# O' Level Physics Theory Facts

## Appendix: 101 'Facts to Know'

**1. State what is meant by scalar and vector quantities and give common examples of each.**

A **scalar** is a quantity having magnitude only. E.g.: length, distance, volume, density, mass, time, speed.

A **vector** is a quantity having both magnitude and direction. E.g.: weight, displacement, force, velocity, acceleration.

**2. State what is meant by speed and velocity.**

**Speed** is the rate of change of distance. **Velocity** is the rate of change of displacement.

**3. State what is meant by uniform acceleration.**

**Uniform acceleration** is a constant rate of change of velocity.

$$\text{Uniform acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

**4. Describe the motion of bodies with constant weight falling**

**(i) with air resistance,**
**(ii) without air resistance.**

**With air resistance**, the falling object's acceleration will start to decrease from 10 $m/s^2$ until the acceleration reaches 0 $m/s^2$. From then on, the object will fall at the final speed constantly. **Without air resistance**, the falling object's gravitational will always be 10 $m/s^2$.

**5. What are the effects of balanced and unbalanced forces on a body?**

**Balanced forces** do not produce a resultant force.

When balanced forces act on a stationary object, the stationary object will continue to be stationary. When balanced forces act on a moving object, the moving object will continue to move at its constant speed.

**Unbalanced forces** produce a resultant force.

When unbalanced forces act on a stationary object, the stationary object will start to move with acceleration.

When unbalanced forces act on a moving object, the object will move with either acceleration or deceleration (depending on the direction of resultant force) or change its direction of motion

**6. Describe the ways in which a force may change the motion of a body.**

A force can make a stationary object move as well as to make a moving object stop.

A force can change the speed of a moving object.

A force can change the direction of a moving object.

**7. Explain the effects of friction on the motion of a body.**

Friction is caused by the interlocking of irregularities between two surfaces. It therefore always opposes motion.

It will cause
- an accelerating object to move with lower acceleration.
- an object moving with constant speed to decelerate.
- a decelerating object to move with higher deceleration.

**8. State what mass is.**

**Mass** is a measure of the amount of matter in a body.

**9. What is gravitational field?**

A **gravitational field** is a region in which a mass experiences a force due to gravitational attraction.

**10. Define gravitational field strength.**

The **gravitational field strength** at any point in a gravitational field is the gravitational force per unit mass exerted on any bodies.

**11. State the principle of moments for a body in equilibrium.**

For a body to be in equilibrium, the sum of clockwise moments about any point is equal to the sum of anti-clockwise moments about the same point.

**12. Describe qualitatively the effect of the position of the centre of gravity on the stability of a simple object.**

To increase the stability of an object, the centre of gravity should be as low as possible.

To increase the stability of an object, the centre of gravity should be as close to the centre of the body as possible.

**13. Define pressure.**

**Pressure** is force acting normally per unit area.

(Pressure = Force ÷ Area)

**14. State the principle of conservation of energy.**

The **principal of conservation of energy** states that energy cannot be created or destroyed. It can only change from one form to another or from one object to another.

**15. State the formulae for kinetic energy and gravitational potential energy.**

**Kinetic energy** $E_k = ½ mv^2$

**Gravitational potential energy** $E_g = mgh$ (for potential energy changes near the Earth's surface)

**16. Describe qualitatively the molecular structure of solids, liquids and gases, relating their properties to the forces and distances between molecules and to the motion of the molecules.**

**Solid**

The intermolecular forces between the molecules are very strong compared to the kinetic energy of the individual molecule. The intermolecular forces between molecules are so strong that the molecules are closely packed and can only vibrate and rotate about a fixed positions.

Hence, solid have high density (closely packed), negligible compressibility, and they have fixed shape and fixed volume (strong bond between molecules).

**Liquid**

When solids gain energy, they melt to liquid state. In the liquid state, the molecules are packed slightly further apart than those in solids. The intermolecular forces can keep the molecules together but not able to hold them at fixed positions. The molecules can vibrate, rotate and move in clusters throughout the liquid bumping into each other. Hence, liquid have moderate to high density, negligible compressibility, and have fixed volume but no fixed shape.

**Gas**

The molecules gain enough energy and liquid vaporises to gaseous state. Intermolecular forces are very weak as compared to the kinetic energy of individual molecules. The molecules are far apart and have unrestricted movement. They can vibrate, rotate and move around freely. Hence, gases have low density, high compressibility, and do not have fixed volume and fixed shape.

**17. What can be inferred from Brownian motion experiment?**

In the experiment, bright specks are seen darting around in a random motion when viewed under a microscope. The bright specks are the illuminated smoke particles. They are unevenly bombarded by numerous air particles which are also moving in a random motion. The air particles are too small to be seen by the microscope and therefore their random motion is inferred by the motion of the smoke particles.

**18. Describe the relationship between the motion of molecules and the temperature.**

When the temperature is increased, the molecules gain kinetic energy. The increase in kinetic energy makes the molecules move faster and increases their separation slightly (known as expansion).

**19. Explain the pressure of a gas in terms of motion of its molecules.**

A gas is made up of many molecules that are in continuous random motion, colliding with one another and with the inner walls of the container.

When the molecules strike and rebound the walls, each molecule exerts a force on the wall for a very small time interval. All these forces add up to produce a total force on the walls.

The force per unit area is the pressure exerted by the gas on the walls of the container.

**20. Describe in molecular terms, how energy transfer occurs in solids.**

The molecules at the hotter part of the solid vibrate vigorously. They collide with the slower moving molecules in the colder part of the solid. As the molecules collide, the faster molecules transfer some of their kinetic energy to the slower molecules. The slower molecules gain more thermal energy and collide with other molecules in the colder part of the solid. This process continues until heat from the hotter part spreads to the colder part.

**21. Describe in terms of density changes, convections in fluids (liquid or gas).**

When the fluid at the bottom of a container is heated, it expands (particles move slightly apart). The fluid is now less dense than the surrounding fluid and therefore starts to rise. In doing so, the cooler region of the fluid in the upper part of the flask descends. This movement of the fluid due to difference in density sets up convection current.

**22. What are the factors affecting heat transfer by radiation?**

Heat transfer by radiation does not require a material medium. The rate of energy transfer is affected by

(1) colour and texture of the surface,
(2) surface temperature,
(3) surface area.

**23. Explain how a physical property which varies with temperature may be used to define temperature scales and state examples of such properties.**

When a physical property changes with temperature, two fixed points (say $P_1$ and $P_2$) can be obtained at two standard temperatures (say $T_1$ and $T_2$). By taking $(P_2 - P_1) / (T_2 - T_1)$ as the change in property corresponding to per unit temperature change, a series of divisions on the temperature scale can be defined.

