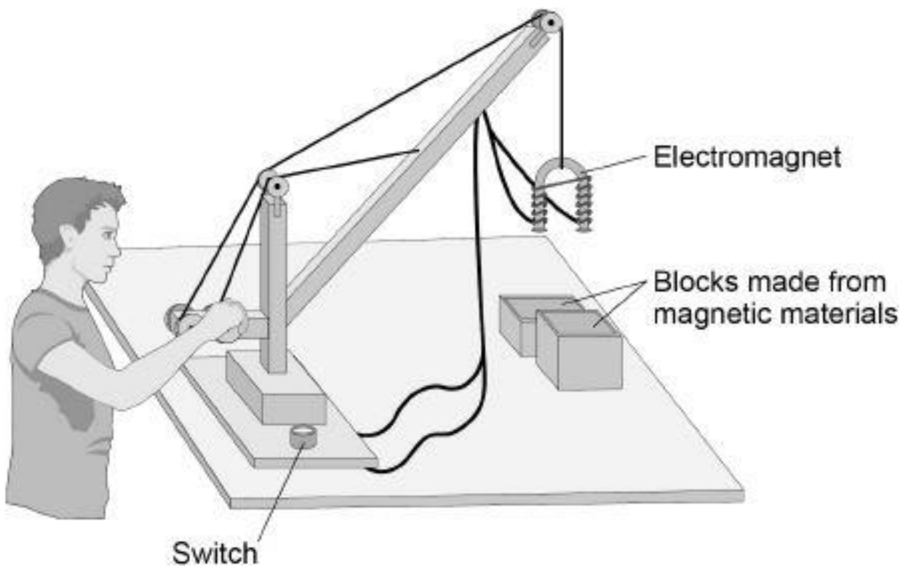
b) Increase the **<u>current</u>**

c) Change the **<u>core</u>**

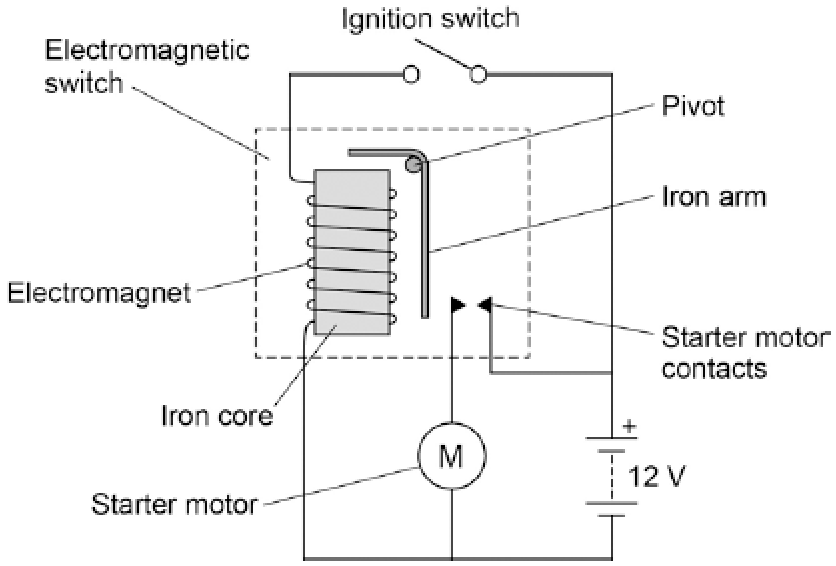
DV: Number of paperclips picked up

CV: Same type of paperclip.

43. 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

44. Fleming Left Hand Rule

When a wire carrying a current is exposed to the magnetic field of another magnet, then a force is produced on the wire at a right angle to the direction of the magnetic field produced.

This is called the motor effect.

force (N) = magnetic flux density (T) × current (A) × length (m)

$F = B I l$

- *F* is force in newtons (N)
- *B* is magnetic flux density (magnetic field strength) in tesla (T)
- I is current in amps (A)
- *l* is length in metres (m)

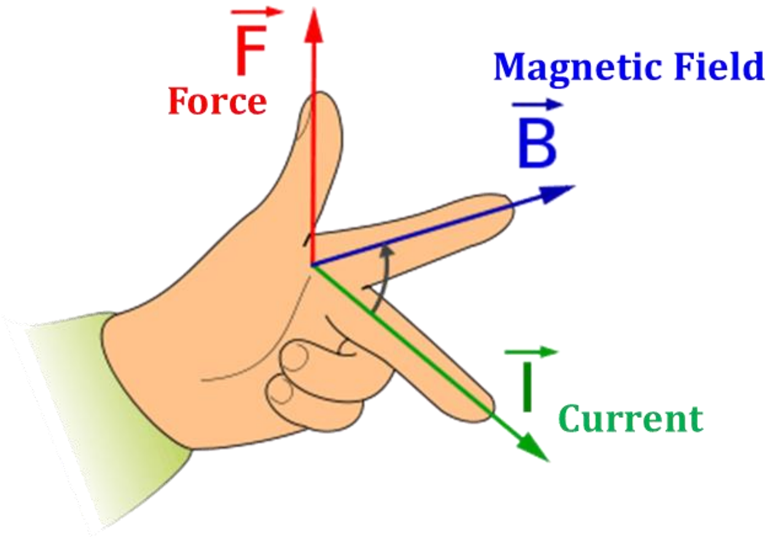
The force on a given length of wire in a magnetic field increases when:

- the current in the wire increases
- the strength of the magnetic field increases

The force is greatest when the direction of the current is 90° to the direction of the magnetic field.

There is **no** motor effect force if the current and magnetic field are parallel to each other.

Use Flemings "left hand rule" to find the direction of the force



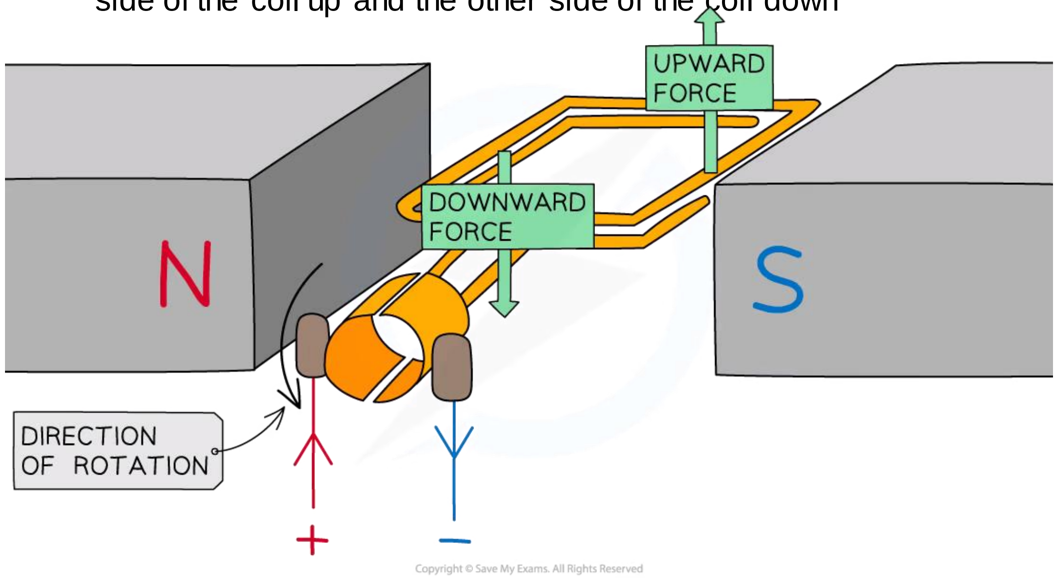
- Use your left hand
- The angle between your index finger and middle finger should be a right angle on the horizontal plane.
- The angle between your index finger and thumb should be a right angle on the vertical plane.
- Your thumb represents the direction of the force.
- Your index finger represents the direction of the magnetic field.
- Your middle finger represents the direction of the current flowing through the wire.

45. Motor Effect

- The motor effect can be used to create a simple d.c electric motor.
- Electricity is used to create motion
- The simple d.c. motor consists of a coil of wire (which is free to rotate) positioned in a uniform magnetic field.

When the current is flowing in the coil at 90º to the direction of the magnetic field:

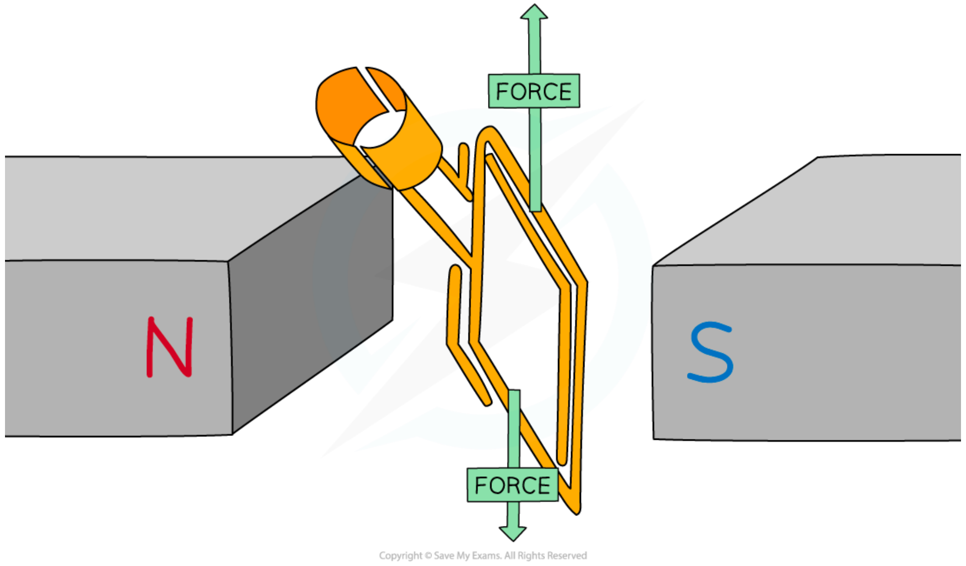
- The current creates a magnetic field around the coil
- The magnetic field produced around the coil interacts with the field produced by the magnets
- This results in a force being exerted on the coil
- As current will flow in opposite directions on each side of the coil, the force produced from the magnetic field will push one side of the coil up and the other side of the coil down



The **split ring commutator** swaps the contacts of the coil. This reverses the direction in which the current is flowing.

The two halves of the split ring commutator ensure that the current supplied to the wire changes direction each half-turn (or that the current supplied is the same direction on each side of the motor) and as a result, the force produced maintains a constant rotation in one direction overall.

Reversing the direction of the current will also reverse the direction in which the forces are acting. As a result, the coil will continue to **rotate**



46. Generator Effect

Generator effect: When a potential difference is induced across a conductor which is experiencing a change in an external magnetic field

Motion is being used to create electricity

Occurs two ways:

Method 1: When a wire cuts through the magnetic fields lines

This induces a potential difference in the wire.

