IGCSE Edexcel (9-1) Physics (4PH1) Revision Notes

Here you will find revision notes for IGCSE Edexcel (9-1) Physics (4PH1)

Motion

Distance/time graphs

Horizontal line means the object is stationary

Diagonal line upwards shows movement away from the origin

Diagonal line downwards means moving towards origin

Steeper gradient means greater velocity (m/s)

Gradient getting steeper shows acceleration

Gradient getting shallower shows deceleration

Speed = distance/time

Acceleration = change in velocity/time

Velocity/time graph

Horizontal line shows constant velocity

Diagonal line upwards show acceleration

Diagonal line downwards shows deceleration

If the value for velocity (y axis) is below 0 then the object is going backwards

Area below the line (above 0) (- any below x axis) is the distance travelled

Stopping distance

Thinking distance is the time it takes to react to something

Braking distance is how long it takes to stop after applying the brakes

Added together these make the stopping distance

Terminal velocity

This is the fastest speed an object will reach

It happens when the friction = the downward force of gravity

Forces

Newton's laws

If the resultant force on an object is 0 it will continue to do what it is doing

If forces are unbalanced then acceleration/deceleration will occur (EAHAEAOR)

Normal reaction force stops objects sinking into the ground

Friction and air resistance slow things down

Thrust pushes things

Hooke's law

The extension of a spring is proportional to the mass applied

This only changes when the spring passes its elastic limit

It will then not return to its original shape as the atomic bonds are broken

F=kx (F = force, k = spring constant, x = extension)

The sag of a long beam follows the same pattern

When identical springs are placed in series the extension doubles

When identical springs are placed in parallel the extension halves

Bungee cords are elastic but rubber bands are not (follow sideways 2 pattern)

Moments

This is the turning affect force

Moment = force (weight in newtons) X distance from the pivot point (metres)

The further the mass is from the pivot point the higher the force

This can be used to give mechanical advantage (levers)

It is measured in Newton metres (Nm)

Key formula

Force (N) = mass X acceleration

Weight = mass (kg) X gravitational field strength

Waves

Key information

Waves are a means of transferring energy or information without moving matter

Transverse waves have oscillations perpendicular to the propagation of the wave (up/down)

Longitudinal waves have oscillations parallel to the propagation of the wave

This causes compressions and rarefactions of particles (won't work in a vacuum)

The distance the wave moves a particle from rest is the wave's amplitude

Distance from one part of a wave to the same part on the next is the wavelength

The amount of times the source vibrates per second is the frequency

The time it takes for the source to make one wave is called the period

Frequency (f) = 1/time period (T)

The speed of a wave (V) = frequency (f in hz) X wavelength (λ in metres)

At higher frequency the wavelength decreases and the speed stays the same

When waves reflect, angle on incidence = angle of reflection

When waves hit a concave barrier, they reflect and converge

When they hit a convex barrier, they reflect and diverge

Information must be converted to digital/analogue signals to travel down telephone lines

Digital signals are better when amplified to create a clear sound

They are formed by 1s and 0s creating top hat graph with horizontals at 1 and 0

They also allow more programs to run on the same frequency

Analogue signals are a constantly varying electrical current but are not as good

Transverse waves

The spectrum of transverse wave is called the electromagnetic spectrum

It contains Radio, micro, infra-red, visible and ultraviolet waves and x-rays and gamma rays

The longest wavelength is radio waves and the shortest is gamma rays

Radio waves are used for TV communication

Microwaves are used to heat food (water and fat molecules) and satellite communication as the pass through the atmosphere. These could easily cook a human.

Infra-red waves are felt as heat and are used in TV remotes and thermal cameras. These can cause burns.

Visible light allows us to see and is used in optical fibres. Can cause blindness.

Ultraviolet light is used in fluorescents as it makes some chemicals glow, causes tanning, absorbed by ozone layer. Can cause sunburn, skin cancer and blindness.