Examples of physical properties which vary with temperature are:

- volume of fixed mass of liquid (liquid-in-glass thermometer)
- pressure of a fixed mass of gas (constant volume gas thermometer)
- electrical resistance of certain material (resistance thermometer, thermistor)
- e.m.f. of certain combination of electrical wires (thermocouple)

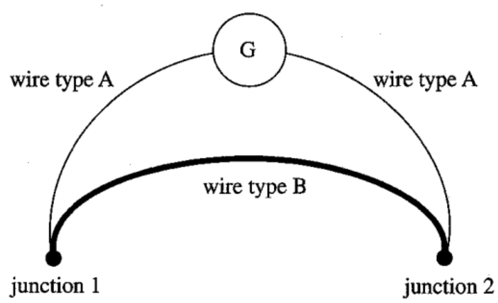
**24. Explain the need for fixed points and state what is meant by ice and steam points.**

**Fixed points** are needed to calibrate thermometers.

**Steam point** is the temperature at which pure water boils at one atmospheric pressure and is assigned the value of 100°C.

**Ice point** is the temperature at which pure ice melts at one atmospheric pressure and is assigned the value of 0°C.

**25. Sketch a simple thermocouple and explain how it can measure high temperature and rapidly changing temperature.**




A **thermocouple** is made by joining two wires of different conducting materials at the ends to form two junctions as shown above.

E.m.f. is induced across the two junctions when there is a temperature difference across the two junctions.

The induced e.m.f. is proportional to the temperature difference across the junctions.

**26. Explain how a simple thermocouple can measure high temperature and rapidly changing temperature.**

The two types of metal wire selected normally have high melting points. The thermocouple will fail if the surrounding temperature cause any of the wires to melt.

The junctions are very small masses of welded metals. Due to the small mass, each junction has small heat capacity and therefore can respond quickly to temperature change (able to reach thermal equilibrium quickly with the environment).

**27. Describe the rise in the temperature of a body in terms of an increase in its internal energy (random thermal energy).**

When the temperature of a body rises, its particles move faster. The increase in kinetic energy of the particles resulted in a gain in the internal energy of the body as internal energy is the sum of kinetic energy and potential energy of the body.

**28. Define the terms heat capacity and specific heat capacity.**

**Heat capacity** of a body is defined as the amount of energy required to raise its temperature by one degree (or one kelvin).

**Specific heat capacity** of a body is defined as the amount of energy required to raise the temperature of one kilogram of the body by one degree (or one kelvin).

**29. Describe melting/solidification and boiling/ condensation.**

**Melting** is the process whereby solid changes to liquid at constant temperature.

**Freezing** is a process whereby liquid changes to solid at constant temperature.

**Boiling** is a process whereby liquid changes to gas at constant temperature.

**Condensation** is a process whereby gas changes to liquid at constant temperature.

**30. Define the terms latent heat and specific latent heat.**

**Latent heat** of a substance is defined as the amount of energy required to change the state of the substance without a temperature change.

**Specific latent heat** of a substance is defined as the amount of energy required to change the state of a unit mass (1 kg) of the substance without a temperature change.

**31. Explain latent heat in terms of molecular behaviour.**

**Latent heat** is absorbed or given out when a substance undergoes state change. When an object loses latent heat, the average distances between the particles decreases. When an object gains latent heat, the average distances between the particles increases. The average kinetic energy of the molecules does not change and therefore the temperature of the object remains constant.

**32. State the differences between boiling and evaporation.**

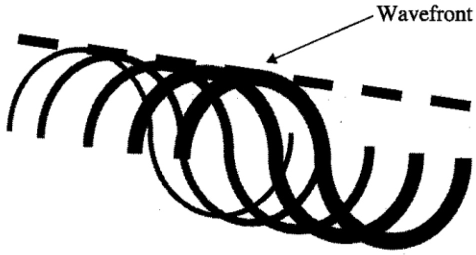
| Boiling | [illegible] |
|---|---|
| - Quick process<br>- Bubbles formed<br>- Occurs throughout liquid<br>- Occurs at one temperature (boiling point)<br>- Source of energy needed (Heating required) | - Slow process<br>- Nothing visible happens<br>- Occurs at surface only<br>- Occurs at all temperatures<br>- Energy comes from surrounding (No heating required) |

**33. What is a wave motion?**

A wave motion is a disturbance that transfers energy from one point to another.

**34. State what is meant by the term wavefront.**

Wavefront is an imaginary line joining points having the same phase on the wave.




**35. Define speed, frequency, wavelength, period and amplitude.**

**Speed** of a wave is the distance travelled by the wave in per unit time.

**Frequency** of a wave is the number of complete waves produced per second.

**Wavelength** of a wave is the minimum distance at which the wave repeats itself. It can be taken as the distance between two successive crest (or troughs).

**Period** of a wave is the time taken for one complete vibration of a particle. It is also the time taken to produce one complete wave.

**Amplitude** of a wave is the maximum displacement of a particle from its resting position.

**36. Compare transverse and longitudinal waves and give suitable examples.**

| [illegible] | [illegible] |
|---|---|
| Travel in a direction that is perpendicular to the direction of vibration | Travel in a direction that is parallel to the direction of vibration |
| Not all transverse waves require a medium to travel. Some can travel through vacuum, e.g. electromagnetic waves | Require a medium to travel |
| Examples of transverse waves: water waves, rope waves and electromagnetic waves. | Examples of longitudinal waves: sound waves and slinky coil waves. |

**37. Define the following terms used in reflection:**

**(i) normal,**
**(ii) angle of incidence,**
**(iii) angle of reflection.**

**Normal** is an imaginary line perpendicular to the surface where the reflection occurs.

**Angle of incidence** is the angle between incident ray and normal. **Angle of reflection** is the angle between reflected ray and normal.

**38. What is reflection?**

**Reflection** is the sudden change in the direction of propagation of light rays that strike the boundary between different mediums where the angle of incidence is equal to the angle of reflection.

**39. State the law of reflection.**

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

**40. Define the following terms used in refraction:**

**(i) normal,**
**(ii) angle of incidence,**
**(iii) angle of refraction.**

**Normal** is an imaginary line perpendicular to the interface of the media where the refraction occurs.

**Angle of incidence** is the angle between incident ray and normal. **Angle of refraction** is the angle between refracted ray and normal.

**41. What is refraction?**

**Refraction** is the bending of light when it passes from one medium to another. It is caused by the change in speed while crossing the boundary between two mediums.

**42. Define refractive index of a medium.**

**Refractive index** of a medium is the ratio of the speed of the light in vacuum and the speed of light in the medium.

**43. Define the term critical angle and total internal reflection.**

**Critical angle** is an angle of incidence in the optically denser medium which causes the angle of refraction in the less dense medium to be 90°.

