Year 12 transition work: Physics Practice Booklet

This document reviews the content that is unique to the Physics GCSE to help you prepare for starting the A Level Physics course.

To do:

1. Read through each section and make your own study notes

2. Attempt the practice questions at the end of each section

3. When you have worked through all sections of this practice booklet, attempt the exam booklet under exam conditions

Practice booklet contents:

Student name: ____

Section one

AQA GCSE Physics topic: P2

Triple-only content: Static Electricity

STATIC ELECTRICITY is about charges which are static, i.e. not moving.

- Either they are on the surface of an insulator
- Or they are on a conductor which isn't connected to anything

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. Static charge can be transferred from one object to another. Therefore, static charge can be transferred from one object to another.

- The material that gains electrons becomes negatively charged.
- The material that loses electrons is left with an equal positive charge.

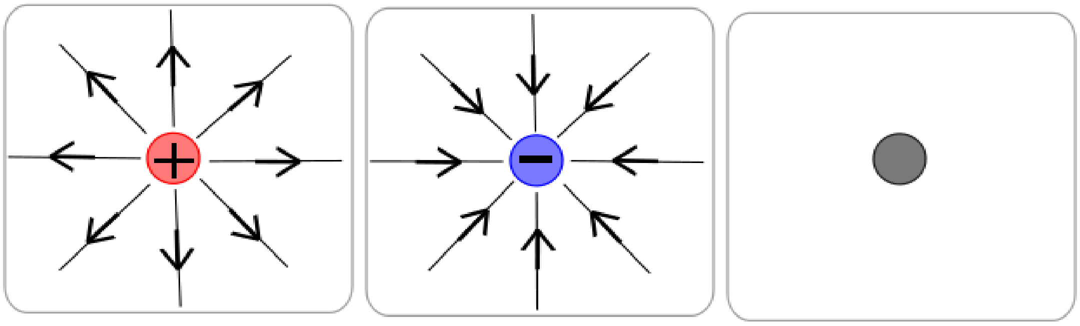
When two electrically charged objects are brought close together, they exert a force on each other. Two objects that carry the same type of charge repel. Two objects that carry different types of charge attract. Attraction and repulsion between two charged objects are examples of non-contact force.

Explanation Video: https://www.youtube.com/watch?v=St_KzxJqUGA

Triple-only content: Electric Fields

A charged object creates an electric field around itself. An **electric field** is the area around a charged object in which another charged object will experience a force. The force gets stronger as the distance between the objects decreases.

Lines of force can be drawn to represent electric fields. The electric field is strongest close to the charged object.



Field around a positive charge (e.g. a proton) | Field around a negative charge (e.g. an electron) | No field around a neutral particle (e.g. a neutron)

Points to note:

- The arrows point in the direction a **positive** charge would move.
- The arrows go **out** from a positive charge. The arrows go **into** a negative charge
- The closer the lines, the stronger the electrostatic force, therefore stronger closer to the charge

When there is a build-up of static charge and the field becomes strong enough, charges can be forced though insulators such as air and a spark will occur. This is what happens during a lightning strike or when a charged person touches a conductor. For example, a person dragging their feet across the carpet may become charged, so if they reach out to touch a door handle there is a spark, and they feel a small shock.

Practice activities:

Follow this link to open the PhET sim John Travoltage:

https://phet.colorado.edu/sims/html/john-travoltage/latest/john-travoltage_en.html

You can move John's foot and hand by clicking and dragging. *Can you explain what you see?*

Follow this link to explore balloons and static electricity:

https://phet.colorado.edu/sims/html/balloons-and-static-electricity/latest/balloons-and-static-electricity_en.html

Is the simulation entirely realistic?

Follow this link to see how static electricity can be useful:

Rolling can https://www.physicsclassroom.com/Physics-Interactives/Static-Electricity/Aluminum-Can-Polarization/Aluminum-Can-Polarization-Interactive

This simulation lets you see how field lines can change:

Electric field lines https://www.physicsclassroom.com/Physics-Interactives/Static-Electricity/Electric-Field-Lines/Electric-Field-Lines-Interactive

Exam practice link: question one

Section two

AQA GCSE Physics topic: P3

Triple-only content: Pressure in Gases

When a particle hits a surface, it exerts a force on that surface. Continued collisions between gas particles and the walls of their container create gas pressure. A gas can be compressed or expanded by pressure changes. The pressure produces a net force at right angles to the wall of the gas container (or any surface).

Watch this video which demonstrates gas pressure using marshmallows:

https://www.youtube.com/watch?v=GEfOC2zNKSY

Practice Activities:

Follow the link to the simulation and use it to help you answer the following questions:
https://phet.colorado.edu/sims/html/gas-properties/latest/gas-properties_en.html

1. When does the 'pressure' dial first give a reading?
2. What do you think is the cause of gas pressure?
3. Play around with the simulation. How can you get the pressure to go up or down?
4. Does this make sense – try to explain it.

Gas pressure changes with temperature, with volume and with the number of particles.

If the temperature increases, the pressure also increases. This is because the particles have more kinetic energy so are moving faster and therefore have more frequent collisions per second with the walls of the container. This increases the force on the walls and therefore the pressure.

If the volume increases, the pressure decreases (if number of particles are kept the same). This is because there are now larger distances for particles to travel before colliding with the walls leading to less frequent collisions per second and therefore reducing the force exerted on the walls and decreasing the pressure.

If the number of particles increase the pressure increases are there are more frequent collisions with the walls of the container leading to a larger exerted force and therefore larger pressure.

We can use the following equation to calculate the changes in pressure:

This equation only applies for a fixed mass of gas held at a constant temperature

$$\textit{pressure} \times \textit{volume} = \textit{constant}$$

where pressure is in pascals, Pa and volume, is in metres cubed, m^3

Work is the transfer of energy by a force. Doing work on a gas increases the internal energy of the gas and can cause an increase in the temperature of the gas. Pumping air into a bicycle tyre does work on the gas and therefore causes and increase in the temperature of the gas.

Exam practice link: question two

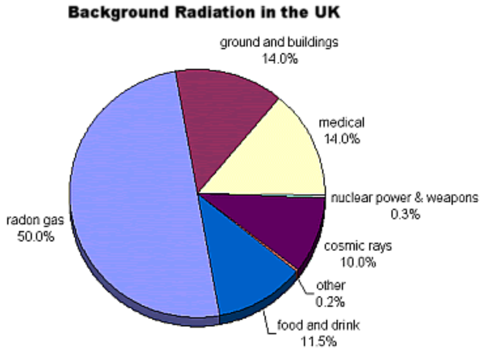
Section three

AQA GCSE Physics topic: P4

Triple-only content: Background Radiation

Background radiation is around us all of the time. It comes from:

- natural sources such as rocks and cosmic rays from space
- man-made sources such as the fallout from nuclear weapons testing and nuclear accidents.



The level of background radiation and radiation dose may be affected by occupation and/or location.

If taking an activity reading from a sample, part of that reading would be due to background radiation. To account for background radiation, take a number of readings without the sample, calculate a mean value and remove this value from all readings taken from the sample.

Triple-only content: Uses of Radiation

Nuclear radiations are used in medicine for the:

- exploration of internal organs
- control or destruction of unwanted tissue.

As nuclear radiation is ionising it can be dangerous. It is therefore important to evaluate the perceived risks.

Explanation Video: https://www.youtube.com/watch?v=gDrR_dVmqZk

Exam practice link: question three and four

Section four

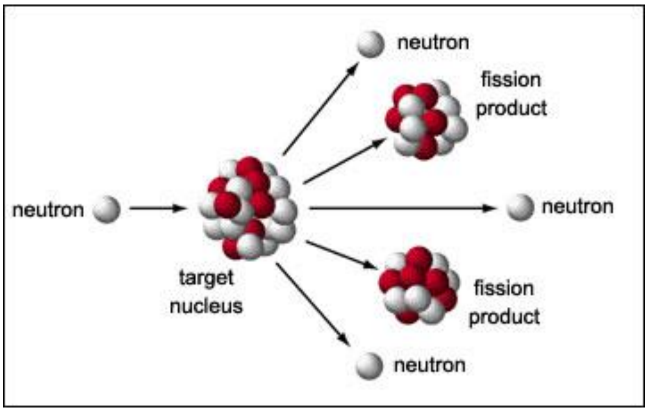
AQA GCSE Physics topic: P4

Triple-only content: Nuclear Fission

Nuclear fission is the splitting of a large and unstable nucleus (eg uranium or plutonium). A lot of energy is released by the fission reaction as there is a mass deficit between reactants and products. Spontaneous fission is rare. Usually, for fission to occur the unstable nucleus must first absorb a neutron.

The process:

1. Slow moving neutron absorbed by target nucleus
2. Unstable nucleus splits (fission) into two smaller daughter nuclei that are roughly equal in size
3. Gamma rays and extra neutrons are emitted, so a chain reaction may be set up.