Method 2: When a magnet moved through the coil, the field lines cut through the turns on the coil. This induces a potential difference in the coil

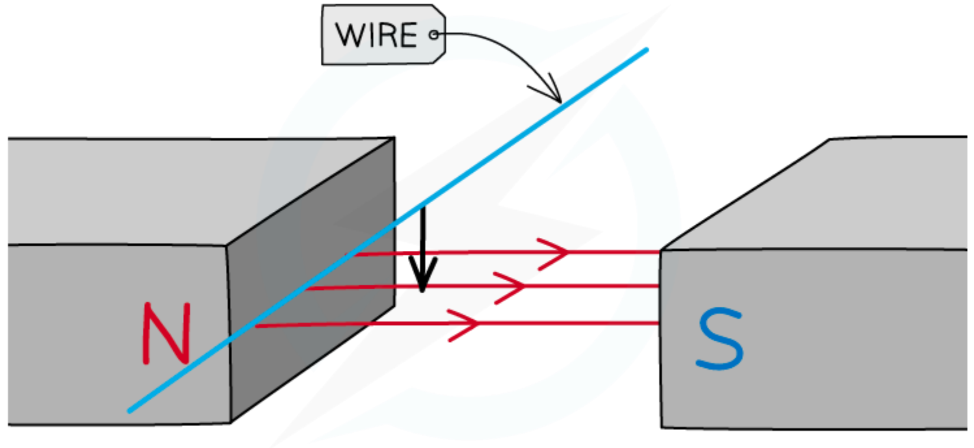
If the magnet is stationary

There is no relative movement between the coil and the magnetic field, so there are no magnetic field lines being cut.

If the magnetic field lines are not being cut then there will not be a potential difference induced

Factors Affecting the Induced Potential Difference

1. The **speed** at which the wire, coil or magnet is moved. Increasing the speed will increase the rate at which the magnetic field lines are cut.
2. The **number of turns** on the coils of wire. This is because each coil will cut through the magnetic field lines and the total potential difference induced will be the result of all of the coils cutting the magnetic field lines.
3. The **size** of the coils. This is because there will be more wire to cut through the magnetic field lines.
4. The **strength** of the magnetic field.



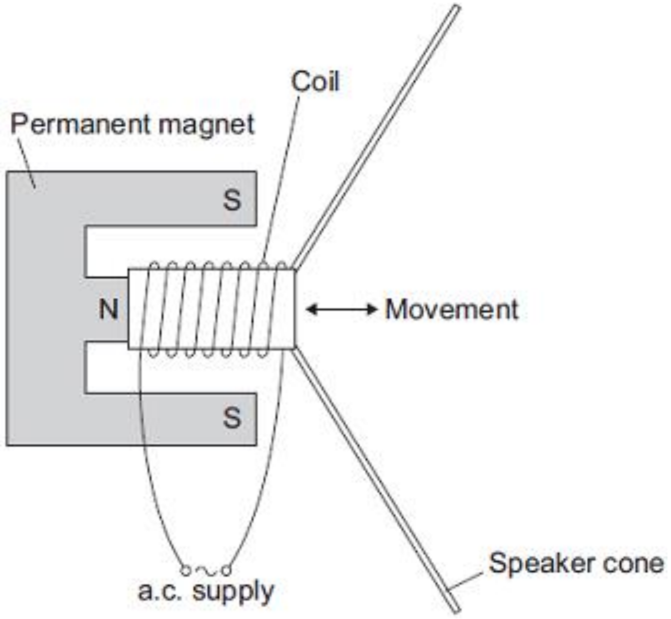
47. How a loudspeaker works

Headphones work because they contain small loudspeakers inside them.

A loudspeaker makes use of the motor effect to produce sound.

Variations in the AC electric current supplied to the device causes variations in the magnetic field produced.

These variations cause the cone in the loudspeaker to move and the vibrations are transferred to the air particles and generate a sound wave.



1. An alternating current is supplied through a coil of wire in the loudspeaker. creating an electromagnetic field around the wire.
2. The electromagnetic field interacts with the permanent magnetic field and a force is produced (the motor effect).
3. The force produced pushes the cone in the loudspeakers outwards.
4. The current is reversed and the force changes direction, pulling the cone back inwards.
5. The vibrations of the cone moving in and out creates vibrations in the air particles, which are transferred as sound waves.
6. The sound waves produced match the electrical signals supplied

48. Uses of the generator effect

AC Generator (Alternator)

•As the coil rotates, it cuts through the field lines

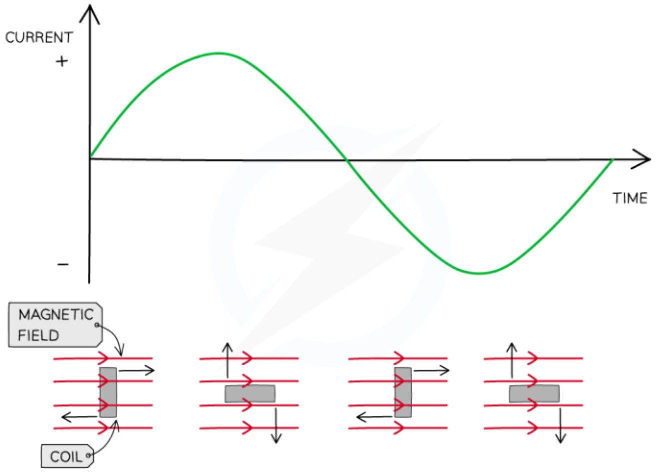
•This induces a potential difference between the end of the coil

Slip rings, attached to the ends of the coil, transfer the current to metal brushes whilst allowing the coil to rotate freely

The A.C. generator creates an alternating current, varying in size and direction as the coil rotates

EMF is greatest when the coil is horizontal, as in this position it cuts through the field at the fastest rate

EMF is smallest when the coil is vertical, as in this position it will not be cutting through field lines



DC generator (dynamo)

•A simple dynamo is the same as an AC generator (alternator) except that the dynamo has a split-ring commutator instead of two separate slip rings

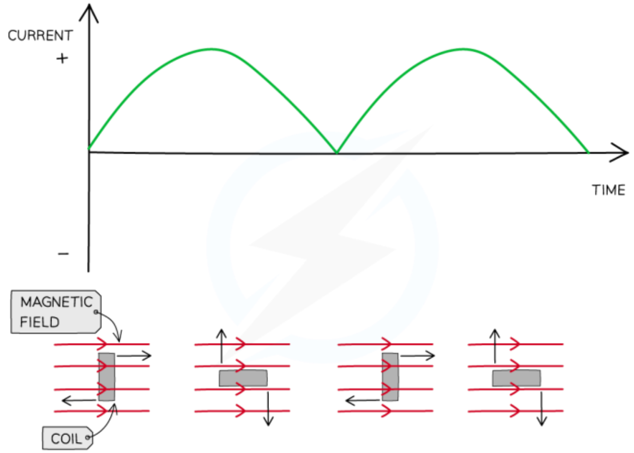
•The split ring commutator changes the connections between the coil and the brushes every half turn in order to keep the current leaving the dynamo in the same direction

•This happens each time the coil is perpendicular to the magnetic field lines

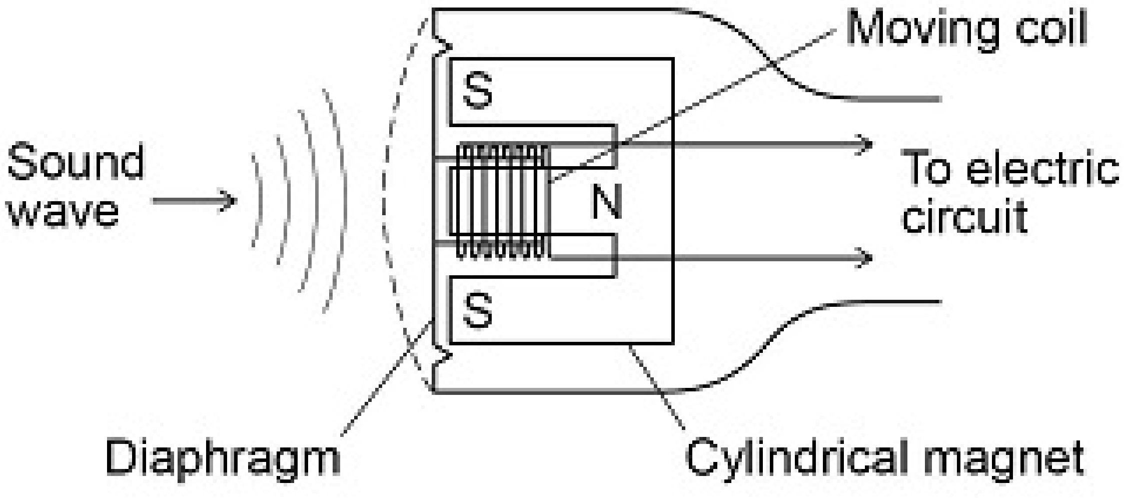
•Therefore, the induced potential difference does not reverse its direction as it does in the alternator

•Instead, it varies from zero to a maximum value twice each cycle of rotation, and never changes polarity (positive to negative)

•This means the current is always positive (or always negative)



49. How a microphone works



How a microphone works

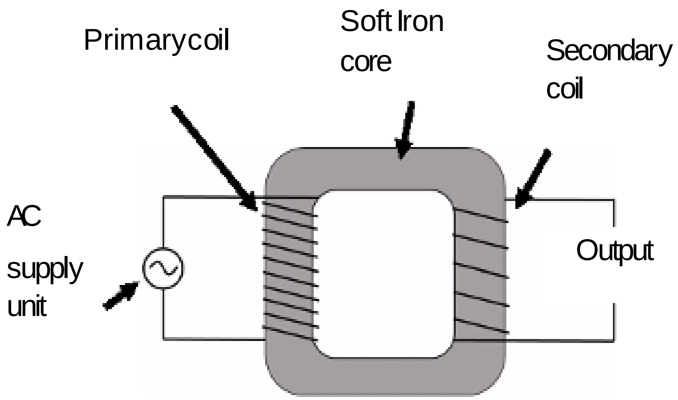
- sound (waves) cause the diaphragm to vibrate
- the diaphragm causes the coil / wire to vibrate
- the coil wire moves through the magnetic field
- a potential difference is induced across the ends of the coil

Function of a microphone: to convert the pressure variations in sound waves into variations in current

50. Transformers

A basic transformer consists of a primary coil and a secondary coil wound on a soft iron core. Iron is used as it is easily magnetised.

Fewer coils → lower potential difference → higher current



How a transformer works:

An alternating current through the primary coil causes an alternating magnetic field around the iron core

This induces an alternating potential difference across the secondary coil

Advantages of a transformer:

The transformer can be adjusted to have different numbers of turns on the secondary coil.

To vary the output potential difference

So that you don't need a different generator for each type of device

Calculating Potential Difference

The ratio of potential differences on the transformer coils matches the ratio of the numbers of turns on the coils.

$$\frac{\text{Voltage in secondary coil } (V_s)}{\text{Voltage in primary coil } (V_p)} = \frac{\text{Number of turns on secondary coil } (n_s)}{\text{Number of turns on primary coil } (n_p)}$$

Assuming that a transformer is 100 per cent efficient, the following equation can be used to calculate the power output from the transformer:

input power = output power

$$V_p \times I_p = V_s \times I_s$$

V_P is input (primary) voltage

I_p is input (primary) current

V_s is output (secondary) voltage

I_s is output (secondary) curren

From Paper 1: Electricity module:

Power (W) = potential difference (V) × current (A)

51. 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 ÷ T

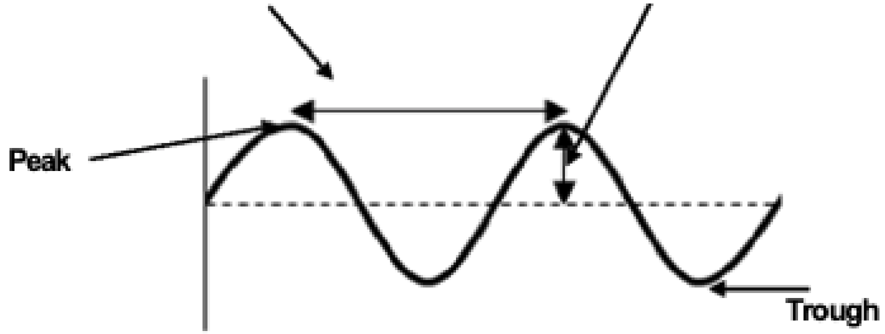
Example: What is the frequency for a wave with a time period of 0.2s

E	f = 1 ÷ T
V	T = 0.2 s
E	f = 1 ÷ 0.2
R	5
Y	Hz

f = 5Hz

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 λ

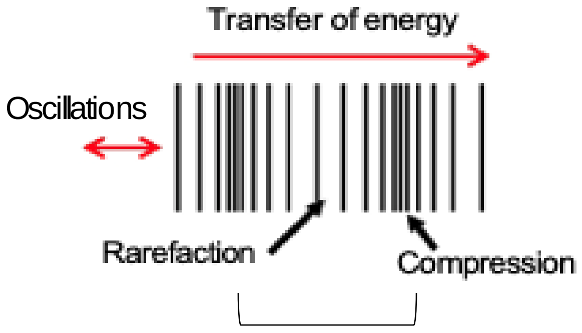
Example: How fast is a wave travelling which has a 3m wavelength and a frequency of 20Hz?