When light travels from an optically denser medium to an optically less dense medium with the angle of incidence greater than the critical angle, all the light is reflected back into the optically denser medium. This is known as **total internal reflection**.

**44. What are optical fibres? How does it work?**

**Optical fibres** (or light pipes) are very fine, optically pure glass fibre through which light can be used (via total internal reflection) to transmit data from one end to the other.

**45. What are the advantages of using optical fibres as compared to cables?**

Optical fibres can carry faster data in the form of light pulses faster than metal cables which carry data in the form of fluctuating electric current.

Optical fibres are also lighter and therefore easier to handle than heavy metal cables.

**46. Describe the action of a thin lens on a beam of light.**

A lens is a piece of clear plastic or glass with curved surface. When a beam of light falls on one side of a thin lens, the rays are refracted.

For a converging lens, the light rays may either converge or diverge on the other side of the lens.

For a diverging lens, the light rays can only diverge on the other side of the lens.

**47. Define the term focal length.**

**Focal length** is the distance between the optical centre and the principal focus.

**48. What are electromagnetic waves?**

**Electromagnetic waves** are transverse waves that travel with the same high speed of ($3.0 \times 10^8$ m/s) in vacuum. The electromagnetic waves consist of radio wave, microwave, infrared radiation, visible light, ultraviolet ray, X-ray and gamma ray.

**49. Describe the main components of electromagnetic spectrum.**

**Gamma rays** are the highest-energy electromagnetic waves and are able to penetrate matter easily. Gamma rays have the shortest wavelengths and highest frequencies. Radioactive substances may emit gamma rays. Gamma ray is used to kill cancerous cells and to sterilise medical equipment in hospital.

**X-rays** are has high penetration ability. X-rays may be produced by X-ray tubes. It is used in hospital for X-ray radiography to view bone structure.

**Ultraviolet (uv) radiation** is produced from very hot bodies, such as the Sun and a particular mercury lamp. The atmosphere blocks most of the ultraviolet radiation from the Sun. Ultraviolet radiation also causes sunburn. It is used in the bank to detect fake notes.

**Visible light** is the only electromagnetic radiation that is visible to our eyes. It is produced from the Sun and other very hot bodies. It is made up of violet, indigo, blue, green, yellow, orange and red colours.

**Infra-red radiation** may be produced by any hot bodies. It is readily absorbed by matter and raises their temperature. We receive heat from the Sun through infrared radiation.

Special electronic devices known as klystron valves may be used to generate **microwave** radiation. It is used to heat up food in microwave ovens.

**Radio waves** have the longest wavelengths, from a few centimetres to thousands of metres. We receive radio and TV programmes through the transmission of radio waves.

**50. Describe the effects of absorbing electromagnetic waves by human beings.**

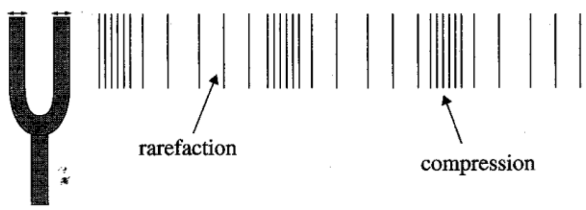
When high frequency electromagnetic waves such as X-rays and gamma rays are being absorbed by a human, the particles of the human will be ionised which results in the destruction or the modification of living tissues.

When low frequency electromagnetic waves such as radio waves, microwaves, infrared radiation, visible light and ultraviolet rays are being absorbed by human, the particles of the human body will vibrate faster and heat up.

**51. Describe the production of sound by vibrating sources.**

A vibrating object will alternately push and pull the air particles adjacent to it. This creates small but rapid changes in air pressure. The changes in air pressure create sound waves.

**52. Describe the propagation of sound waves in terms of the processes of compressions and rarefaction.**




When an object, say a tuning fork vibrates outwards, a compression (a region where air pressure is slightly higher than the surrounding air pressure) is formed as layers of air are pushed together.

When the tuning fork vibrates inwards, a rarefaction (a region where air pressure is slightly lower than the surrounding air pressure) is formed as layers of air are pulled apart.

The air molecules push one another and move the compression and rarefaction away from the source.

**53. Explain why sound cannot pass through vacuum and why the speed of sound differs in different medium.**

Sound waves cannot travel through vacuum because there are no particles to pass on the energy.

Sound is transmitted through collisions between adjacent particles.

When the particles in the medium are closely packed, sound energy can be passed from particles to particles much faster.

When particles are held together by strong forces of attraction, they quickly return to the original positions and can vibrate faster. Thus the speed of sound is higher in mediums like steel and lower in mediums like water.

In general, the bond strength between particles in solid materials is much greater than in gases.

As a result, the speed of sound in solid is generally much higher than in liquid and the speed of sound in liquid is generally higher than in gas.

- Speed of sound in air = 330 m $s^{-1}$
- Speed of sound in water = 1500 m $s^{-1}$
- Speed of sound in steel = 5000 m $s^{-1}$

**54. Describe a direct method to determine the speed of sound in air.**

Apparatus: Pistol, stopwatch

1. Observer A and B are positioned at a distance, s, far apart. (The distance s must be far enough to minimise human reaction error.) Measure and record *s*.
2. Observer A fires a pistol.
3. Observer B starts the stopwatch on seeing the flash of the pistol and stops the stopwatch when he hears the sound. The time interval, *t*, is recorded.

4. The speed of sound, v, can be calculated by

$$\text{Speed} = \frac{\text{distance}}{\text{time}} = \frac{S}{t}$$

Note:

a) For better accuracy, the experiment is repeated and the average speed of sound can be calculated.

b) The experiment is repeated by interchanging the positions of observers A and B as to minimise the effect of wind.

**55. Explain how the loudness and pitch of sound waves relate to amplitude and frequency.**

The loudness of sound depends on the amplitude. An increase in amplitude increases the loudness of the sound.

The pitch of a sound depends on its frequency. A high pitch corresponds to a high frequency and a low pitch corresponds to a low frequency.

**56. Describe how the reflection of sound may produce an echo.**

Sound waves obey the laws of reflection. When sound waves are reflected by objects, the reflected sound is known as echo. Echo will be strong if the reflecting surface is large and hard.

**57. Describe how echo may be used for measuring distances.**

When a source emits a sound and receive the echo, the sound must have travelled $2d$ where d is the distance between the source and the reflected surface.

If the time taken for the sound to travel to and fro ($2d$) is measured and recorded as $t$, and the speed of sound in that particular medium is known as $v$, $d$ can be calculated using $d = \frac{v \times t}{2}$.

**58. Define ultrasound and describe one use of ultrasound.**

Ultrasound is sound with frequencies higher than 20 000 Hz.

Using ultrasound, delicate machinery can be cleaned without dismantling it. The machinery is immersed in a tank of liquid and vibrations of high powered ultrasound are used to dislodge the bits of dirt and grease.