X-rays are absorbed differently by some materials and so can locate breaks. Can cause mutations and cancer

Gamma rays cause cell mutation/death but used to sterilise medical instruments and treat cancer. Can cause mutations and cancer.

Longitudinal waves

Sound is an example of a longitudinal wave through compressions and rarefactions

Sound travels through solids at 5000m/s, liquids at 1500m/s and gas at 330m/s

You can measure speed of sound by time taken to hear someone hit something

You can use a oscilloscope to find the wavelength and frequency

You can use resonance to find the wavelength

When sound is reflected it is called an echo. Ships use this to find water depth

SONAR (SOund Navigation And Ranging)

Objects that vibrate at a high frequency create a high pitch

Different animals hear different sound ranges, humans hear from 20hz to 20,000hz

This range becomes narrower as you get older

Sounds below hearing are infrasound and above are ultrasound

Dolphins use ultrasound and elephants use infrasound

The larger the vibration and amplitude the louder the sound

Energy transfers

Key facts

Heat, sound, electric (electrostatic), kinetic, elastic potential, gravitational potential, chemical, light and nuclear are all types of energy

Efficiency = useful output energy/total imput

Sankey diagrams show this (useful energy to right and wasted energy down)

Thermal energy

Radiation transfers heat energy using infra-red waves

Convection transfers heat through fluids as warmer fluids rise (convection currents)

Conduction transfers heat without moving (particles vibrate and collide)

Work

Work done (J) = force (N) X distance moved (m)

This is equal to the useful energy

GPE

Gravitational potential energy = mass (kg) X gravitational field strength (m/s2) X height (m)

Kinetic

Kinetic energy = ½ X mass (kg) X velocity2 (m/s2)

Non-linear as velocity is squared

Power

Power (w) = work done (J)/time taken (s)

A watt is a joule per second

Electricity

Current: the amount of charge transferred over time I (amps) = Q (coulombs)/t (seconds)

Current is the same in series but is split in parallel

Current varies with resistance I (amps) = V (volts)/R (ohms)

I–V and V–I graphs (y axis first) show relations between them in different components

Resistor is a straight line through the origin,

filament lamp is an S shape through the origin,

diode is a curve after the threshold voltage

thermistors/LDRs are inverse proportion graphs on an I-V

Ammeters are connected in series

Voltage: energy transferred per coulomb of charge V (volts) = E (joules) /Q (coulombs)

Energy used by a circuit = VIt = VQ

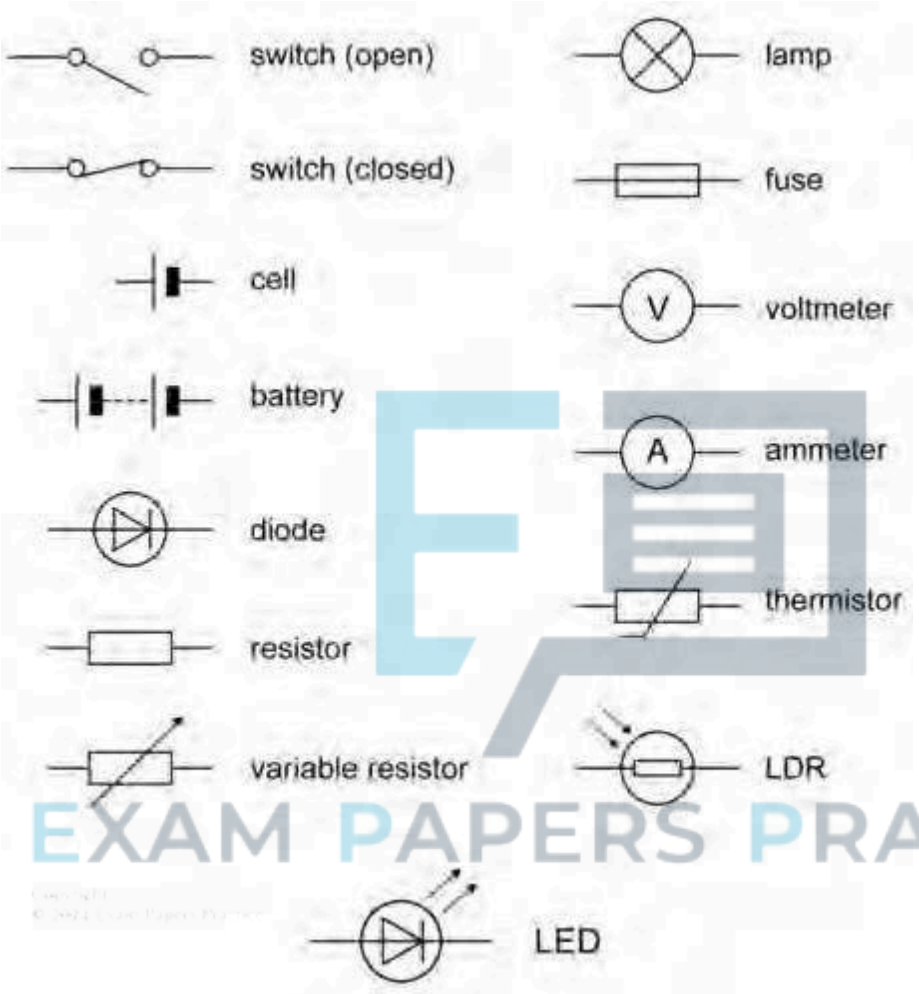
Voltage is split in series but is the same across branches in parallel