E	V = f x λ
V	f = 20 Hz; λ = 3 m
E	V = 20 x 3
R	V = 60
Y	m/s

52. Transverse and Longitudinal waves

Longitudinal Waves

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



One wavelength

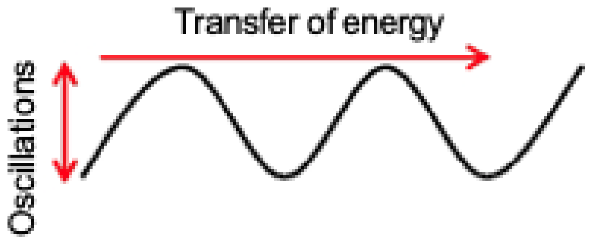
Compression: particles bunch up

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

53. 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:

Speed (m/s) = distance (m) ÷ time (s)

Unit conversions:

km to m:	x 1000
cm to m:	÷ 100
minutes to seconds:	x 60
hours to seconds:	x 3600

Sound waves

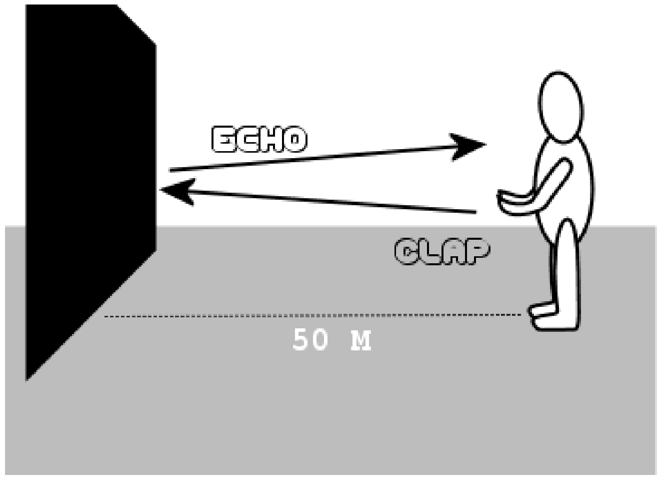
Bigger the amplitude – taller the wave – louder the sound

Higher the frequency – more waves per second – higher pitch

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 hearings it's echo.
4. Use the equation,

   speed = distance ÷ time.



54. Sound and Seismic waves

Human hearing can detect sound in the frequency range of 20Hz to 20,000Hz.

Ultrasound > 20kHz

Infrasound < 20Hz

Ultrasound is used to detect the depth of the sea bed, where inclusions or other defects are found in solid metal and to image soft tissue in humans.

When ultrasound is used to measure the depth of an object, or the distance below a surface to a defect, the signal travels from the transducer to the object and is bounced back to the transducer. The total distance travelled by the sound is twice the depth of the object.

Depth of object (m) = 0.5 x speed of ultrasound (m/s) x time (s)

Seismic Wave type	Description
Primary (P-waves)	• Causes the initial Earth tremor • Longitudinal waves which push or pull on material. • Bend as they travel through the earth's mantle • Refract at boundary between mantle and core • Travels through solids and liquids
Secondary (S-waves)	• Transverse waves that travel more slowly than P-waves • Shake material from side-to-side. • Bend as they travel through the Earth's mantle • Cannot travel through liquid outer core • Travels through solids only
Long (L-waves)	• Arrive last and and cause violent movements on the surface • Only happen in the Earth's crust.

55. Reflection, transmission and absorption of waves

Reflection

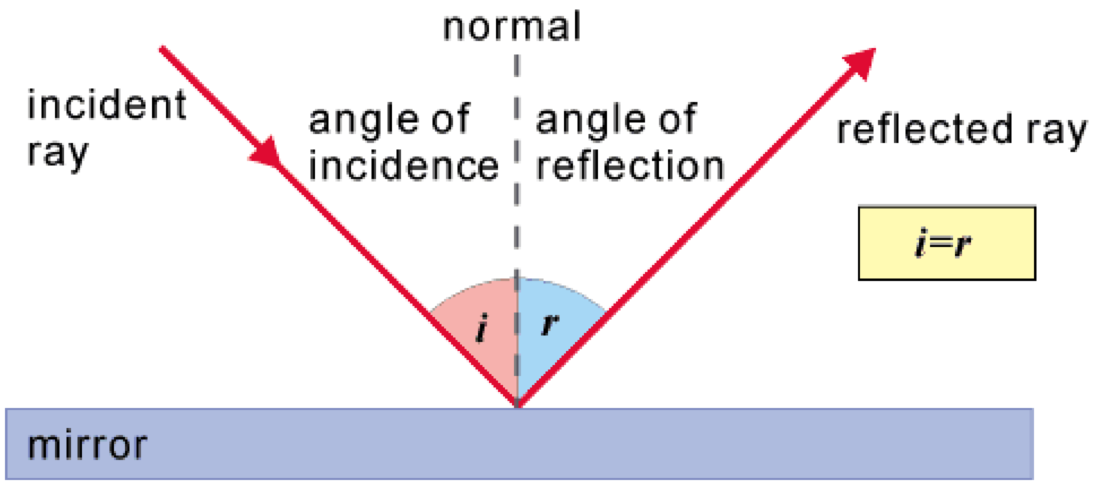
Angles are measured between the wave direction (ray) and a line at 90º to the mirror (boundary)

Normal = an imaginary line drawn at 90º to the surface

The angle of the wave approaching the boundary is called the angle of incidence (i)

The angle of the wave leaving the boundary is called the angle of reflection (r)

Angle of incidence (i) = Angle of reflection (r)



Transmission

Transmission occurs when a wave passes through a substance

The more transparent the material, the more light will pass through

For the process to count as transmission, the wave must pass through the material and emerge from the other side

When passing through a material, waves are usually partially absorbed

The transmitted wave may have a lower amplitude because of some absorption

For example, sound waves are quieter after they pass through a wall

Absorption

Occurs when energy is transferred from the wave into the particles of a substance

Sound waves are absorbed by brick or concrete in houses

Light will be absorbed if the frequency of light matches the energy levels of the electrons

If an object appears red, only red light has been reflected. All the other frequencies of visible light have been absorbed

56. Refraction of waves

Refraction

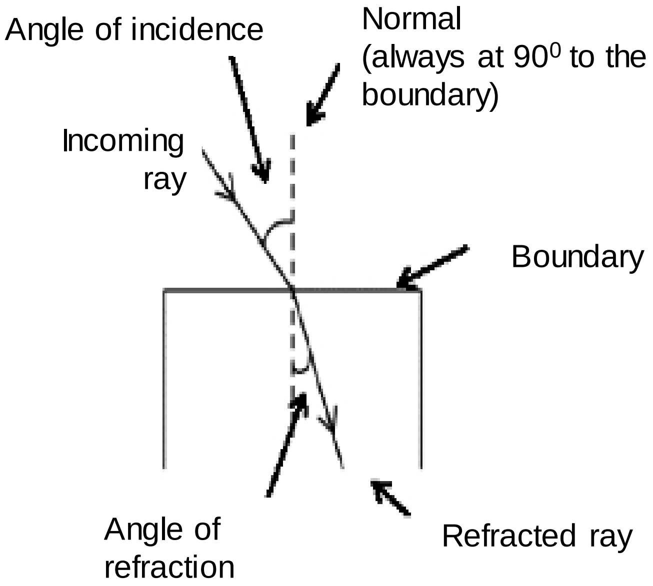
Waves change speed when they cross a **boundary** between two materials of different density or a boundary of different depths.

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**.

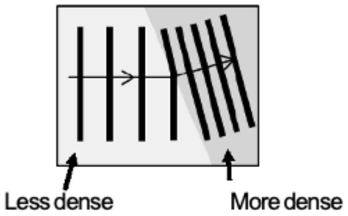
(waves closer together on diagram below but have not changed direction)

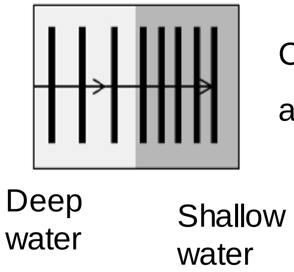
Refraction of Light ray



Wave Front Diagrams

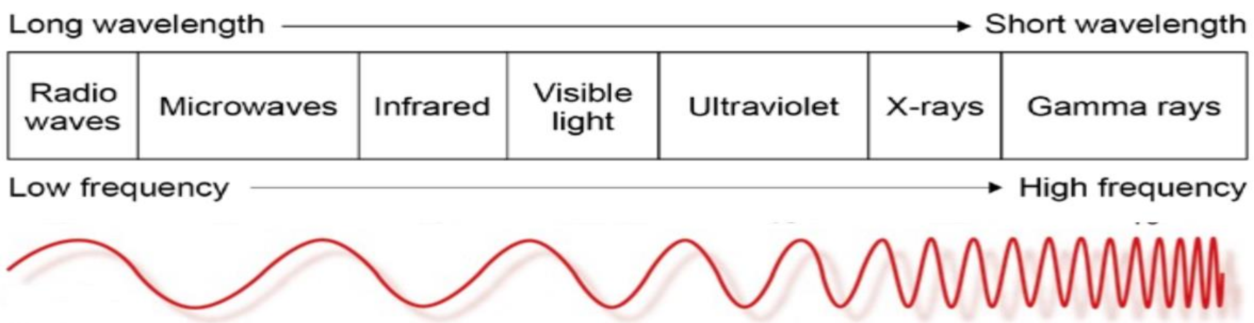
The part of the wave front that enters the more dense medium first, slows down as the rest of the wave front continues at the same speed but has to travel further. The difference in distance and speed causes the wave to refract. A wave travelling from deep to shallow water also refracts.





Change in speed but no change in direction as wave entered **along the normal**

57. Electromagnetic Spectrum



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

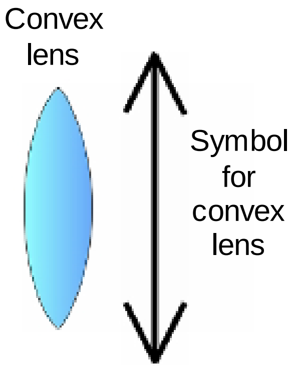
They all travel at 300,000,000 m/s.