In hospitals, concentrated beams of ultrasound can be used to break up kidney stones and gall stones without patients needing surgery.

Pregnant women go for ultrasound scans to see images of their babies and for doctors to detect birth defects.

**59. Explain how electrostatic charge is produced by rubbing.**

Electrostatic charge is produced by rubbing two insulated materials.

Electrons are being dragged off from one material to another by friction between the two materials.

The material which gains electrons is negatively charged and the material that losses electrons is positively charged.

The electrostatic charge stays at the area where rubbing occurs because it is not able to spread as both materials used are insulators.

**60. What are the two types of charges and the unit of charge?**

They are positive and negative charges. The unit is coulombs.

**61. What is the basic law of electrostatics?**

Unlike charges attract and like charges repel.

**62. Describe an electric field.**

An electric field is a region in which an electric charge experiences a force.

**63. Distinguish between electrical conductor and insulators and give typical examples of each.**

Materials that allow electrons to flow through them easily are called electrical **conductors**. In metals, outermost electrons in each atom are so loosely held that they are able to move freely between atoms. These free electrons make metals very good electrical conductors.

Materials, which do not conduct charges, are called non-conductors or **insulators**. Their electrons are all tightly held to atoms and are not normally free to move. Examples of insulators are rubber, glass, most plastics, dry wood and dry air.

**64. Describe examples in which electrostatic charging is a potential hazard.**

Lightning

In thunderstorm, the clouds are charged by friction with air current. Electrons are deposited at the bottom of the cloud and induced a strong positive charge at the Earth surface. The strong attractive force on the air molecules pulls the electrons from the air molecules and causes a avalanche of electrons rushing at high speed towards the Earth. The lightning flash produced is so powerful that it can burn forests, damage houses and kill people.

Fire and Explosion

A spark may appear near a charged object. If there is a nearby inflammable liquid, the spark can cause fire or even explosions. This is extremely dangerous.

**65. Describe an example of the use of electrostatic charging such as a photocopier, spraying of paint or an electrostatic precipitator.**

Photocopier

A light sensitive drum is first coated with positive charges.

The shadow of the printing material is being cast onto the drum by strong light.

The area exposed to the light is being discharged, whereas the shaded area retained the positive charges.

Negatively charged powder (toner) is sprayed onto the drum. The light powder is attracted to the positively charged region only.

The toner on the drum is then rolled onto a piece of paper.

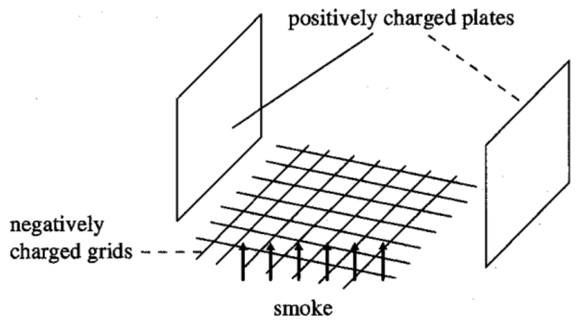
The paper is being heated to melt the toner to stay permanently on the paper.

Spray painting

In spray painting, particles of paint are given positive charges as they leave the nozzle of a spray gun. The object to be painted is earthed so that there is an electric field between the nozzle and the object. The charge paint droplets follow the field lines and are deposited evenly over the surface of the object.

Electrostatic precipitator

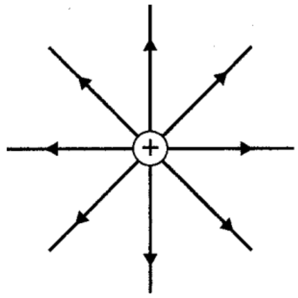
1. Precipitator is used to remove dust particles from the smoke in a factory chimney.
2. Convection current causes the smoke to rise. Smoke first passes through the negatively charged grid, making the dust particles negatively charge.
3. Positively charged plates are placed above the grid. Negatively charged smoke particles are attracted to the walls and the air that goes to the environment is thus less polluted.



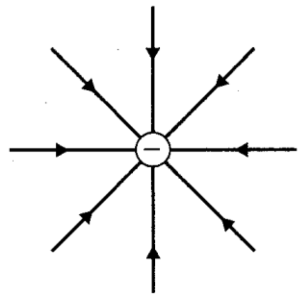

**66. Sketch the electric field**

**(i) of a single positive point charge,**
**(ii) of a single negative point charge,**
**(iii) between two oppositely charged plates,**
**(iv) between two point charges of the opposite charge and**
**(v) between two point charges of the same charge.**

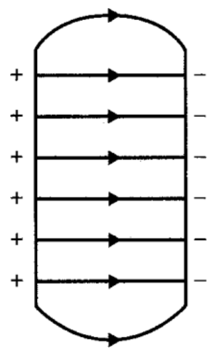
Single positive point charge



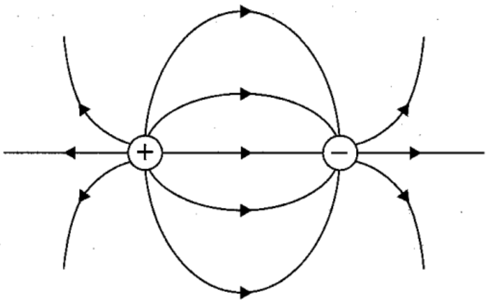
Single negative point charge



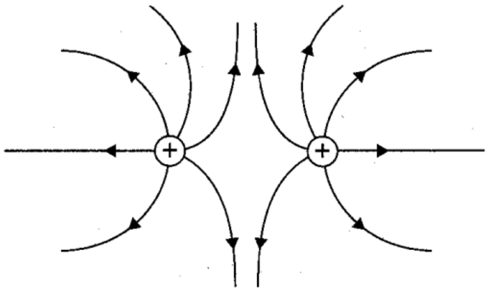
Between two oppositely charged plates



Two point charges of the opposite charge



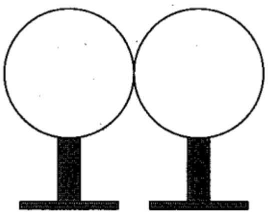
Two point charges of the same charge



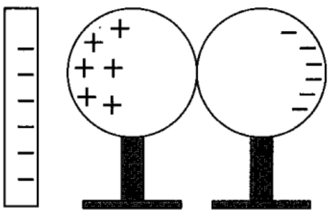
**67. Describe experiments to show electrostatic charging by induction.**

With two conducting spheres

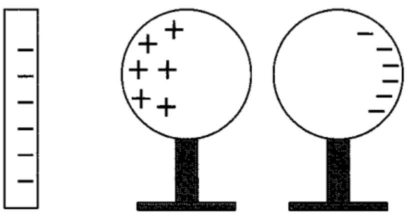
1. Place two uncharged conducting spheres in contact.



