science physics

Topic 5a – Forces and Motion 1

Key Definitions

Air resistance	The frictional force caused by air on a moving object
Centre of mass	Point where the mass of an object appeas to be concentrated.
Contact force	A force acting between/on objects that are touching
Displacement	How far an object travels in a certain direction
Drag	The frictional force caused by any fluid (a liquid or gas) on a moving object
Elastic object	An object which returns to its original size after being deformed
Extension	How much longer an object is compared to its original size.
Force	A push or a pull on an object caused by interacting with something
Free body diagram	A diagram that shows all the forces acting on an object, the direction the forces are acting and their relative magnitudes
Friction	A force that opposes an object's motion. It acts in the opposite direction to motion.
Gravitational field strength	Force exerted by gravity on each kilogram of mass (9.8N/kg)
Hooke's Law	The extension of a spring is directly proportional to the force applied provided the limit of proportionality is not exceeded.
Mass	A measure of the amount of matter in an object
Resultant force	Single force that replaces all forces on an object giving the same effect as the original forces.
Scalar quantity	A quantity that has magnitude but no direction e.g. speed, mass
Vector quantity	A quantity which has both magnitude (size) and direction e.g. force, velocity
Weight	The force acting on an object due to gravity
Work done	When energy is transferred
Thinking distance	How far a vehicle travels while the driver is reacting to a situation
Braking distance	How far the vehicle travels while braking
Stopping distance	Thinking distance + braking distance.
Circular motion (HT)	An object **moving in a circle** has **constant speed but changing velocity** because the direction in which the object is moving is constantly changing.

Key Equations and units not given in the exam

Weight = mass x gravitational field strength
W = m x g
W= weight in Newtons (N)
m = mass in kilogrammes (kg)
GFS = Newtons per kilogram (N/kg) 9.81 N/kg on Earth

Force = spring constant x extension
F= k x e
F = force in Newtons (N)
k = spring constant in Newtons per kilogramme (N/kg
e = extension in m

Speed = distance/time
s = d/t
s= speed in metres per second (m/s)
d = distance moved in metres (m)
t= time takin in seconds (s)

Acceleration = change in velocity/time
a = (v – u)/t
a = acceleration in m/s^2
v = final velocity in m/s, u = initial velocity in m/s
t = time taken in s

Work Done = force x distance moved
W = f x d
W = work done in Joules (J)
F = force applied in Newtons (N)
d = distance moved in metres (m)

Force = mass x acceleration
F = m x a
F = force applied in Newtons (N)
m = mass in kilogrammes (kg)
a = acceleration in m/s^2

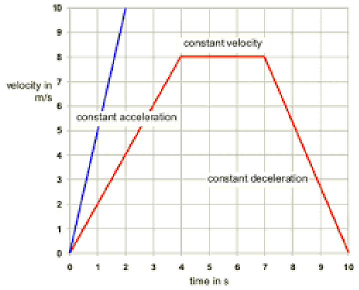
Momentum = mass x velocity (HT only)
p = m x v
p = momentum in kgm/s
m = mass in kilogrammes (kg)
v = velocity in metres per second (m/s)

Key Graphs

Distance Time Graphs

Average Speed = Gradient of the line/curve
Acceleration = Draw a tangent to the curve and calculate the gradient

Velocity Time Graphs



Acceleration = Gradient of the line.
Distance = Area under the graph

Falling Objects
Any object falling through a fluid (air or liquid) will initially accelerate due to gravity. Eventually the resultant force will become zero and the object will move at its terminal velocity.

Inertia - the tendency of objects to continue in their state of rest or uniform motion. Inertial mass = how difficult it is to change the velocity of an object (the ratio of force over acceleration)
Inertial mass (HT only)
How difficult it is to change the velocity of an object.
Inertial mass = force/acceleration

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Topic 5b – Forces and Motion 2

Key Information

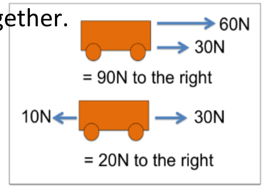
Contact and Non Contact Forces

Contact	Non Contact
Friction Air/water resistance Tension Push/pull Normal	Gravitational force Electrostatic Magnetic

Forces are vectors they have size and direction

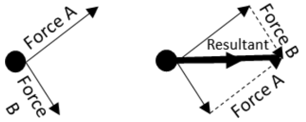
Resultant Forces (F Tier)

A single force which has the same effect of all of the forces acting together.