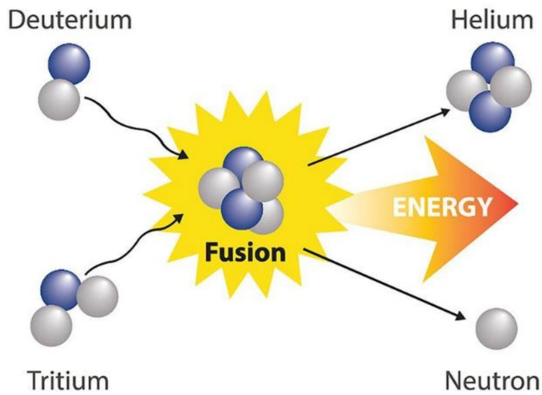
All of the fission products have kinetic energy. The chain reaction is controlled in a nuclear reactor to control the energy released. The explosion caused by a nuclear weapon is caused by an uncontrolled chain reaction.

Fission Explanation Video: https://www.youtube.com/watch?v=ZKHpix5dgAU

Triple-only content: Nuclear Fusion

Nuclear fusion is the joining of two light nuclei to form a heavier nucleus. In this process some of the mass may be converted into the energy of radiation. This is the process that powers stars including our Sun.

In both Fission and Fusion reactions there is a mass deficit between the reactants and the products. The mass deficit determines the amount of energy released. This can be calculated using Einstein's Equation: $E = mc^2$



Watch this video – what do you think? Should we invest in fusion research?
https://www.youtube.com/watch?v=mZsaaturR6E

Exam practice link: question four

Section five

AQA GCSE Physics topic: P5

Triple-only content: Moments, Levers and Gears

The **'moment'** of a force is the turning effect of a force. Moments can be clockwise or anti-clockwise. If an object is balanced, the total clockwise moment about a pivot equals the total anticlockwise moment about that pivot.

Moment (Nm) = Force (N) x Distance (perpendicular from pivot) (m)

Caution: This equation looks very similar to work done but the distance in this case is the perpendicular distance from the pivot and is not in the same direction as the force.

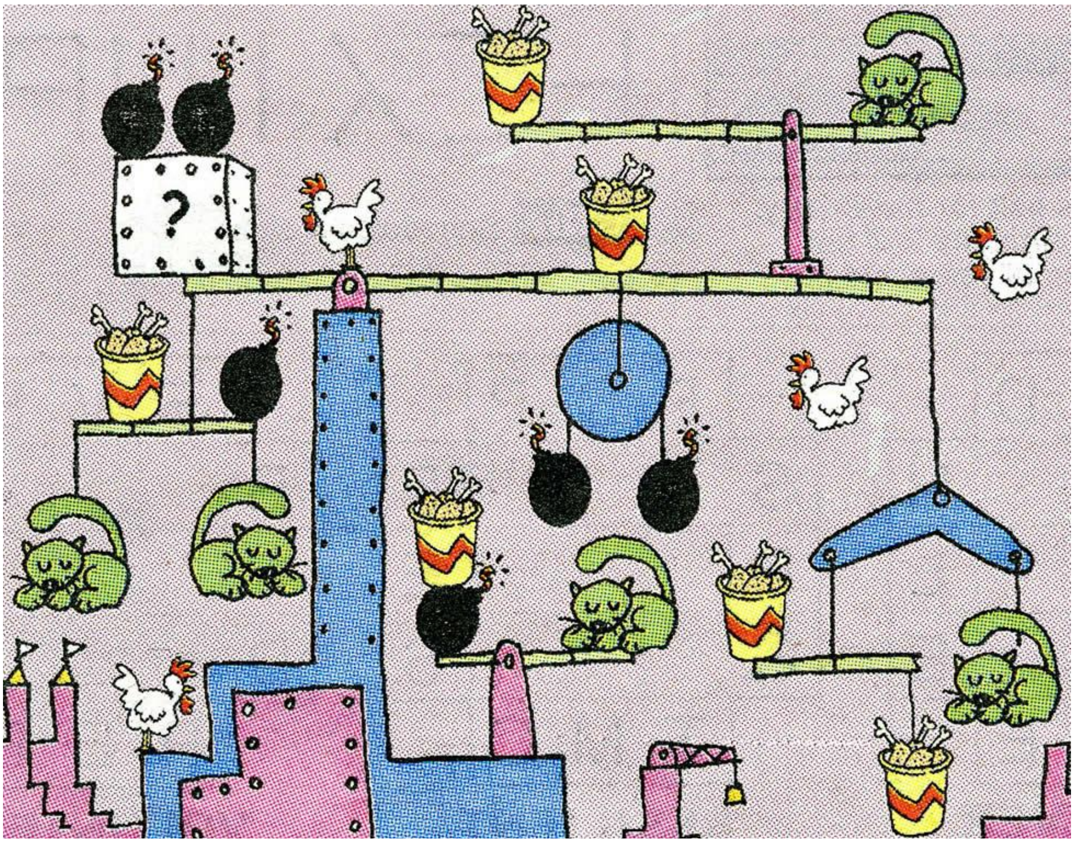
Use this link to explore moments, answer the following questions:

https://phet.colorado.edu/sims/html/balancing-act/latest/balancing-act_all.html

1. Use the 'Intro' tab to help you understand the simulation.
2. Use the 'Balance lab' to calculate the masses of each of the mystery boxes A, B, C, D, E, F, G and H.
3. Use the 'Game' tab to practice some calculations.

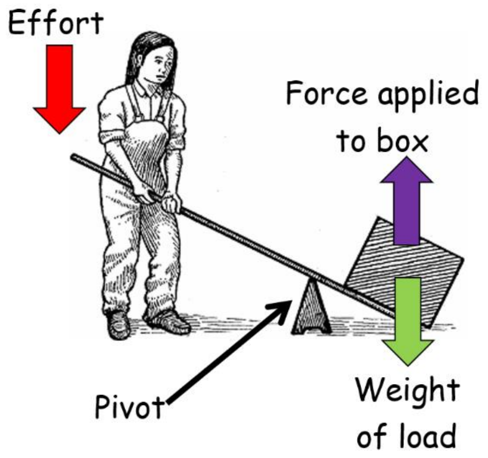
Challenge Question:

How many cats are in the box? My answer is at the end of the doc. Do you agree?



A simple lever be used to transmit the rotational effects of forces:

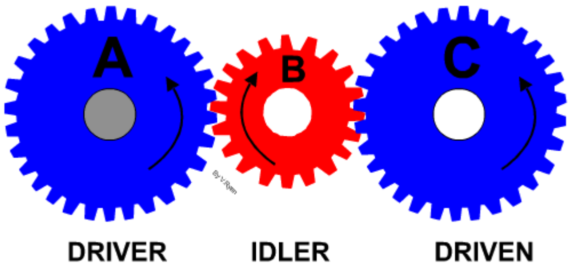
- The turning effect of the **downward** force of the effort will create a **turning effect** at the other end of the lever.
- These **moments** either side of the pivot will be **equal.**
- Since the load is closer to the pivot the **upward** force on the load will be **greater** than the **downward** effort.
- The load can be moved when the upward force from the lever is just greater than the weight of the load.



Gears can also be used to transmit the turning effect of a force from one place to another.

- The **linear** speed must be the same where the gears meet.
- But the outside of the bigger gear has further to go.
- So the bigger gear **rotates** more slowly.

The direction of rotation switches with each gear in the train.



The **forces** on each gear must be the same where the gears meet (Newton's 3rd law!). But the outside of the bigger gear is further from the axle. So there is a **bigger** moment causing rotation around gear B's axle

Exam practice link: question five

Section six

AQA GCSE Physics topic: P5

Triple-only content: Pressure in Fluids and Atmospheric Pressure

A fluid can be either a liquid or a gas. The pressure in fluids causes a force normal (at right angles) to any surface.

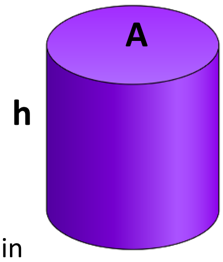
The pressure at the surface of a fluid can be calculated using the equation:

$$Pressure = \frac{Force\ normal\ to\ a\ surface}{Area\ of\ that\ surface}$$

Where pressure, p, in pascals, Pa force, F, in newtons, N area, A, in metres squared, m^2

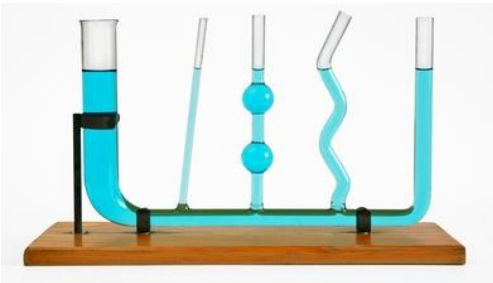
The pressure due to a column of liquid can be calculated using the equation:

$$pressure\ = height\ of\ the\ column\ \times\ density\ of\ the\ liquid\ \times\ gravitational\ field\ strength$$



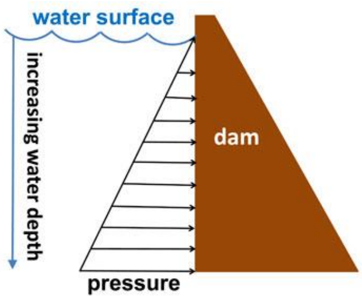
[p = h ρ g] Where pressure, p, in pascals, Pa; height of the column, h, in metres, m; density, ρ, in kilograms per metre cubed, kg/m^3; gravitational field strength, g, in newtons per kilogram, N/kg.