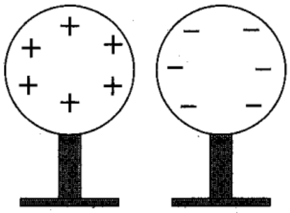
2. Place a negatively charged object near one sphere. Many electrons in the conducting sphere nearer to the charged object are repelled into the other conducting sphere.



3. Separate the two spheres without removing the negatively charged object.

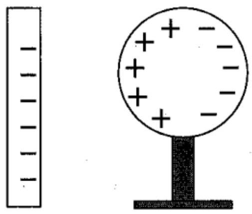


4. The sphere previously nearer to the negatively charged object is positively charged and the other is negatively charged.

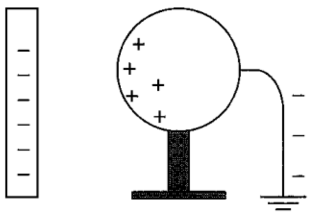


With one conducting sphere

1. Place a negatively charged object near an uncharged conducting sphere. The electrons in the conducting sphere will be repelled to the further end of the sphere.

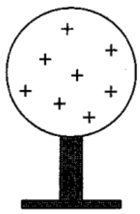


2. Earth the sphere momentarily (touch and remove). The electrons will flow out of the sphere to the Earth.



Electrons flow to the Earth

3. Remove the negatively charged object.
4. The sphere is now positively charged.



**68. What is current and its units?**

Current is the rate of flow of charge. It is measured in amperes.

**69. Distinguish between conventional current and electron flow.**

Electric current is the flow of electrons along the connecting wires in a circuit. The electrons flow from negative to positive of the power supply.

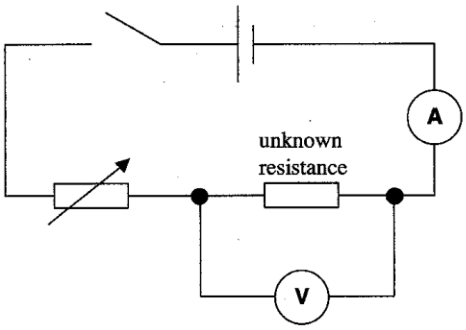
The direction of the convectional current is always treated as the opposite direction to the electron flow.

**70. Describe an experiment to determine the resistance of a metallic conductor using a voltmeter and an ammeter.**

Apparatus: Voltmeter, ammeter and variable resistor (rheostat).

1) Ammeter is used to measure the current and must be connected in series in a circuit.
2) Voltmeter is used to measure the potential difference (V) between two points in a circuit and must be connected in parallel to the unknown resistor.
3) Variable resistor is adjusted to change the current and thus the p.d. across the resistor.

Procedure:




1) Set up the apparatus as shown.
2) Adjust the variable resistor to allow the smallest possible current to flow in the circuit ands note the corresponding ammeter reading ($I$) and voltmeter reading ($V$).
3) Adjust the variable resistor in steps to increase current flow in the circuit and note the values of $V$ and $I$ for at least five sets of readings.
4) Plot the graph of $V$ against $I$. The graph plotted must be a best fit straight line passing through the origin.
5) The gradient of the graph gives the resistance of the metallic conductor.

**71. Define electromotive force (e.m.f.) and potential difference across a component in a circuit.**

**Electromotive force (e.m.f.)** is the work done by a source in driving a unit charge around a complete circuit.

**Potential difference** across a component in a circuit is the work done to drive a unit charge through the component.

**72. State Ohm's law.**

Ohm's law states that the current through a metal conductor is directly proportional to the potential difference across the ends of the conductor provided that the physical conditions and the temperature remain constant.

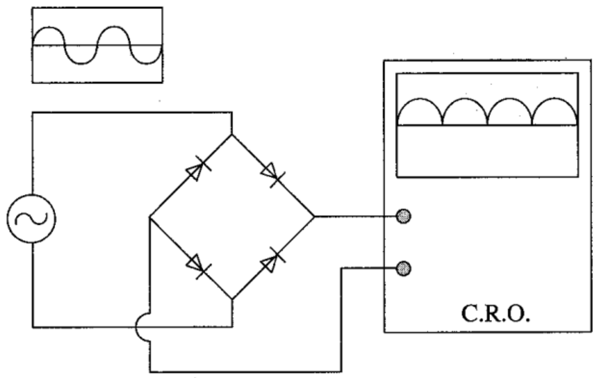
**73. Describe the effect of temperature increase on the resistance of a metallic conductor.**

When the temperature of a metallic conductor increases, the particles in the metallic conductor vibrate faster and thus obstruct the flow of the moving electrons more readily. When the electrons are being obstructed and slowed down, it means that the resistance of the metallic conductor has increased.

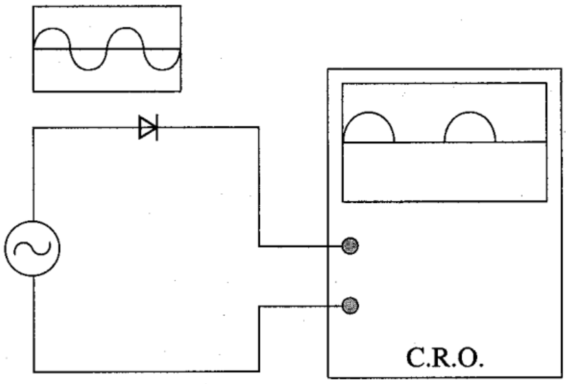
**74. Show the use of diodes as rectifier.**

Rectifier is an electrical device for converting alternating current to direct current.

For a full-wave rectifier circuit, the arrangement is shown below.

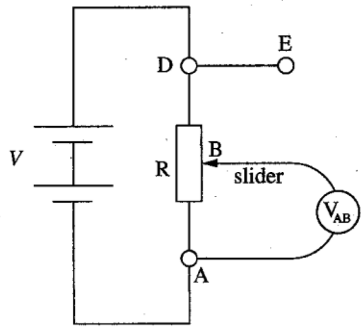


For a half-wave rectifier circuit, the arrangement is shown below.




**75. Describe the action of a variable potential divider (potentiometer).**

In the simple circuit shown, we obtain any voltage between zero and supply voltage, $V_B$ across A and B (i.e. $V_{AB}$) by sliding the contact P along the variable resistor, R.




This arrangement is called potential divider or potentiometer since it can divide the supply voltage in any ratio that is required.