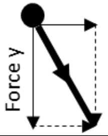
Resultant Forces (H Tier)

You need to be able to draw a scale diagram to show how to calculate the resultant force when 2 forces are perpendicular.



Resolving Forces (H tier)

A single force can be resolved into two components acting at right angles to each other using a scale diagram.



Scalar	Vector
Size only	Size and direction
Distance Time Speed Height	Velocity Displacement Acceleration Force

Typical values: Walking 1.5m/s / Running 3m/s / Cycling 6m/s

Key Information

Elasticity

When a force is used to deform an object but it can gain its original shape that is elasticity.

Elastic deformation is when an object stretches or bends but goes back to its original shape

Inelastic deformation is when an object does not stretch or bend and does not go back.

If an object snaps or does not recoil then it has gone past its elastic limit.

Force applied and extension in a spring are directly proportional.

Newton's First Law

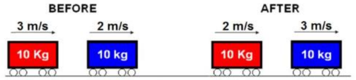
An object at rest stays at rest, and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an resultant force

Newton's Third Law

Whenever two objects interact, they exert an equal and opposite force on each other.

Conservation of Momentum (HT only)

In a closed system, the total momentum before an event is equal to the total momentum after the event.

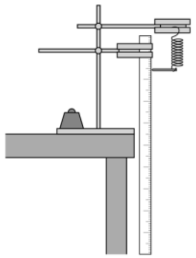


Braking

When a force is applied to the brakes, work is done by the friction force between the brakes and the wheels. This reduces the kinetic energy and increases the temperature of the brakes. The greater the speed, the greater the braking force needed to stop it.

Thinking distance	Braking dsitance
Drugs and alcohol Tiredness Age Distractions (phone)	Quality of Brakes Quality of tyre tread Road conditions (icy/wet)

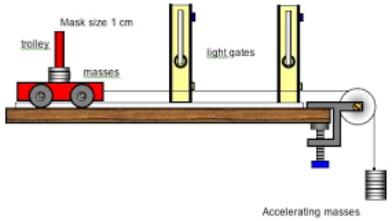
Required Practical – Hookes Law



Investigate the relationship between:
Independent = Force applied (N)
Dependent = Extension of a spring (m)
Control = material of spring, measuring points

You need to convert the mass attached to the spring to a weight before you plot the graph.
The relationship is directly proportional

Required Practical - Acceleration



1. Effect of changing the mass on the acceleration
Ind = Mass of system (not the trolley)
Dep = Acceleration (change in velocity/ time)
Control = Force applied, type of trolley, slant of ramp

2. Effect of changing the force applied on the acceleration
Ind = Force applied
Dep = Rate of acceleration
Control = Mass, type of trolley, angle of ramp

Light gates are used as they are more accurate – to measure the velocity at each light gate we do V = s/t
To measure the acceleration, we need to know the change in velocity) between each light gate and the time it takes to get between the two light gates.

Sources of error = friction between the trolley and the ramp and in the pulley system.

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Topic 5a – Forces and Motion Triple only

Key Definitions

Moment	Turning effect of a force around a pivot
Principle of moments	In a balanced system, the sum of the clockwise moments equals the sum of the anti clockwise moments
Gears	Increase or decrease the turning effect of a force
Fluid	A liquid or gas (that can flow)
Levers	A force multipliers as less force is required to get the same moment by increasing the distance
One joule	One joule of work is done when a force of one newton causes a displacement of one metre.
Newton's Second Law	The acceleration of an object is proportional to the resultant force acting on the object, and inversely proportional to the mass of the object.

Key Equations and units not given in the exam

Moment = force x distance from pivot

M = f x d

Moment in newton metres (Nm)

Force in Newtons (N)

Distance in metres (m)

Key Equations and units given in the exam

Pressure in a fluid = height of column x density of fluid x gravitational field strength.

P = h x ρ x g

Pressure in Pascals or Newtons per metre^2 (Pa or N/m^2)

Height in metres (m)

Density in kilograms per metre^3 (kg/m^3)

GFS in Newtons per kilograms (N/kg)

(final velocity)^2 – (initial velocity)^2 = 2 x acceleration x distance

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

Velocity in mertres per second (m/s)

Acceleration in metres per second^2 (m/s^2)

Displacement in metres (m)

Force = change in momentum ÷ time taken

F = Δp ÷ Δt

Force in Newtons (N)

Momentum in kilograms metres per second (kg.m/s)

Time in seconds (s)

Elastic potential energy = 0.5 x spring constant x (extension)^2

EPE in Joules (J)