For a particular liquid in a particular place density and *g* are constant. Therefore, pressure in a particular liquid depends ONLY on the depth. The shape of the liquid above DOES NOT affect the pressure <u>in</u> the <u>liquid</u>.



The water moves until the pressure at a **given depth** is the **same** throughout the apparatus. So each branch fills to the **same height**.

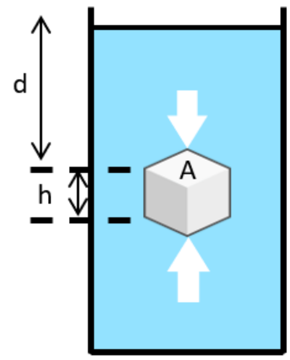
The greater the depth of the water the greater the pressure of water against the dam wall – this greater pressure requires a thicker structure to safely hold the water back.



Triple-only content: Changes in Pressure

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.

Resultant force on object from water pressure:
$F = p \times A\ = \rho \times g \times h \times A$ = **UPTHRUST**

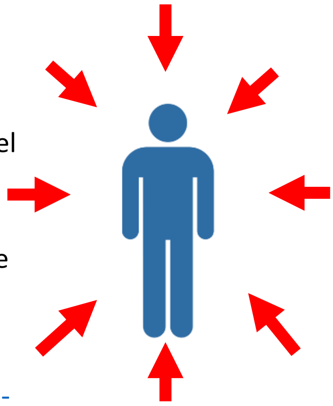


- h x A is simply the volume of the object and ρ is the density of water
- Therefore ρ x h x A is the <u>*mass*</u> of water displaced

UPTHRUST = <u>*weight*</u> of water displaced (mass x g)

To decide if an object will float or sink, compare the <u>object's</u> **weight** to the **upthrust**. For **solid** objects this is easily done by comparing the **density** of the object and the liquid. If the density of object is greater than the fluid the object will sink.

Triple-only content: Atmospheric Pressure



The **atmosphere** is a thin layer of air that surrounds the earth. Air molecules colliding with a surface create atmospheric pressure. The number of air molecules (and so the weight of air) above a surface decreases as the height of the surface above ground level increases. Therefore, the **pressure** of the atmosphere changes with height. The atmosphere gets less dense with increasing altitude. So as height increases there is always less air above a surface than there is at a lower height. So atmospheric pressure decreases with an increase in height.

Breathing at high altitude video:
https://www.pbslearningmedia.org/resource/ess05.sci.ess.watcyc.nooxygen/trying-to-breathe-on-mount-everest/

Exam practice link: question six

Section seven

AQA GCSE Physics topic: P5

Triple-only content: Changes in Momentum

When a force acts on an object that is moving, or able to move, a change in momentum occurs.

Combining the equations: $F = m \times a$ and $a = \frac{v-u}{t}$ to give $F = \frac{m\Delta v}{\Delta t}$ where $m\Delta v$ is the change in momentum shows that the resultant force is equal to the rate of change of momentum.

Safety features such as air bags and seat belts in vehicles, gymnasium crash mats, cycle helmets and cushioned surfaces for playgrounds are all used to increase the time over which the change in velocity happens therefore decreasing the force on the person and reducing the risk of injury.

Explanation Video: https://www.youtube.com/watch?v=ZU6rJQTz7FI

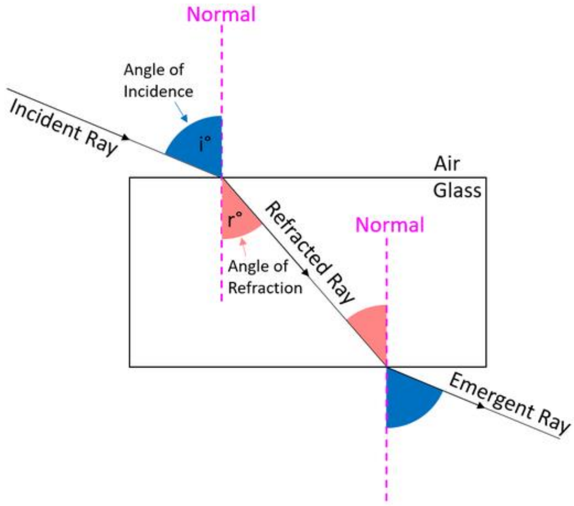
Rockets and Jetpacks video: https://www.youtube.com/watch?v=Hx9TwM4Pmhc

Exam practice link: question seven

Section eight

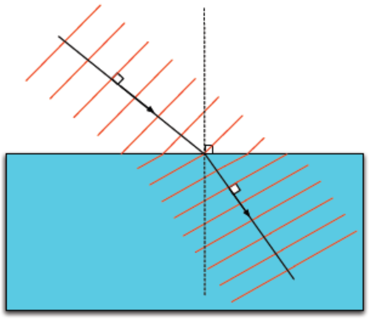
AQA GCSE Physics topic: P6

Triple-only content: Drawing Ray Diagrams



In Combined Scie at GCSE you will have learned about reflection and refraction of waves. In the separate Physics course students had to be able to draw ray diagrams and wave front diagrams to illustrate this behaviour.

The diagram on the right-hand side is a ray diagram showing the path of a refracted ray.



This representation of refraction is called a **wave-front diagram.**

The red lines indicate lines of constant phase (imagine them as the crests of a water wave out at sea).

We can see that the leading edge of the wave-front hits the boundary first, slows down, and so the wave changes direction.

Triple-only content: Sound Waves

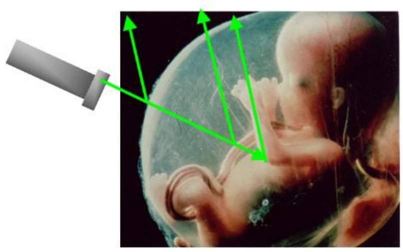
Sound waves can travel through solids causing vibrations in the solid. The volume of the sound depends on the amplitude of the wave. How high or low a note sounds is called the **pitch.** The **pitch** depends on the **frequency**. The more **frequent** the vibrations the **higher** the note. The **fewer** the vibrations the **lower** the note

Within the ear, sound waves cause the ear drum and other parts to vibrate which causes the sensation of sound. The conversion of sound waves to vibrations of solids works over a limited frequency range. This restricts the limits of human hearing. The range of normal human hearing is from 20 Hz to 20 kHz.

Triple-only content: Waves for detection and Exploration

Ultrasound:

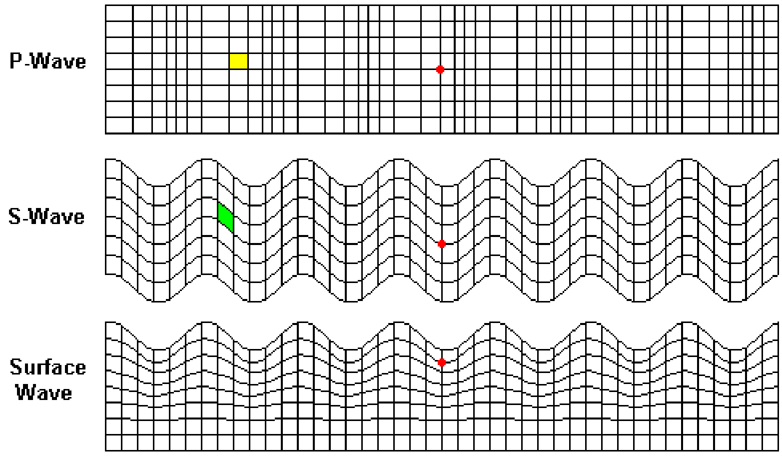
- Ultrasound waves have a frequency higher than the upper limit of hearing for humans.
- Ultrasound waves are **partially reflected** when they meet a boundary between two different media.
- The **time taken** for the reflections to reach a **detector** can be used to determine how far away such a boundary is.
- This allows ultrasound waves to be used for both medical and industrial **imaging**.

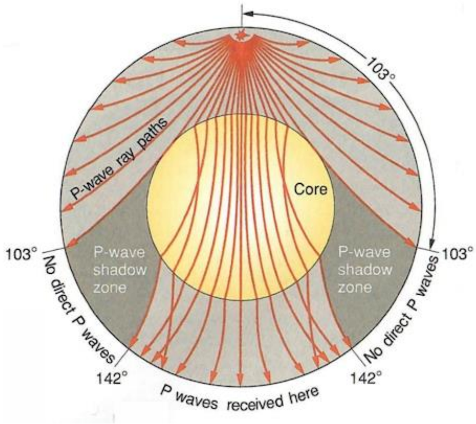


Seismic Waves

Seismic waves are produced by earthquakes. P-waves are longitudinal, seismic waves. P-waves travel at different speeds through solids and liquids. S-waves are transverse, seismic waves. S-waves cannot travel through a liquid.