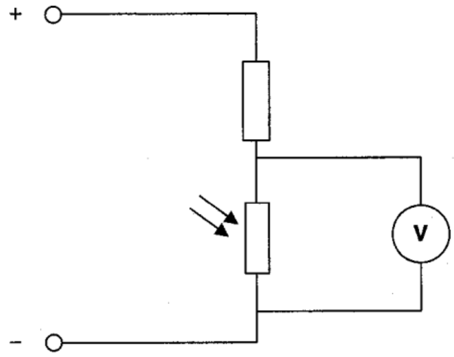
It is very useful in experimental work when we need a variable voltage supply. In electronics, such a circuit is used, for example, as simple volume control in audio amplifier circuits. When we adjust the volume control, we are adjusting the slider.

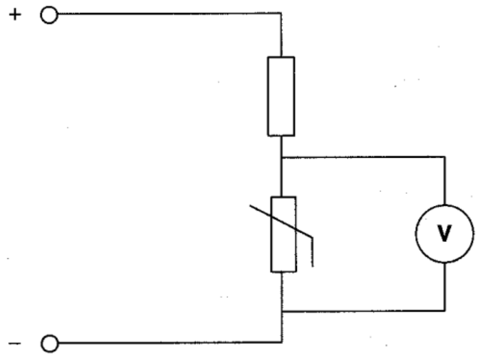
**76. Describe the action of thermistors and light dependent resistors and explain their use as input transducers in potential divider.**

Resistance of a thermistor decreases with increasing temperature.

Resistance of a light-dependent resistor (LDR) decreases with increasing light intensity.

Input transducers are devices that convert physical quantity into electrical quantity. Thermistors and LDRs are such devices. Thermistors or LDRs can be connected in electrical circuit such that when there is a change in temperature or brightness, the resistance of the thermistors or LDRs will change to cause a change in the potential difference across the transducer.




**77. What is the use of a cathode-ray oscilloscope (c.r.o.)?**

A cathode-ray oscilloscope is used to display waveforms and to measure potential difference and short interval of time.

**78. State the characteristics of a parallel circuit.**

The current from the source is the sum of the currents from the branches. The potential differences across the branches are the same.

**79. Describe the use of the heating effects of electricity in appliances such as electric kettles, oven and heaters.**

Electric kettles, oven and heaters are appliances, which make use of the heating effect of an electric current. There is a heating element inside all these appliances. This element is usually made of metal wire with high resistance such as nichrome. Varying the current flowing through the heating element controls the amount of heating produced.

**80. Explain the use of fuses and circuit breakers in electrical circuits and of fuse rating.**

A **fuse** is usually made up of a tin-coated copper wire. When currents exceed its design rating value, the wire will overheat and melt, thus opening the electrical circuit. It will prevent further damage to the appliance or user. It cannot be reused.

A **circuit breaker** is usually made up of a reusable spring-loaded type of switch. The function of the circuit breaker is similar to that of the fuse. If current exceeds its breaking setting, it will spring open and break the circuit as in a fuse. Resetting the spring-loaded switch can reuse the device.

The **fuse rating** is the maximum current that the fuse can carry without melting. The fuse rating should be slightly larger than the normal working current of an appliance.

**81. Explain the need for earthing metal cases and for double insulation.**

**Earth wire** is connected to the metal casing of an electrical appliance. In case of a leakage of electricity, the user may get shock if the live wire is connected to the metal casing. The earth wire (copper wire) allows the current to flow through it to the ground. It can protect the user from fatal electric shock.

**Double insulation** protects the user of the appliance from an electrical shock by preventing any possibility of external casing becoming live, thus eliminating the need for an earth connection. Firstly, the electric cable is insulated from the internal components of the appliance. Secondly, the internal metal parts, which could become live if a fault developed is also insulated from external casing.

**82. State the meaning of the terms live, neutral and earth.**

**Live wire** carries electric current to the appliances.

**Neutral wire** completes the circuit by forming a path for the current back to the mains. It is usually at zero volts.

**Earth wire** is low resistance; usually connected to the metal casing of the appliances. It forms a safety outlet for current in case of the appliance becomes live.

**83. Explain why switches, fuses and circuit breakers are wired into the live conductors.**

They must be fitted onto the live wire so that when the switch is off or when the fuse/circuit breaker is broken, they disconnect the high voltage from the appliances.

**84. State the properties of a magnet.**

A magnet attracts magnetic materials such as iron, cobalt, nickel and some other alloys such as steel.

A magnet has two poles, the North-seeking pole (N-pole) and the South-seeking pole (S-pole). When suspended freely, N-pole always points towards the north and the S-pole always points towards the south.

Like poles repel and unlike poles attract.

**85. Describe induced magnetism.**

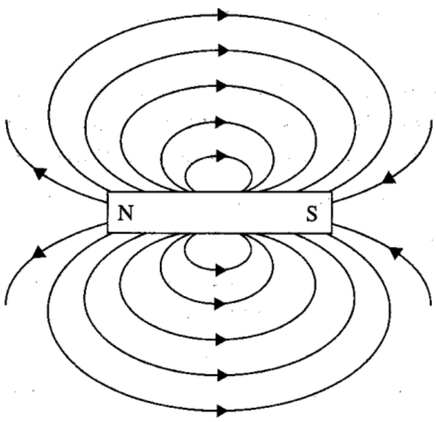
**Induced magnetism** is the temporary magnetisation of a magnetic material when it is placed near to or in contact with a magnet. It is the process of inducing magnetism in a magnetic material.

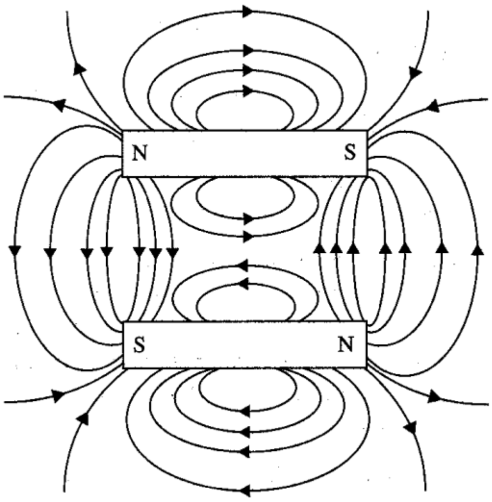
**86. Distinguish between magnetic and non-magnetic materials.**

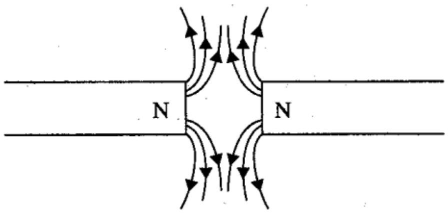
A **magnetic material** is one, which can be magnetised and is attracted to magnets. All magnetic materials contain iron, nickel or cobalt. For example, steel is mainly iron.