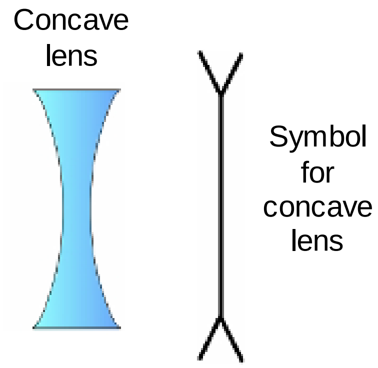
They are all transverse waves

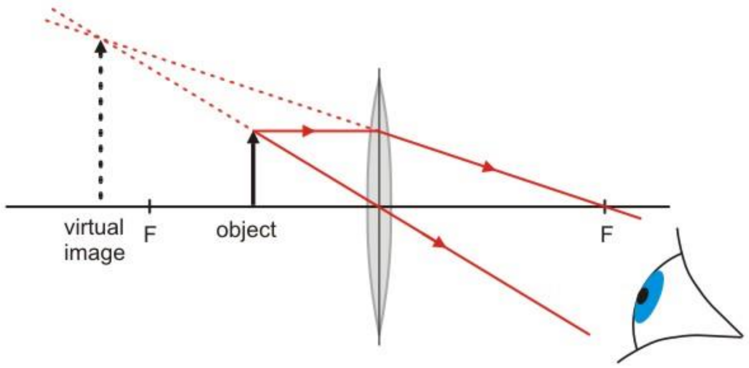
All parts of the EM spectrum can travel through a vacuum (e.g. space)

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

58. Lenses and Virtual Image Ray Diagrams

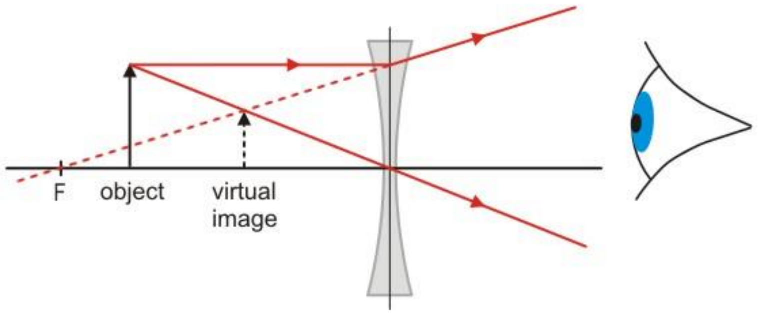






With a convex lens when object is placed at a distance less than the focal length away from the lens the image appears **upright**, **magnified** and is **virtual. Virtual images** cannot be projected on to a screen.

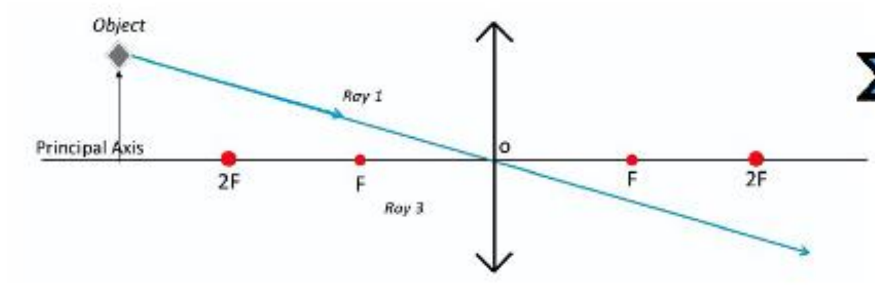
Magnification = $\frac{\textbf{Image size}}{\textbf{Actual size}}$

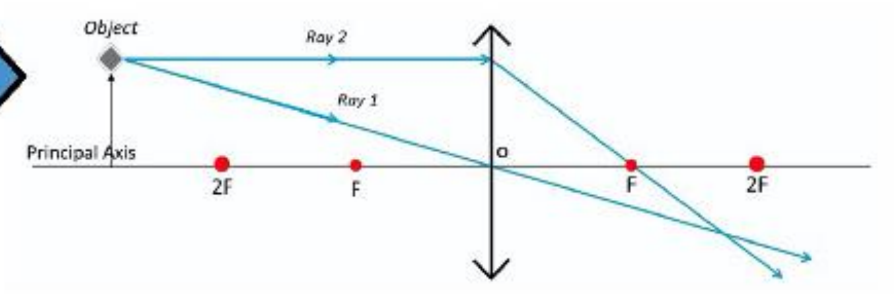


Concave lenses always produce virtual images. The image is **upright, diminished** and **virtual**

59. Ray Diagrams for Convex lens: Real Image

Drawing Ray Diagram for convex lens





Ray 1 - Draw a ray from the object, passing through the optical centre of the lens 'O'

Ray 2 - Draw a ray parallel to the principal axis, which refracts through the lens, passing through the principalfocus

Ray Diagram Key Terms

F = focal point of the lens.

Focal length = Distance from F to the centre of the lens

2F = Twice the focal length.

Depending on how far away from the lens the object is (measured in focal lengths) the image can appear either **magnified** or **diminished** (smaller than the object).

The image produced can be **upright** or **inverted** (upside down compared to the object).

An image is **real** if it can be projected , it will appear on the opposite side of the lens to the object.

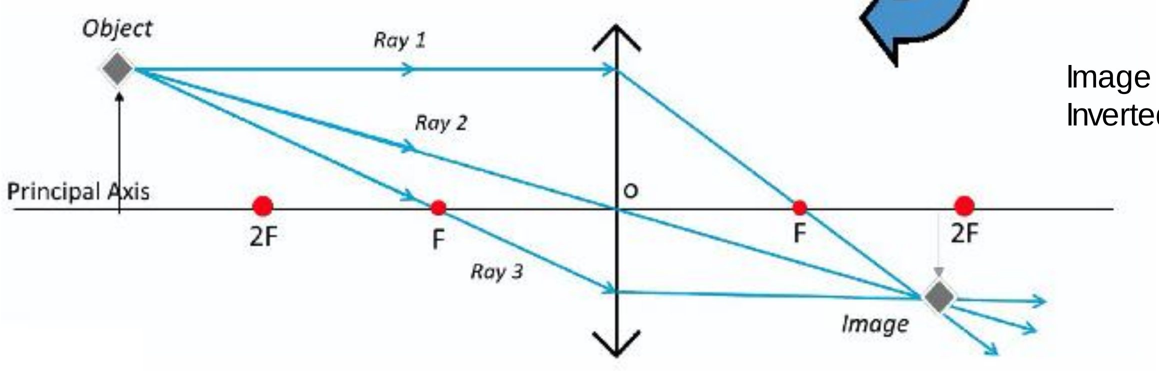


Image is real
Inverted and diminished

Ray 3 - Draw a ray passing through the principal focus (on the same side as the object) and being refracted through the lens, emerging parallel to the principal axis

60. Light

Transparent (window)	Transmits all the incident light through the object enabling a clear image to be seen.
Translucent (obscured glass)	Allows light to pass through but scatters it due to internal boundaries that repeatedly changes the direction of light meaning no clear image is seen through it.
Opaque (wooden block)	Absorbs, reflects or surface scatters all of the light that hits it. No light is transmitted through it

Surfaces and Colour

The colour of an opaque object is determined by which wavelengths of light are more strongly reflected. Wavelengths that are not reflected are absorbed.

- If all wavelengths are reflected equally the object appears white.
- If all wavelengths are absorbed the objects appears black.

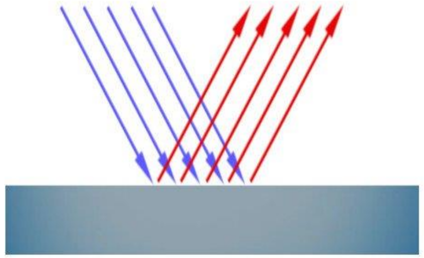
Specular Reflection

Reflection from a smooth, flat surface is called **specular reflection**. This is the type of reflection that happens with a flat mirror. The image in a mirror is **upright** and **virtual**.

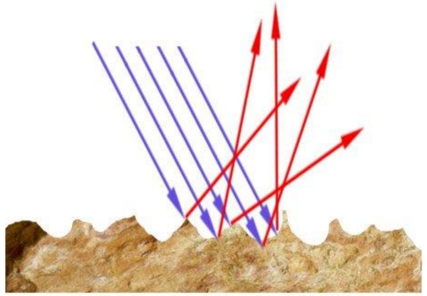
In a **virtual image**, the rays appear to diverge from behind the mirror, so the image appears to come from behind the mirror.

Diffuse Reflection

If a surface is rough, **diffuse reflection** happens. Instead of forming an image, the reflected light is scattered in all directions. This may cause a distorted image of the object, as occurs with rippling water, or no image at all. Each individual reflection still obeys the law of reflection, but the different parts of the rough surface are at different angles.



Specular Reflection



Diffuse Reflection

61. Black body radiation

All bodies (objects) emit and absorb infrared radiation.

The hotter the body:

•the more infrared radiation it gives out in a given time

•the greater the proportion of emitted radiation is visible light

A perfect black body is a theoretical object.

Properties of a black body:

- It would absorb all the radiation that falls on it
- It would not reflect or transmit any 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.

Different temperatures emit different intensities of infrared which are represented on the infrared camera as different shades

All bodies (objects) emit a spectrum of thermal radiation in the form of electromagnetic waves

The intensity and wavelength distribution of any emitted waves depends on the temperature of the body

This is represented on a black body radiation curve

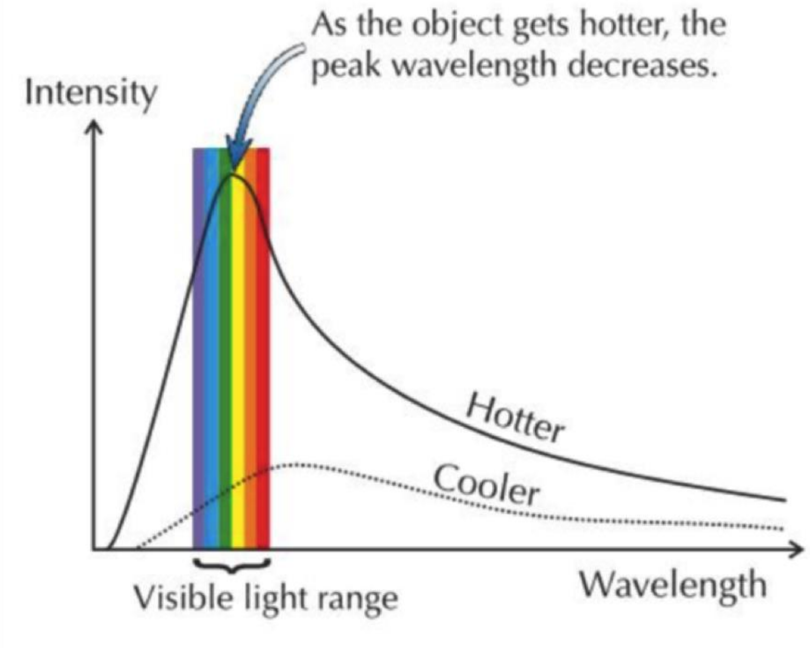
As the temperature increases, the peak of the curve moves

This moves to a lower wavelength and a higher intensity

From the electromagnetic spectrum, waves with a smaller wavelength have higher energy (e.g. UV rays, X-rays)

When an object gets hotter, the amount of thermal radiation it emits increases

This increases the thermal energy emitted and therefore the wavelength of the emitted radiation decreases



62. 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..

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

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

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

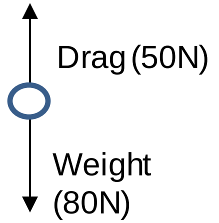
W = mg

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

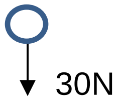
E	W=m x g
V	m = 2kg and g = 9.8N/kg
E	W = 2 x 9.8
R	W = 19.6
Y	N

63. 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**.