Echo sounding, using high frequency sound waves is used to detect objects in deep water and measure water depth.





By comparing the differences in the waves, **seismograph stations** in different places around the world can compare P and S waves produced in earth quakes and can calculate the size of the earths core and that it is liquid. The study of seismic waves provided new evidence that led to discoveries about parts of the Earth which are not directly observable.

Practice Questions:

An earthquake occurs an unknown distance from seismic station D. The average speed of P waves is 10km/s and S waves 6km/s. The time taken by the P waves was 900s

1. Calculate the distance from the earthquake to the detector.
2. Calculate the time between the arrival of the P waves and the arrival of the S waves.

Exam practice link: question eight

Section nine

AQA GCSE Physics topic: P6

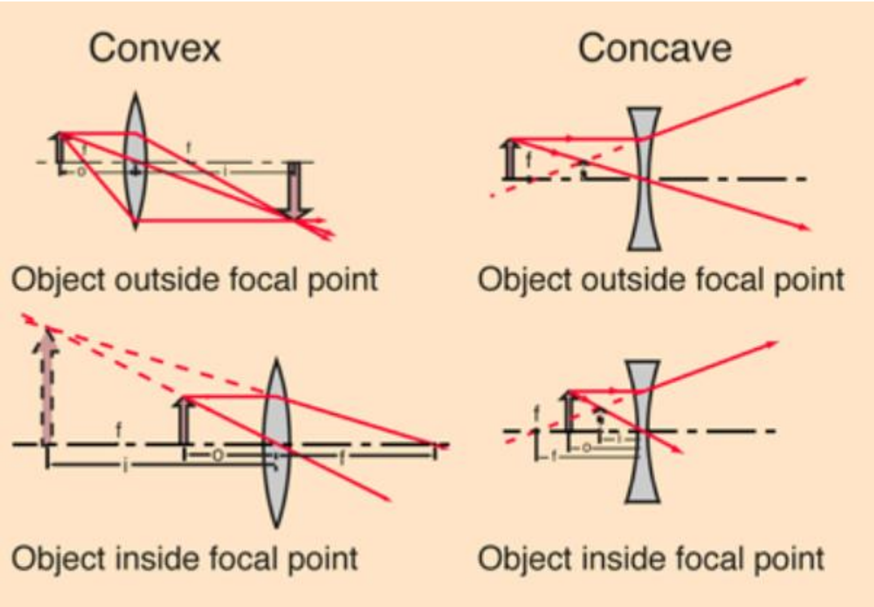
Triple-only content: Lenses

Ray diagrams are used to show the formation of images by convex and concave lenses.

In a convex lens, parallel rays of light are brought to a focus at the principal focus. The distance from the lens to the principal focus is called the focal length. The image produced by a convex lens can be either real or virtual.

In a concave lens, the image produced by a concave lens is always virtual. It appears on the same side of the lens as the object as the concave lens causes the rays to diverge.

Drawing ray diagrams for lenses:



The "three principal rays" which are used for visualizing the image location and size are:

1. A ray from the top of the object proceeding parallel to the centerline perpendicular to the lens. Beyond the lens, it will pass through the principal focal point. For a negative lens, it will proceed from the lens as if it emanated from the focal point on the near side of the lens.
2. A ray through the center of the lens, which will be undeflected. (Actually, it will be jogged downward on the near side of the lens and back up on the exit side of the lens, but the resulting slight offset is neglected for thin lenses.)
3. A ray through the principal focal point on the near side of the lens. It will proceed parallel to the centerline upon exit from the lens. The third ray is not really needed, since the first two locate the image.

Use this simulation to help you visualise each case: https://phet.colorado.edu/sims/html/geometric-optics/latest/geometric-optics_all.html

Practice drawing out each scenario. You should always use a ruler. Squared paper can also be useful.

The magnification produced by a lens can be calculated using the equation:

$$Magnification = \frac{image\ height}{object\ height}$$

Magnification is a ratio and so has no units. Image height and object height should both be measured in either mm or cm.

Exam practice link: question nine

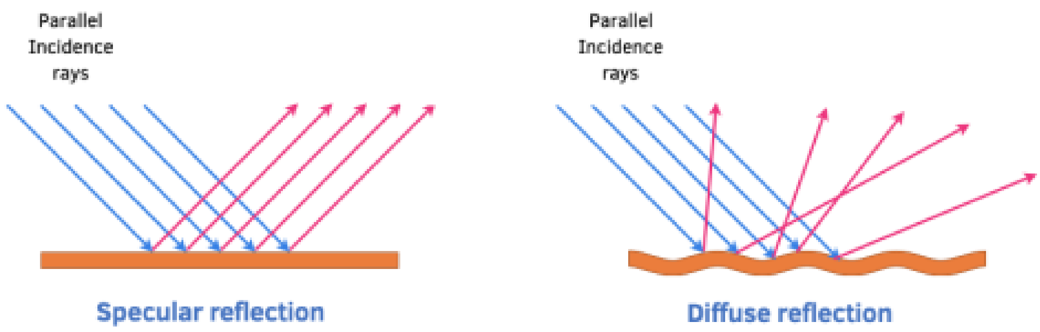
Section ten

AQA GCSE Physics topic: P6

Triple-only content: Visible Light and Blackbody Radiation

Each colour within the visible light spectrum has its own narrow band of wavelength and frequency.

- Reflection from a smooth surface in a single direction is called specular reflection.
- Reflection from a rough surface causes scattering: this is called diffuse reflection.



Objects that transmit light are either transparent or translucent.

Colour filters work by absorbing certain wavelengths (and colour) and transmitting other wavelengths (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.

Use this simulation to investigate the mixing of colours of light. This will give you very different results to the mixing of coloured paints.

https://phet.colorado.edu/sims/html/color-vision/latest/color-vision_all.html

Triple-only content: Blackbody Radiation

All bodies (objects), no matter what temperature, emit and absorb infrared radiation. The hotter the body, the more infrared radiation it radiates in a given time, therefore the intensity of the radiation of emission depends on the temperature of the body. Wavelength distribution also depends of the temperature of the body.

Use this simulation to see how the temperature of a body determines the spectrum of light it emits: https://phet.colorado.edu/sims/html/blackbody-spectrum/latest/blackbody-spectrum_all.html

A perfect black body is an object that absorbs all of the radiation incident on it and therefore does not reflect or transmit any radiation. Since a good absorber is also a good emitter, a perfect black body would be the best possible emitter. A body at constant temperature is absorbing radiation at the same rate as it is emitting radiation. The temperature of a body increases when the body absorbs radiation faster than it emits radiation.

Stars are considered to be perfect Blackbodies.

Exam practice link: question ten

Section eleven

AQA GCSE Physics topic: P7

Triple-only content: Induced Potential and the Generator Effect

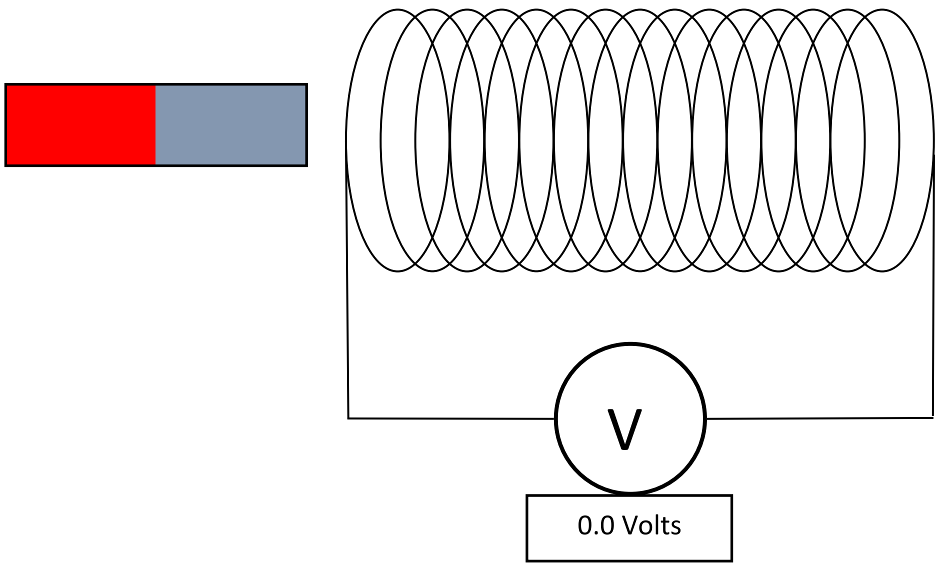
If an electrical conductor moves relative to a magnetic field or if there is a change in the magnetic field around a conductor, a potential difference is induced across the ends of the conductor. If the conductor is part of a complete circuit, a current is induced in the conductor. This is called the generator effect. An induced current generates a magnetic field that opposes the original change, either the movement of the conductor or the change in magnetic field.