Voltmeters are connected in parallel across a component

Resistance: is caused by electrons colliding with ions as they flow

R = V/I and tends to increase with temperature as ions move about more

Circuit symbols!



Gas Law and Specific Heat Capacity

SHC: the amount of energy needed to raise the temperature of 1kg of material by 1°**C**

Delta Q (joules) = m (mass in kg) X c (SHC) X delta T (°**C**)

Absolute 0: particles have no kinetic energy, this cannot be reached

Solid: particles are arranged in a regular pattern held together by strong forces with particles only able to vibrate

Liquid: there are weaker forces between particles, so they can move past each other and flow. They have more energy and move in random directions.

Gas: almost no forces between particles and they move around quickly as they have more energy

The density of a substance changes with state as particles tend to be closer together in a solid with the exception of water and ice

Density and Pressure

Density = mass/volume (symbol for density is Rho, a slanted P)

When particles are closer together the density is higher

Pressure = force/area

A small area causes a high pressure

pressure is measured in pascals, 1 pascal = 1N/m^2 or 0.0001N/cm^2

Liquid pressure = density of liquid X height X gravitational field strength

Atmospheric pressure = 100,000 pa

Radioactivity and Particles

Radioactive decay is random and spontaneous – changing things like temperature doesn't affect it

There are 4 main types of ionising decay emitted by unstable atoms

Alpha particles have 2 protons and 2 neutrons and are highly ionising due to their high mass but have low penetration power (stopped by paper). They will only deflect slightly in magnetic and electric fields.

Beta particles are electrons with negligible mass but a –1 charge and are reasonable ionising ability and penetration power (stopped by 5mm aluminium). They will deflect massively in magnetic and electric fields in the opposite direction to Alpha particles

Gamma rays have no mass and are the least ionising but can only be stopped by 1.3 feet of lead

Neutrons can also be given out by an atom

Activity of a source can be measured in Bequerels – 1Bq = 1 emission per second

Radiation can be detected by photographic film or a GM counter

There is always a low level background radiation caused by cosmic rays, radon gas from rocks, medical equipment and nuclear testing etc

The activity of a source will decrease over time

Half life: how long it takes for the count rate of a substance to halve

How long it takes for there to be half the number of particles of a particular isotope

Unstable atoms must emit radioactive particle to become stable

Uses of radiation: smoke detectors use alpha radiation to ionise air to pass charge