Spring constant in Newtons per metre

Extension in metres (m)

Key information

Moment	Turning effect of a force around a pivot
Principle of moments	In a balanced system, the sum of the clockwise moments equals the sum of the anti clockwise moments
Gears	Increase or decrease the turning effect of a force
Fluid	A liquid or gas (that can flow)
When an object is balanced, what can be said about the moments?.	If an object is balanced, the total clockwise moment about a pivot equals the total anticlockwise moment about that pivot
What does the pressure in fluids cause?	The pressure in fluids causes a force normal (at right angles) to any surface)
Where causes upthrust?	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; the upthrust.
What causes atmospheric pressure?	Air molecules colliding with a surface create atmospheric pressure.
Why does atmospheric pressure decrease with an increase in height?	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. So as height increases there is always less air above a surface than there is at a lower height.
What is the principle of conservation of momentum?	In a closed system, the total momentum before an event is equal to the total momentum after the event.
What happens to momentum when a force acts on an object that is moving or able to move?	A change in momentum occurs, where the force is the rate of change of momentum.
What does an air bag, or most other safety features in a car, have to do with the rate of change of momentum?	It increases the time over which the momentum changes to reduce the force on the passenger.

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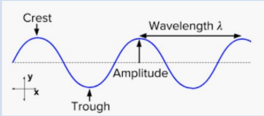
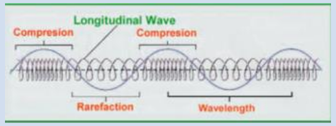
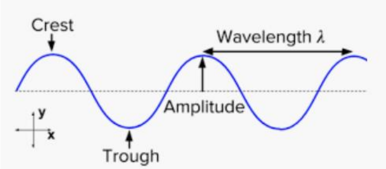
Topic 6 – Waves

Transverse	Longitudinal
	
Oscillations are perpendicular to the direction of energy	Oscillations are parallel to the direction of energy
Electromagnetic Waves Ripples on water	Sound Waves



Wavelength (m) is the length from one point on one wave to the same point on the next wave.

Amplitude – the height of the crest or the depth of the trough.
Frequency (Hz) – the number of waves per second

Long wavelength → Short wavelength

Radio waves	Microwaves	Infrared	Visible light	Ultraviolet	X-rays	Gamma rays

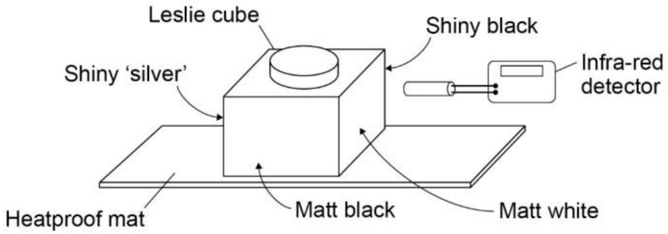
Low frequency → High frequency

1. All Electromagnetic Waves travel at the same speed in a vacuum
2. EM waves can be absorbed, transmitted and reflected

Uses of EM waves

Radio – TV and radio
Micro – satellite communications and cooking food
Infrared – electric heaters, cooking food, infrared cameras
Visible light – Fibre optic communications
Ultraviolet – energy efficient lamps, sun tanning
X ray and gamma – medical imaging and treatments

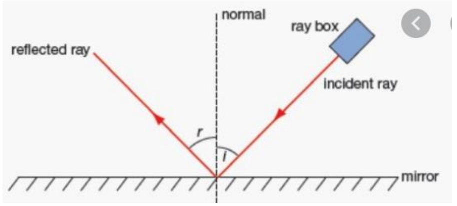
Dangers of EM waves	• Microwaves: Heating of brain (mobile phone use) • Infrared: Burns • Ultraviolet: Skin cancer, premature aging of skin. • X-rays & Gamma rays: Cancer

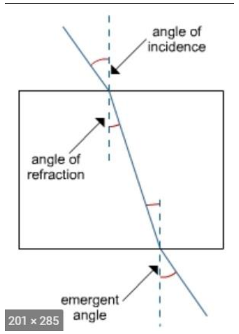


Put the Leslie cube on a heatproof mat. Fill the cube with very hot water and put the lid on. Use a infrared detector to measure the amount of infrared radiation from each surface.