Think of the magnetic field around a bar magnet. If one of these **field lines** moves through an area where we have an electrical **conductor** (perhaps a piece of wire) then we **induce** a **voltage** (strictly speaking this is called a **potential difference**). If the conductor is part of a complete circuit then this allows a **current** to flow.

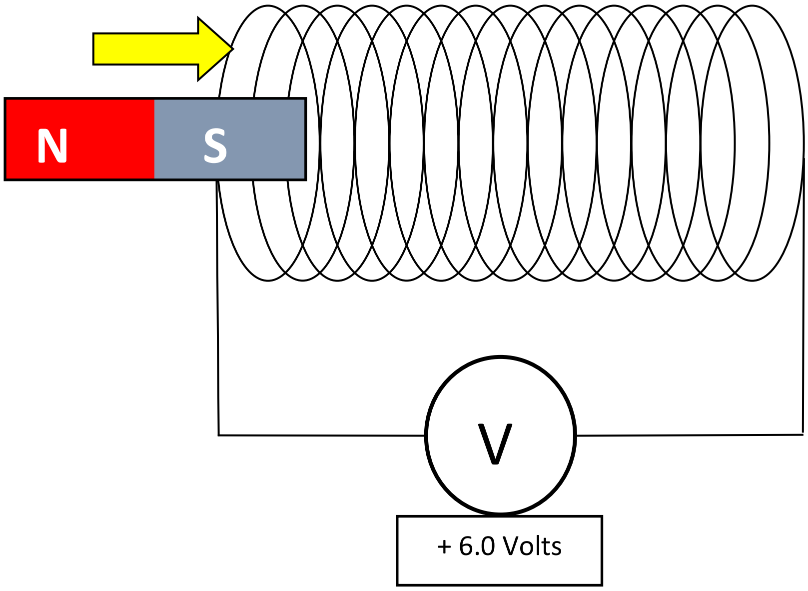
The reason for this is rather complicated! Charged particles, like electrons, experience a force due to a magnetic field which causes them to move – you will learn more about this effect at A level physics. You don't have to understand why just yet at GCSE.

We can say If an electrical conductor '**cuts**' through magnetic **field lines**, an electrical potential difference is **induced** across the ends of the conductor.

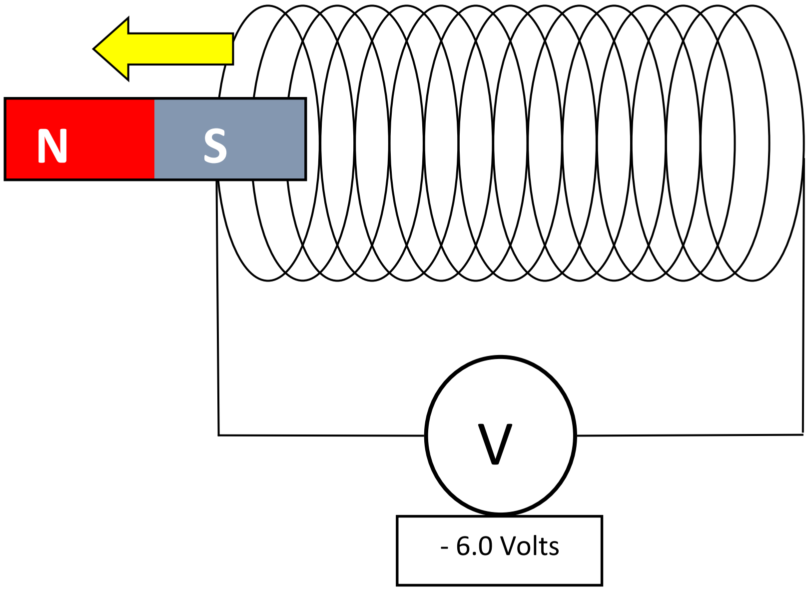
If we hold a magnet stationary outside a coil of wire, a voltmeter would register a reading of zero volts. This is because **no** field lines are being **cut**.



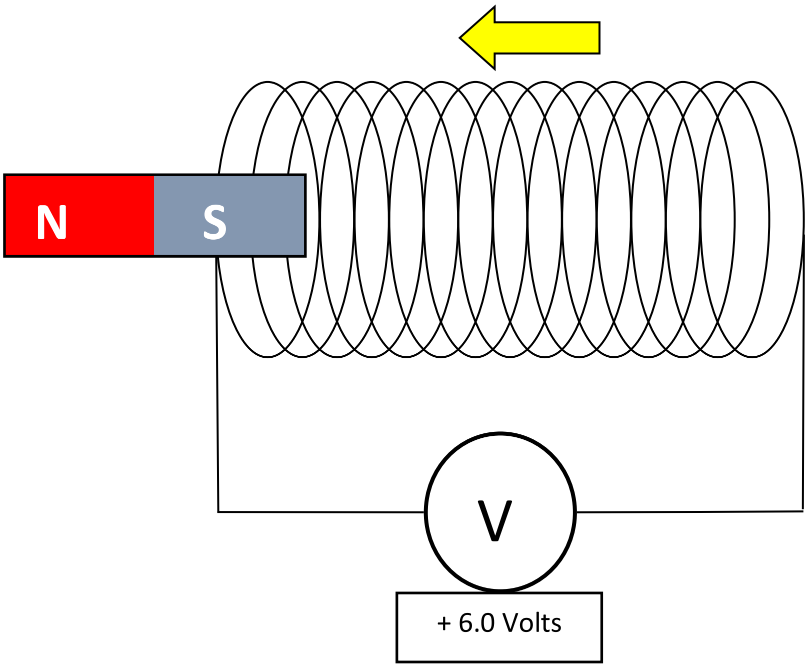
If we were to then **move** the **magnet** into the **coil of wire** at a steady speed we would **induce** a **voltage** (and also induce a current in a complete circuit). This voltage would register on the voltmeter – perhaps +6.0 volts. This is because the magnetic **field lines** are **moving across** the coils of wire. They are being '**cut**'.



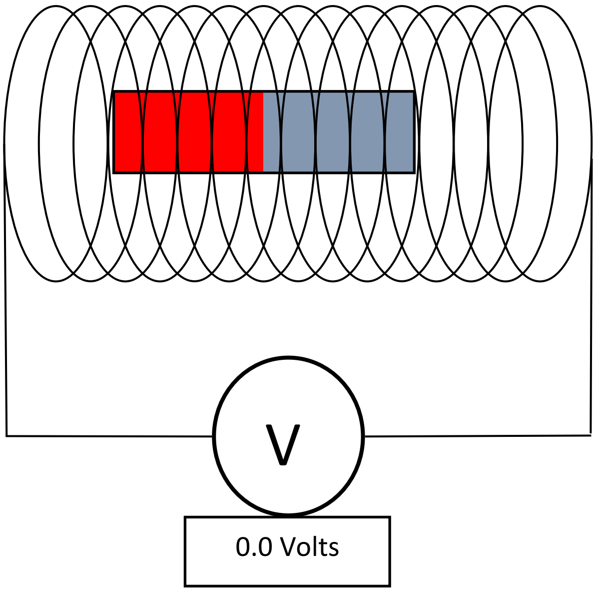
If we were to now move the **magnet back out** at the same speed then we would see the reading on the **voltmeter** would **change direction** – this time to -6.0 volts. We are still inducing a voltage but this time in the opposite direction.



It does not matter if we move the **magnet into** the coil, or if we move the **coil over** the magnet. As long as one is **moving relative** to the other we induce a voltage. **This is called the generator effect.**



If **nothing is moving,** we have **no induced voltage**. Here the magnet is stationary inside the coil: Therefore, no voltage registered.



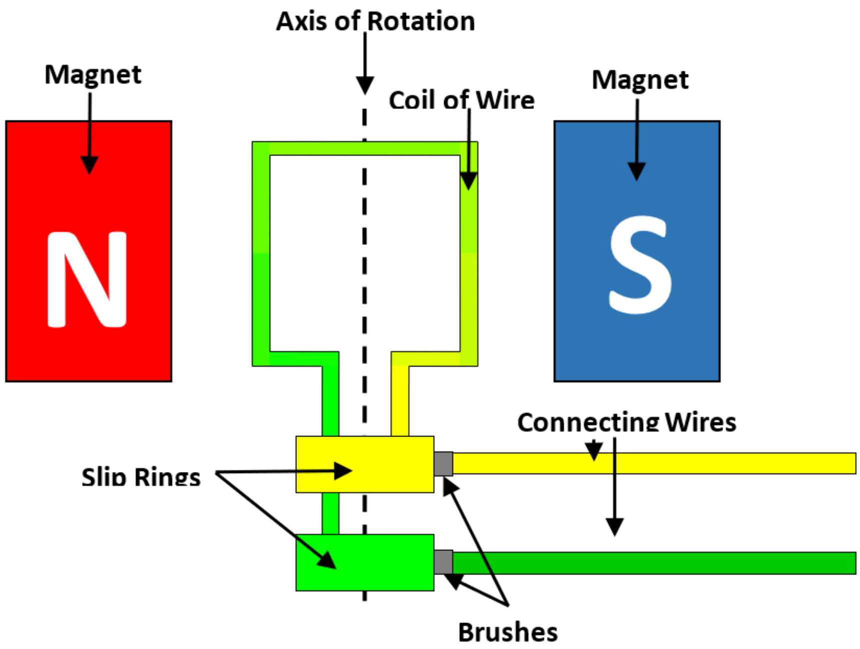
If a magnet is **moved** into a coil of wire, an electrical potential difference is induced across the ends of the coil.If the **direction** of **motion**, or the **polarity** of the magnet, is **reversed,** the **direction** of the induced potential difference and the induced current is **reversed**.

