IGCSE Physics Notes

0625

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A complete set of notes for Cambridge IGCSE Physics

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1. General Physics

2. Thermal Physics

3. Properties of waves, including Light and Sound

4. Electricity and Magnetism

5. Atomic Physics

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1. General Physics

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1.1 Length and time

1.1 Length and time

Core

- Use and describe the use of rules and measuring cylinders to calculate a length or a volume
- Use and describe the use of clocks and devices for measuring an interval of time

Supplement

- Use and describe the use of a mechanical method for the measurement of a small distance (including use of a micrometer screw gauge)
- Measure and describe how to measure a short interval of time (including the period of a pendulum)

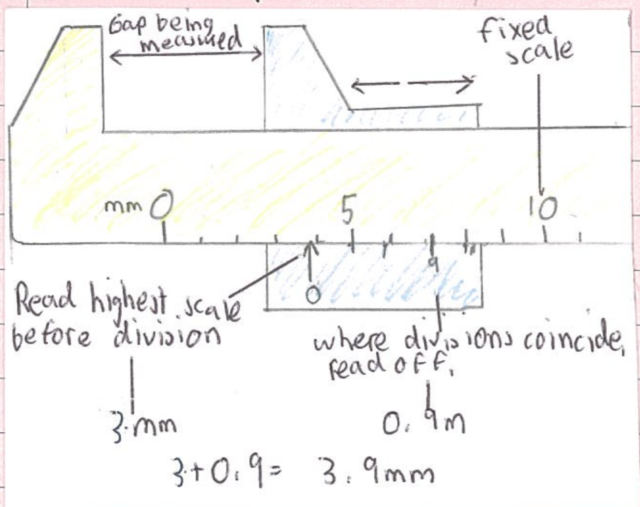
Volume

- To measure volume of a 'regular' solid: measure dimensions with rule, then multiply.
- To measure volume of an irregular solid: place object in measuring cylinder and measure the difference in height of the water.

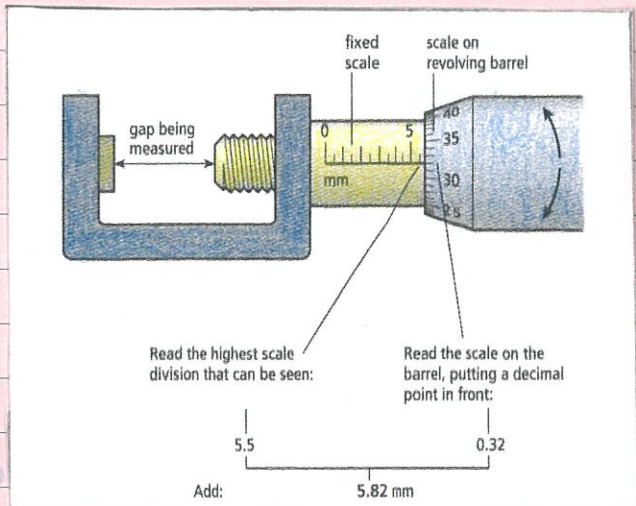
Small distance

- Vernier callipers - nearest 0.1 mm
- Micrometer - nearest 0.01 mm

Vernier callipers



Micrometer



NB: Before measuring length of object, check the zero reading and make note of the error. Once you measure the length, add the error.

Time

Devices like digital stopwatches are very precise, to 0.01s.
However the main accuracy issue is human error.

Measuring period of pendulum:

1. Place a marker at the pendulum's rest position.
2. Make sure that your line of sight is perpendicular to oscillations.
3. Time how long pendulum takes to undergo x oscillations ($x \geq 10$)
4. Repeat to find average time.
5. Calculate individual oscillation time by: dividing mean time by x.

This method is more accurate and reliable.

1.2 Speed, Velocity and Acceleration

1.2 Speed, velocity and acceleration

Core	Supplement
• Define speed and calculate speed from $\frac{\text{total distance}}{\text{total time}}$ • Plot and interpret a speed/time graph or a distance/time graph • Recognise from the shape of a speed/time graph when a body is – at rest – moving with constant speed – moving with changing speed • Calculate the area under a speed/time graph to work out the distance travelled for motion with constant acceleration • Demonstrate some understanding that acceleration is related to changing speed	• Distinguish between speed and velocity • Recognise linear motion for which the acceleration is constant and calculate the acceleration • Recognise motion for which the acceleration is not constant

Speed - the rate of change of distance (scalar)

$$\text{Speed } (ms^{-1}) = \frac{\text{total distance (m)}}{\text{total time (s)}} \qquad s = \frac{d}{t}$$

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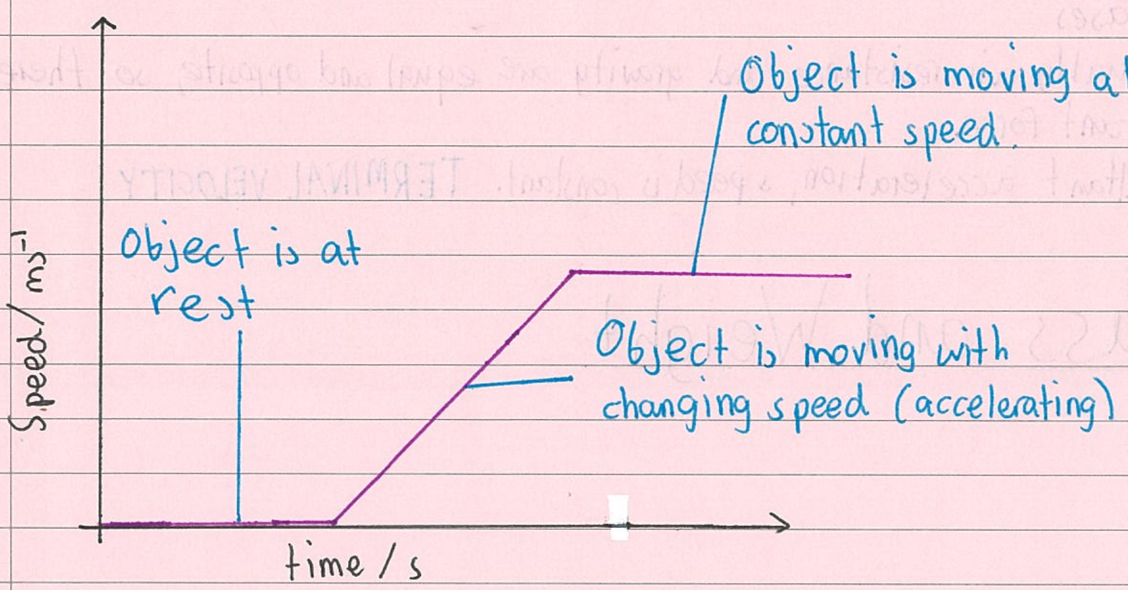
Velocity - the rate of change of displacement (vector)
i.e speed in a particular direction

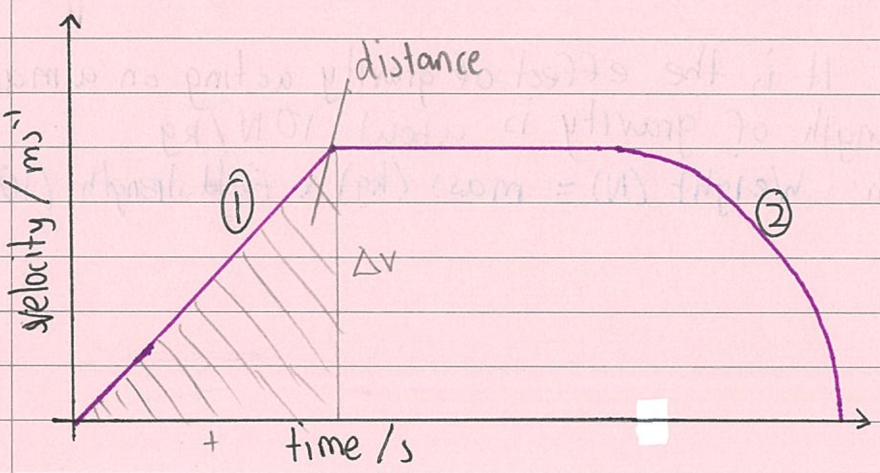
Speed-time graphs



Acceleration - the rate of change of velocity (vector)

$$\text{acceleration } (ms^{-2}) = \frac{\text{change in velocity } (ms^{-1})}{\text{time } (s)}. \qquad a = \frac{v-u}{t}$$

Deceleration is negative acceleration.



1 Acceleration is constant
2 Acceleration is not constant

- Gradient = acceleration.
- For motion with constant acceleration, distance is area under the graph.

NB: An object travelling in a circular path is always accelerating (towards centre of circle). This is because its direction (and therefore velocity) is always changing.

green range A'ZONE

• State that the acceleration of free fall for a body near to the Earth is constant	• Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)

Acceleration of free fall for a body near earth is constant.

Without air resistance, the pull of gravity causes an acceleration of $9.8ms^{-2}$

With air resistance:

1. object falls → speed increases → air resistance increases → acceleration decreases
2. Eventually air resistance and gravity are equal and opposite, so there is no resultant force.
3. No resultant acceleration, speed is constant. TERMINAL VELOCITY

1.3 Mass and Weight

1.3 Mass and weight

Core	Supplement
• Show familiarity with the idea of the mass of a body • State that weight is a force • Demonstrate understanding that weights (and hence masses) may be compared using a balance	• Demonstrate an understanding that mass is a property that 'resists' change in motion • Describe, and use the concept of, weight as the effect of a gravitational field on a mass

Mass is the amount of matter in an object (kg)

Massive objects 'resist' change in motion.

↳ Inertia - reluctance to move from rest or change speed.

Weight is a force. It is the effect of gravity acting on a mass

On earth the strength of gravity is about 10 N/kg

Therefore on earth: Weight (N) = mass (kg) x field strength (10N/kg)

1.4 Density

1.4 Density

Core	Supplement
• Describe an experiment to determine the density of a liquid and of a regularly shaped solid and make the necessary calculation	• Describe the determination of the density of an irregularly shaped solid by the method of displacement, and make the necessary calculation

Density is the mass per unit volume of a substance (kg/m^3)

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \qquad \rho = \frac{m}{v}$$

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Density of a liquid

1. Find the mass of $10 cm^3$ of the liquid
2. Divide the mass by the volume to find the density.

Density of a regular solid

1. Calculate volume of object by finding length of each dimension then multiplying.
2. Find mass of object using a balance
3. Divide mass by volume to find density.

Density of an irregular solid

1. Find volume of object by displacement in a measuring cylinder.
2. Find mass of object using a balance.
3. Divide mass by volume to find density.

1.5(a) Effects of forces

1.5 (a) Effects of forces

Core	Supplement
• State that a force may produce a change in size and shape of a body	
• Plot extension/load graphs and describe the associated experimental procedure	• Interpret extension/load graphs • State Hooke's Law and recall and use the expression $F = kx$ • Recognise the significance of the term 'limit of proportionality' for an extension/load graph
• Describe the ways in which a force may change the motion of a body • Find the resultant of two or more forces acting along the same line	• Recall and use the relation between force, mass and acceleration (including the direction) • Describe qualitatively motion in a curved path due to a perpendicular force ($F = mv^2/r$ is *not* required)

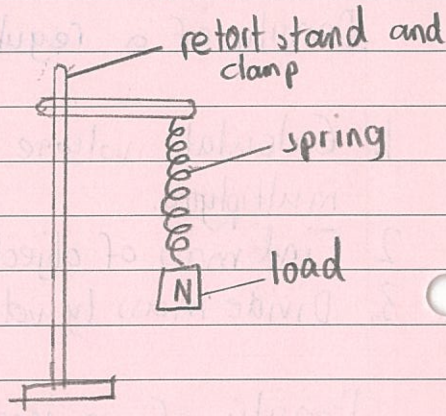
Forces can change: • size and shape of a body
• speed of a body
• direction of movement of a body.

Hooke's law:

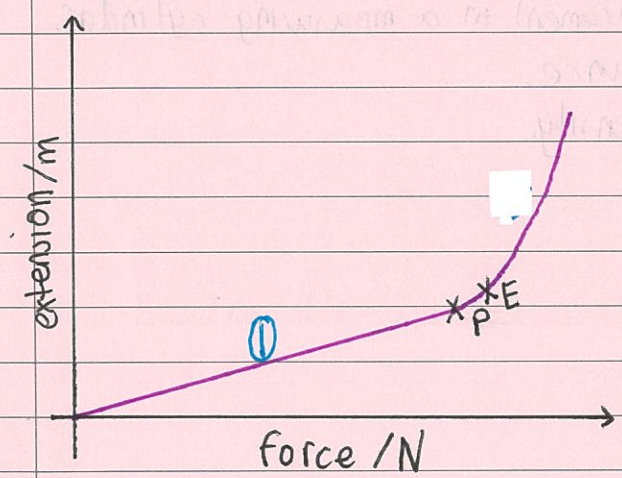
the extension of a spring is directly proportional to the applied force, provided that the elastic limit is not exceeded.

Force applied = spring constant × extension

$F = kx$



1. Set up apparatus - hang spring
2. Measure initial length of spring
3. Add 100g mass (1N weight)
4. Measure new length and subtract initial length to calculate extension
5. Repeat 6 times, adding 100g each time.
6. Plot extension against force.



1 Extension directly proportional to force. $F = kx$

P - limit of proportionality. After this $F \neq kx$. (not directly proportional)

E - Elastic limit. After this spring is deformed and will not return to initial length.

Newton's second law of motion

The resultant force acting on an object is proportional to the mass of the object and its acceleration.

Force (N) = mass (kg) × acceleration (ms^{-2})

$F = ma$

Resultant force

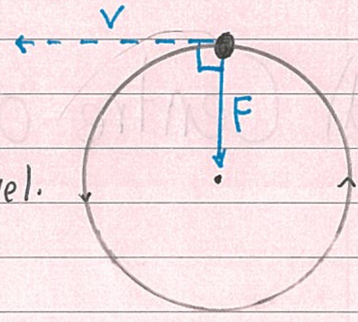
The net force when size and direction are taken into account.

e.g

Resultant = 1000 - 100 = 900N

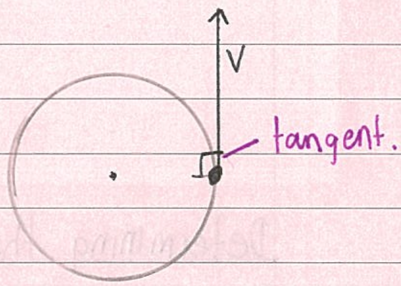
When resultant force is zero, forces are equal and opposite
- object is at rest
- object travels at constant speed in a straight line.

Centripetal force



An object will moved in a curved path when the force acts perpendicular to direction of travel.

Speed stays constant. Velocity changes.
Object is accelerating towards the centre.



If the force which provides the centripetal acceleration is suddenly removed, the object will leave at a tangent to the original circle.

1.5(b) Turning effect

1.5 (b) Turning effect Core	Supplement
• Describe the moment of a force as a measure of its turning effect and give everyday examples • Describe qualitatively the balancing of a beam about a pivot	• Perform and describe an experiment (involving vertical forces) to show that there is no net moment on a body in equilibrium • Apply the idea of opposing moments to simple systems in equilibrium

The moment of a force is a measure of its turning effect
e.g Hinged door, spanner.