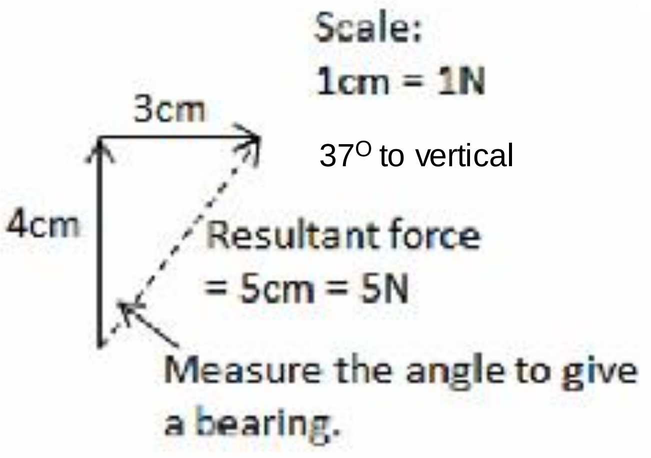
To make something move a force must be applied, which requires energy.

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

Calculating Resultant Forces using a diagram

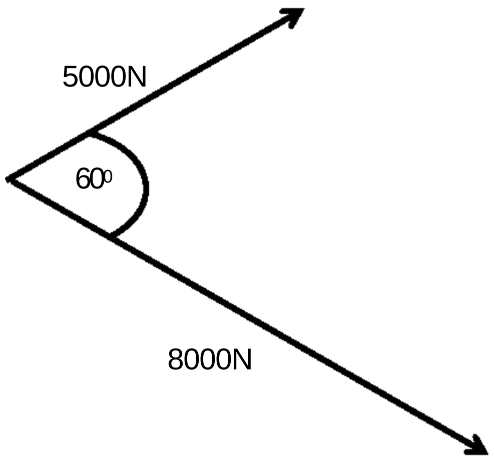
A scooter is pushed with 4N north and is blown 3N east by the wind. Find the magnitude and direction of the resultant force.

1. Draw a scale diagram.
2. Join the ends of the two forces (dotted arrow)
3. Measure the length of this line and use the scale to work out the size (magnitude) of the force.
4. Measure the bearing (angle) with a protractor.

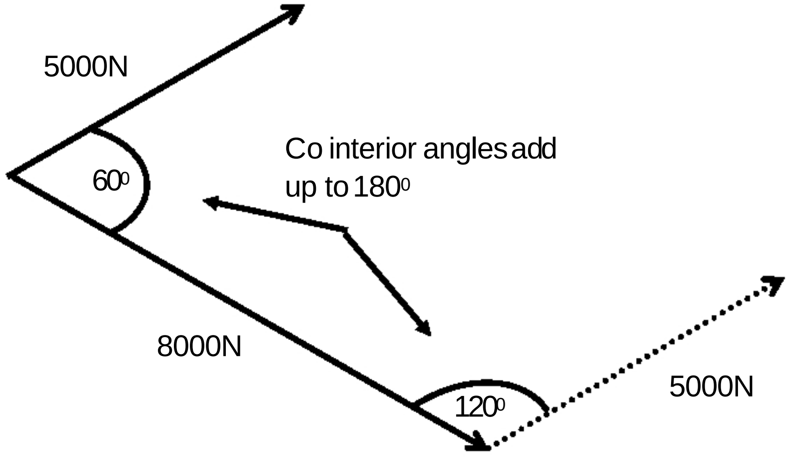


64. Resolving Forces—Parallelogram of forces 1

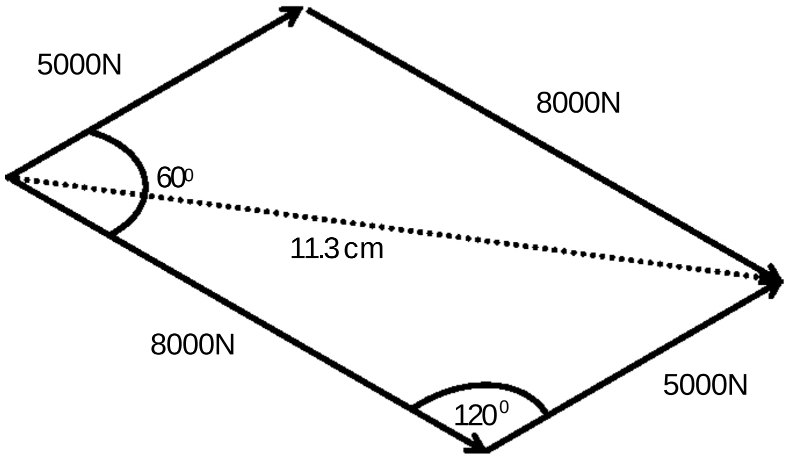
You will be given this vector diagram



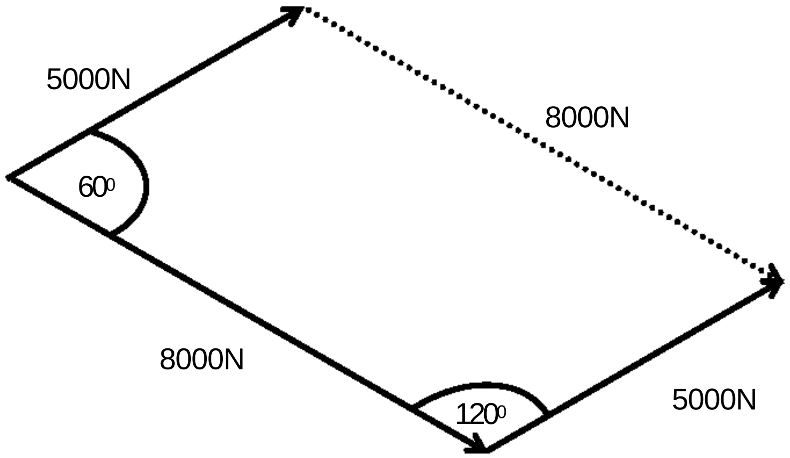
1. Draw the missing side of the parallelogram from the highlighted force



3. Draw the resultant force and measure with a ruler

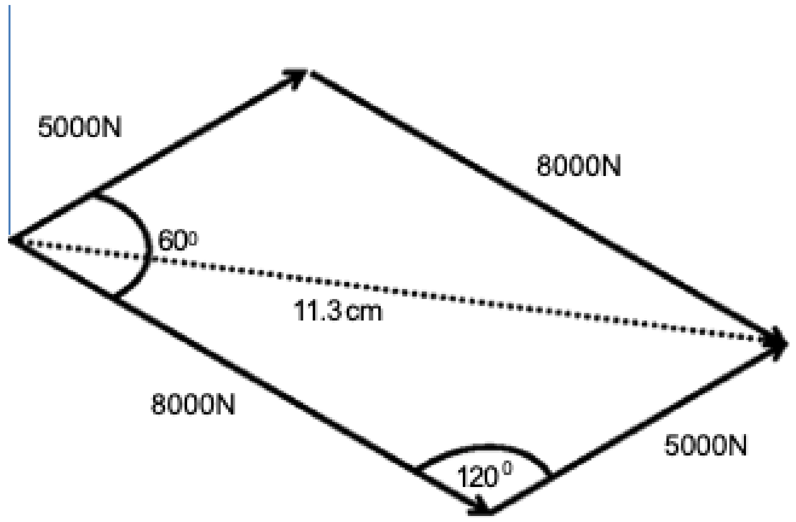


2. Draw in the last side of the parallelogram

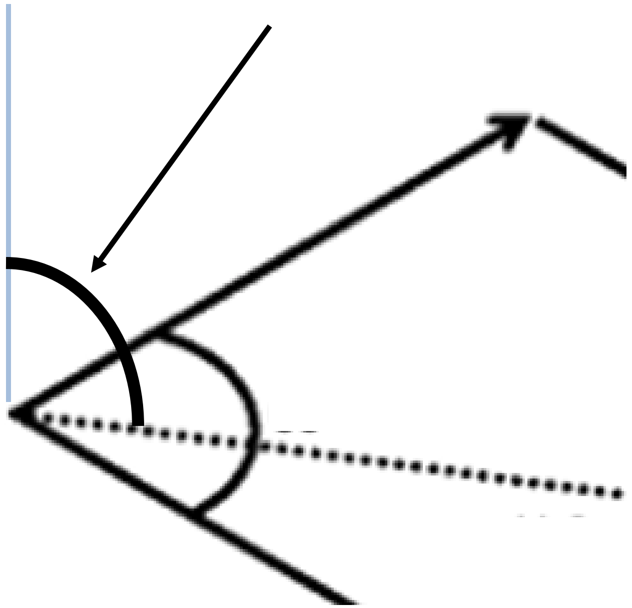


65. Resolving Forces—Parallelogram of forces 2

4. Use your scale to calculate the size of the resultant force



Measure angle to give vector angle e.g 110^0 from vertical



Resultant force length = 11.3 cm

Scale = 1 cm = 1000 N

11.3 x 1000 = 11300N Resultant force = 11300 N

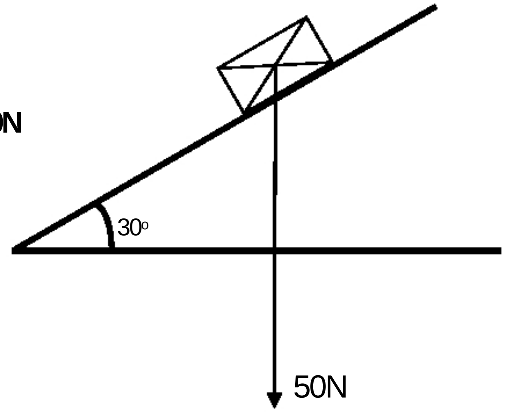
Measure angle resultant force acts at from vertical because vector requires magnitude and direction.

Resultant force = 11.3 kN at 110^0 to vertical

66. Resolving Forces – On an inclined plane 1

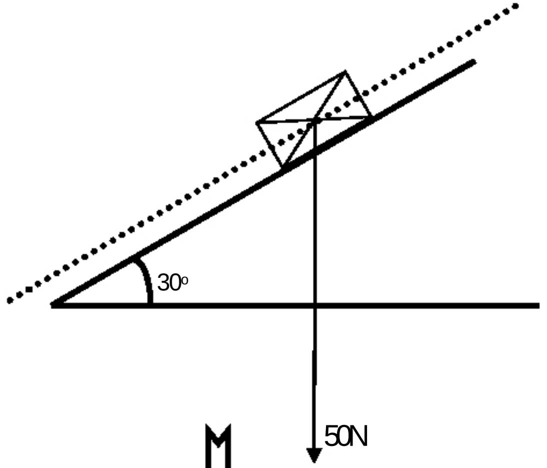
A box is resting on a 30° incline. Resolve the force into a parallel & perpendicular components. The box has a weight of 50N.