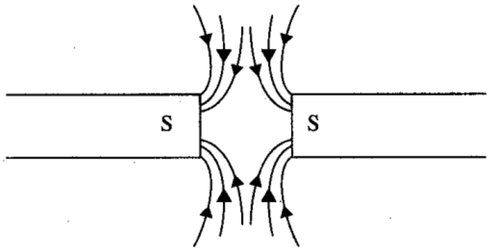
A **non-magnetic material** is one, which cannot be magnetised and is not attracted by magnets, which include metals, such as brass, copper, zinc, tin, and aluminium, as well as non-metals.

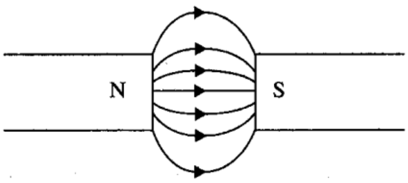
**87. Draw the magnetic field pattern around a bar magnet and between the poles of two bar magnets.**





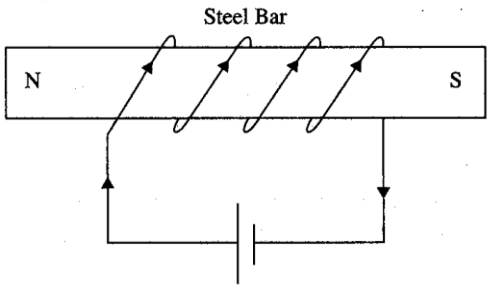




**88. Describe electrical methods of magnetisation and demagnetisation.**

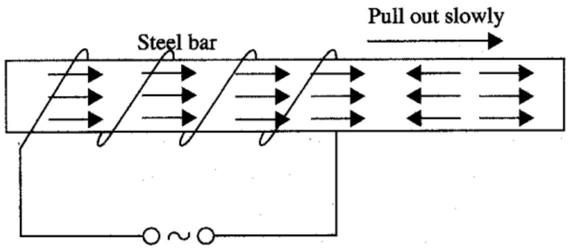
**Magnetisation**

A coil made up of copper wire is connected in series with a battery. The steel bar, which is to be magnetised, is inserted into the coil. A direct current flows through the coil anda magnetic field is produced around it. The magnetic field will magnetise the steel bar.




**Demagnetisation**

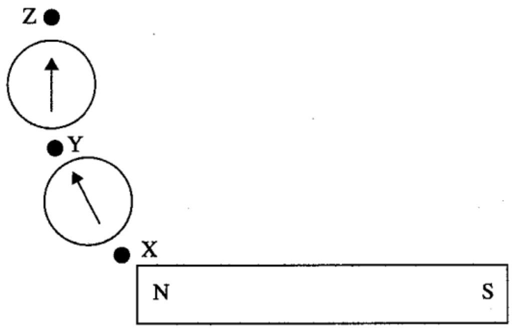
A magnet is inserted into a copper coil. An alternating current flows through the coil. When the magnet is withdrawn slowly from the coil, the magnetic field around the coil causes the magnet to lose its magnetism. This happens because the magnet is constantly being magnetised in opposite direction by the alternating current. As the magnet is being slowly withdrawn from the coil, the dipoles in the magnet will be arranged in different directions, cancelling their magnetic effect.




**89. Describe the plotting of magnetic field lines with a compass.**

Apparatus: Bar magnet, plotting compass, plain paper

Procedure:




1. Place the bar magnet at the centre of the piece of paper so that its North Pole faces north and its South Pole faces south.
2. Place the compass near one pole of the magnet, and mark the positions of the ends N and S of the compass needle by pencil dots as Y and X.
3. Move the compass until one end of the compass needle is exactly over mark Y and mark the new position of the other with a third dot Z.
4. Repeat the above until reaching the other pole. Join the series of dots and this will give a field line of the magnetic field. Use this method to plot other field lines on both sides of the magnet.
5. Indicate the direction of the magnetic field lines as given by the compass needle.

**90. Distinguish between the properties and uses of temporary magnets and permanent magnets.**

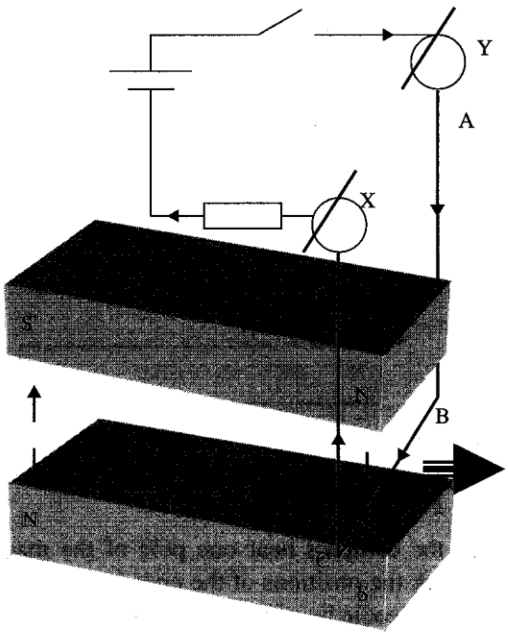
**Temporary magnets** are made from soft magnetic materials such as iron. They can be magnetised and demagnetised easily. They can be magnetised by a weak magnetic field and are used in electromagnets, transformer cores and magnetic shields.

**Permanent magnets** are made from hard magnetic materials such as steel. They are harder to magnetise and demagnetise. They have the ability to retain their magnetism and are used to make permanent magnets such as needle of the plotting compass.

**91. Describe experiments to show the force on a current-carrying conductor, and on a beam of charged particles, in a magnetic field, including the effect of reversing**

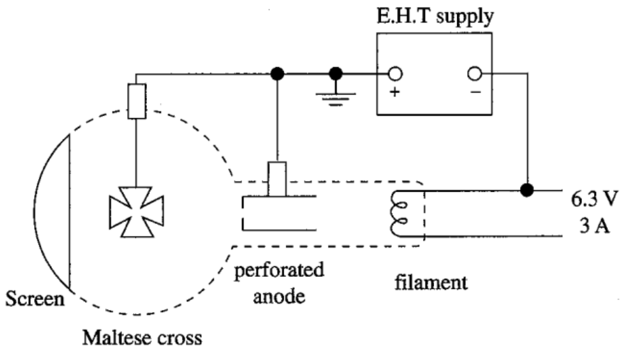
**(I) the current,**
**(II) direction of the field.**