Moment (Nm) = Force (N) × perpendicular distance (m)

$M = Fd$

For a body in equilibrium (e.g a balanced beam on a pivot):

- There is no net moment
- Anticlockwise moment is equal to clockwise moment

$M_1 = M_2 \quad \therefore \quad F_1 d_1 = F_2 d_2$

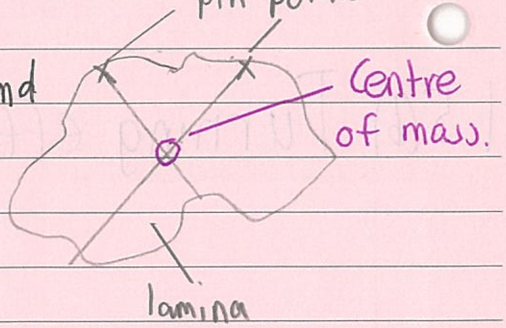
1.5 (c) When there is no resultant force and no resultant turning effect, a system is in equilibrium

1.5 (d) Centre of Mass

1.5 (d) Centre of mass	
Core • Perform and describe an experiment to determine the position of the centre of mass of a plane lamina • Describe qualitatively the effect of the position of the centre of mass on the stability of simple objects	

Determining the centre of mass of a plane lamina

1. Push pin through point on edge of lamina and allow to swing freely.
2. Use plumb line to mark vertical line
3. Repeat for a second point on edge of lamina
4. Where two lines cross is centre of mass



The centre of mass of an object is the point where its mass seems to be concentrated, and therefore the point through which the weight of an object seems to act.

As such, centre of gravity affects stability. If centre of gravity lies outside base of object, it topples. The lower the centre of gravity is, the more stable the object.

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1.5(e) Scalars and Vectors

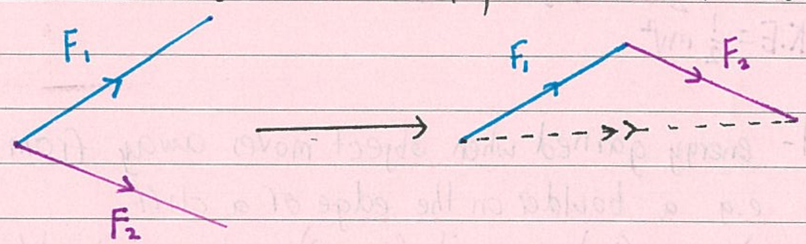
1.5 (e) Scalars and vectors	Supplement
	• Demonstrate an understanding of the difference between scalars and vectors and give common examples • Add vectors by graphical representation to determine a resultant • Determine graphically the resultant of two vectors

A scalar quantity has size, but no direction.
e.g Mass, speed, energy, time

A vector quantity has both size and direction.
e.g Velocity, acceleration, moment, force

To determine graphically resultant of two vectors:

1. put the vectors 'nose to tail', then draw resultant.



2. Measure length of resultant.

1.6(a) Energy

1.6 (a) Energy **Core**	**Supplement**
• Demonstrate an understanding that an object may have energy due to its motion or its position, and that energy may be transferred and stored • Give examples of energy in different forms, including kinetic, gravitational, chemical, strain, nuclear, internal, electrical, light and sound • Give examples of the conversion of energy from one form to another, and of its transfer from one place to another • Apply the principle of energy conservation to simple examples	• Recall and use the expressions k.e. = ½ mv^2 and p.e. = mgh

An object may have energy due to its: • motion - kinetic energy
• position - potential energy.

Types of energy

- Kinetic - energy from movement. e.g a vehicle moving

$$K.E\ (J) = \frac{1}{2} \times m\ (kg) \times v^2\ (ms^{-1})$$

$$K.E = \frac{1}{2} mv^2$$

- Gravitational potential - energy gained when object moves away from the earth e.g a boulder on the edge of a cliff

potential energy (J) = mass (kg) × gravity ($10ms^{-2}$) × change in height (m)

$$P.E = mgh$$

- Chemical - stored energy that can be released by chemical reaction. e.g a battery
- Strain - stored energy when an object changes shape e.g a stretched rubber band
- Nuclear - stored energy released by nuclear reaction e.g uranium fuel rod.
- Internal - total K.E and P.E of particles in an object e.g energy in hot object
- Electrical - energy carried by current e.g current in toaster
- Light - energy carried by EMR e.g hot objects glowing
- Sound - energy carried by sound wave e.g piano playing.

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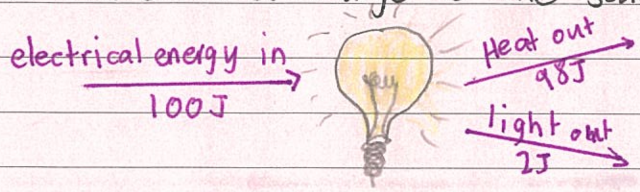
Energy conservation

Energy can be transformed from one form to another.
e.g rock falling from cliff P.E → K.E

Energy can be transferred from one object to another.
e.g snooker K.E of cue → K.E of white ball → K.E of black ball

Energy is neither created or destroyed, so the total amount of energy before and after a change is the same.



100 J in = (98J + 2J) out

1.6(b) Energy resources

1.6 (b) Energy resources

Core

- Distinguish between renewable and non-renewable sources of energy
- Describe how electricity or other useful forms of energy may be obtained from:
  - chemical energy stored in fuel
  - water, including the energy stored in waves, in tides, and in water behind hydroelectric dams
  - geothermal resources
  - nuclear fission
  - heat and light from the Sun (solar cells and panels)
- Give advantages and disadvantages of each method in terms of cost, reliability, scale and environmental impact
- Show a qualitative understanding of efficiency

Supplement

- Show an understanding that energy is released by nuclear fusion in the Sun
- Recall and use the equation:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

In the sun, energy is released by nuclear fusion, whereby hydrogen nuclei with great K.E collide and fuse to form helium nuclei.

Energy Source	R or NR	How energy is released	Advantages	Disadvantages
Oil	NR	Chemical energy is transformed to heat through combustion. Heat boils water. Steam transfers K.E to turbines, which is transformed to electrical energy through generator.	-easily combustible -fairly cheap -efficient -can be done on small scale -reliable	-fast depleting -harmful by-products including carbon dioxide -mining oil can cause damage to surrounding environment
Natural Gas			-cleaner than other fossil fuels -easily transported -relatively abundant -can be done on small scale	-limited -still contributes greenhouse gases -it can leak and cause explosions
Coal			-cheap -widely available and easily distributed -abundant source of energy	-limited -harmful by-products -pollution
Tidal	R	Gravitational potential energy of water drives turbine (K.E) which drives generator to produce electricity	-no by-products -unlimited	-expensive -can cause silt to build -can disrupt fish
Hydroelectric	R		-no by-products -cheap to run -reliable	-vast natural impacts -high initial capital -can cause human displacement
Geothermal	R	Water pumped underground gains heat energy and boils, steam drives turbine to produce electricity.	-low cost to run -reliable -no by-products	-high initial capital -only available in certain areas
Nuclear fission	NR	Nuclear energy stored in Uranium-235 is released by nuclear fission, giving out heat which boils water to drive turbine.	-releases large amounts of energy -no greenhouse emissions -reliable	-expensive to build, maintain and decommission -radioactive waste -meltdowns
Solar	R	Light energy transformed to electricity in solar cell.	-easy to install, little maintenance -can be done on small scale with little environmental impact	-not a powerful source -not reliable -expensive

Efficiency

Not all energy is useful (used for its intended purpose). Some energy is lost to the surroundings (e.g by heat).

$$\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy output}} \times 100\%$$

1.6(c) Work

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1.6 (c) Work **Core**	**Supplement**
• Relate (without calculation) work done to the magnitude of a force and the distance moved	• Describe energy changes in terms of work done • Recall and use $\Delta W = Fd = \Delta E$

Work is movement against an opposing force.
Energy is the ability to do work.

Work done (J) = force (N) × distance (m)

$$W = F \times d = \Delta E$$

Work being done causes energy changes.

1.6(d) Power

1.6 (d) Power **Core**	**Supplement**
• Relate (without calculation) power to work done and time taken, using appropriate examples	• Recall and use the equation $P = E/t$ in simple systems

Power is the rate at which energy is used.
It is the rate at which work is done.

$$\text{Power (W)} = \frac{\text{Energy transferred / Work done (J)}}{\text{time (s)}}$$

$$P = E/t$$

1.7 Pressure

1.7 Pressure **Core**	
• Relate (without calculation) pressure to force and area, using appropriate examples	• Recall and use the equation $p = F/A$
• Describe the simple mercury barometer and its use in measuring atmospheric pressure	
• Relate (without calculation) the pressure beneath a liquid surface to depth and to density, using appropriate examples	• Recall and use the equation $p = h\rho g$
• Use and describe the use of a manometer	

Pressure is the force exerted per unit area

$$\text{Pressure } (N/m^2 \text{ or } Pa) = \frac{\text{force applied } (N)}{\text{area}}$$

$$P = F/A$$

e.g it is easier to poke a hole with a pin than a hammer

Pressure in liquids

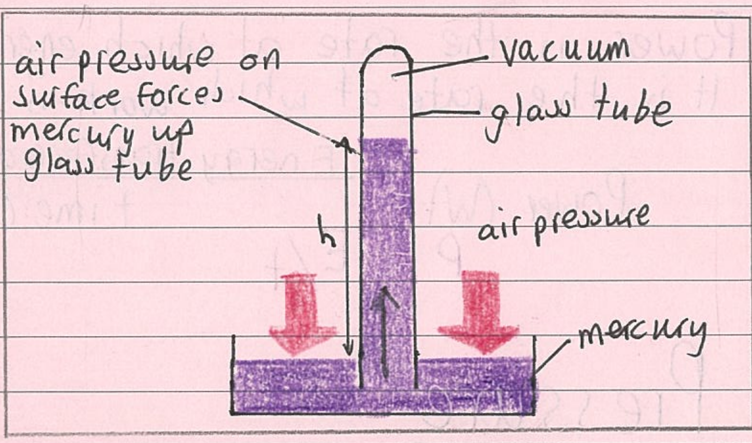
- Transmitted throughout equally
- Acts in all directions
- increases with depth / density.

$$\text{Pressure } (Pa) = \text{density } (kg/m^3) \times \text{gravity } (N/kg) \times \text{height } (m)$$

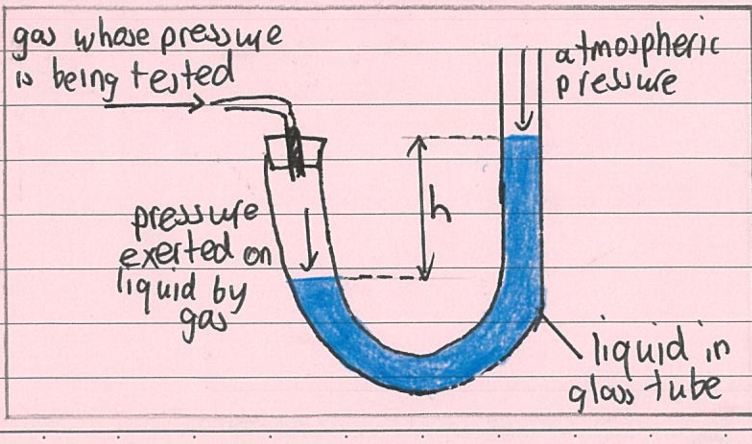
$$p = \rho \times g \times h$$

Measuring pressure

- Mercury Barometer:
  - used to measure atmospheric pressure
  - height 'h' of mercury is directly proportional to outside



- Manometer:
  - used to measure pressure of a gas e.g in pipe
  - pressure of gas relative to atm = $\rho g h$
  - pressure of gas = $\rho g h$ + atm



2. Thermal Physics

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2.1(a) States of Matter

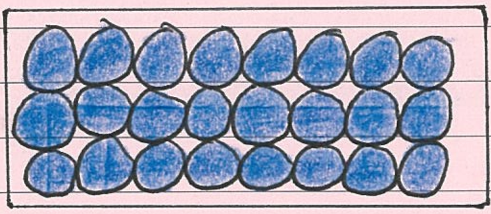
2.1 (a) States of matter	
Core • State the distinguishing properties of solids, liquids and gases	

SOLIDS	LIQUIDS	GASES
· very difficult to compress	· difficult to compress	· easy to compress
· cannot flow	· can flow	· can flow
· fixed shape	· takes shape of bottom of container	· fills container
· fixed volume	· fixed volume	· volume easily changes

2.1(b) Molecular Model

2.1 (b) Molecular model	
Core • Describe qualitatively the molecular structure of solids, liquids and gases • Interpret the temperature of a gas in terms of the motion of its molecules • Describe qualitatively the pressure of a gas in terms of the motion of its molecules • Describe qualitatively the effect of a change of temperature on the pressure of a gas at constant volume • Show an understanding of the random motion of particles in a suspension as evidence for the kinetic molecular model of matter • Describe this motion (sometimes known as Brownian motion) in terms of random molecular bombardment	**Supplement** • Relate the properties of solids, liquids and gases to the forces and distances between molecules and to the motion of the molecules • Show an appreciation that massive particles may be moved by light, fast-moving molecules

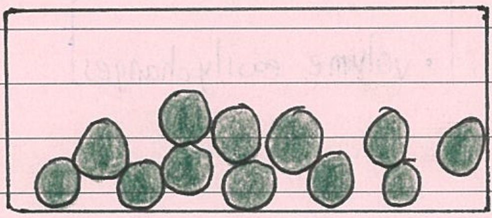
Solids



- Particles in regular, fixed arrangement
- Particles are close together, and vibrate around fixed positions.

- Strong attractive forces between particles
  - solids keep their shape and are hard to break.
- Particles are packed tightly, close together
  - they cannot be forced closer so are incompressible.

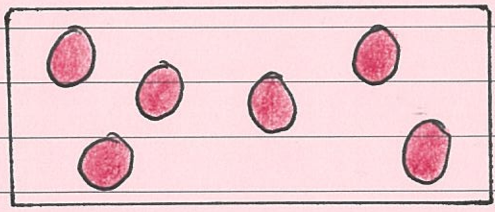
Liquids



- Particles are arranged randomly
- Particles are close together and vibrating
- Particles are able to move past one another

- Weak attractive bonds between particles
  - particles can slide past one another, so liquids can flow
- Particles are quite close together
  - they cannot be forced much closer together, so liquids are incompressibl

Gases



- Particles are arranged randomly
- Particles are very far apart
- Particles move randomly in all directions

- Negligible attractive forces between particles
  - particles fill up container and can flow
- Particles are very far apart
  - particles can easily be forced together, so gases are compressible.

Substances that can flow are called fluids.