1 cm = 10N

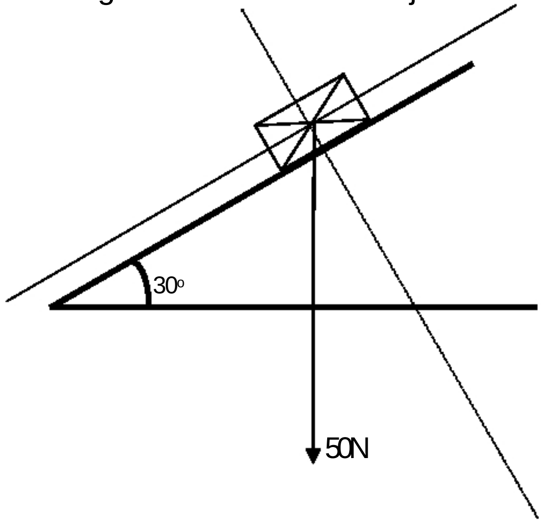


50N
represented by drawing 5cm long line downwards

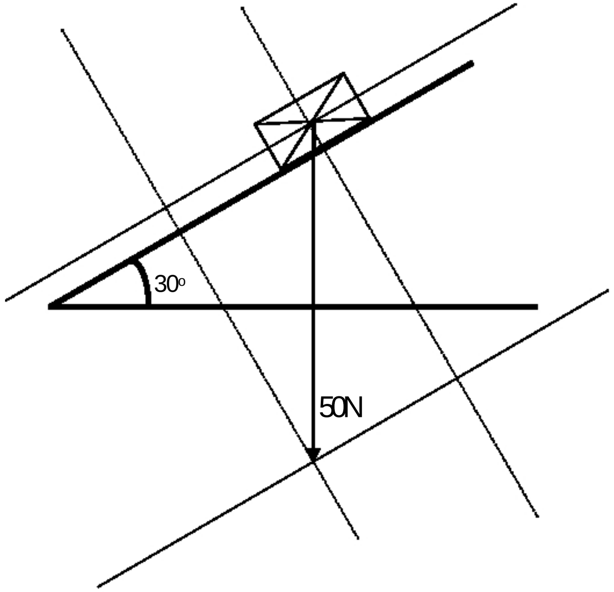
1. Draw a line parallel to the slope



2. Draw a line perpendicular to this and through the centre of the object

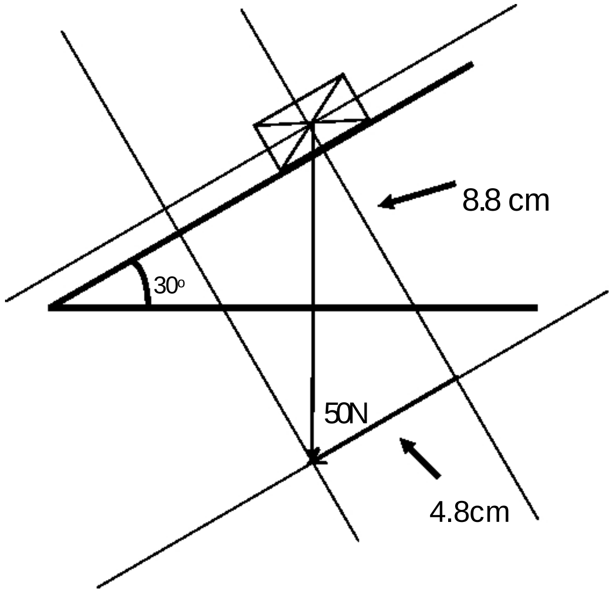


3. Draw a second line parallel to the slope at the end of the 50N line



67. Resolving Forces – On an inclined plane 2

4. Measure the length of the perpendicular and parallel



5. Calculate your parallel and perpendicular component lines as below

1 cm = 10 N

Parallel Component = 4.8 cm

4.8 X 10 = 48 N

Perpendicular Component = 8.8 cm

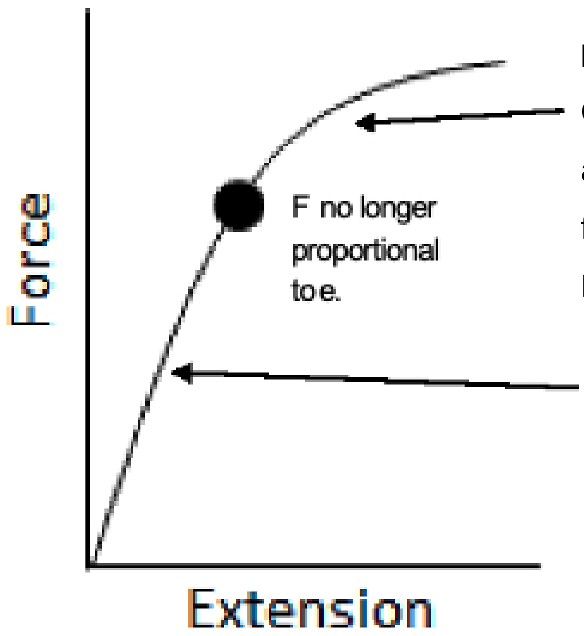
8.8 X 10 = 88 N

68. Elasticity

To stretch, compress or bend an object more than one force must act on it.
Extension is directly proportional to force:

Force (N) = spring constant (N/m) x extension (m)

$$F = ke$$



Inelastically deformed

Object cannot return to its original shape and extension is not directly proportional to force.

F no longer proportional to e. (curved line)

Elastically deformed

Object can return to its original shape and

Extension ∝ force. (Straight Line)

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 extension^2 (m)

Unit conversions:
kJ to J: x 1000
cm to m: ÷ 100

69. Newton's laws of motion

First Law	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. Inertia is the tendency of a body to remain in the same state of motion	
Second Law .	The amount a body accelerates is directly proportional to the force applied to it and inversely proportional to the mass of the body. F = ma e.g. An aeroplane accelerates from a low speed to a high speed with the engines at maximum power At maximum power the forward force of the engines is constant as it accelerates the air resistance increases resultant force = force from engines – air resistance Therefore resultant force decreases acceleration is directly proportional to resultant force	**Inertial mass** is the property of an object which describes how difficult it is to change its velocity Inertial mass = force ÷ acceleration Inertial mass is defined as the ratio of force to acceleration Inertial mass is inversely proportional to acceleration (mass = 1 ÷ acceleration) Larger inertial masses will experience small accelerations Smaller inertial masses will experience large accelerations
Third Law	When two objects interact, the forces they exert on each other are **equal** and **opposite**. This is an **equilibrium** situation - neither object moves because the forces are balanced.	

70. Moments and gears

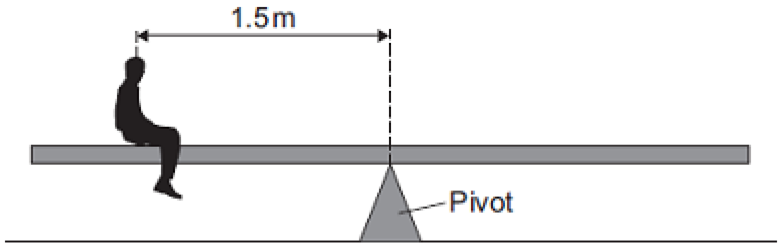
Moments

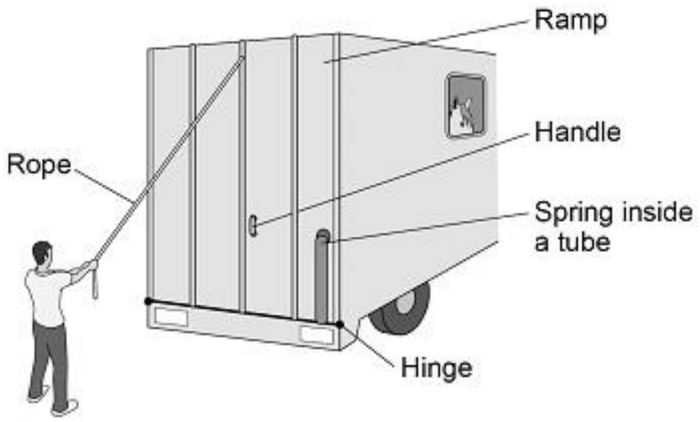
Moment: The turning effect of a force.

Moments act about a point in a clockwise or anticlockwise direction.

The point chosen could be any point on the object, but the **pivot,** also known as the fulcrum, is usually chosen for calculation purposes.

Moment (Nm) = force (N) x perpendicular distance (m)





Use of moments

Easier to pull down ramp with rope than the handle because

The perpendicular distance from the pivot / hinge to the line of action of the force is greater.

So a smaller force is required

Levers **increase** the size of a **force** acting on an object to make the object turn more easily. The force applied to a lever must act **further** from the pivot than the force has to overcome.

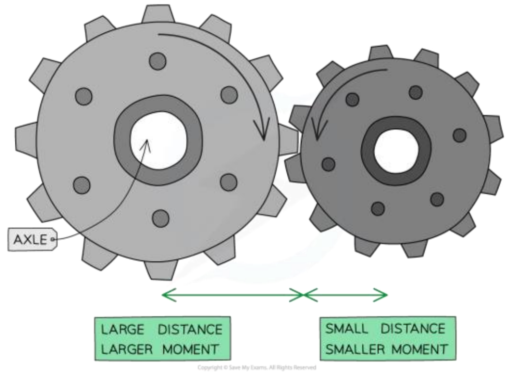
Gears

Gears, like levers, can transmit turning forces. They can transfer turning effects whilst increasing or decreasing the required force.

As one gear turns, the other gear must also turn. Where the gears meet, the teeth must both move in the same direction.

The forces acting on the teeth are identical for both gears (newtons 3rd law equal and opposite), but their moments can be different depending upon the radius from the centre of the gear to where the force is applied (where the gears touch).

If a larger gear is driven by a smaller gear, the large gear will rotate slower but will apply a greater moment for the same force. If a smaller gear is driven by a larger gear, the smaller gear will rotate quickly but will apply a smaller moment.



71. Momentum

A vector quantity (has size and direction).

Momentum (kg m/s) = mass (kg) x velocity (m/s)

P = mv

Conserved momentum:

total momentum before = total momentum afterwards

e.g. A 2 kg object (A) moving at 3m/s crashes into a 4 kg stationary object (B) causing both objects to move away locked together.

What velocity do they move away at?

Total momentum before = $(m_A \times v_A) + (m_B \times v_B)$

= (2 x 3) + (4 x 0) = 6kgm/s

Total momentum after = 6kgm/s = $(m_A + m_B) \times v_{new}$

V_{new} = 6 / (2+4) = 1m/s

Momentum is a vector therefore the direction is the same because it is a positive answer. A negative sign would show the opposite direction.

$$\textbf{Force} = \frac{\text{change in momentum}}{\text{change in time}}$$

Change in momentum safety features

Seat belts

Seat belts stop you tumbling around inside the car if there is a collision. However, they are designed to stretch a bit in a collision.

This increases the time taken for the body's momentum to reach zero, and so reduces the forces on it.

Air bags

Air bags increase the time taken for the head's momentum to reach zero, and so reduce the forces on it.

They also act a soft cushion and prevent cuts.

Crumple zones

Crumple zones are areas of a vehicle that are designed to crush in a controlled way in a collision.

They increase the time taken to change the momentum of the driver and passengers in a crash, which reduces the force involved.

72. 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

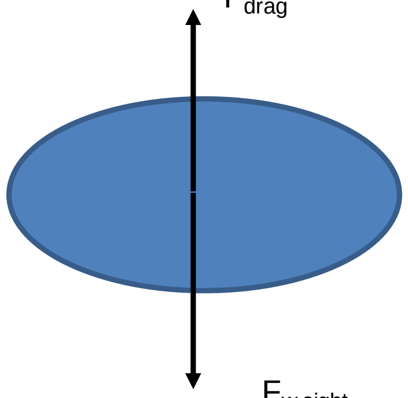
Speed	How fast something is going without reference to a direction. It is a scalar quantity.
Velocity	A speed in a given direction
Acceleration	How quickly something is speeding up, or its rate of change of velocity. Deceleration is how quickly something is slowing down or negative acceleration.

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.