Smoke blocks this and so the current will decrease

Radioactive tracers are used in medicine to find cancerous tumours etc

Food irradiation

Thickness control

sterilisation

Contamination: radioactive source enters the body through ingestion etc

Irradiation: being exposed to a radioactive source

ionising radiation can remove electrons from atoms causing mutations or cell death

When nuclear power plants are closed they must be decommissioned

This involves removing all radioactive waste and containing it

Nuclear power: fission is the splitting of large nuclei with a slow-moving neutron

U-235 breaks down into 2 daughter nuclei and some more neutrons

This releases energy and can cause a chain reaction

Boron control rods are used to absorb these neutrons

A graphite or water moderator slows down other neutrons to react again

Nuclear reactors must be shielded in thick concrete to prevent radiation escaping

Nuclear fusion is combining two smaller atoms to create a larger atom

This produces little waste and lots of energy and is the power source of the future

However high temperature and pressure is needed to overcome electrostatic repulsion

Properties of Light

Waves can be reflected and refracted

When a wave reflects the angle of incidence = the angle of reflection

Light is refracted differently based of the shape of the block and the refractive index

The speed of a wave is determined by the medium it is travelling through

Sin i / sin r = n (refractive index)

Each medium has a critical angle at which it will reflect light

This process is called total internal refraction and happens if i>C

This is also dependant on the refractive index n = 1/sin C

TIR is used in optical fibres and periscopes

It preserves a better image (mirrors lose 5% and distort image due to thickness)

Mirrors provide a virtual image (an optical image formed from the apparent divergence of light rays, as opposed to an image formed from their actual divergence)

Y11 Physics revision

Astronomy

Stars begin as a cloud of dust called a nebula and this is pulled together by the force of gravity to form a protostar. As the temperature rises, fusion starts keeping the core hot.

Stars then enter the stable main sequence in which the force of gravity is able to balance the outward pressure from the fusion. Heavier stars have shorter main sequences

Stars will slowly stop fusing hydrogen as the supply runs out and will collapse under their own gravity. This raises the temperature and fusion rapidly restarts and the star expands

Smaller stars form red giants and then eject their outer layer leaving behind a white dwarf. This will then cool and leave a black dwarf.

Larger stars expand and form red supergiants. This will expand and collapse repeatedly before causing a supernova in which they explode (this forms all elements heavier than iron 56). This

will normally leave a neutron star but in some cases, when the star is really big, it collapses in on itself and forms a black hole

Orbiting objects move at a constant speed but changing velocity so there is acceleration

Acceleration is towards the centre of the circle and is called centripetal acceleration

Acceleration is caused by centripetal force, $F = ma = mv^2/r$

Orbital speed = $2\pi r/t$ when r = distance between centre of the objects and t = time to orbit

The closer something is to the centre of orbit, the faster it will move

Circular orbits occur when the object has a constant speed at right angles to the gravitational field

Satellites must enter orbit at the correct speed and angle or they will fall back/leave orbit

Geostationary orbits are about 42,000km above the earths centre and stay in the same position relative to earth, used in communications

Polar orbits are only at about 150km up and are used for monitoring

Comets have elliptical orbits which means they have changing GPE and kinetic energy