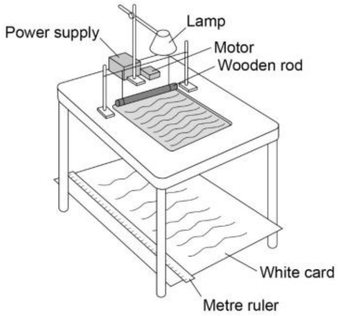
Use a bar chart for your results because the data is catagoric:

Highest	Matte Black
	Shiny Black
	Matte white
Lowest	Shiny Silver





Observing Water waves in a ripple tank

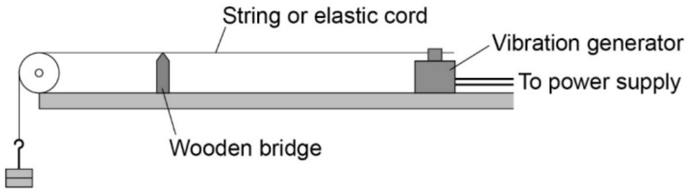


Pour water into the tank and make sure that the rod just touches the water
Switch on the lamp and the motor adjust the speed to get low frequency waves. Place a metre ruled at right angle to the waves on the card

Measure across as many waves as you can then divide that length by the number of waves = wavelength.
Count how many waves pass in 10s
Divide the number of waves counted by 10 = frequency

Wave speed = wavelength x frequency.

Measuring Wave Speed in a Solid



Switch on the vibration generator and adjust the tension so that you can see the waves.
Use a metre ruler to measure across half wavelengths multiply by 2 to get wavelengths.
The frequency is the number on the vibration generator
Speed = frequency x wavelength

To measure the speed of sound in air

Stand away from a wall and measure the distance to the wall (m)
Make a sound and time how long it takes for the sound to reflect and come back.
Speed = distance ÷ time

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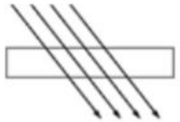
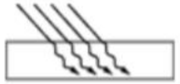
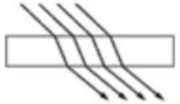
Topic 6 – Waves

Key Definitions for trilogy HIGHER TIER ONLY

Transmission	
Specular reflection	
Diffuse reflection	
Absorption	
Refrection	

Key definitions for TRIPLE AWARD ONLY

Concave lens	A lens which converges light rays.
Black body	A body which absorbs all the radiation incident on it.
Constant temperature	A body who's power input is equal to its power output.
Principle focus	Location where parallel rays of light are brought to a focus.
Focal length	The length between the lens and the principle focus.
Real image	An image formed where light rays are focused.
Virtual image	An image formed where light rays appear to be coming from.

Key Equations and units not given in the exam

Period = 1 ÷ Frequency
(s) (Hz)

Wave speed = Wavelength x Frequency
(m/s) (m) (Hz)

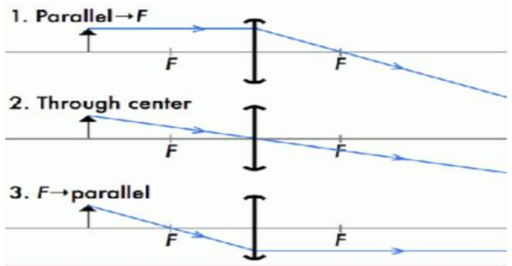
Key Equations and units given in the exam

$$\text{Magnification} = \frac{\text{Image height}}{\text{Object height}}$$

Key Laws

Law of reflection	The angle of incidence is equal to the angle of reflection.

Key diagrams TRIPLE AWARD ONLY



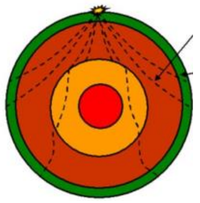
Key information

Transverse waves	• Electromagnetic waves • S-waves • Surface waves
Longitudinal waves	• Sound waves • P-waves
Radio waves (H tier only)	• Oscillations in electrical circuits produce radio waves which are absorbed by an aerial, producing an alternating curret. • The AC has the same frequency as the original radio wave. This is how TV and radio siganls are broadcast.
The temperature of the earth (H tier only)	• EM radiation absorbed by the earth causes the earth to increase in temperature. • Energy from the earth can be transferred to the atmosphere by conduction and convection. • The infrared radiation emitted from the earth's surface will either travel through the atmosphere back into space or it will be and reflected back by the greenhouse gases in the earth's atmosphere.