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Temperature

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

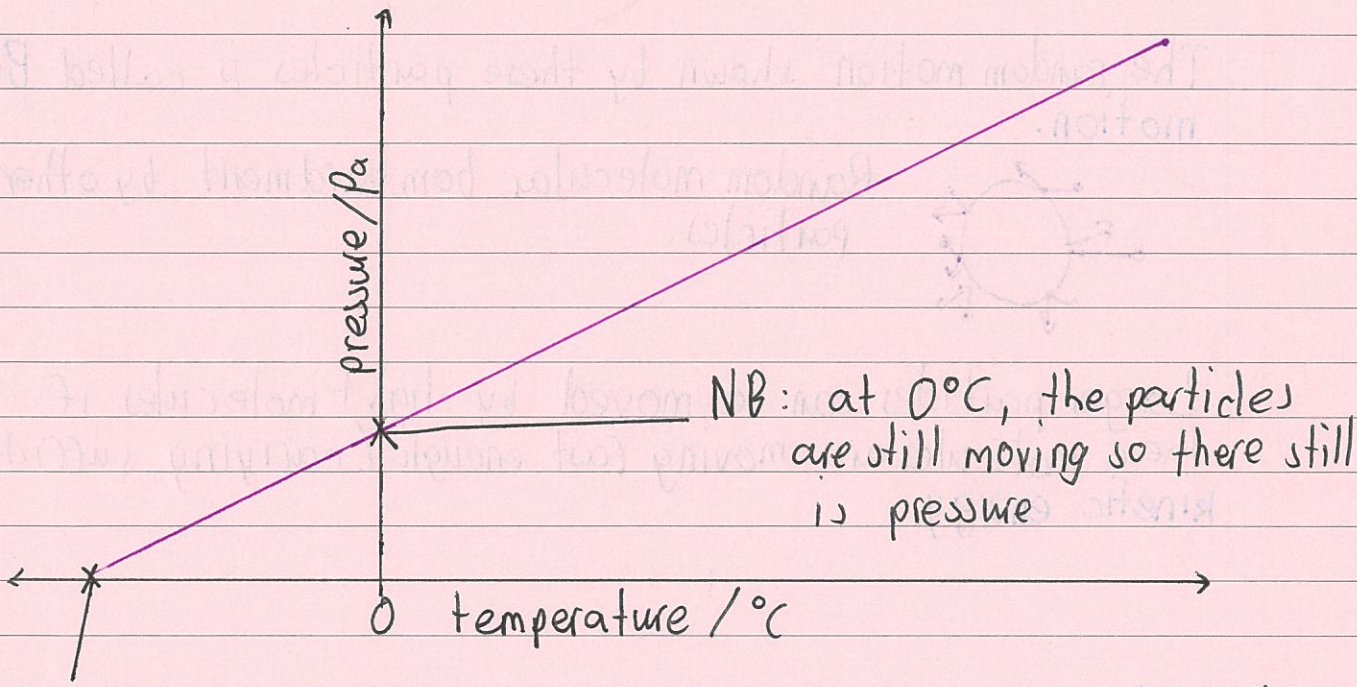
higher temperature ⟶ particles gain K.E

Pressure

Particles in gas are constantly colliding with the walls of the container, exerting a force - causing pressure.

Effect of temperature on pressure - Pressure law

For a fixed mass of gas at constant volume, pressure is directly proportional to temperature (when using Kelvin)

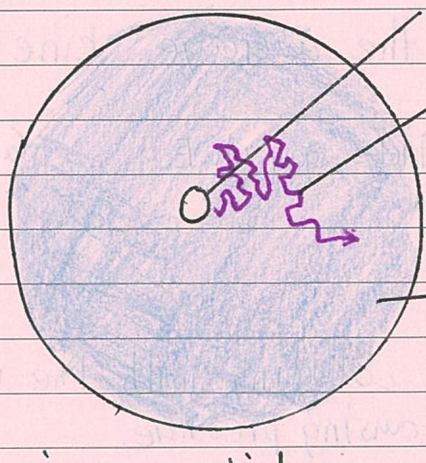


Absolute zero, 0 kelvin, -273°C. Particles are not moving, they have no kinetic energy. No pressure is exerted.

$$\frac{\text{pressure (Pa)}}{\text{temperature (°C)}} = \text{constant}$$

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Brownian motion

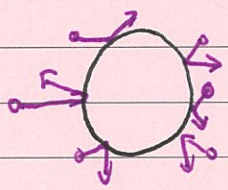


In suspension, particles appear to be in random motion. The explanation for this is they are constantly being hit by numerous fast-moving invisible particles.

↓

evidence for kinetic theory

The random motion shown by these particles is called Brownian motion.



Random molecular bombardment by other particles.

Larger particles can be moved by light molecules if these molecules are moving fast enough (carrying sufficient kinetic energy.

2.1(c) Evaporation

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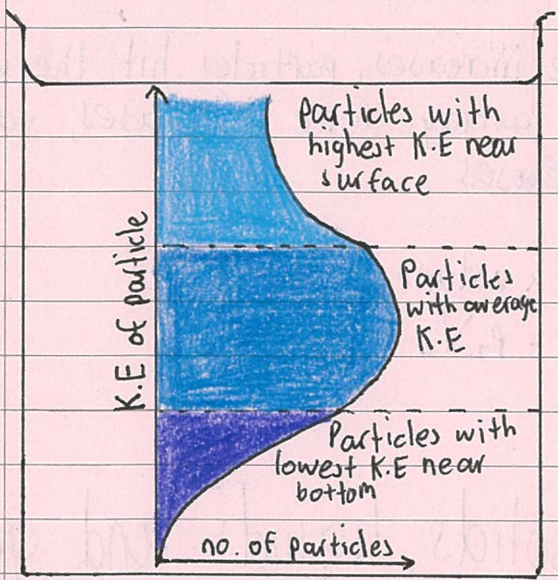
2.1 (c) Evaporation **Core**	 **Supplement**
• Describe evaporation in terms of the escape of more-energetic molecules from the surface of a liquid • Relate evaporation to the consequent cooling	• Demonstrate an understanding of how temperature, surface area and draught over a surface influence evaporation

Evaporation is the process by which liquids turn to gas below the boiling point of the liquid.



• The particles near the surface with the highest K.E can have enough energy to escape from the liquid

• After they escape, the average K.E of the remaining particles decreases

↓

Therefore temperature has decreased.

Factors affecting evaporation

• Temperature - increase in temperature increases rate of evaporation.
 - because it gives the particles more K.E to escape

• Surface area - increase in surface area increases rate of evaporation
 - because more surface molecules are able to escape

• Wind speed - increase in wind speed over surface increases rate of evaporation
 - because it gives the particles more K.E to escape

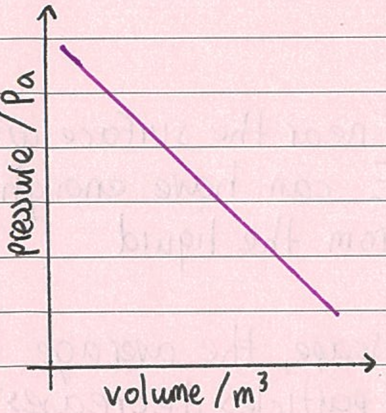
• Humidity - increase in humidity decreases rate of evaporation
 - because increase in humidity decreases capacity to hold water vapour

• Atmospheric pressure - increase in a.t.m decreases rate of evaporation
 - particles require more K.E to escape

2.1(d) Pressure changes

2.1 (d) Pressure changes **Core**	**Supplement**
• Relate the change in volume of a gas to change in pressure applied to the gas at constant temperature	• Recall and use the equation pV = constant at constant temperature

Boyle's law: For a fixed mass at a constant temperature, pressure is inversely proportional to volume.



As the volume increases, particles hit the wall less often, so average force decreases, so pressure decreases

pressure x volume = constant

$p_1V_1 = p_2V_2$

2.2(a) Thermal expansion of solids, liquids and gases

2.2 (a) Thermal expansion of solids, liquids and gases **Core**	**Supplement**
• Describe qualitatively the thermal expansion of solids, liquids and gases • Identify and explain some of the everyday applications and consequences of thermal expansion • Describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure	• Show an appreciation of the relative order of magnitude of the expansion of solids, liquids and gases

When objects are heated they expand.
- Heat applied, temperature increases
- Average K.E of molecules increases
- Particles vibrate and take up more space

NB: Particles themselves DO NOT get bigger.

Rate of expansion is determined by the type of atom.

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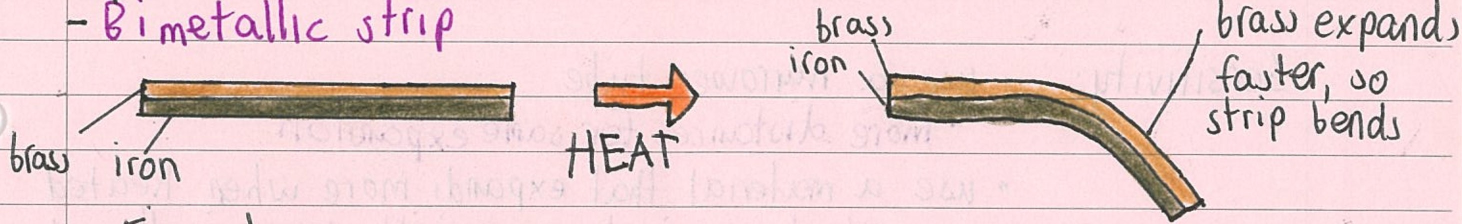
Thermal expansion of solids:

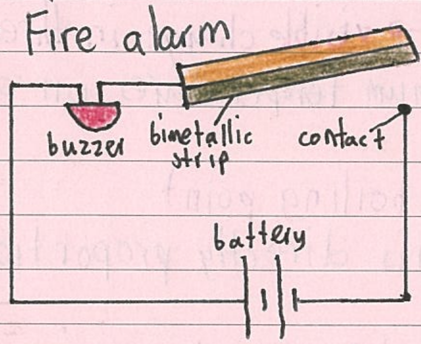
Solids expand the least, usually too little to see with the naked eye.

Consequences:
- Railway tracks have to have gaps to allow for expansion
- can cause wires to snap
- long structures like bridges need rollers

Applications:
- Bimetallic strip



- Fire alarm



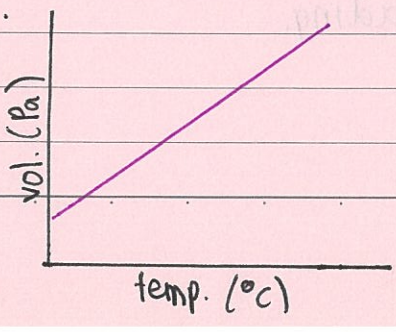
1. When heat is applied, the brass expands more than the iron so the strip bends
2. This completes the circuit and activates the buzzer.

Thermal expansion of a liquid

Liquids expand more than solids, but less than gases.
The expansion of liquids can be visible to the naked eye.
This effect can be used in liquid-in-glass thermometers

Thermal expansion of a gas

Gases expand the most.
Charles' law: at constant pressure, the volume of a gas is directly proportional to its temperature.



$$\frac{\text{volume}}{\text{temp.}} = \text{constant}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

2.2(b) Measurement of temperature

2.2 (b) Measurement of temperature **Core**	**Supplement**
• Appreciate how a physical property that varies with temperature may be used for the measurement of temperature, and state examples of such properties	• Demonstrate understanding of sensitivity, range and linearity
• Recognise the need for and identify fixed points • Describe the structure and action of liquid-in-glass thermometers	• Describe the structure of a thermocouple and show understanding of its use for measuring high temperatures and those that vary rapidly

The expansion of a subtance can be used to measure temperature.

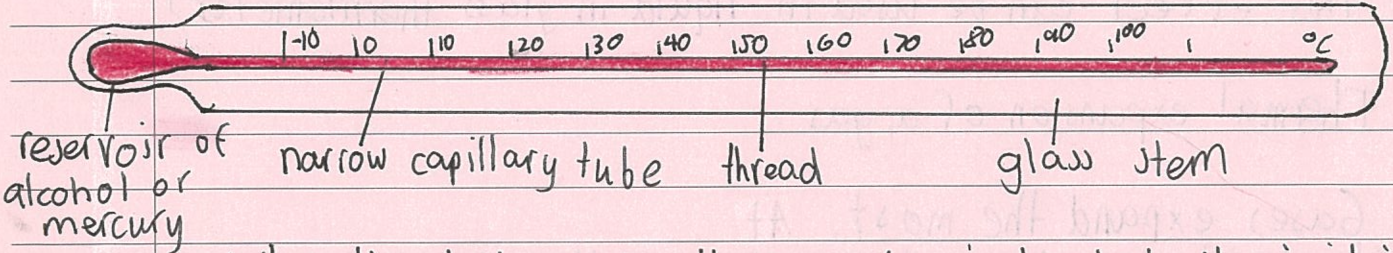
Sensitivity:
- use a narrower tube
  - more distance for same expansion
- use a material that expands more when heated
  - small change in temp. → visible change in thread.

Range:
- the maximum and minimum temperatures on a thermometer
  - low melting point, high boiling point

Linearity:
- whether or not expansion is directly proportional to temperature
  - e.g water cannot be used because its expansion is irregular

Fixed points are used to calibrate thermometers.

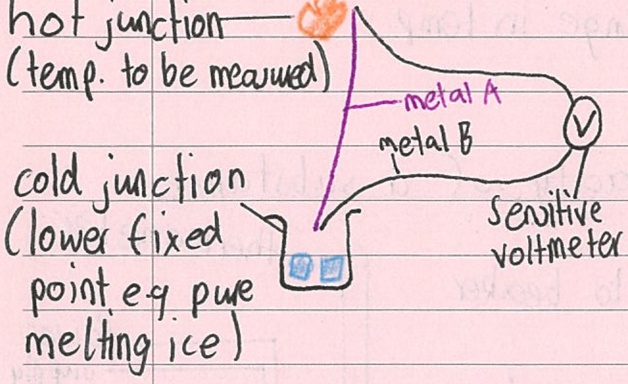
Liquid-in-glass thermometer



When the bulb of the thermometer is heated, the liquid inside heats up and expands, forcing the alcohol up the tube. This gives a greater temperature reading.

Thermocouples

A thermocouple is a commonly-used electrical thermometer



- A thermocouple consists of two dissimilar wires joined together
- When one junction is at a higher temperature an e.m.f is generated, read by voltmeter
- Output voltage is proportional to temperature difference.

- Thermocouples can be made very small, so they can heat and cool quickly - can measure rapidly varying temperatures
- Thermocouples can measure temperatures up to the melting point of the metal - can measure high temperatures

2.2(c) Thermal Capacity

2.2 (c) Thermal capacity **Core**	**Supplement**
• Relate a rise in the temperature of a body to an increase in internal energy • Show an understanding of the term thermal capacity	• Describe an experiment to measure the specific heat capacity of a substance

As heat is supplied and the temperature of a body increases, its internal energy increases.

The thermal capacity of an object is the energy required to raise temperature by 1°C.

An object with a higher thermal capacity requires more energy to raise its temperature, so it takes longer to heat and cool

The temp. increase of a substance depends on:

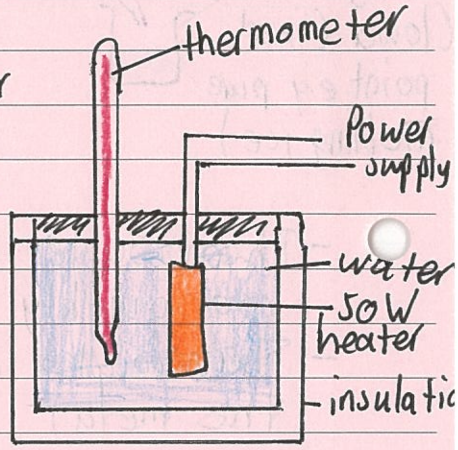
1. Amount of energy applied
2. Mass of substance
3. Nature of substance

The specific heat capacity of a substance is the amount of energy (J) required to raise the temperature of 1kg of the substance by 1 °C

Energy = mass x s.h.c x change in temp.