They have the most GPE furthest from the sun and vice versa

stars have different colours based on their surface temperatures

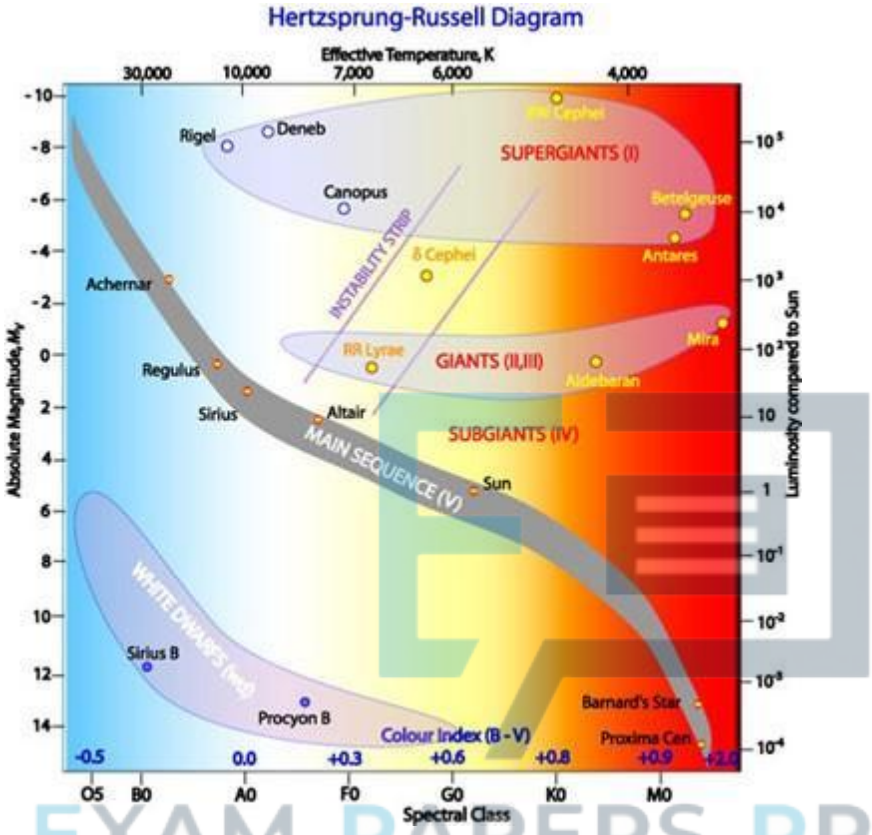
Blue > 7500, white/blue > 6000, yellow/white > 5000, red/orange > 3500, red < 3500

Luminosity – the amount of energy the star radiates per second

Apparent Magnitude – how bright the star appears to an observer, affected by distance

Absolute Magnitude – how bright the star would appear from a standard distance (10 parsecs)

A higher value for absolute magnitude means it is dimmer



Doppler effect – as something approaches you the frequency increases as the waves are forced together

Redshift – the light from galaxies moving away from us is redshifted and the wavelength increases

Blueshift – rare in the universe but happens when something is getting closer to you

Change in wavelength/reference wavelength = velocity of the galaxy/speed of light

We look at spectral lines of the most abundant elements like hydrogen to measure the changes

The universe expanded and is expanding from an infinitely small singularity at the start of time

Space, time and matter were all created by the big bang

This is shown by the fact that all galaxies a red-shifted compared to us, and those further away are more red-shifted, showing that they are moving away more quickly. This uniform expansion is evidence for the big bang

Just after the Big Bang, high energy gamma radiation was created and as the universe expands, the wavelength has increased. These waves are called Cosmic Microwave Background Radiation.

Electricity

Alternating current is one which is changing direction all the time (50Hz in the UK)

Direct current is one that always flows in the same direction

An oscilloscope measures voltage (y axis) and time (x axis)

Most plugs have 3 pins, earth, live and neutral

The earth pin has a yellow and green wire, live has a brown wire and neutral is blue

The case of the plug is an insulator, often plastic, and the pins are brass as it is stronger than copper

Double insulation involves making the appliance from plastic and removes the need for an earth pin as the current can't reach anyone

The symbol for double insulation is a box inside a box

The wires are copper, but these are surrounded in plastic

A fuse can be used to break a circuit as it melts when the current is too high

The fuse is put into the live wire and prevents damage to the appliance

More often we now use Residual current circuit breakers as these break the circuit faster and can be reset

electrical power – P=E/t, E=VQ, P=VQ/t, Q=It, P=VI, P=V2/R

Power is measured in watts which are 1 joule per second

1 unit of electricity is 1kWh and 1kWh=3,600,000 Joule

Static electricity – electricity that is not moving, usually cause by friction

There can be positive and negative static electricity based on the materials used

All objects are neutral to begin with but friction strips electrons from one and gives them to the other

Charges will build up at a point as they have a smaller surface area to spread the same charge

Smoke precipitators – smoke passes through a negatively charged metal grid so the particles become negatively charged.