The generator effect also occurs if the magnetic field is stationary and the coil is moved – as long as one is moving relative to the other.

Use this simulation to explore the generator effect:
https://phet.colorado.edu/en/simulations/faradays-law

AC Generator

We use a **slip ring** for **alternating current**. Every **half rotation** of the coil (each 180°) the direction of the current induced by the rotating coil **changes direction**.



The **size** of the induced **potential difference increases** when:

- We **increase** the **speed** of the movement;
- We **increase** the **strength** of the **magnetic** field;
- We **increase** the number of **turns** on the coil;
- We **increase** the **area** of the coil.

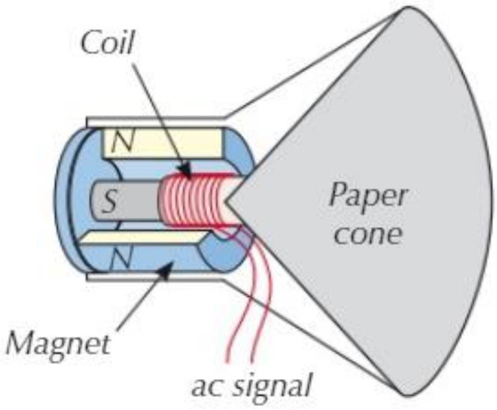
Exam practice link: question eleven

Section twelve

AQA GCSE Physics topic: P7

Triple-only content: Loudspeakers and Microphones

Loudspeakers and headphones use the motor effect to convert variations in current in electrical circuits to the pressure variations in sound waves

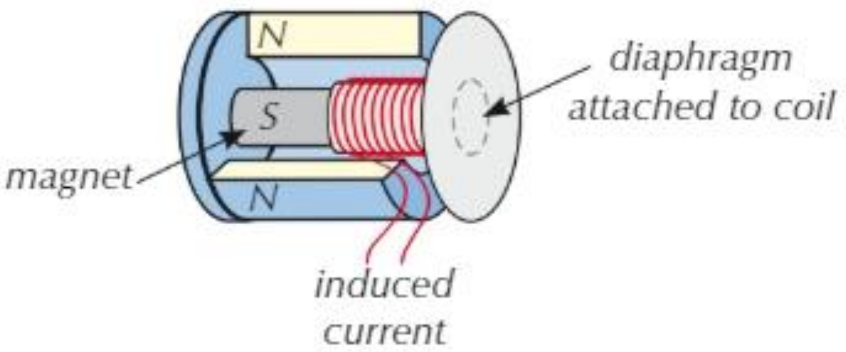


The fluctuating ac voltages causes a fluctuating magnetic field around the coil.

This produces attraction and repulsion between the coil and the magnets.

The paper cone (attached to the coil) will then also move backwards and forward causing vibrations in the air – this is sound.

Microphones use the generator effect to convert the pressure variations in sound waves into variations in current in electrical circuits. To do this, sound wave vibrations are incident on a diaphragm which moves a coil on a magnet. This moving coil generates a matching potential difference.



This idea is also used in electric guitar pickups:

https://nationalmaglab.org/education/magnet-academy/watch-play/interactive/guitar-pickup

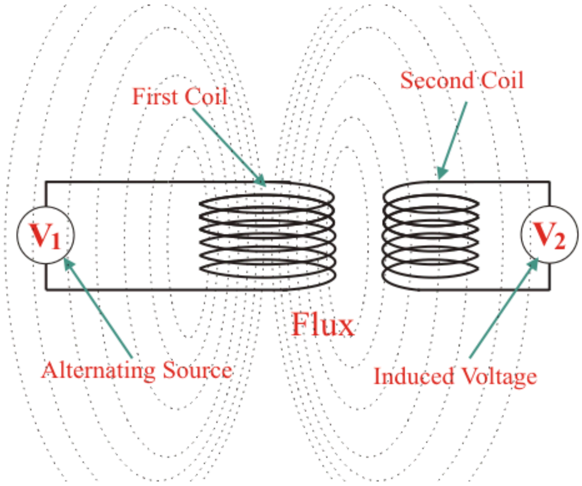
Exam practice link: question twelve

Section thirteen

AQA GCSE Physics topic: P7

Triple-only content: Transformers

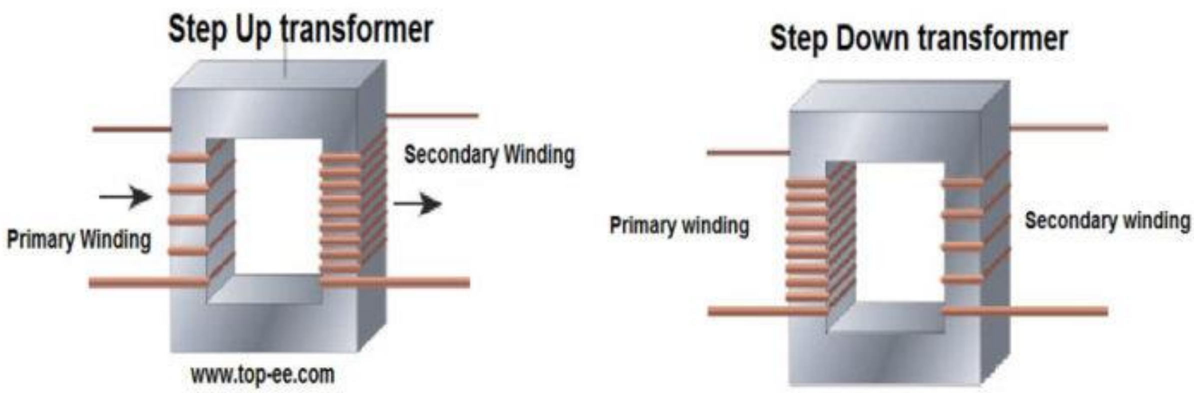
A basic transformer consists of a primary coil and a secondary coil wound on an iron core. Iron is used as it is easily magnetised. *Knowledge of laminations and eddy currents in the core is not required.*



The ratio of the potential differences across the primary and secondary coils of a transformer V_p and V_s depends on the ratio of the number of turns on each coil, N_p and N_s.

$$\frac{N_s}{V_s} = \frac{N_p}{V_p}$$

In a step-up transformer $V_s > V_p$. In a step-down transformer $V_s < V_p$.



If transformers were 100% efficient, the electrical power output would equal the electrical power input. From $P = I \times V$

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

Where Vs × Is is the power output (secondary coil) and Vp × Ip is the power input (primary coil).