$Q = mc\Delta T$

Experiment to determine specific heat capacity of a substance e.g water



1. measure out 0.5kg of water and pour into beaker insulated with cotton.
2. Take initial temp. of water with thermometer
3. Place electrical 50W heater into water for 2 minutes
4. Measure temperature
5. Use formula $Q = mc\Delta T$ to find 'c'

2.2(d) Melting and Boiling

2.2 (d) Melting and boiling

Core	**Supplement**
• Describe melting and boiling in terms of energy input without a change in temperature	• Distinguish between boiling and evaporation
• State the meaning of melting point and boiling point	
• Describe condensation and solidification	• Use the terms latent heat of vaporisation and latent heat of fusion and give a molecular interpretation of latent heat
	• Describe an experiment to measure specific latent heats for steam and for ice

For any pure substance undergoing a change of state, there is an energy input without a change in temperature

Melting point – temp. at which solids change to liquids
Boiling point – the temp. at which all liquid changes to gas

Solidification – particles arrange themselves into 'low energy' positions closer together, liquid → solid

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Condensation - gas particles move into 'lower energy' positions closer together, gas → liquid

Differences between boiling and evaporation

1. Boiling occurs at fixed temperature, which depends on the substance being heated and its pressure
2. Evaporation can occur at temperatures below boiling point
3. Evaporation decreases temp., during boiling temp. is constant

Latent heat

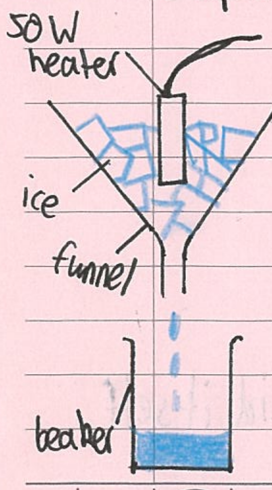
- Latent heat of fusion: energy which must be put in to melt a solid at its melting point, or is given out during solidification at melting point.

- Latent heat of vapourisation: energy which must be put in to vapourise a liquid at its boiling point, or is given out during condensation at b.p.

Heat energy is used to overcome attractive forces between particles, so there is no increase in K.E, so temp. stays constant.

- Specific latent heat is energy required to change state of 1 kg of a substance at constant temperature. $Q = mL$

Experiment to find latent heat of fusion of ice

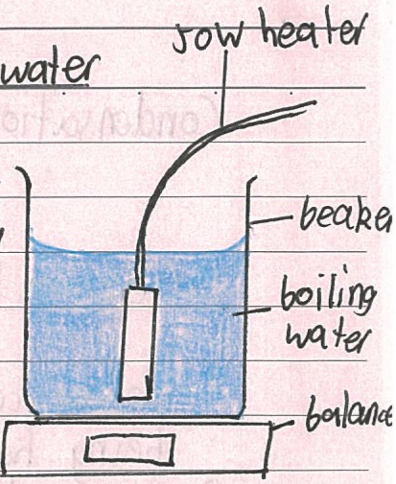


1. Fill funnel with ice and place 50W heater in ice
2. After 10 minutes of heating, remove heater.
3. Find mass of water collected
4. Use formula $Q = mL$
5. Substitute values for Q and m
6. Rearrange to $L = Q/m$
7. Find L

A'ZONE

Experiment to find latent heat of vaporisation of water

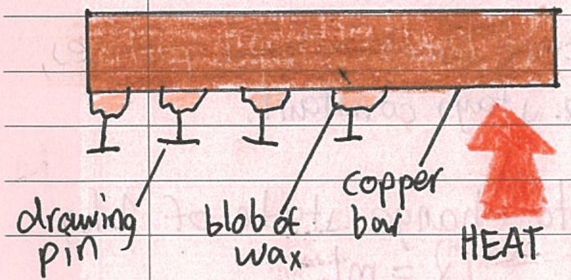
1. Fill a beaker with water and place 50W heater in.
2. Heat, timing 5 minutes from when it starts boiling
3. After 5 minutes of heating, note loss in mass
4. Use $L = Q/m$ to find specific latent heat of vapourisation



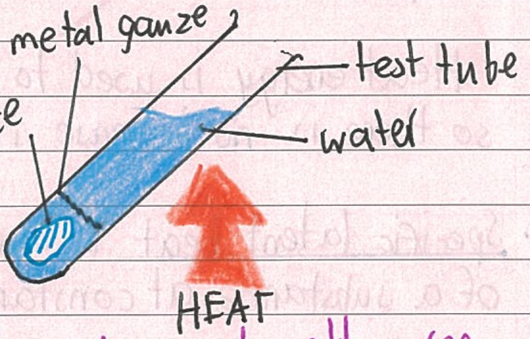
2.3(a) Conduction

2.3 (a) Conduction **Core**	**Supplement**
• Describe experiments to demonstrate the properties of good and bad conductors of heat	• Give a simple molecular account of heat transfer in solids

Particles in solids vibrate more when heated, and they pass their vibrations to neighbouring particles spreading heat.
Metals are good conductors because they have delocalised electrons which carry K.E throughout the metal.



Pins drop off - copper is a thermal conductor

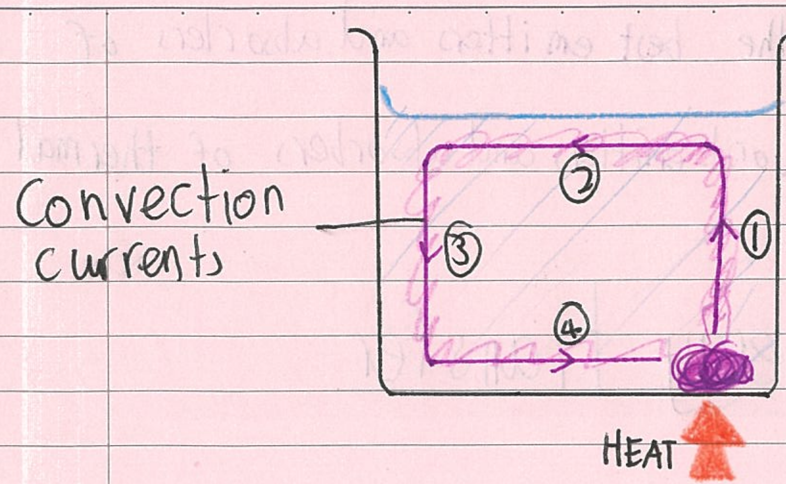


Ice does not melt even when water boils - water is a thermal insulator

2.3(b) Convection

2.3 (b) Convection **Core**	
• Relate convection in fluids to density changes and describe experiments to illustrate convection	

Transfer of heat in a fluid by movement of the fluid itself



- Potassium permanganate crystals placed in bottom corner
- When heated purple colour forms a loop

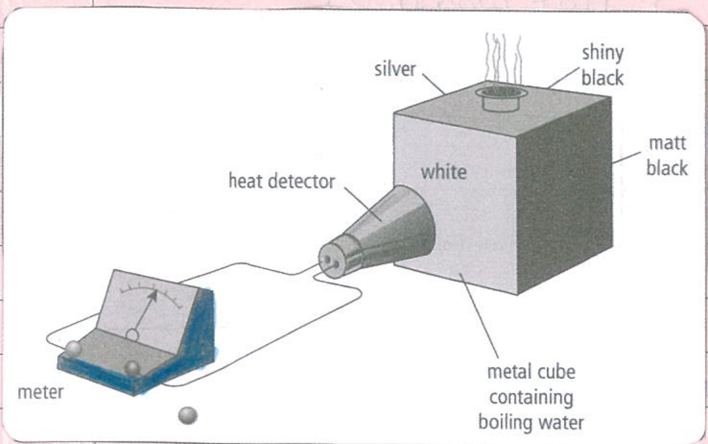
1. When heated, the water expands, becomes less dense and rises
2. The water begins to cool and is pushed away by rising hot water
3. As water cools, it contracts, becomes more dense, and sinks
4. Cool water moves to take place of rising water

2.3(c) Radiation

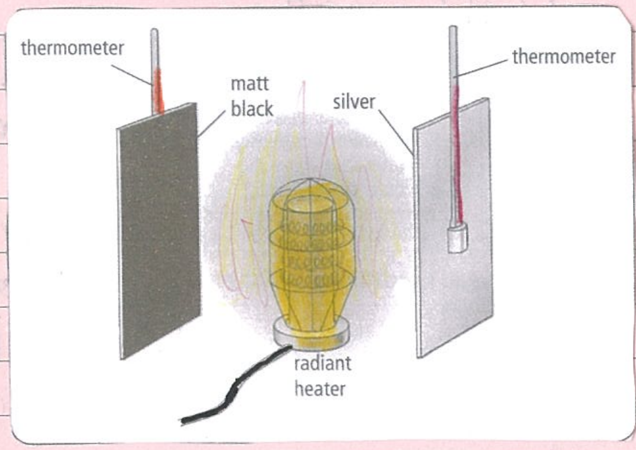
2.3 (c) Radiation **Core**	**Supplement**
• Identify infra-red radiation as part of the electromagnetic spectrum	• Describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation

Transfer of heat through infrared radiation, which is part of the electromagnetic spectrum, which can traverse a vacuum.

Emitters



Absorbers

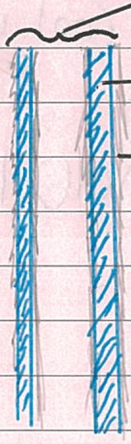


- Matt black surfaces are the best emitters and absorbers of thermal radiation
- Silver surfaces are the worst emitters and absorbers of thermal radiation.

2.3(d) Consequences of energy transfer

2.3 (d) Consequences of energy transfer **Core** • Identify and explain some of the everyday applications and consequences of conduction, convection and radiation	

Vacuum flask



- Vacuum between double-walled glass
  - reduces heat transfer by conduction & convection
- Silvered surfaces on walls
  - reflect infrared radiation, reduce heat transfer by radiation
- Materials used are insulators (plastic and glass)

Reducing heat transfer at home

Cold weather:	Hot weather:

• loft insulation e.g fibreglass
• cavity wall insulation (air insulates)
• double glazed windows
  - reduce conduction & convection
• 'lagging' (plastic foam) around water tank, which traps air
  - reduces conduction & convection
	• painting walls and roof white
	  - absorb less heat
	• white blinds / window shutters
	• thick walls to reduce heat transfer

3. Properties of Waves

3.1 General Wave Properties

3.1 General wave properties

Core	Supplement
• Describe what is meant by wave motion as illustrated by vibration in ropes and springs and by experiments using water waves	
• Use the term wavefront	
• Give the meaning of speed, frequency, wavelength and amplitude	• Recall and use the equation $v = f\lambda$
• Distinguish between transverse and longitudinal waves and give suitable examples	
• Describe the use of water waves to show: – reflection at a plane surface – refraction due to a change of speed – diffraction produced by wide and narrow gaps	• Interpret reflection, refraction and diffraction using wave theory

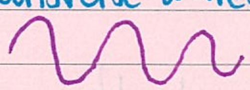
Waves transfer energy from one place to another through periodic oscillations.
Wavefronts are the peaks of transverse waves or compressions of longitudinal waves, drawn perpendicular to direction of travel.

v Wave speed – distance travelled per second (ms^{-1})
f Frequency – number of cycles per second (Hz)
λ Wavelength – distance between two consecutive points on a wave in phase (i.e from peak to peak) (m)
a Amplitude – maximum displacement from equilibrium

wave speed = frequency × wavelength

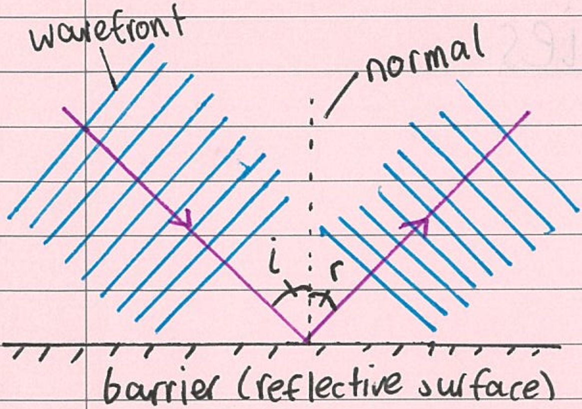
$$v = f\lambda$$

Transverse waves: oscillations are perpendicular to direction of travel. e.g light, water waves, S-waves



Longitudinal waves: oscillations are along direction of travel e.g sound, p-waves, pressure waves

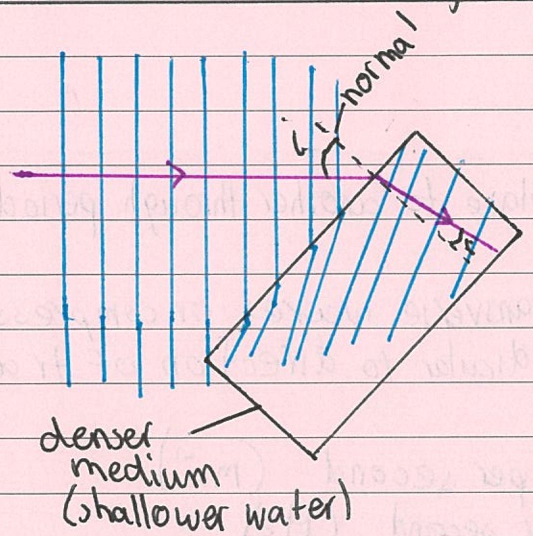
Reflection at a plane surface (e.g mirror)



- Water cannot pass through surface so bounces back
- Same speed, frequency and wavelength
- angle of incidence = angle of reflection

$\angle i = \angle r$

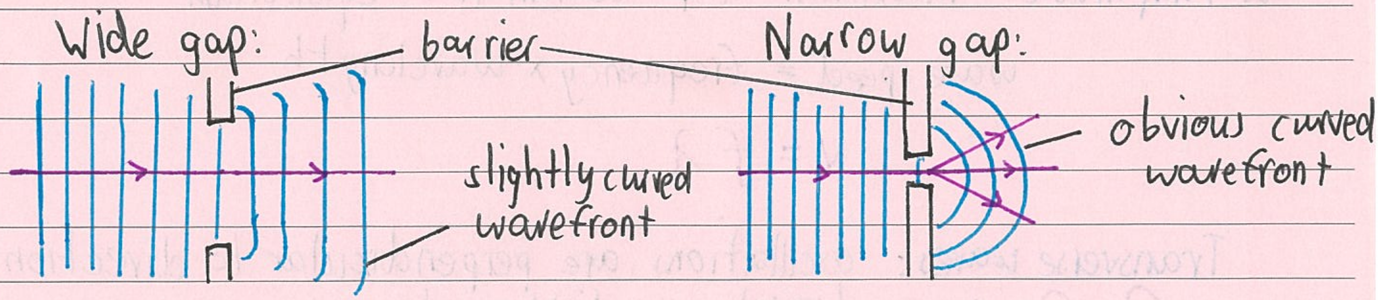
Refraction due to a change of speed



- As water reaches a shallower area it slows down and bends (because the upper side continues at same speed).
- Speed decreases, wavelength decreases, frequency stays the same

$\angle i \neq \angle r$

Diffraction



- Only part of the wave can pass through the gap
- The waves that come out have curved wavefronts
- Speed, frequency and wavelength stay the same.
- Maximum diffraction occurs when gap = wavelength.