Key information TRIPLE AWARD ONLY

1 S waves Transverse Only travel through solid

2 P waves Longitudinal Travel through the earth and are refracted when they



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Topic 7 – Magnetism and Electromagnetism

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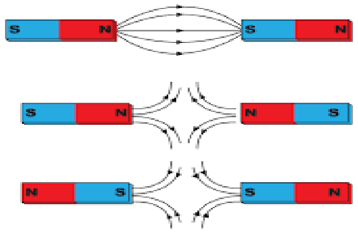
Magnets

2 like poles will repel
2 unlike poles will attract
Magnetic materials Iron, steel (contains iron), nickel and cobalt

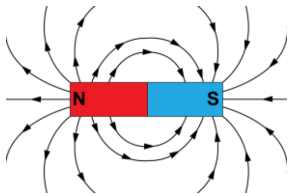


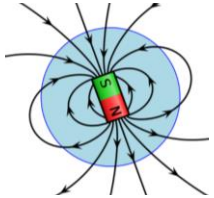
Permanent magnet – produces its own magnetic field and can attract or repel another magnet
Induced magnet – Becomes a magnet when it is placed in a magnetic field (temporary and can only attract another material)

Magnetic field

'A region around a magnet where a magnetic material will experience a force'

Magnetic field goes North to South.
Magnetic field is strongest at the poles
The strength of the magnetic field decreases the further you get from the magnet



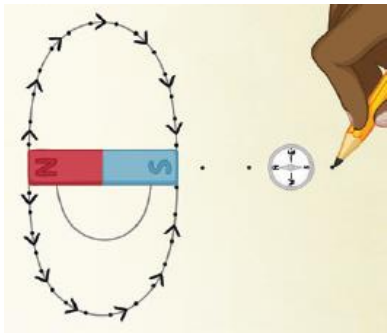


The way a compass needle behaves tells us the earths core is magnetic

Plotting a magnetic field

Plotting compasses can be used to show the magnetic field.

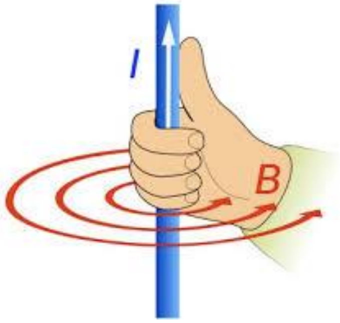
Place them around the bar magnet
Mark the direction of the arrow at each point
Join the arrows to show the magnetic field.



Magnetic Field around a current carrying wire

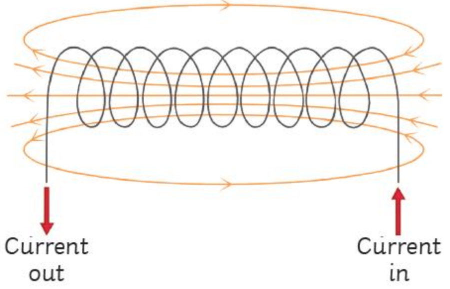
When a current flows through a wire, a circular magnetic field is produced around the wire. It is stronger closer to the wire.

Right hand grip rule shows the direction of the magnetic field.



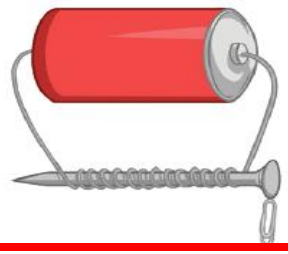
Solenoids

A solenoid is a coiled wire. This increases the strength of the magnetic field. It is strong and uniform (the same strength everywhere) inside the coil



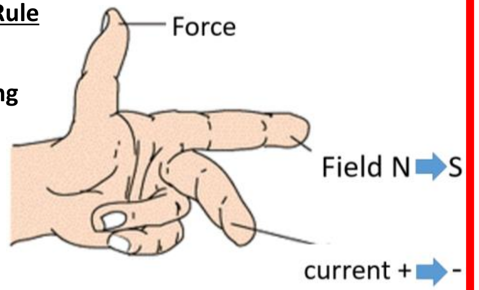
Electromagnets

A solenoid with an iron core.
Electromagnets are induced magnets that can be turned on and off
The magnetic field can be increased by:
1. Adding turns of wire onto the coil
2. Increasing Current
3. Adding an iron Core



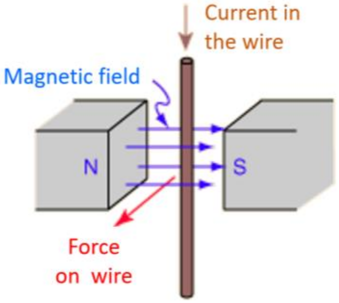
HT Flemming's Left Hand Rule

This is use to show the direction of the Force acting on a current carrying conductor placed in a magnetic field. The motor effect



HT The Motor Effect:

A current carrying conductor will experience a force if it is placed cutting a magnetic field. The conductor will not experience a force if it is parallel to the magnetic field conductor in the field (m)



HT The Motor Effect Equation

$$F = BIL$$

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

F : force (N),

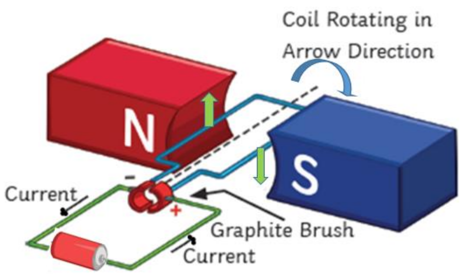
B : magnetic flux density (T) or (Tesla)

I : the current (A) or (Amps)

L is the length of the wire in the field (m)

HT The Motor

The forces on the sides of the coil cause it to turn. The split ring commutator and brush contacts maintain an electrical contact, switching the current direction in the coil every half turn. Without these the coil would come to rest in a vertical position



The force on a motor can be increased by: increasing the strength of the magnetic field increasing the size of the current. This will make it turn faster. The direction it turns can be changed by reversing the current or the magnets

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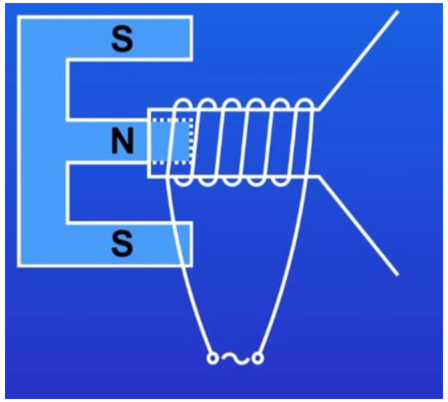
Topic 7 – Magnetism and Electromagnetism Physics only content

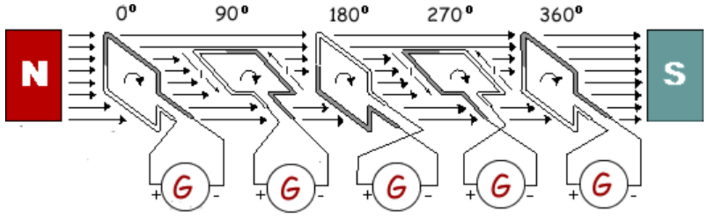
Loud speakers and headphones

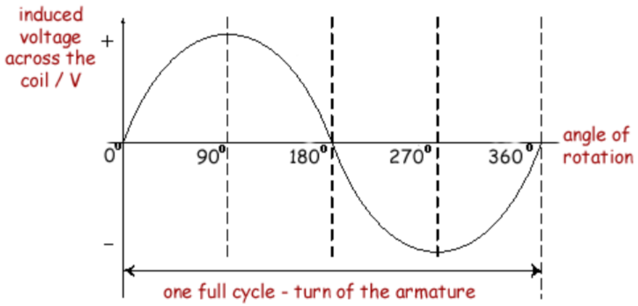
An alternating current flows in the coil, this is in a magnetic field so a force acts on the coil to move it in and out. The vibration of the coil is at the same frequency as the a.c and produces a sound wave also at the same frequency



Generator effect

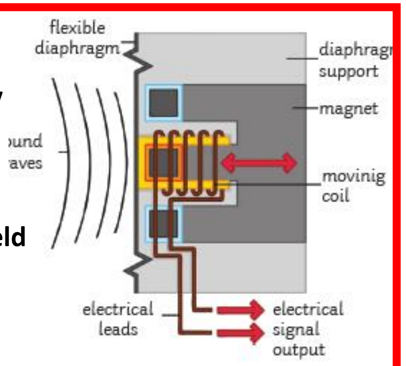
If a magnet is moved into a coil of wire or a coil is turned in a magnetic field then a potential difference is induced across the ends of the coil.
Dynamos generate d.c
Alternators generate a.c





Microphones

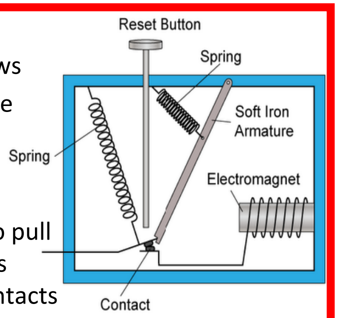
These work the opposite way to loudspeakers. The sound wave causes a flexible diaphragm to vibrate, this moves a coil in a magnetic field and this generates a.c of the same frequency as the sound wave