Uniform Acceleration

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

$$v^2 - u^2 = 2as$$

v = final velocity (m/s)
u = initial velocity (m/s)
a = acceleration (m/s^2)
s = distance (m)

Velocity and circular motion

When an object travels along a circular path, its velocity is always changing

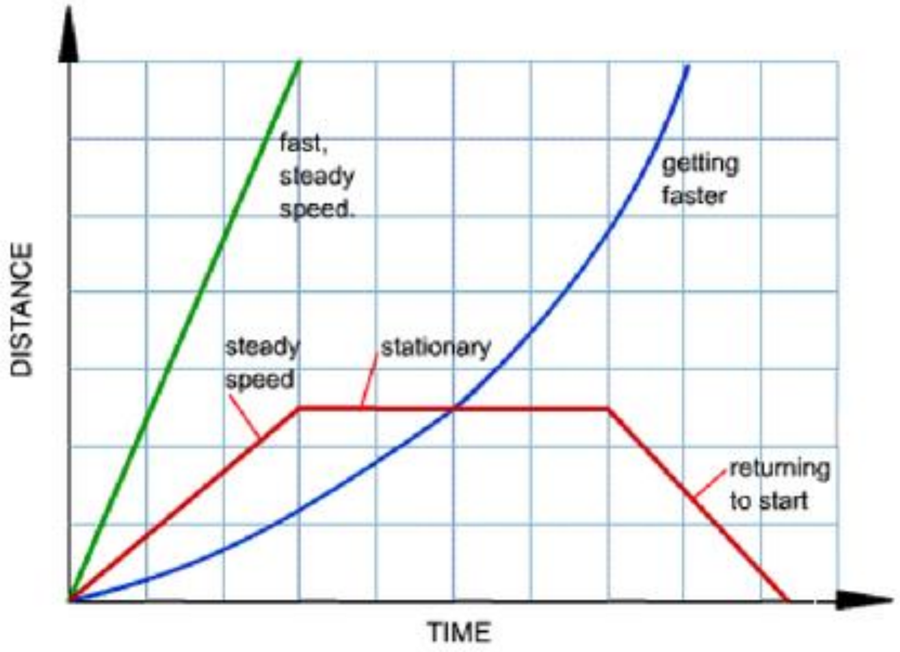
The **speed** of the object moving in a circle is constant (travelling the same distance every second)

The **direction** of travel is always changing as the object moves along the circular path

This means that an object moving in circular motion travels at a **constant speed** but has a **changing velocity**

73. Graphs of Motion

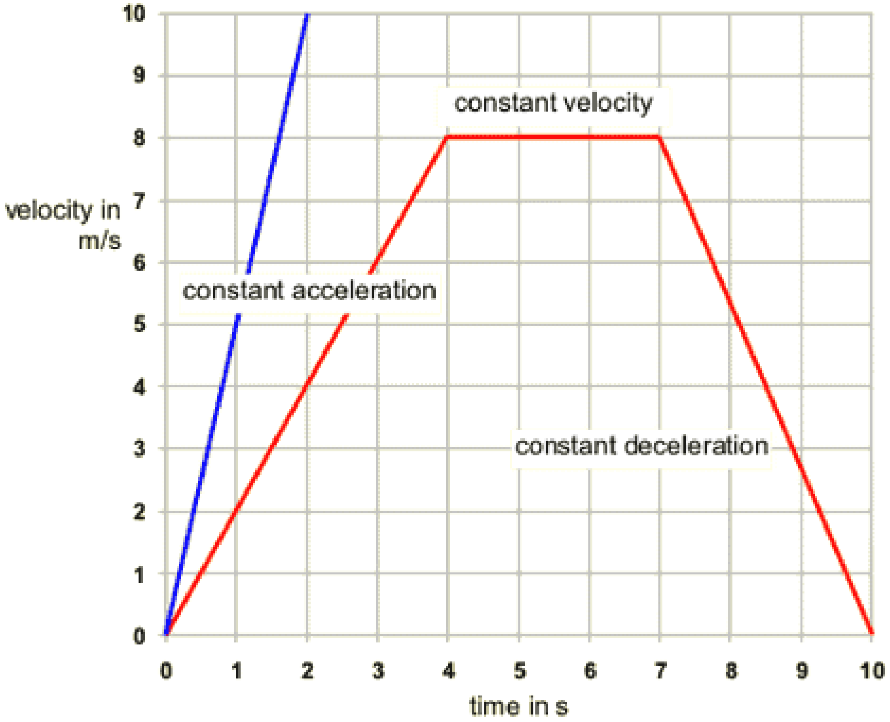
Distance – time graph



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

Average velocity = (v + u) / 2

74. 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

75. Pressure and fluids

Pressure

The pressure in fluids causes a normal **force** (at right angles) to any surface.

The pressure at the surface of a fluid can be calculated using the equation:

Pressure (Pa) = force (N) ÷ area (m^3)

p=F/ A

Pressure in a column of liquid

The pressure of liquid increases with depth (height). The deeper you are in a swimming pool the greater the pressure acting on you.

Pressure (Pa) = height of column above object (m) x density (kg/m^3) x gravitational field strength (N/kg)

$p = h\rho g$

e.g. What is the water pressure at the bottom of a diving pool which is 6m deep. g – 9.8N/kg, ρ_{water} – 1000kg/m^3

$p = h\rho g$ = 6 x 1000 x 9.8 = 58800Pa or 58.8 kPa

Atmospheric Pressure

The atmosphere is a thin layer of air around the Earth. The density of the atmosphere reduces with height. The weight acting upon a surface reduces, as the object is increased in height within the atmosphere, therefore reducing the pressure too. ($p = h\rho g$)

The atmospheric pressure at ground level is therefore higher than it is at the top of a mountain because the height of the column of air at the top of the mountain is smaller and the average density of the air would be lower.

Upthrust and flotation

A partially (or totally) submerged object experiences a greater pressure on the bottom surface than on the top surface. This creates a resultant force upwards. This force is called the upthrust.

76. Space

Keyword	Description
Asteroid	A lump of rock (may or may not be orbiting anything)
Comet	A ball of ice, dust and gas orbiting a star in an ellipticalorbit
Galaxy	A group of billions of stars. Earth is in the Milky Way galaxy
Meteor	A small piece of rocky matter entering Earth's atmosphere from space
Moon	A sphere of rock orbiting a planet
Planet	A sphere of rock or gas orbiting a star
Red Shift	Objects which are moving away from us are said to be red shifted because the wavelengths of light from these objects is shifted towards the red end of the spectrum. Hubble determined that the most distant galaxies are those most red shifted, meaning they are accelerating away from us. This supports the big bang theory.
Satellite	An object which orbits another. Natural (moon) or man-made (space station). They travel at a constant speed. Their orbit is determined by their speed.
Star	A sphere of (mainly) hydrogen carrying out nuclear fusion, producing heat and light
Universe	Everything that exists. Contains billions ofgalaxies

77. Star formation

Process of star formation: nuclear fusion

Main fuel source: Hydrogen

The Sun is a stable star. This is because the forces pulling inwards caused by gravity are in equilibrium with the forces pushing outwards caused by the energy released by nuclear fusion.

Range of wavelengths of a star depend on the temperature of the star.

A light year is the distance that light travels in a year

The life cycle of a star

Nebula
Clouds of gas or hydrogen

→

Nebula pulled together by gravity causing increasing temperature to start the fusion process to become a protostar. Hydrogen nuclei fuse to form helium nuclei and the star becomes **main sequence**

→ red giant → white giant → black dwarf

Stars much larger than our sun become supergiant

→

Hydrogen begins to run out. The helium nuclei fuse to make heavier elements up to iron. The star expands to become a **red super giant**

→

The star collapses rapidly and explodes called a **supernova** creating elements heavier than iron and distributing them throughout the universe. Leaving behind a neutron star or a black hole.

78. Creation of the Universe

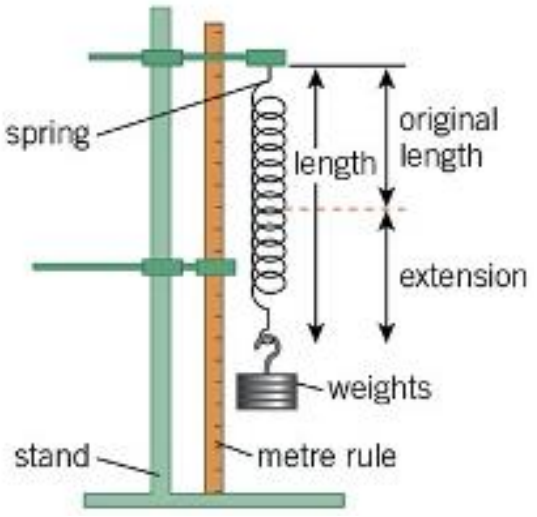
Much is still unknown about the universe and galaxies spin faster than they should based on the amount of mass in them. Scientist think that the missing mass is made up of something they have named **dark matter**.

The universe is not only expanding but accelerating in its expansion. Scientists think that **dark energy** is responsible for this acceleration but like **dark matter** they have no idea what **dark energy** is.

The universe could either end in a **big crunch** where the rapid expansion stops and a rapid contraction occurs or it could expand for ever in what is called the **big yawn**.

Mid 20th Century theories for the creation of the universe	**Key points**
Stay State Theory	Universe expands with a constant density, white holes leak matter into the universe to maintain the density as volume increases. Dropped after the discovery of cosmic microwave background radiation (CMBR)
Big Bang Theory	Universe expanded from an extremely small, hot, dense region creating space, time and matter

79. Required Practical 6: Force and extension



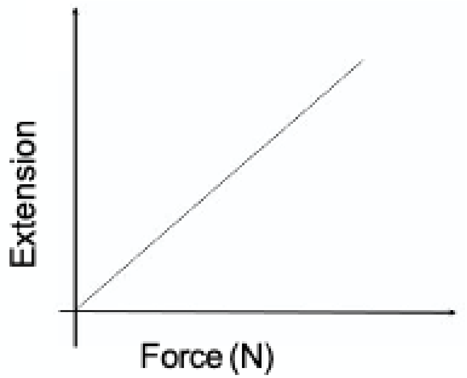
Force and Extension

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.

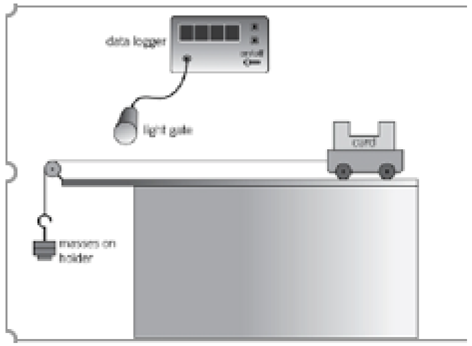


Method

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

80. 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

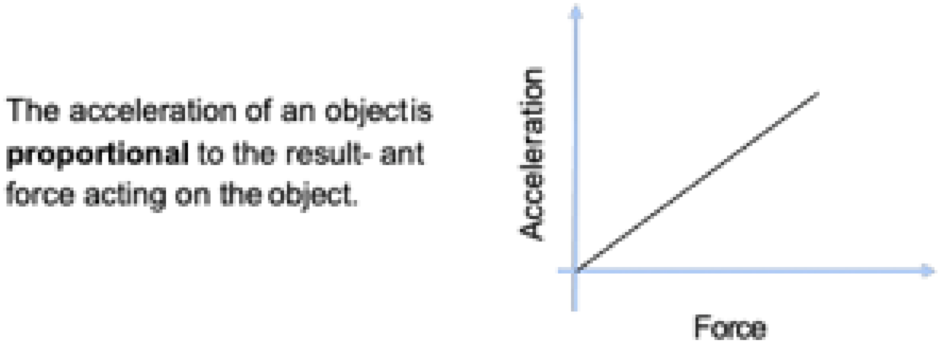
1. Measure the length of each card segment and make a note of this.
2. Set up the apparatus as shown in the diagram below. When the trolley is as close to the pulley as it can get, the bottom of the mass holder should be between 0.5 cm and 1 cm above the floor.
3. During this experiment the trolley will 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.