3.2(a) Reflection of light

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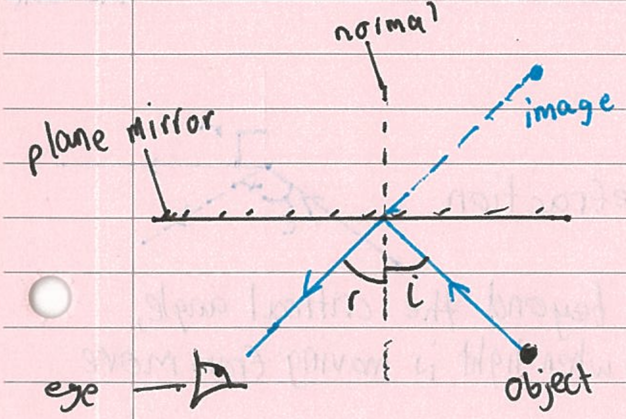
3.2 (a) Reflection of light **Core**	**Supplement**
• Describe the formation of an optical image by a plane mirror, and give its characteristics • Use the law angle of incidence = angle of reflection	• Perform simple constructions, measurements and calculations

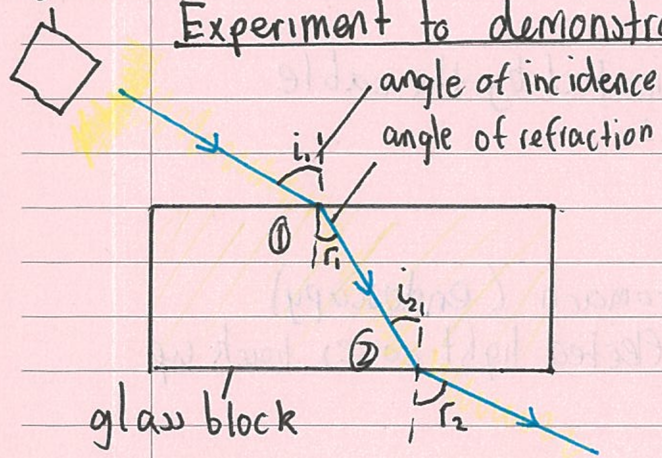


- image is same size as object
- image is as far behind mirror as object is in front
- image is laterally inverted
- $\angle i = \angle r$
- image is virtual (can not be projected onto screen)

3.2(b) Refraction of light

3.2 (b) Refraction of light **Core**	**Supplement**
• Describe an experimental demonstration of the refraction of light • Use the terminology for the angle of incidence *i* and angle of refraction *r* and describe the passage of light through parallel-sided transparent material • Give the meaning of critical angle • Describe internal and total internal reflection	• Recall and use the definition of refractive index *n* in terms of speed • Recall and use the equation sin *i*/sin *r* = *n* • Describe the action of optical fibres particularly in medicine and communications technology

Experiment to demonstrate refraction



① As the ray of light enters the block, it slows and bends towards the normal

② As the ray of light exits the block, it speeds up and bends away from normal

$\angle i \neq \angle r$

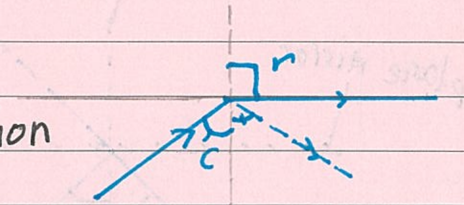
Frequency does NOT change, only speed and wavelength

Refractive Index

The refractive index of a substance is the degree to which light refracts when entering or exiting the medium

$$n = \frac{\sin i}{\sin r} = \frac{\text{speed of light in vacuum/air}}{\text{speed of light in medium}} = \frac{\sin r}{\sin i}$$ (if light is leaving the block)

Critical angle

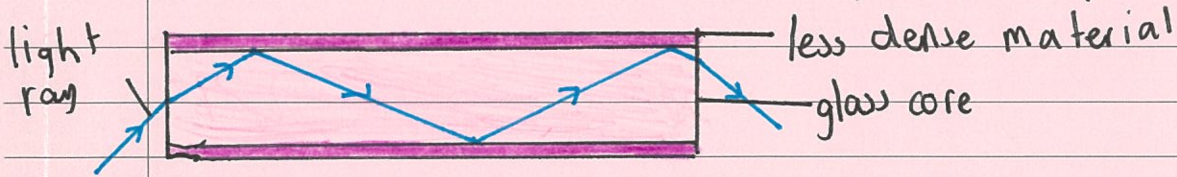


The incident angle for which ∡ of refraction is 90°.

When the incident angle is increased beyond the critical angle, total internal reflection occurs (only when light is moving from more dense to less dense medium).

Optical fibres

Total internal reflection can be used for optical fibres



Total internal reflection occurs for all rays that hit the boundary at an angle greater than the critical angle.

Used in:

1. Telecommunications
   - digital signals can be communicated by the cable
   - thinner than conventional cables

2. Medicine
   - Examining inside of body eg stomach (endoscopy)
   - Light illuminates the inside, reflected light comes back up

3.2(c) Thin Converging Lens

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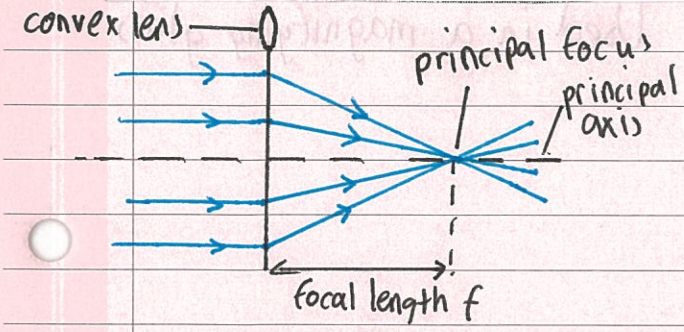
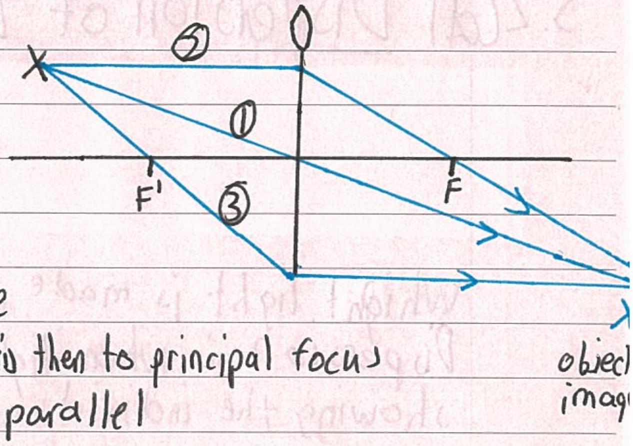
3.2 (c) Thin converging lens **Core**	**Supplement**
• Describe the action of a thin converging lens on a beam of light	
• Use the terms principal focus and focal length	
• Draw ray diagrams to illustrate the formation of a real image by a single lens	• Draw ray diagrams to illustrate the formation of a virtual image by a single lens
	• Use and describe the use of a single lens as a magnifying glass



• When parallel rays of light pass through a convex converging lens, they are focused to a point, the principal focus



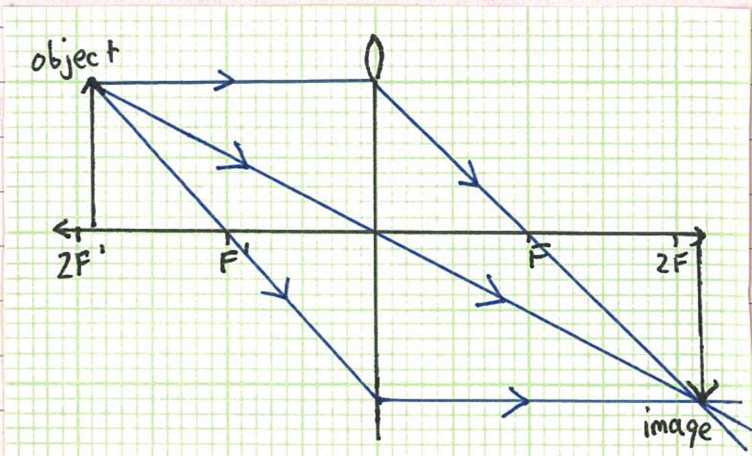
Ray diagrams

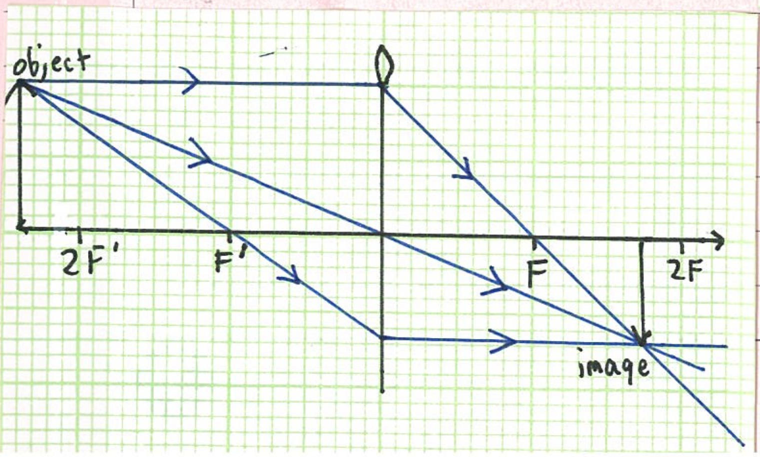
To draw a ray diagram:
1. Ray from object through optical centre
2. Ray from object: parallel to principal axis then to principal focus
3. From object through F' to lens, then parallel

Formation of a real image

Object between F and 2F: →
- inverted
- magnified

Used in projector.

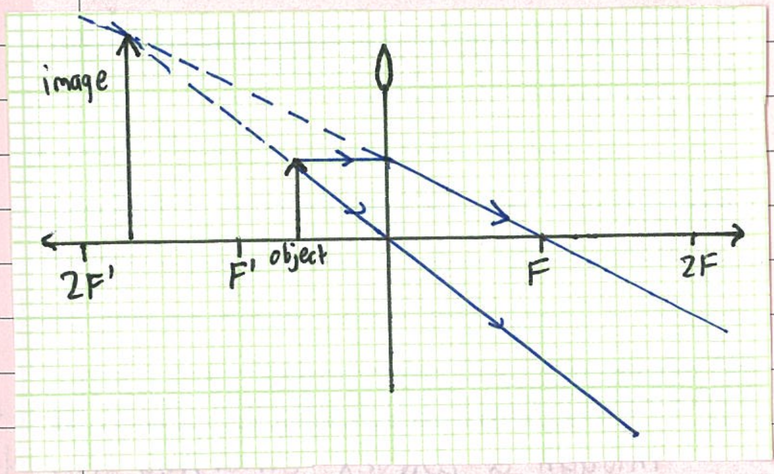




← Object beyond 2F:
- inverted
- diminished

Used in camera

Formation of a virtual image



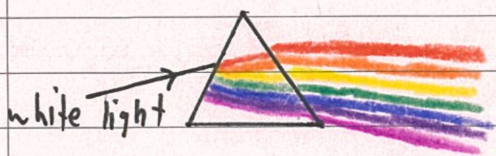
Object between lens and F:
- upright
- magnified
- cannot be projected onto screen

Used in a magnifying glass

3.2(d) Dispersion of Light

3.2 (d) Dispersion of light	
Core	
• Give a qualitative account of the dispersion of light as shown by the action on light of a glass prism	

White light is made up of a range of different frequencies (colours).
Dispersion is when light spreads out into the colours of the spectrum, showing the individual frequencies.



- Light with lower frequency travels faster in glass
- Therefore violet travels slowest and refracts most.

3.2(e) Electromagnetic spectrum

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3.2 (e) Electromagnetic spectrum **Core**	**Supplement**
• Describe the main features of the electromagnetic spectrum and state that all e.m. waves travel with the same high speed *in vacuo* • Describe the role of electromagnetic waves in: – radio and television communications (radio waves) – satellite television and telephones (microwaves) – electrical appliances, remote controllers for televisions and intruder alarms (infrared) – medicine and security (X-rays) • Demonstrate an awareness of safety issues regarding the use of microwaves and X-rays	• State the approximate value of the speed of electromagnetic waves • Use the term monochromatic

- All electromagnetic waves can travel through a vacuum at $3\times10^8 ms^{-1}$
- Monochromatic colours are of only one frequency

Radio: used in telecommunications - electromagnetic oscillations transmitted and received

Microwave: used for rapid heating, sending satellite signals (e.g mobile phones)
- can heat and destroy living cells

Infrared: produced by hot objects; used in burgular alarms, remote controllers

Visible: produced by very hot objects; used in optical fibre commmunication

Ultra-violet: causes fluorescence, used in sterilising equipment
- can ionise atoms and cause mutations, can damage retina

X-rays: used in medical diagnosis of bones, security detectors
- dangerous in high doses because it is ionising

Gamma rays: used to sterilise food, equipment; used in radiotherapy
- destroys cells

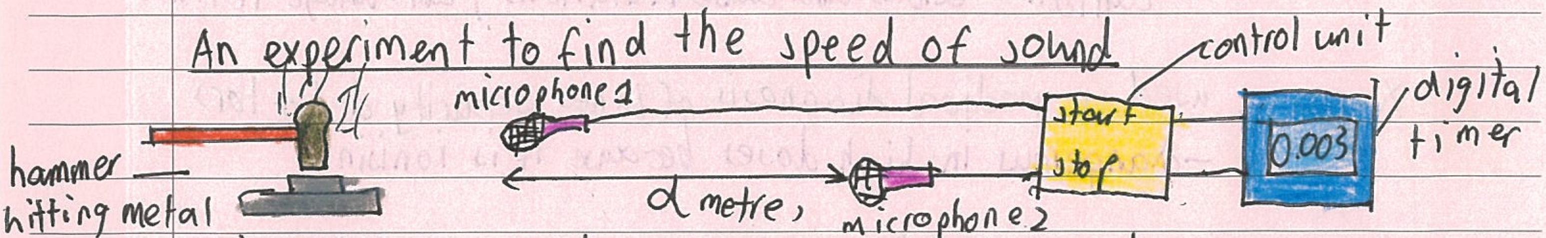
3.3 Sound

3.3 Sound **Core**	**Supplement**
• Describe the production of sound by vibrating sources	
• Describe the longitudinal nature of sound waves	• Describe compression and rarefaction
• State the approximate range of audible frequencies	
• Show an understanding that a medium is needed to transmit sound waves	
• Describe an experiment to determine the speed of sound in air	• State the order of magnitude of the speed of sound in air, liquids and solids
• Relate the loudness and pitch of sound waves to amplitude and frequency	
• Describe how the reflection of sound may produce an echo	

Vibrating objects such as tuning forks can produce sounds by vibrating the air molecules to form a series of
- Compressions - higher pressure than normal where air molecules are closer together
- Rarefactions - lower pressure than normal where air molecules are further apart.