Use of electromagnet 1 : Circuit Breaker

Turns off a circuit if too much current flows

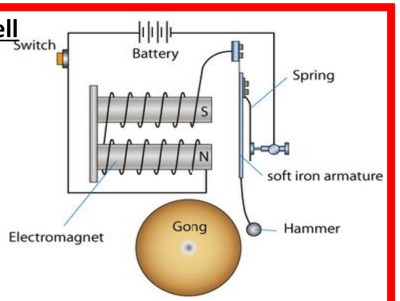
- The electromagnet turns on when the circuit is made
- It attracts the iron armature
- If the current gets too high the electromagnet gets strong enough to pull the armature away from the contacts
- The large spring can now pull the contacts apart breaking the circuit



Use of electromagnet 2 : Electric Bell

Uses a make and break circuit

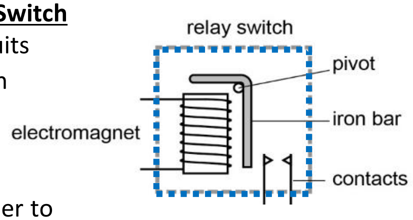
- The electromagnet turns on
- It attracts the iron armature
- Which pulls the hammer to strike the bell
- Breaking the contacts
- Turning off the electromagnet
- The spring pulls the armature back to make the circuit again



Use of electromagnet 3 : Relay Switch

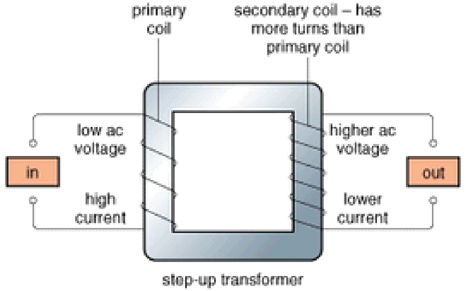
Used to control high power circuits

- The electromagnet turns on
- Attracts the iron bar
- Which rocks on the pivot
- Pushing the contacts of the higher power circuit together to turn it on

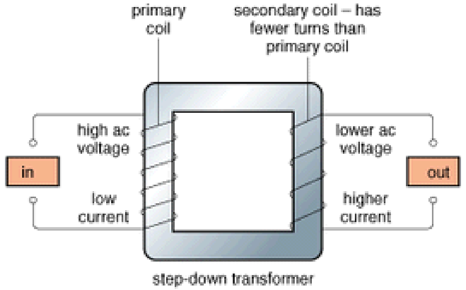


Transformers

- The transformer has an iron core which is easily magnetized
- An alternating current is provided to the primary coil
- This induces a changing magnetic field in the iron core
- This induces an alternating current in the secondary coil



In a step-up transformer the potential difference across the secondary coil is more than the potential difference across the primary coil.



In a step-down transformer the potential difference across the secondary coil is less than the potential difference across the primary coil.

Transformer equation:

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

Vp and Vs are the primary and secondary potential differences

Np and Ns are the primary and secondary turns on the coils

If transformers are 100% efficient, the electrical power output would equal the electrical power input (Watts) P=V x I

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

Ip and Is : primary and secondary current in the coils

The National Grid: Transformers are used in the national grid. A step up transformer increases the p.d before the electricity is transmitted across the country. This reduces the current in the transmission cables. A low current means less heat is generated and so less energy is lost due to heating in the cables.

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Topic 8– Space Physics (Physics only content)

The Sun and our Solar System

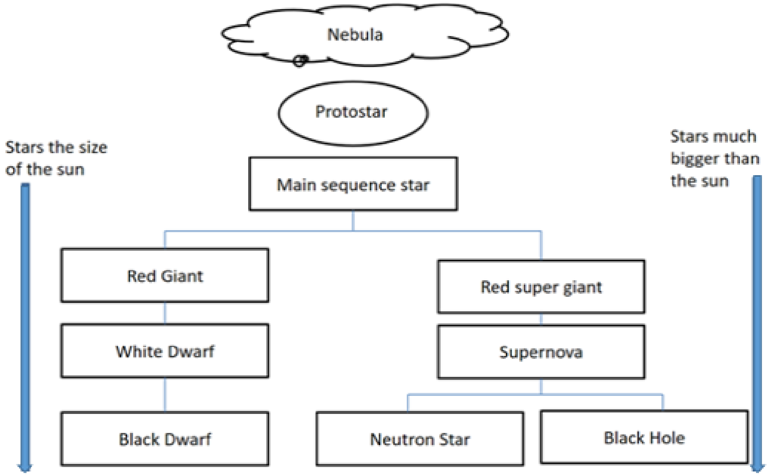
Within our solar system there is one star, the Sun, plus the eight planets and the dwarf planets that orbit around the Sun. Natural satellites, the moons that orbit planets, are also part of the solar system.