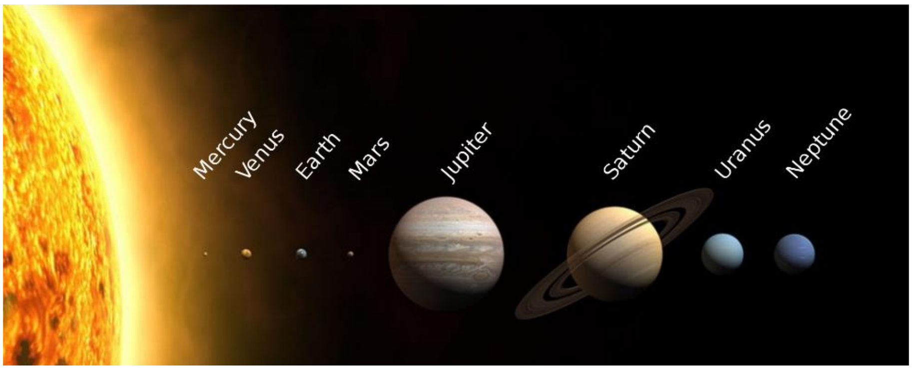
Exam practice link: question thirteen

Section fourteen

AQA GCSE Physics topic: P8

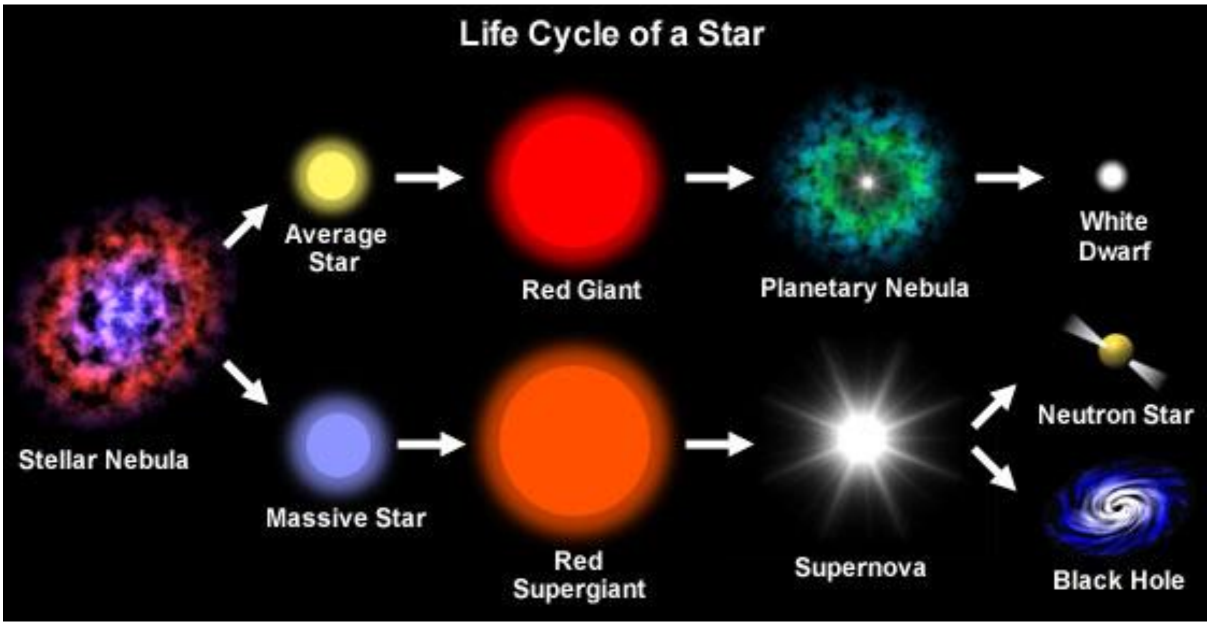
Triple-only content: Space – Stellar Evolution

Within our solar system there is one star, the Sun, plus the eight planets and the dwarf planets that orbit around the Sun. Natural satellites, the moons that orbit planets, are also part of the solar system. Our solar system is a small part of the Milky Way galaxy.



This image gives a good representation of the size of each planet but NOT their separation.

All stars go through a life cycle; they are 'born' when they begin fusing hydrogen, 'live' while fusion is taking place in their cores and 'die' when they have exhausted the fuel for fusion. The steps of the life cycle are determined by the mass of the star. Our Sun is considered an average or low mass star which follows the upper path on the diagram below. For stars of 10 solar masses or more, they follow the lower path in the diagram.



Watch the following videos for more information on each step.

Overview: https://youtu.be/PM9CQDIQI0A

Star formation: https://youtu.be/80eMTnnLjhs

Nebula

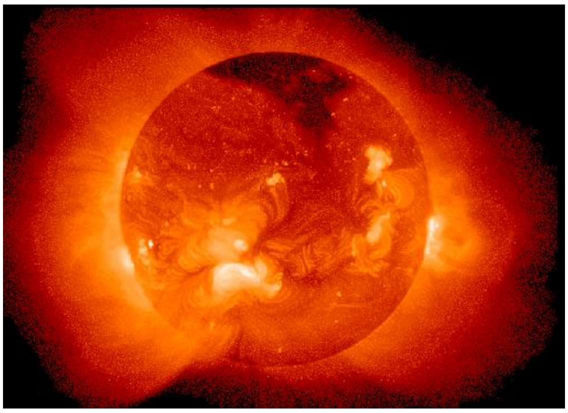
- Stars form from clouds of dust and gas called nebulae.
- Nebulae are large clouds of dust and gas, mainly hydrogen
- Gravitational attraction causes the particles to clump together.

Protostar

- Gravity causes the dust and gas in nebulae to become denser and more concentrated.
- The pressure increases and the centre gets hotter forming a protostar.
- No fusion yet – once the core is hot and dense enough for fusion of hydrogen atoms to occur it becomes a main sequence star.

Fusion in Stars: https://youtu.be/W1ZQ4JBv3-Y

Main Sequence Stars



- Nuclear fusion of hydrogen atoms to form helium is now in full flow and a protostar becomes a **main sequence star.**
- This star is much hotter and brighter than before, releasing energy and a flow of radiation from its core.
- A main sequence star is in equilibrium; it is stable because the **forces of gravity** are balanced by the **pressure** from fusion reactions.
- These processes take several billion years.

Stellar Death - Stars with mass similar to the sun:

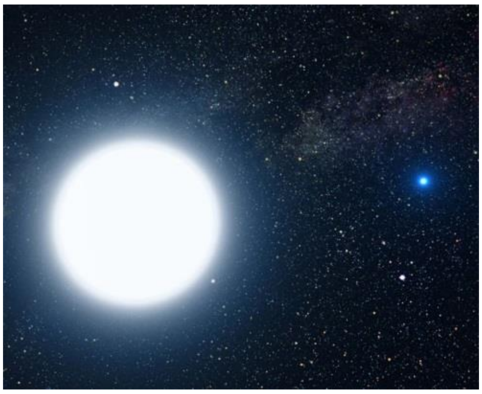
Red Giant: https://youtu.be/5ZFnA51WsnY

Red Giant Phase

- The hydrogen fuel eventually runs out; helium and other light elements in the core fuse to form heavier elements.
- This process releases even more energy, causing the star to expand.
- As the core runs out of hydrogen and then helium, the core contracts and the outer layers expand, cool, and become less bright; forming a red giant.

White Dwarf: https://youtu.be/qsN1LglrX9s

White Dwarf Phase



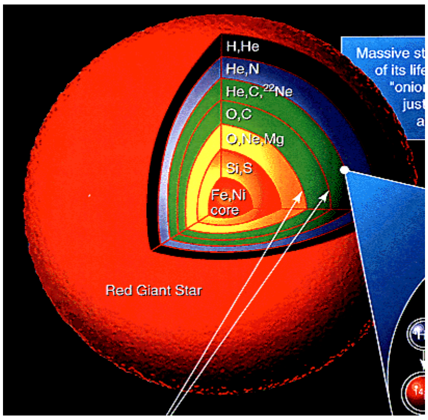
- A red giant will eventually run out of its 'fuel' of light elements - nothing else in it will fuse.
- When the red giant has run out of fuel it will lose its outer layers leaving behind the core of the star.
- This is so dense and hot that it glows white, giving rise to its new name, a white dwarf which is much smaller than before.

Black Dwarf

- A black dwarf is created when a white dwarf cools so it no longer emits heat or light.
- Since the time required for a white dwarf to become a black dwarf is longer than the age of the universe (13.7 billion years), no black dwarfs exist yet.

Stellar Death- Stars with mass much larger than the sun (at least 10 Solar Masses)

Red Super Giants



- After the hydrogen in a giant star's core has been used up, they become red super giants - the stars in the universe in terms of volume.
- Unlike a Red Giant, a Red Super Giant is large enough and hot enough to maintain fusion reactions with ever heavier elements up to iron.
- At the end of a Red Supergiant's life it leaves layers of elements in the structure of the star like layers in an onion

Supernova

- Energy production in the core of a red super giant slows down.
- The pressure in the core decreases - he outer layers are not held up and they collapse inwards.
- As the core is so dense, the outer material collides and bounces off, resulting in a huge explosion seen as a supernova.
- Elements larger than Iron formed this way.
- Thrown out into space and eventually coalescing together to form new objects

What is left behind has undergone huge pressures that cause a massive increase in density. The final stage is determined by the original mass of the star. Only the most massive stars will form black holes.

10-29 Solar Masses - Neutron Stars: https://youtu.be/udFxKZRyQt4

Neutron Stars

- The large amount of energy released in a supernova allows **elements heavier than iron** to form, and distributes them through the universe.
- After a supernova, only the star's compressed core consisting of neutrons is left behind.
- The resulting **neutron star** is extremely dense.

Great than 29 Solar Masses - Black Holes: https://youtu.be/kOEDG3j1bjs

Black Holes

- The largest stars can collapse further under the extreme effects of gravity.
- The gravitational field is now so strong, nothing can escape from it, not even light or any electromagnetic radiation… presenting a black hole.