- Sound waves are mechanical longitudinal waves which require a medium to travel through. Sound travels fastest in solids, slowest in gases, and cannot travel in a vacuum.
- We can hear sounds between 20Hz to 20kHz
- sound can be reflected to produce an echo
  - this can be used for sonar and ultrasound imaging

An experiment to find the speed of sound



- Timer measures how long it takes for sound to go from mic. 1 to 2.
- Repeat for reliability, then speed = $\frac{d}{\text{average time}}$

For sound:
- amplitude = loudness
- frequency = pitch

4. Electricity & Magnetism

No. 0625
Date RM.

4.1 Simple Phenomena of Magnetism

4.1 Simple phenomena of magnetism	
Core • State the properties of magnets • Give an account of induced magnetism • Distinguish between ferrous and non-ferrous materials • Describe methods of magnetisation and of demagnetisation • Describe an experiment to identify the pattern of field lines round a bar magnet • Distinguish between the magnetic properties of iron and steel • Distinguish between the design and use of permanent magnets and electromagnets	

Properties of magnets

- Like magnetic poles repel
- Unlike magnetic poles attract
- Magnetic poles attract ferromagnetic materials

Induced Magnetism

- When a permanent magnet is placed next to iron (or any ferromagnetic material) it attracts it. The domains of the material line up - induced magnetism

- When the permanent magnet is removed, the domains become randomly arranged again and the temporary magnetism is lost

Iron: 'soft'
- easier to magnetise and demagnetise
- used in electromagnets and transformers

Steel: 'hard'
- harder to magnetise, much harder to demagnetise - retains its magnetism.
- used in permanent magnets

Ferrous materials contain iron - can be magnetised and demagnetised.

Methods of magnetising

- Stroking method:
  1. Stroke unmagnetised ferrous material with north pole of magnet from one end to the other
  2. Repeat many times (10)
  3. The starting end will be north.

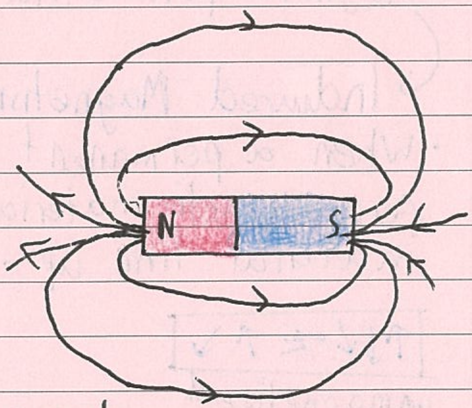
- Electrical method:
  1. Wind a wire round the ferrous material
  2. Run a direct current through

Methods of destroying magnetism

- Hammering - dis aligns domains
- Heating
- Running alternating current through.

Field lines around a bar magnet

1. Put a magnet below a piece of paper
2: sprinkle iron filings



Uses of electromagnets and permanent magnets

Electromagnets:
- Used in scrapyards to lift metals such as cars
- used in relay switches

Permanent magnets:
- compasses
- loudspeakers
- iron oxide is used in CDs, videotapes and for tape in tape-recorders.

4.2 (a) Electrical charge

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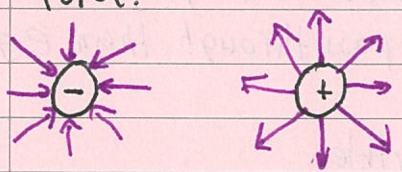
4.2 (a) Electric charge

Core	Supplement
• Describe simple experiments to show the production and detection of electrostatic charges	
• State that there are positive and negative charges	• State that charge is measured in coulombs
• State that unlike charges attract and that like charges repel	
• Describe an electric field as a region in which an electric charge experiences a force	• State the direction of lines of force and describe simple field patterns, including the field around a point charge and the field between two parallel plates
• Distinguish between electrical conductors and insulators and give typical examples	• Give an account of charging by induction
	• Recall and use the simple electron model to distinguish between conductors and insulators

- There are positive and negative charges. Like charges repel, unlike charges attract.
- An electric field is a region in which an electric charge experiences a force.

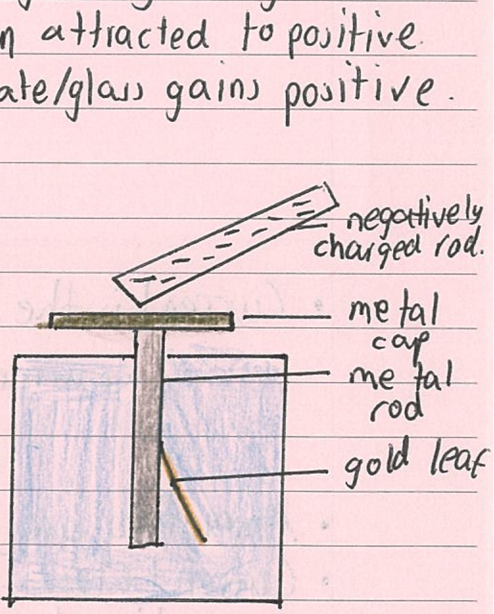


The field lines show the direction a positive charge would move if placed in the field.

- Charge is measured in coulombs (C)
- For example: if you rub a balloon on clothes it becomes charged with static electricity.
  - electrons are transferred to balloon → negatively charged
  - balloon sticks to ceiling: repels electrons then attracted to positive.
- Polythene gains a negative charge, cellulose acetate/glass gains positive.

Detection of electrostatic charges

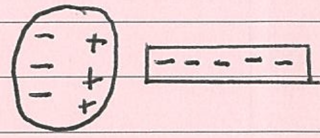
Gold-leaf electroscope:



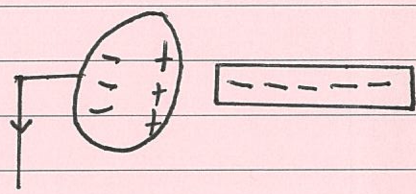
- when a charged object is brought near the cap, the electrons in the electroscope either move to the cap or away. This causes the gold leaf to repel the rod and bend.
- same happens if a charged rod touches the cap.

Charging by induction

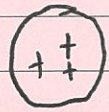
1. Bring a negatively charged rod close to an isolated metal sphere -electrons repellled to other end of sphere leaving a positive charge



2. Attach a conducting wire between ground and far end of sphere -electrons flow off into ground.



3. Remove wire -sphere has a net positive charge



Conductors and Insulators

- Conductors allow charge (electrons) to flow through it e.g metals.
- Good conductors have electrons that can move through their structure
- Insulators do not allow charge (electrons) to pass through them e.g wood, rubber, air, plastic.
- Insulators do not have mobile charged particles

4.2(b) Current

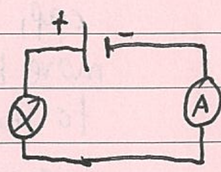
4.2 (b) Current

Core	Supplement
• State that current is related to the flow of charge • Use and describe the use of an ammeter	• Show understanding that a current is a rate of flow of charge and recall and use the equation $I = Q/t$ • Distinguish between the direction of flow of electrons and conventional current

- Current is the rate of flow of charge through a conductor

current (A) = charge (C) / time (s)

$I = Q/t$ $\quad Q = It$



- Ammeters are used to measure current in series.
- Current flows from negative to positive,
- Conventional current flows from positive to negative.

4.2(c) Electro-motive Force

4.2 (c) Electro-motive force	
Core	**Supplement**
• State that the e.m.f. of a source of electrical energy is measured in volts	• Show understanding that e.m.f. is defined in terms of energy supplied by a source in driving charge round a complete circuit

- e.m.f is measured in volts.
- e.m.f is the energy per unit charge supplied by a source to drive charge round a complete circuit.

$$\text{e.m.f (V)} = \frac{\text{energy (J)}}{\text{charge (C)}}$$

4.2(d) Potential Difference

4.2 (d) Potential difference	
Core	
• State that the potential difference across a circuit component is measured in volts • Use and describe the use of a voltmeter	

- The p.d across a circuit is measured in volts
- The p.d across a component is measured with a voltmeter in parallel

4.2(e) Resistance

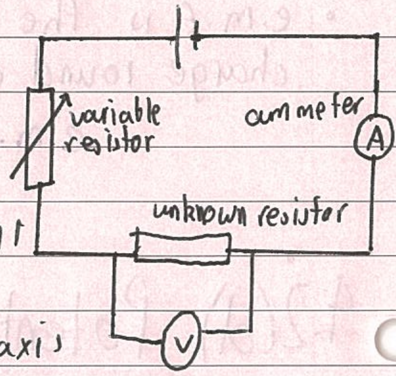
4.2 (e) Resistance	
Core	**Supplement**
• State that resistance = p.d./current and understand qualitatively how changes in p.d. or resistance affect current • Recall and use the equation $R = V/I$ • Describe an experiment to determine resistance using a voltmeter and an ammeter • Relate (without calculation) the resistance of a wire to its length and to its diameter	• Recall and use quantitatively the proportionality between resistance and length, and the inverse proportionality between resistance and cross-sectional area of a wire

- For a constant p.d, ↑resistance ↓current
- For a constant resistance, ↑p.d ↑current

resistance (Ω) = p.d / current

$R = \frac{V}{I}$ $V = IR$

Experiment to determine resistance of an unknown resistor



1. Vary p.d across unknown resistor by changing resistance of variable resistor
2. Measure the p.d across the unknown resistor at each setting as well as measuring the current
3. Repeat at 5 different settings
4. Plot graph with p.d on x axis, current on y-axis
5. resistance = 1/gradient

Resistance of a uniform wire

- Length (L) – ↑ length ↑ resistance
- Cross-sectional area (A) – ↑ area ↓ resistance

$$R = \frac{\rho L}{A}$$ (ρ = resistivity)

4.2(f) Electrical Energy

4.2 (f) Electrical energy	
	Supplement • Recall and use the equations $P = IV$ and $E = IVt$

Power is the rate at which energy is used

power (W) = voltage (V) x current (A) $P = VI$

energy (J) = power (W) x time (t) $E = VIt$

4.3(a) Circuit Diagrams

4.3 (a) Circuit diagrams	
Core • Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), lamps, ammeters, voltmeters, magnetising coils, transformers, bells, fuses and relays	**Supplement** • Draw and interpret circuit diagrams containing diodes and transistors

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Description	Symbol
Conductors crossing with no connection	
Junction of conductors	
Open switch	
Closed switch	
Open push switch	
Closed push switch	
Cell	
Battery of cells	
Power supply	(d.c.) or (a.c.)
Transformer	
Ammeter	A
Milliammeter	mA
Voltmeter	V
Fixed resistor	
Variable resistor	

Description	Symbol
heater	
thermistor	
light-dependent resistor (LDR)	
relay	
diode	
light-emitting diode (LED)	
lamp	
capacitor	
microphone	
electric bell	
earth or ground	
motor	M
generator	G
fuse/circuit breaker	
magnetising coil	
transistor	

4.3(b) Series and Parallel circuits

4.3 (b) Series and parallel circuits **Core**	**Supplement**
• Understand that the current at every point in a series circuit is the same • Give the combined resistance of two or more resistors in series • State that, for a parallel circuit, the current from the source is larger than the current in each branch • State that the combined resistance of two resistors in parallel is less than that of either resistor by itself • State the advantages of connecting lamps in parallel in a lighting circuit	• Recall and use the fact that the sum of the p.d.s across the components in a series circuit is equal to the total p.d. across the supply • Recall and use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit • Calculate the effective resistance of two resistors in parallel

Series circuits

- current is the same at every point
- p.d across supply is split between appliances - energy is shared
- resistance is increased by adding resistors.

- $R_{Total} = R_1 + R_2$

Parallel circuits

- the current from the source is larger than the current in each branch – current splits at a junction and is shared.
- each component receives same voltage as p.d across supply
- the combined resistance of two resistors in parallel is less than that of either resistor by itself
- $\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$
- In parallel, if a resistor/component breaks current can still flow through the other components

4.3(c) Action and use of Circuit Components

4.3 (c) Action and use of circuit components

Core	Supplement
• Describe the action of a variable potential divider (potentiometer) • Describe the action of thermistors and light-dependent resistors and show understanding of their use as input transducers • Describe the action of a capacitor as an energy store and show understanding of its use in time-delay circuits • Describe the action of a relay and show understanding of its use in switching circuits	• Describe the action of a diode and show understanding of its use as a rectifier • Describe the action of a transistor as an electrically operated switch and show understanding of its use in switching circuits • Recognise and show understanding of circuits operating as light sensitive switches and temperature-operated alarms (using a relay or a transistor)

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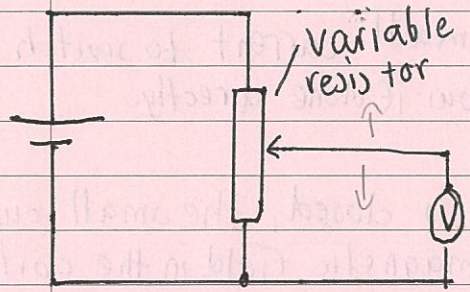
Variable Potential Divider (Potentiometer)

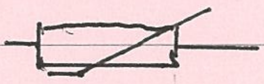


- Sliding the contact changes the reading on the voltmeter
- Increasing the resistance in parallel increases the share of p.d from the cell
- Voltmeter can be replaced with other things

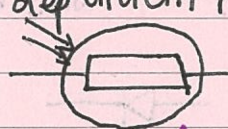
Input transducers

Input transducers convert a quantity (e.g heat) into an electrical signal (voltage or resistance).

- Thermistor: temp. ↑ resistance ↓

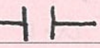


- Light dependent resistor (LDR)

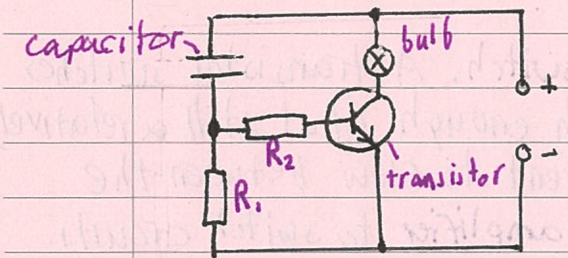


light intensity ↑ resistance ↓

Capacitor



A simple capacitor consists of two metal plates separated by an insulator. Capacitors store charge, and therefore energy. Capacitors can be used in time-delay circuits:

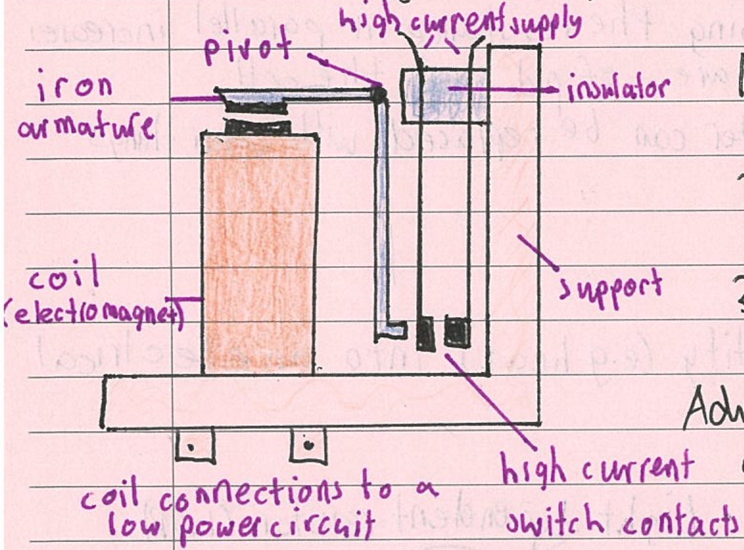


1. Initially bulb is lit and the uncharged transistor gets a small share of the p.d
2. As the capacitor charges, it gets a ↑ p.d, and R_1 and R_2 get a ↓ p.d.
3. When the p.d across R_2 is low enough, the base current switches off the collector-emitter current. Bulb turns off
4. So, after a time delay (depending on size of capacitor and resistance of circuit) the bulb goes out.