The particles repel each other towards the walls of the precipitator which are positively charged

The gases leave the precipitator free of particles, reducing pollution

Photocopiers – the drum is given a positive charge

Light shines on the original and is reflected strongly by the white parts, absorbed by the black parts

When the light is reflected it causes the charge to leak away because the drum is an insulator

The black powder is given a negative charge, so it is attracted to the charged parts of the drum

The image is rolled onto paper which is positively charged and then heated to make the powder stick

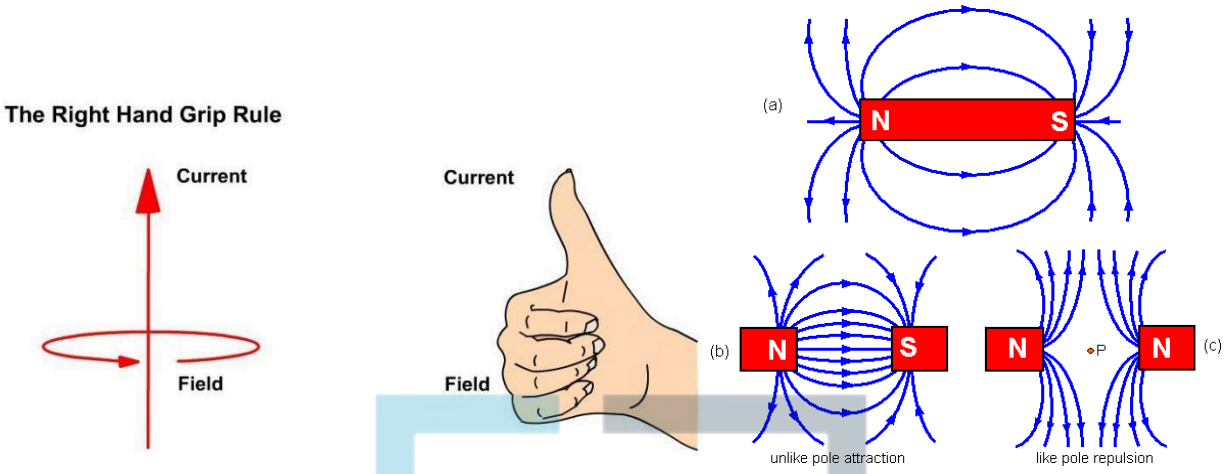
Gold leaf Electroscope – the gold pointer in the electroscope is deflected

When the object has a negative charge, electrons are repelled down the metal rod and the gold leaf, making them negatively charged and they will repel each other

A positive charge will attract electrons from the gold leaf and the metal rod and they will still repel

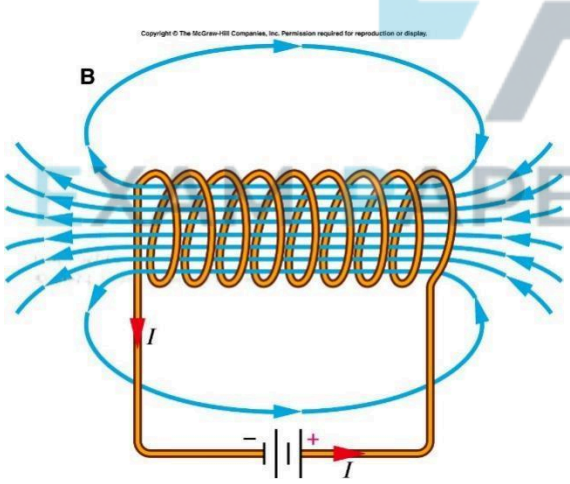
To test for the charge type on an object you must test by repulsion with something of a known charge as neutral objects will be attracted to any charged object