The Milky way Galaxy.

Our solar system is a small part of the Milky Way galaxy, a spiral system that contains 100 billion stars. Our sun is near the end of one of the spiral arms.

Satellites

Man made satellites are used for weather and communications and are placed in orbit around the earth.
A planet is a natural satellite of a star.
A moon is a natural satellite of a planet.
Gravitational forces keep objects in their circular orbits.
The larger the circular orbit then the slower the speed of the satellite Eg. Mercury moves with the greatest speed and Neptune the slowest
For a stable orbit, the radius must change (increase) if the speed changes (decreases). Satellites in a higher orbit travel more slowly.



Nebula

A region of dust and gas in space.

Protostar

Dust and gas in a nebula are pulled together by gravity. This forms a protostar. No nuclear fusion reactions happen yet.

Main Sequence Star

Gravitational forces have now pulled so much dust and gas together with so much force that nuclear fusion reactions start, where Hydrogen and Hydrogen nuclei are joining together to make Helium nuclei. Heat and light are given off. This is a very stable state which could continue for several billion years. The fusion reactions lead to an equilibrium between the gravitational collapse of a star and the expansion of a star due to fusion energy.

Red Giant

Stars the same size as the sun will start to run out of hydrogen nuclei. The nuclear fusion reactions slow and helium nuclei are now fusing to form heavier elements (up to iron). The star swells, cools and becomes red in colour.

Red Super Giant

Stars bigger than our sun will also start to run out of hydrogen nuclei and form all the elements up to iron. They will then swell, cool and become in red colour and eventually collapse in a more dramatic way as a supernova

White Dwarf

Eventually the smaller nuclei in the core run out and the fusion reactions stop. It collapses in on itself causing it to heat up again. Its colour changes from red to yellow to white. It is hotter, denser and smaller in diameter than it was.

Black Dwarf

Finally a white dwarf will cool down and stop giving off any light.

Supernova

When a Red super giant collapses dramatically, its compression suddenly reverses in a supernova explosion. In this event all the elements heavier than iron are made. All the elements are spread out across space.

Neutron star

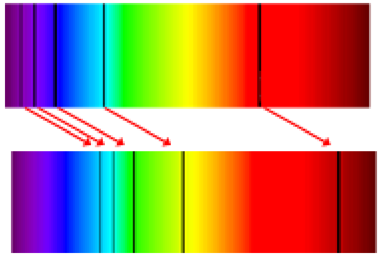
What's left of the core after a supernova explosion is compressed into an incredibly dense object made of only neutrons.

Black hole

If the star was massive enough then the collapse of its core continues and forms a black hole. Gravity is so high that not even light can escape it.

Red shift

As a galaxy moves away from observers on earth, its light becomes longer in wavelength this means its light is shifted towards the longer, red waves. This can be shown in absorption spectra, where the dark lines are shifted towards the red



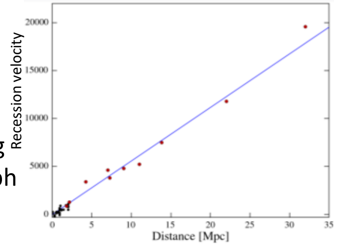
Spectra of Light from our sun

Spectra from a distant galaxy is red shifted

Red shift can only be explained if whatever you are looking at is moving away from you. If all the galaxies are moving away from each other then the universe must be expanding.

The Expanding Universe

The further the galaxies are, then the faster they are moving away (receding) and the greater the red shift. This is evidence that the universe is expanding and supports big bang theory. This graph shows recession velocity increases with distance



Big Bang Model The universe began from an initial small point, which was extremely hot and dense, 13.7 billion years ago and it has been expanding ever since. Scientists use observations such as Red Shift and CMBR to provide evidence to support this theory

CMBR Cosmic Microwave Background Radiation: this was detected and explained as the high energy gamma radiation which was emitted at the start of the universe. The universe has been expanding ever since and so has the radiation, it has been stretched into the microwave region. Scientists are able to use evidence like this and red shift to arrive at theories such as the big bang theory

Dark mass and Dark Energy There is still much that scientist can't explain about the universe and are developing new theories such as dark mass and dark energy to explain observations.