This circuit could be used in a switch on a hall light, which would turn off after a time delay once the person has climbed the stairs.

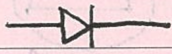
Relay 

An electromagnetic switch which uses a small current to switch on a much larger current, which may be dangerous if done directly.

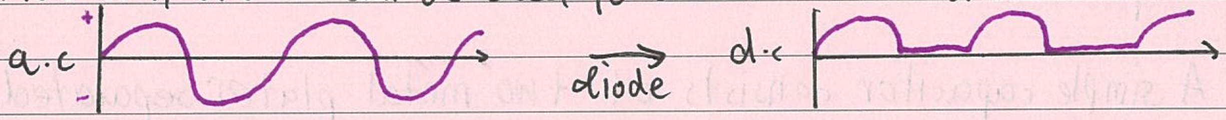


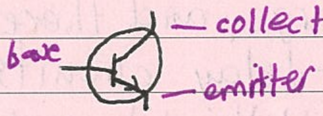
1. When switch is closed, the small current creates a magnetic field in the coil
2. this attracts the armature and pushes the high-current contacts together.
3. This closes the high-current circuit.

Advantage is that operator does not come into contact with high current.

Diodes 

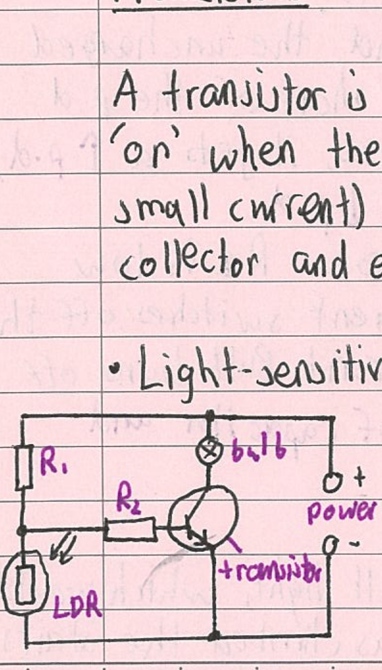
- A diode only lets current flow one way through it.
- As such, diodes can be used to convert a.c to d.c - rectification.



Transistors 

A transistor is an electrically operated switch. A transistor switches 'on' when the current in the base is high enough (but still a relatively small current), which then allows a current to flow between the collector and emitter. It also acts as an amplifier to switch circuits.

- Light-sensitive switch:
  1. As light intensity↓, LDR resistance↑, so it takes a larger share of the p.d
  2. R_1 takes a smaller share, but R_2 gets more p.d
  3. p.d across base is large enough to switch on collector emitter current and turn on bulb



This circuit could be used to light a bulb at night.

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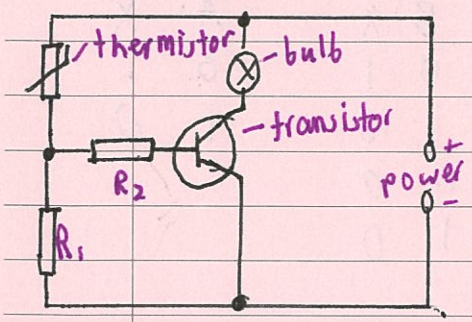
- temperature-operated switch



1. As temp. ↑, thermistor resistance ↓, so ↓ p.d
2. R_1 and R_2 get ↑ p.d, enough current through base to switch on collector-emitter, lighting up the bulb.

This circuit could be used as an indicator light for when something is hot enough or too hot

4.3(d) Digital Electronics

4.3 (d) Digital electronics

Supplement

- Explain and use the terms digital and analogue
- State that logic gates are circuits containing transistors and other components
- Describe the action of NOT, AND, OR, NAND and NOR gates
- Design and understand simple digital circuits combining several logic gates
- State and use the symbols for logic gates (candidates should use the American ANSI#Y 32.14 symbols)

Digital - a signal that has only two states: high or low (or on and off; or 1 and 0)
Analogue - a signal that varies continuously in amplitude

A logic gate is a circuit containing transistors and other components.

Block diagrams can be used to represent logic gates:
e.g to switch on a light at night when it is cold.

LDR - NOT ┐
thermistor - NOT ┘ AND - Relay - bulb

- At night LDR output is 0 (lower resistance ∴ ↓ voltage)
- In the cold thermistor output is 0 (↓ resistance ↓ voltage)

OR:

A	B	X
0	0	0
0	1	1
1	0	1
1	1	1

AND:

A	B	X
0	0	0
0	1	0
1	0	0
1	1	1

NAND:

A	B	X
0	0	1
0	1	1
1	0	1
1	1	0

NOR:

A	B	X
0	0	1
0	1	0
1	0	0
1	1	0

NOT:

A:	X
0	1
1	0

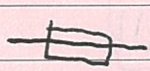
4.4 Dangers of Electricity

4.4 Dangers of electricity

Core

- state the hazards of
  - damaged insulation
  - overheating of cables
  - damp conditions
- Show an understanding of the use of fuses and circuit-breakers

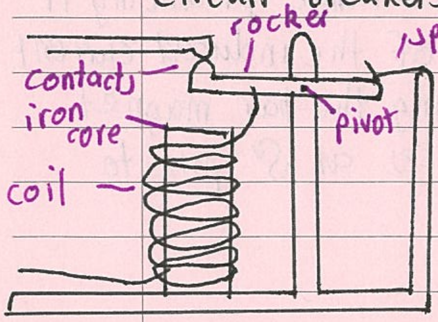
- Damaged insulation
  - the plastic insulation around a wire can wear away, leaving a bare exposed wire
  - if you touch the exposed wire you will get an electric shock
- Overheating of cables
  - when too much current flows, e.g because of short circuit, it may cause a fire because the cables get too hot.
- Damp conditions
  - since water conducts, it can cause short-circuit
  - also it may provide a conducting path to a surface, which will give a shock if touched.

<u>Fuses</u> 

- Fuses are deliberate weak points in a circuit.
- If the current gets too high, the thin piece of metal in the fuse melts and breaks the circuit

Circuit-breakers

Circuit breakers can be used instead of fuses

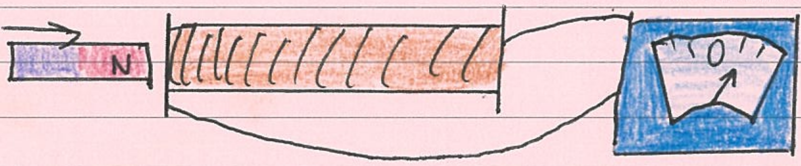


- If the current is too large, the iron core becomes strongly magnetised and it attracts the iron rocker, pulling it down
- this opens the contacts and breaks the circuit.
- it can be reset by flicking a switch which pushes down the springy piece of metal and closes the contacts.

- Circuit breakers do not have to be replaced, 'blown' fuses do.

4.5 (a) Electromagnetic Induction

4.5 (a) Electromagnetic induction **Core**	**Supplement**
• Describe an experiment that shows that a changing magnetic field can induce an e.m.f. in a circuit	• State the factors affecting the magnitude of an induced e.m.f. • Show understanding that the direction of an induced e.m.f. opposes the change causing it



- When the N pole of the bar magnet is moved into the coil of copper wire, the needle on the sensitive voltmeter momentarily shifts to the right.
- When the N pole is moved out of the coil, the needle briefly moves to the left.

The movement of the magnetic field lines induces an e.m.f across the coil. As the magnet moves into the coil, the coil cuts the magnetic field lines.

To increase the induced e.m.f:
- Move the magnet faster
- Put more turns on the coil
- Use a stronger magnet

Lenz's law

the direction of an induced current opposes the change producing it.

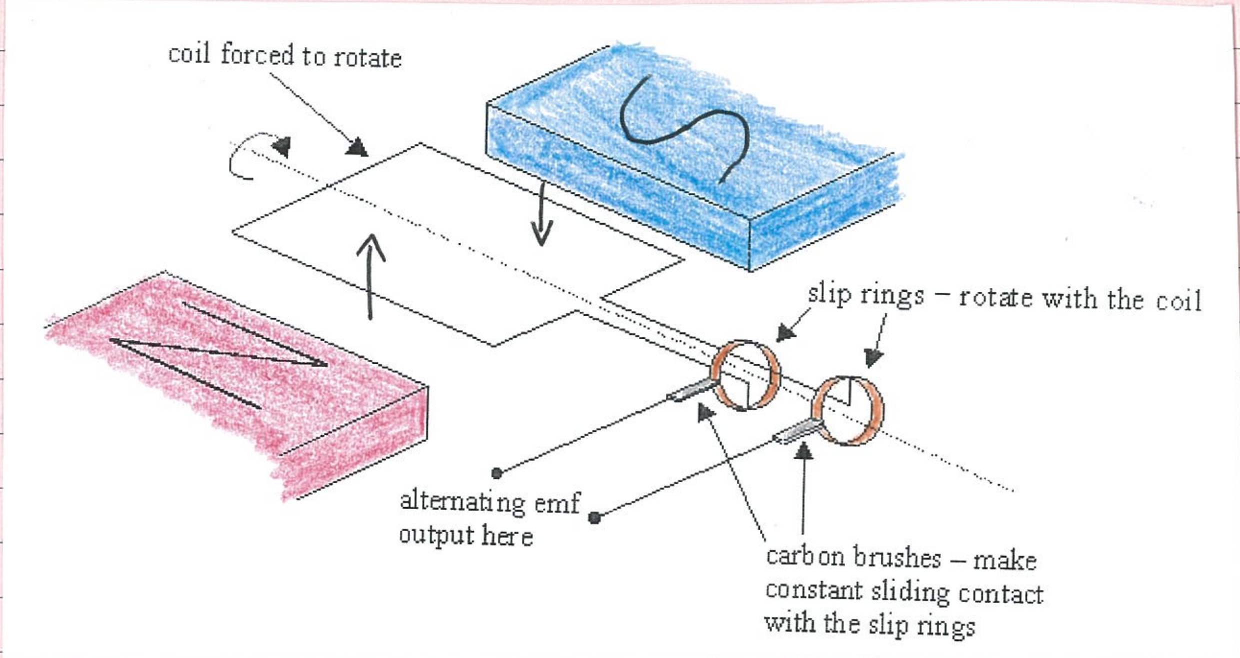
- when moving the N pole in, the direction of the induced current is such that it produces an 'N' pole, repelling the bar magnet
- when moving the N pole out, the coil produces an 'S' pole to attract the magnet.

4.5(b) a.c Generator

4.5 (b) a.c. generator

Core

- Describe a rotating-coil generator and the use of slip rings
- Sketch a graph of voltage output against time for a simple a.c. generator



1. As the coil spins, one side cuts up through the magnetic field lines inducing an e.m.f, causing a current to flow,
2. When the coil reaches the vertical position, the side that was cutting up through the field lines now cuts down - induced e.m.f will change direction, and therefore current will change direction.

This produces an alternating current.

→

4.5(c) Transformer

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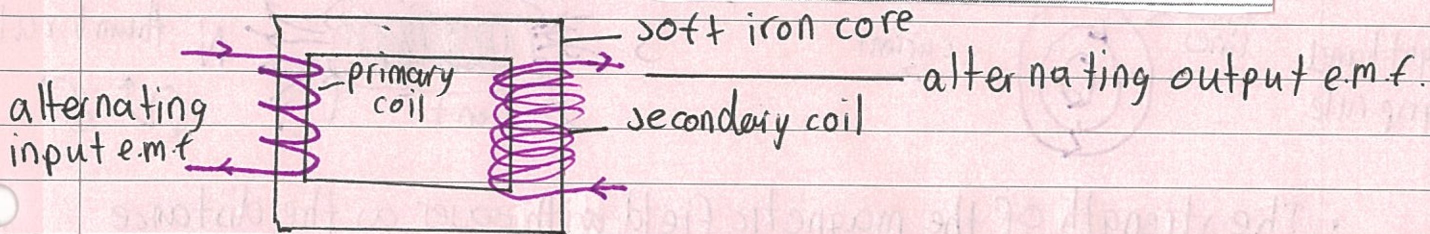
4.5 (c) Transformer	
Core	**Supplement**
• Describe the construction of a basic iron-cored transformer as used for voltage transformations	• Describe the principle of operation of a transformer
• Recall and use the equation $(V_p/V_s) = (N_p/N_s)$	• Recall and use the equation $V_p I_p = V_s I_s$ (for 100% efficiency)
• Describe the use of the transformer in high-voltage transmission of electricity	
• Give the advantages of high-voltage transmission	• Explain why energy losses in cables are lower when the voltage is high



- The alternating input voltage produces an alternating current in the primary coil, causing a constantly changing magnetic field in the core
- The changing magnetic field induces an alternating e.m.f in the secondary coil.

- In a step-down transformer, there are more turns on the primary coil. so output voltage is less than input.
- In a step-up transformer, there are more turns on the secondary coil, so output voltage is greater than input.

$$\frac{\text{voltage across secondary coil}}{\text{voltage across primary coil}} = \frac{\text{number of turns in } 2^{nd}}{\text{number of turns in } 1^{st}} \qquad \frac{V_s}{V_p} = \frac{N_s}{N_p}$$

- If the transformer is 100% efficient, input power = output power.

$$V_p I_p = V_s I_s$$

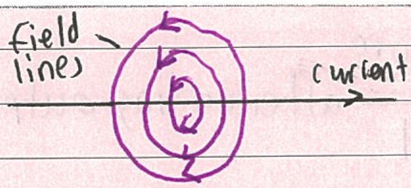
- Transformers are often used to step-up voltages from power stations onto power lines that transmit the electricity.
  - ↑voltage ↓current
  - Transferring energy at low current (and ∴ high voltage) reduces energy lost as heat from power lines - more efficient.

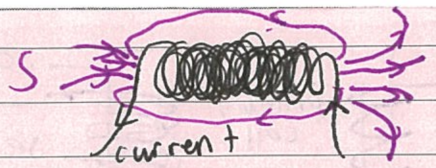
4.5(d) The Magnetic Effect of a Current

4.5 (d) The magnetic effect of a current

Core	Supplement
• Describe the pattern of the magnetic field due to currents in straight wires and in solenoids • Describe applications of the magnetic effect of current, including the action of a relay	• State the qualitative variation of the strength of the magnetic field over salient parts of the pattern • Describe the effect on the magnetic field of changing the magnitude and direction of the current

right hand grip rule





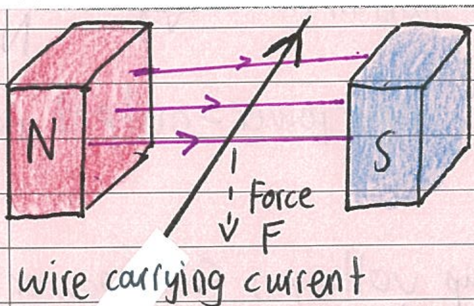
thumb rule

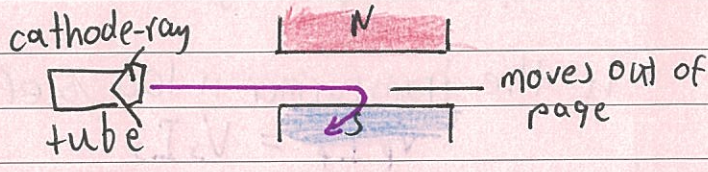
- The strength of the magnetic field decreases as the distance from the wire / solenoid increases.
- ↑current ↑strength of magnetic field.
- reversing the current reverses the magnetic field.