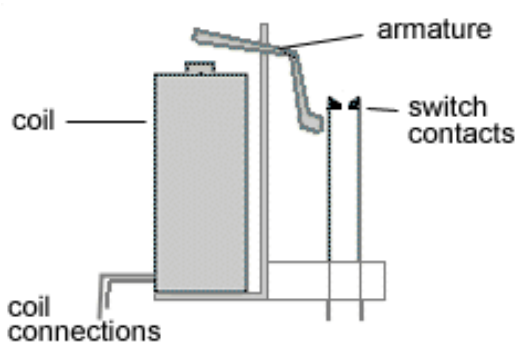
Magnetism



The magnetic field is stronger at the poles – shown by more magnetic field lines

The magnetic field of electromagnets can be increased by increasing the current, the number of coils or by adding an iron core

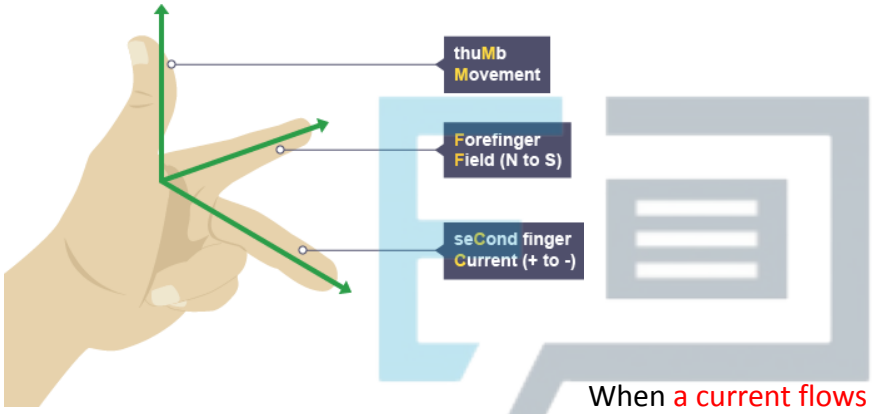




A relay circuit can be used to turn on a circuit with a high voltage for safety

There is only a small current to the electromagnet which pull the iron arm, hitting the contacts and turning on the larger circuit

A circuit breaker uses this technology to pull apart the contacts when the current is too high



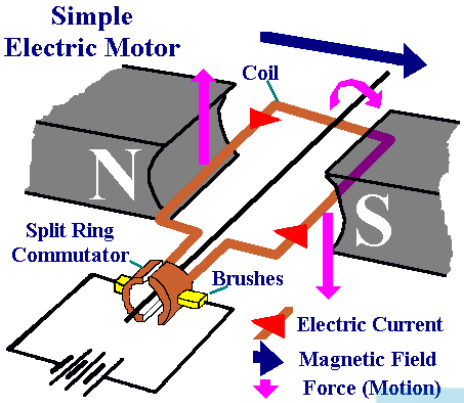
When a current flows through a wire in a magnet field, the fields interact causing a force on the wire

This is called the Motor Effect

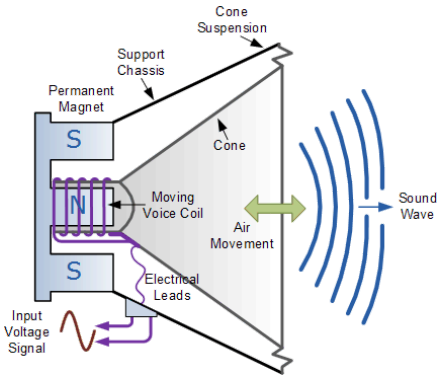
This doesn't occur when the magnetic field and the current are parallel

This force can be affected by the strength of the permanent magnet and the strength of the current

Changing the direction of the current or the direction of the magnetic field, changes the direction of the force



A motor can be created by passing a direct current through a coil of wire in a magnetic field



When a current flows through the loudspeaker, it induces a magnetic field which interacts with the permanent magnet.