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

How to reduce random errors

Repeat the measurements/investigation

Ignore anomalies and calculate the mean

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

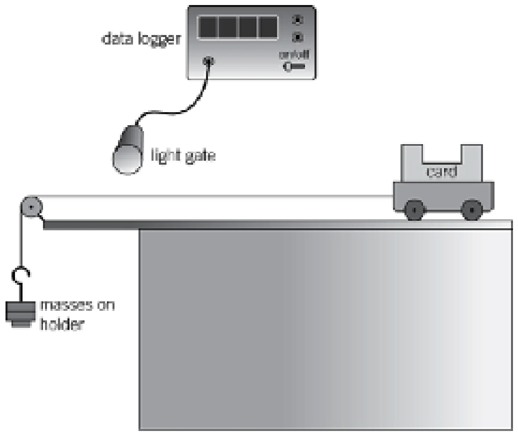
Independent variable – mass of the trolley (N)

Dependent variable – acceleration (m/s^2)

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

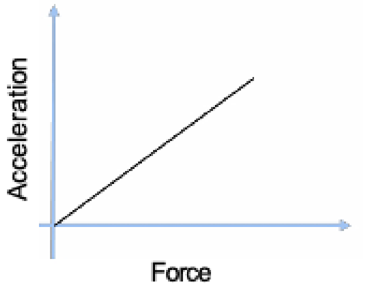
Method

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, depend- ing 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.



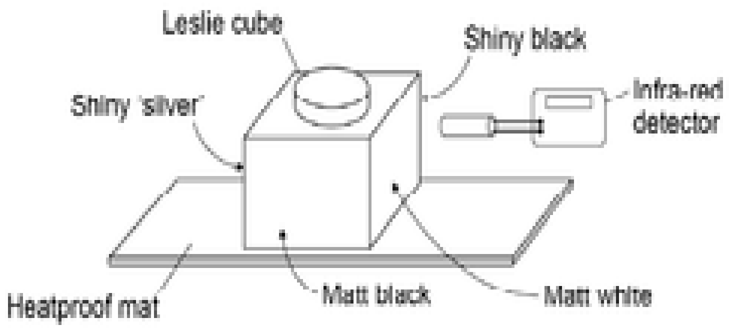
The acceleration of an object is **inversely proportional** to the mass of the object.

a = F/m



82. 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

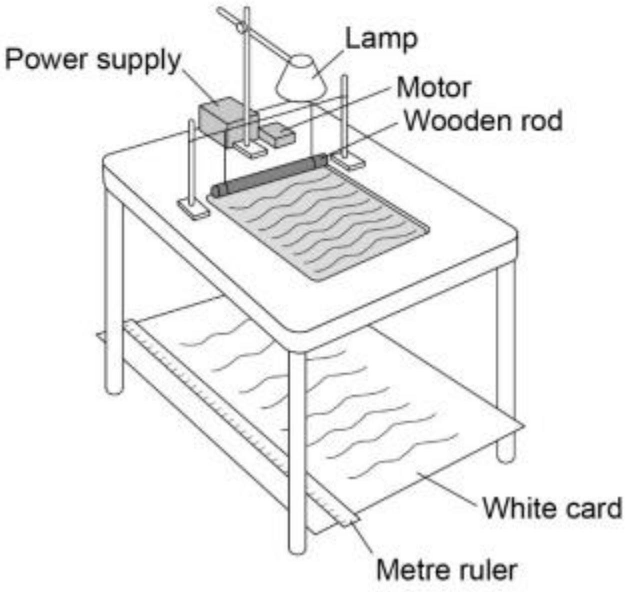
DV: temperature of hot water

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.

83. 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.

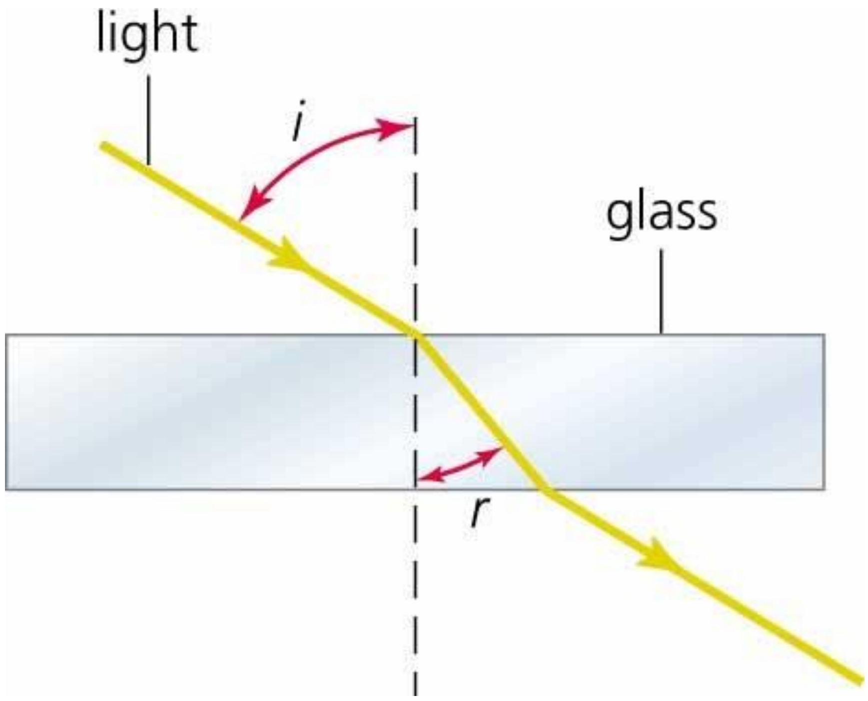
Deeper water means longer wavelength because velocity increases and frequency is constant

84. Required practical 11: Refraction of light

1. Place a glass block on a piece of paper
2. Draw around the glass block and then remove from the paper
3. Draw a line at 90° to one side of the block (the normal)
4. Use a protractor to measure and then draw a line at an angle of 20° to the normal
5. Replace the glass block
6. Using a ray box and slit point the ray of light down the drawn line
7. Mark the ray of light emerging from the block
8. Remove the block and draw in the refracted ray
9. Measure the angle of refraction with a protractor
10. Repeat the procedure for a range of values of the angle of incidence

Source of inaccuracy: The width of the light ray

Reason for inaccuracy: Makes it difficult to judge where the centre of the ray causes a large uncertainty



Normal (90º to the surface)

85. 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 ÷ 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	∏ x (radius)^2

Prefixes

1 kJ = 1 x 10^3 J = 1000 J

1 pm = 1 x 10^{-12} m

1 mm = 1 x 10^{-3} m= 0.001 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 x 10^3

2 decimal places: 5607.38

3 significant figures: 5610

0.03581

Standard form: 3.581 x 10^{-2}

2 decimal places: 0.04

3 significant figures: 0.0358

86. 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 ÷ 90) x 100 = 44 %

Calculating percentage change:

(difference ÷ starting value) x 100

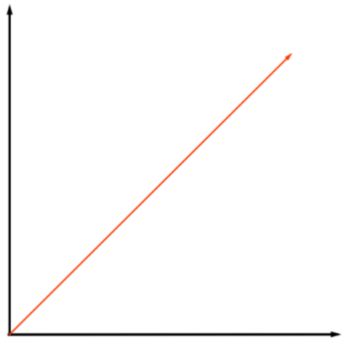
(0.59 ÷ 2.22) x 100 = 26.6 %

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)

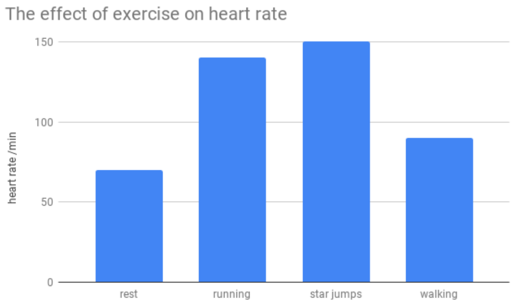
When the line passes through the origin



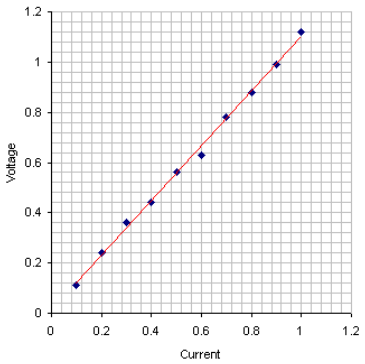
x axis = independent variable = left hand column of results table

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

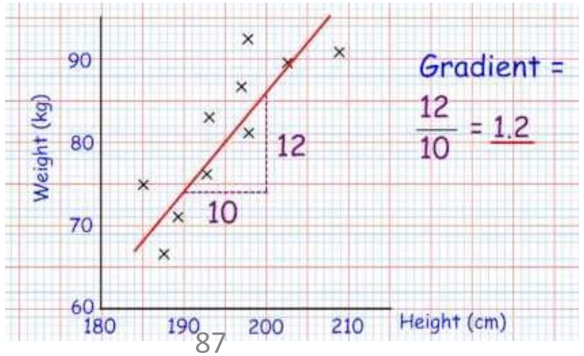


Continuous data: data that can take any value e.g. current
Draw a line graph



Gradient and Graphs

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



kinetic energy = 0.5 × mass × (speed)^2	$E_k = \frac{1}{2} m v^2$
elastic potential energy = 0.5 × spring constant × (extension)^2	$E_e = \frac{1}{2} k e^2$
gravitational potential energy = mass × gravitational field strength × height	$E_p = m g h$
change in thermal energy = mass × specific heat capacity × 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 = current × time	$Q = I t$
potential difference = current × resistance	$V = I R$
power = potential difference × current	$P = V I$
power = (current)^2 × resistance	$P = I^2 R$

energy transferred = power × time	$E = P\,t$
energy transferred = charge flow × potential difference	$E = Q\,V$
density = $\frac{\text{mass}}{\text{volume}}$	$\rho = \frac{m}{V}$

	thermal energy for a change of state = mass × specific latent heat	$E = m\,L$
	For gases: pressure × volume = constant	$p\,V = constant$
	weight = mass × gravitational field strength	$W = m\,g$
	work done = force × distance (along the line of action of the force)	$W = F\,s$
	force = spring constant × extension	$F = k\,e$
	moment of a force = force × distance (normal to direction of force)	$M = F\,d$
	pressure = $\frac{\text{force normal to a surface}}{\text{area of that surface}}$	$p = \frac{F}{A}$
HT	pressure due to a column of liquid = height of column × density of liquid × gravitational field strength	$p = h\,\rho\,g$

	distance travelled = speed × time	$s = v\,t$
	acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$	$a = \frac{\Delta v}{t}$
	(final velocity)² – (initial velocity)² = 2 × acceleration × distance	$v^2 - u^2 = 2\,a\,s$
	resultant force = mass × acceleration	$F = m\,a$
HT	momentum = mass × velocity	$p = m\,v$
HT	force = $\frac{\text{change in momentum}}{\text{time taken}}$	$F = \frac{m\,\Delta v}{\Delta t}$
	period = $\frac{1}{\text{frequency}}$	$T = \frac{1}{f}$
	wave speed = frequency × wavelength	$v = f\,\lambda$
	magnification = $\frac{\text{image height}}{\text{object height}}$	
HT	force on a conductor (at right angles to a magnetic field) carrying a current = magnetic flux density × current × length	$F = B\,I\,l$
HT	$\frac{\text{potential difference across primary coil}}{\text{potential difference across secondary coil}} = \frac{\text{number of turns in primary coil}}{\text{number of turns in secondary coil}}$	$\frac{V_p}{V_s} = \frac{n_p}{n_s}$
HT	potential difference across primary coil × current in primary coil = potential difference across secondary coil × current in secondary coil	$V_p\,I_p = V_s\,I_s$