4.5(e) Force on a Current-carrying Conductor

4.5 (e) Force on a current-carrying conductor

Core	Supplement
• Describe an experiment to show that a force acts on a current-carrying conductor in a magnetic field, including the effect of reversing: (i) the current (ii) the direction of the field	• Describe an experiment to show the corresponding force on beams of charged particles • State and use the relative directions of force, field and current





- A current-carrying wire or beam of charged particles has a magnetic field.
- When placed in another magnetic field the two fields interact and there will be a force on the wire.
- If either the current or the magnetic field is reversed, the direction of the force is reversed.
- The direction of F is given by Fleming's Left hand Rule.

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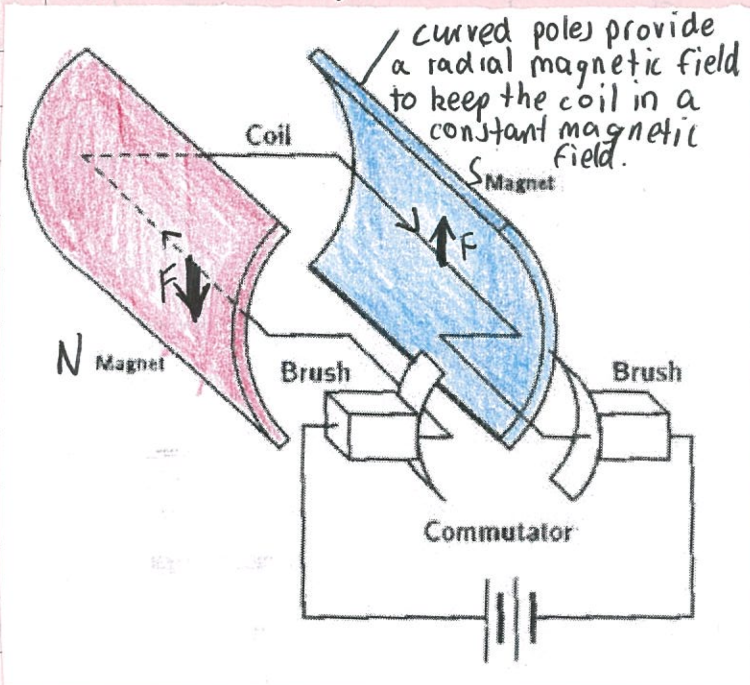
4.5(f) d.c Motor

4.5 (f) d.c. motor **Core**	**Supplement**
• State that a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing the number of turns on the coil • Relate this turning effect to the action of an electric motor	• Describe the effect of increasing the current

A current-carrying coil in a magnetic field experiences a turning effect which can be increased by increasing the number of turns on the coil.



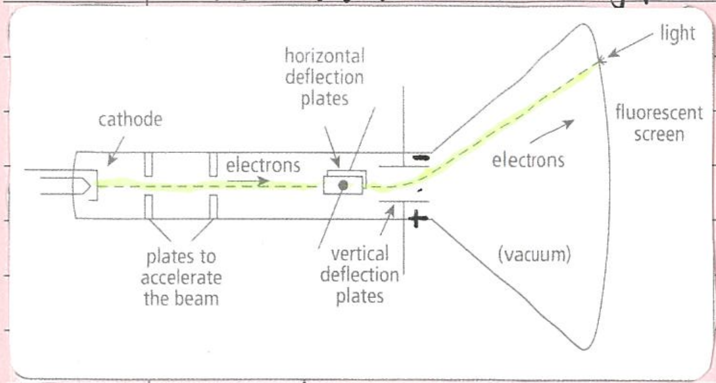
- Since the coil is in a magnetic field and carries current, there is a force on each side of the coil.
- the commutator turns with the coil. Every time the coil reaches a vertical position, the two sides of the commutator swap brushes and the flow of current is reversed. This means the direction of the force is reversed, so the coil keeps spinning in the same direction.

The speed at which the coil spins can be increased by:
- increasing the number of turns on the coil
- increasing the current
- increasing the strength of the magnetic field.

4.6(a) Cathode rays

4.6 (a) Cathode rays **Core**	
• Describe the production and detection of cathode rays • Describe their deflection in electric fields • State that the particles emitted in thermionic emission are electrons	

- Cathode rays are simply beams of electrons. They can be produced and detected with cathode-ray tubes



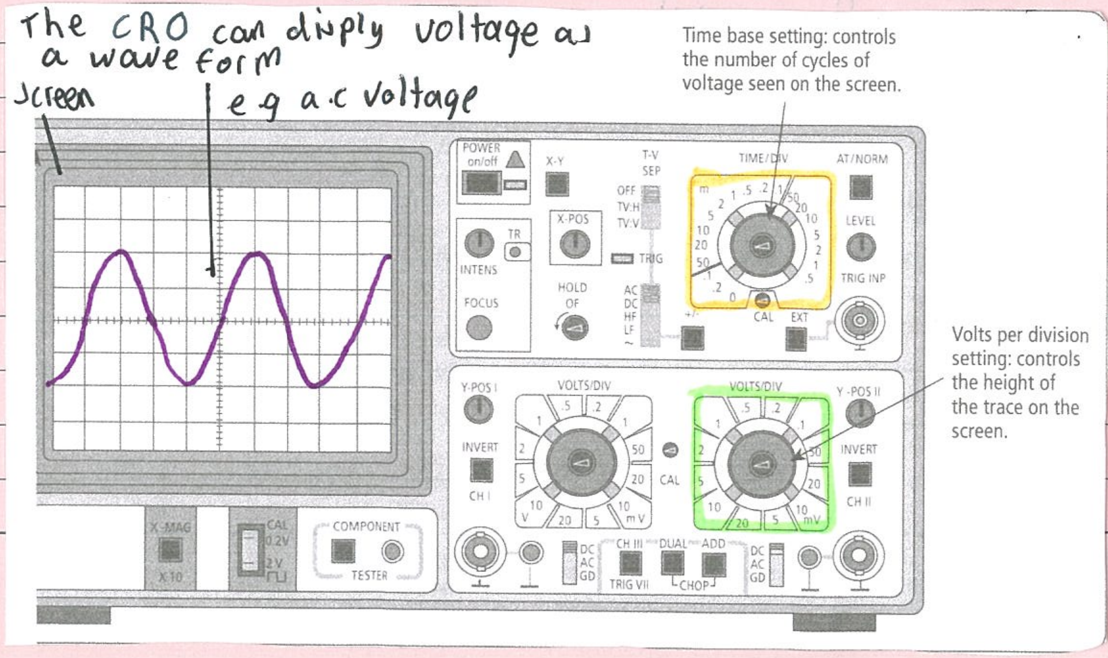
- The cathode produces electron when heated by thermionic emission.
- The electrons are accelerated by a p.d away from the -ve cathode
- The electrons can be deflected by the plates to change their direction.

- When the electrons hit the fluorescent screen, their K.E changes to light energy and a bright spot appears.

4.6(b) Simple treatment of Cathode-ray Oscilloscopes

4.6 (b) Simple treatment of cathode-ray oscilloscope	
	Supplement • Describe (in outline) the basic structure and action of a cathode-ray oscilloscope (detailed circuits are **not** required) • Use and describe the use of a cathode-ray oscilloscope to display waveforms

- A CRO can be used as a high resistance voltmeter, showing how PD varies with time on the screen.
- The Y-gain (volts/div) controls the Y scale (i.e number of volts per square)
- The time base setting controls the X scale (e.g 10ms per square)



5. Atomic Physics

No. 0625
Date RM

5.1(a) Detection of radioactivity

5.1 (a) Detection of radioactivity	
Core • Show awareness of the existence of background radiation • Describe the detection of α-particles, β-particles and γ-rays (β^+ are not included: β-particles will be taken to refer to β^-)	

Background radiation – radiation already around us from our surroundings, e.g: cosmic rays, radioactive minerals, nuclear power

• Photographic film:	alpha	beta	gamma
• Cloud chamber:	alpha	beta	gamma
• Spark counter:	alpha		
• Gold-leaf electroscope:	alpha		
• Geiger-muller (GM) tube:	alpha	beta	gamma

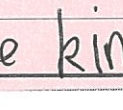
5.1(b) Characteristics of the three kinds of emission

5.1 (b) Characteristics of the three kinds of emission	
Core • State that radioactive emissions occur randomly over space and time	
• State, for radioactive emissions: – their nature – their relative ionising effects – their relative penetrating abilities	• Describe their deflection in electric fields and magnetic fields • Interpret their relative ionising effects

Radioactive emissions occur randomly over space and time.

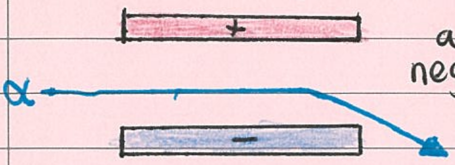
α Alpha particles

- Similar to helium-4 (^4_2He)
- Travels at 10% speed of light
- Very weak penetration power
  - stopped by paper, skin, 6cm of air

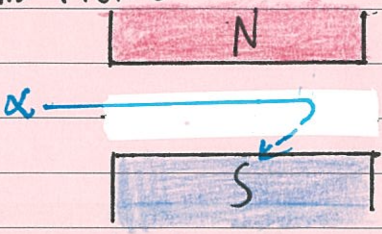


– mass of 4
– charge of 2+
2 protons, 2 neutrons

- Strongly ionising because it can knock electrons out of atoms. Dangerous when inside body because it can cause exotic reactions to occur with living cells and can cause mutations
- Deflected by electric and magnetic fields



attracted to negative plate



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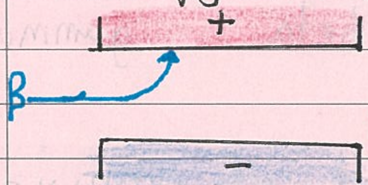
β **Beta particles**

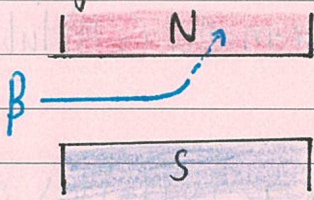
n → p + e⁻ (+ $\bar{\nu}$)

- High energy nuclear electrons formed when neutron transmutes to proton.
- Travels at 50% speed of light
- Medium penetration - absorbed by 3mm aluminium
- Weakly ionising - but dangerous because it is a free radical
- Strongly deflected by electric and magnetic fields (> α)

⊖ - charge of −1
- mass of 1/1836 ≈ 0



strongly attracted to positive plate



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γ **Gamma rays**

- High frequency high energy electromagnetic waves
- Travel at speed of light
- Very strong penetration - reduced by lead
- Very weak ionisation, but very dangerous - damages cells and can cause mutations
- Not deflected by electric/magnetic fields.

- charge = 0
- mass = 0

5.1(b) Radioactive Decay

5.1 (c) Radioactive decay **Core** • State the meaning of radioactive decay, using equations (involving words or symbols) to represent changes in the composition of the nucleus when particles are emitted	

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Radioactive decay is the breakdown of unstable nuclei. Although it is a random process there is a constant probability.

α - decay: heavy nucleus spontaneously emits alpha particle

e.g $^{222}_{88}Ra \longrightarrow {}^{218}_{86}Rn + {}^{4}_{2}He$ — alpha particle

$^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$

β -decay: neutron spontaneously turns into proton and electron (emitted)

e.g $^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e^{-}$ —beta particle

$^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e^{-}$

γ -decay: emitted after other decay to take away energy → ground state

e.g $^{99}_{43}Tc \longrightarrow {}^{99}_{43}Tc + {}^{0}_{0}\gamma$

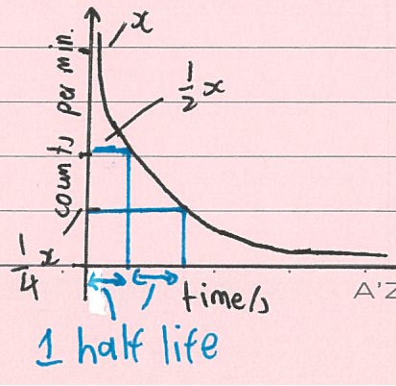
$^{A}_{Z}X \longrightarrow {}^{A}_{Z}X + {}^{0}_{0}\gamma$

5.1(d) Half life

5.1 (d) Half-life	
Core	
• Use the term half-life in simple calculations, which might involve information in tables or decay curves	

The activity (number of radioactive particles emmitted per second) of a radioactive substance decreases over time but never reaches 0.

The half life of a radioisotope is:
- time taken for $\frac{1}{2}$ the nuclei to decay
- time taken for the activity to halve



5.1(e) Safety Precautions

5.1 (e) Safety precautions **Core** • Describe how radioactive materials are handled, used and stored in a safe way	

- Limit exposure to radiation, and maintain distance
- Use lead as a barrier and store radioisotopes in lead-lined containers
- Radiation workers wear film badges to monitor dose of radiation received to ensure that it does not exceed safe levels.

5.2(a) Atomic model

5.2 (a) Atomic model **Core** • Describe the structure of an atom in terms of a nucleus and electrons	**Supplement** • Describe how the scattering of α-particles by thin metal foils provides evidence for the nuclear atom

- Atoms consist of negative electrons orbiting the positive nucleus which consists of nucleons - protons (+) and neutrons (-)
- Nucleus discovered early in 20th century when Rutherford fired alpha particles at gold foil.
  - Most of the α-particles went through, showing that the atom was mainly empty space
  - Some were deflected by small angles, showing that there was a positive charge in the atom repelling the α-particle
  - A few were deflected back to the source, showing that the mass and the positive charge were concentrated at the centre

5.2(b) Nucleus

5.2 (b) Nucleus **Core** • Describe the composition of the nucleus in terms of protons and neutrons • Use the term proton number Z • Use the term nucleon number A Use the term nuclide and use the nuclide notation ${}^{A}_{Z}X$	

$^{A}_{Z}X$ A = nucleon number (protons + neutrons)
Z = proton number

A nuclide is an atom specified by its proton number & nucleon number

5.2(c) Isotopes

5.2 (c) Isotopes	
	Supplement • Use the term isotope • Give and explain examples of practical applications of isotopes

An isotope is another form of the element with the same number of protons in the nucleus but different numbers of neutrons.

Uses of radioisotopes

- Radiotherapy - Cobalt-60 which emits γ-rays is used. A beam of gamma rays is focused onto tumour, which destroys the cells
- Monitoring thickness - paper mills use β-emitting source, placed on one side of paper with detector at the other side. If the paper gets thicker the count rate decreases, sending a signal to rollers.
- Medical tracers - γ emitting isotope e.g technetium-99 with 6-hour half-life injected into patient. 'Gamma cameras' are then used to find hotspots
- Fuel - nuclear fission of uranium-235, releases neutrons for chain reaction
- Leak detection - γ-emitter with short half-life put into water supply. If there is leak, GM tube will have a high reading.