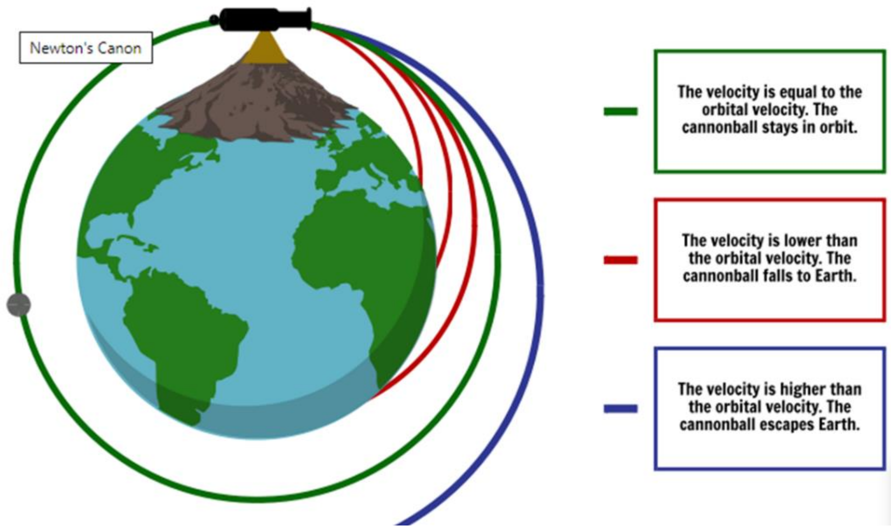
Practice Activity:
Use this link to see if you can place each step in the correct order to represent the lifecycle of a star.
https://www.flippity.net/ma.php?k=1xpThhHPcddg861sWNhHmc_p-tfh5l20sj6cDpr65TwQ

Triple content only: Orbital motion

Gravity provides the force that allows planets and satellites (both natural and artificial) to maintain their circular orbits

Orbiting objects are accelerating.

Although their speed (scalar) is constant their velocity (vector) is changing due to a constantly changing direction. Therefore, they are accelerating.



Exam Practice Link: question fourteen

Section fifteen

AQA GCSE Physics topic: P8

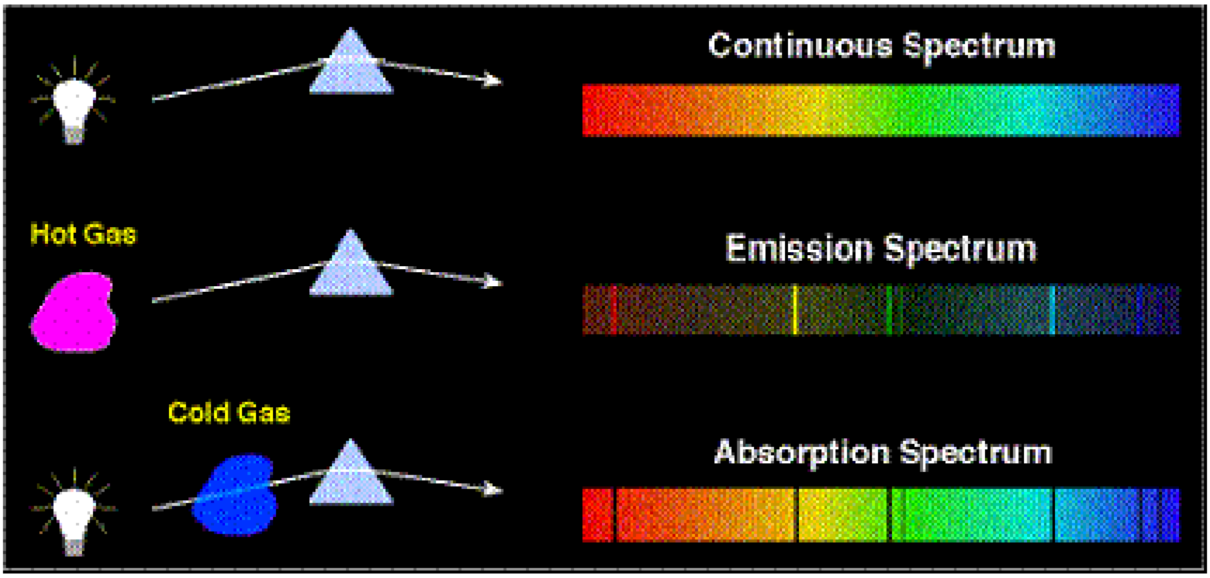
Triple-only content: Space – Redshift

There is an observed increase in the wavelength of light from most distant galaxies. The further away the galaxies, the faster they are moving and the bigger the observed increase in wavelength. This effect is called redshift.

Redshift: the displacement of spectral lines towards longer wavelengths (the red end of the spectrum) in radiation from distant galaxies and celestial objects.

But what are spectral lines?

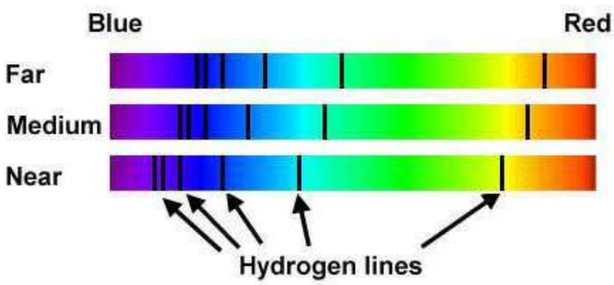
You might have seen these in Chemistry lessons. If you look at light using a spectroscope – it breaks the light down into separate wavelengths and you can see which particular ones are present for each element (these act like a fingerprint). Specific colours are due to the emission of specific wavelengths of light.



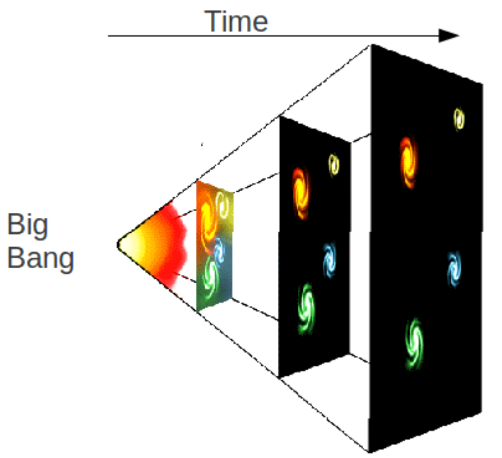
This is interpreted as a Doppler shift that is proportional to the velocity of recession and thus to distance.

Doppler Effect: https://www.youtube.com/watch?v=h4OnBYrbCjY

If we look at the light from distant galaxies, we can see that the pattern is shifted towards the red end of the spectrum.



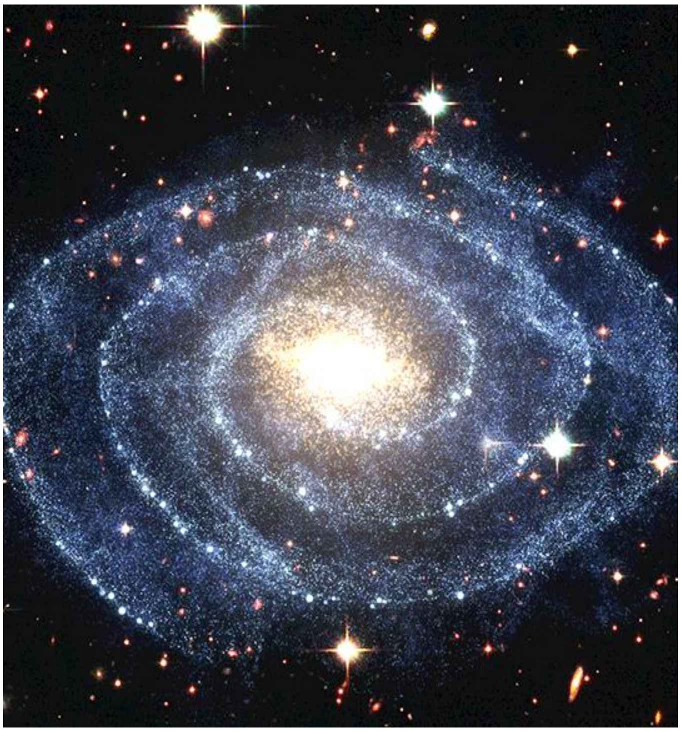
The Big Bang theory suggests that the universe began from a very small region that was extremely hot and dense. The observed redshift provides evidence that space itself (the universe) is expanding and supports the Big Bang theory.



Modelling an expanding universe:
https://www.youtube.com/watch?v=VDZO9BtImG4

Since 1998 onwards, observations of supernovae suggest that distant galaxies are receding ever faster. The change of each galaxy's speed with distance is evidence of an expanding universe.

There are many things we still do not know:



Observation: Many galaxies are seen rotating so fast that they *should* fall apart given the gravitational attraction that would be holding them together due to the mass of the things we can detect.

Explanation: There *must* be something else that is helping to hold them together, but we can't detect it. We call that **Dark Matter**

Observation: Recent observations of distant supernovae show that the universe is expanding at an accelerating rate.

Explanation: There *must* be Something driving this acceleration, but we as yet don't know what that is. We call this **Dark Energy**

Exam Practice Link: question fifteen

Moments Levers and Gears Challenge Question:

How many cats are in the box? My answer is at the end of the doc. Do you agree?

9 Cats