This creates a force which moves the paper cone back and forth (as the current is alternating) to create a sound

If there is a relative movement between a wire and a magnetic field, it induces a voltage

When there is a complete circuit, a current will flow

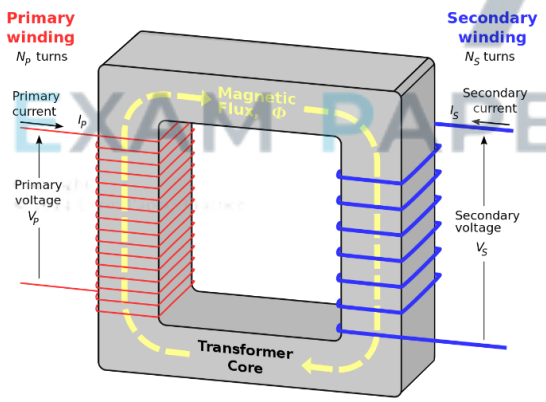
The size of the induced voltage is directly proportional to the change in the magnetic field

To increase the voltage: increase the field strength, increase the rate of change in field, have more coils on the solenoid, adding an iron core or putting the magnet closer

The generator effect – the wires are spun in a magnetic field causing field lines to be cut

An a.c. current is induced as each side of the coil first moves up and then down through the field

A generator that produced a.c. is called an alternator and slip rings must be used to avoid wires twisting



Transformers change the current and voltage of a circuit

They are used in the national grid to increase the voltage in power lines to decrease the loss of energy as heat (increase efficiency)

An alternating current is passed through the primary coil which induces an alternating magnetic field in the iron core (laminated to reduce heat/sound energy loss)

The changing magnetic field induces a voltage in the secondary coil which will create a current in a complete circuit

Np/Ns = Vp/Vs with very little loss - step-up transformers increase the voltage

As Energy cannot be created/destroyed and E=VIt Vp X Ip = Vs X Is

Switch-mode transformers – are smaller and work with higher frequencies of current

They do not contain iron cores and are used in phone chargers or laptops

They use very little energy when no load is applied and so can be left on

Momentum

Momentum is the product of mass and velocity (p=mv) and has the unit kgm/s

Momentum has direction and therefore can be negative

Momentum before a collision = momentum after a collision

M1u1 + m2u2 = m1v1 + m2v2 making sure you account for direction of momentum

In an elastic collision, momentum and kinetic energy are conserved but in an inelastic collision only momentum is conserved

A linear air track can be used to demonstrate this with 2 gliders of different masses

Magnets can be used to repel each glider with the same force and their resultant velocities can be measured using light gates and a data logger

The length of the interrupt card must be known to calculate velocity

Likewise, this experiment can be carried out with a mass (weights) to show F=ma

Changes in momentum cause a force as F=ma and a=(v-u)/t

Therefore F=(mv-m u)/t and so the force is reduced if the time taken is longer

Seatbelts both extend the time for deceleration and stretch to convert energy to elastic potential energy and heat

They must be replaced if they are overstretched

Crumple zones and airbags also extend the time and transfer energy away as heat as work is done to change the shape of the material

Moments

Moment = force X perpendicular distance between the direction of the force and the pivot

The moment must be measured in Newton metres (Nm) rather than joules

The moment of a beam etc acts down from its centre of mass

The centre of mass is the point at which the mass of the object can be thought to be concentrated

The centre of mass of an irregular object can be found using a pin and plumb line

Suspend the object freely from the pin and attach a plumb line to this pin

Mark on the line formed by the plumb line then repeat, the intersection is the centre

Moments can be used in levers as they ensure that the force is applied from a greater distance

If the object is balanced, then the sum of the clockwise moments = sum of anticlockwise moments

In order for an object to be stable its weight, passing through the centre of mass, must lie over the base of the object

Stability is affected by the height of the centre of mass and the width of the base

A large base (e.g. a Bunsen burner) and a low centre of mass (balancing toys) are stable