Procedure: Force on a current-carrying conductor

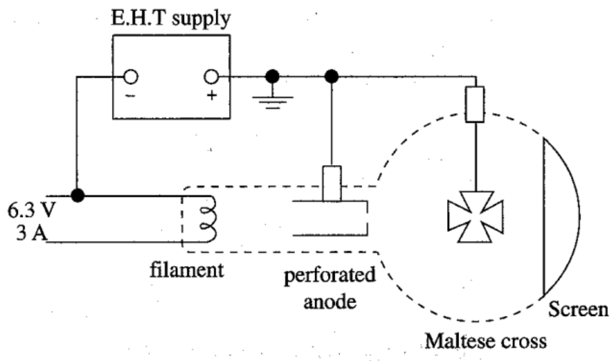



1. Bend a stiff wire ABCD into a U shape and hang it freely on two insulating rods X and Y.
2. Place the bent wire between two unlike poles with BC perpendicular magnetic field lines as shown in the diagram.
3. Close the circuit to allow direct current to flow from B to C.
4. The U-shape wire will swing in a direction perpendicular to the direction of the field and the direction of the current, according to Fleming's left hand rule.
5. When the magnetic field is reversed, the direction of deflection of the U-shaped wire is reversed.
6. When the current direction is reversed, the direction of deflection of the U-shaped wire is reversed.
7. When a beam of moving charged particles enters a magnetic field, there is force acting on the charged particles. They are deflected inside the magnetic field. Fleming's left hand rule can be applied to determine the direction of deflection of the beam of charged particles.
8. When the magnetic field is reversed, the direction of deflection of the charged particles is opposite.
9. When the direction of motion of the charged particles is reversed, the direction of deflection of the charged particles is opposite.

Procedure: Force on a beam of charged particles



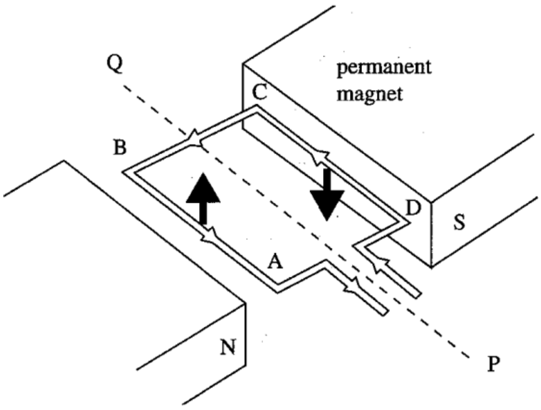

1. Set up the Maltese cross tube as shown to produce a shadow of the cross on the screen.
2. Create a magnetic field perpendicular to the direction of flow of electrons by placing a magnet near the tube.
3. When electrons enter the magnetic field, there are forces acting on the electrons. They are deflected inside the magnetic field. Fleming's left hand rule can be applied to determine the direction of deflection of the beam of electrons. The deflection of the beam is shown by the shift in the shadow of the cross.
4. When the magnetic field is reversed, the direction of deflection of the electrons is opposite.
5. When the direction of motion of the charged particles is reversed by reversing the tube, the direction of deflection of the charged particles is reversed.



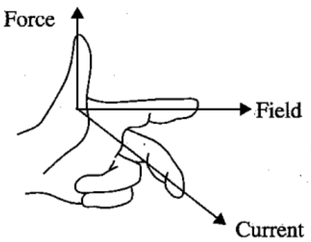

**92. Explain how a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing:**

**(I) the number of turns in the coil**
**(II) the current**

Coil ABCD is placed horizontally in a magnetic field and the coil is free to rotate around axis PQ axis as shown.




Once current passes through the coil (anti-clockwise), the AB and CD part of the current-carrying coil will each experience an equal but oppositely directed force in a magnetic field (shown in the diagram above). AD and BC portions of the coil experience no force, as the directions of the current and magnetic field are parallel to each other.




The direction of the two forces can be deduced using Fleming's left-hand rule.

These two equal forces, acting in opposite directions will start to turn the coil around the axis PQ. Hence the current-carrying coil ABCD experiences a turning effect in a magnetic field .

The turning effect can be increased by either increasing the number of turns on the coil or increasing the current in the coil.

**93. Describe how a d.c. motor work.**

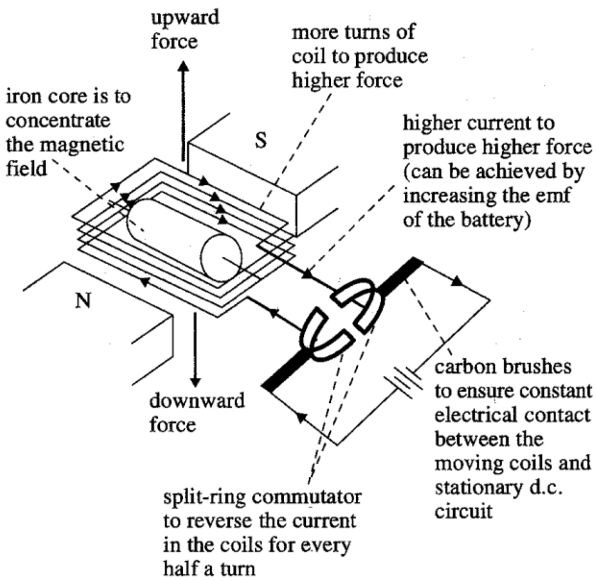
A simple d.c. motor is shown below.

The constant magnetic field provided by two permanent magnets interacts with the magnetic field produces by the current in the coil.

Based on Fleming's left hand rule, the wires at each side of the coil experience an equal and opposite force (as shown in the diagram). The turning effect created by the forces causes the coil to rotate.

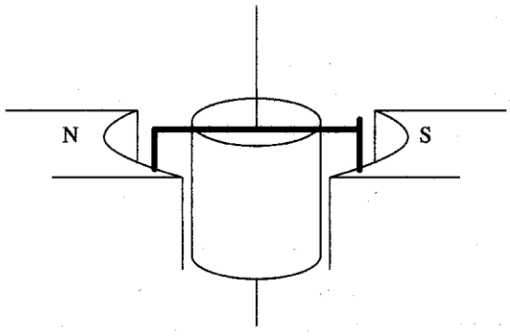
A pair of carbon brushes is placed in between the moving coil and the stationary external d.c. circuit to ensure that there is a constant contact between them.

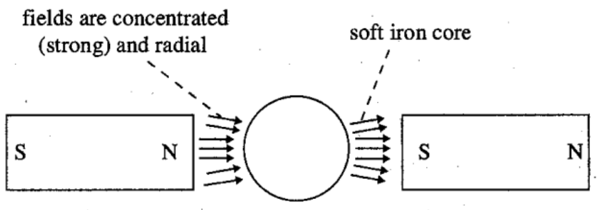
A split-ring commutator is connected between the coil and the carbon brushes to reverse the direction of the current in the coil in every half a turn to make the coil rotate continuously.




**94. Describe the action of a split-ring commutator in a two-pole, single-coil motor and the effect of winding the coil on to a soft-iron cylinder.**

Winding the coil on to a soft iron core cylinder creates radial magnetic field pattern. This produces almost constant force acting on the coil as it turns. Soft iron increases the magnetic field strength, thus increasing the turning effect.



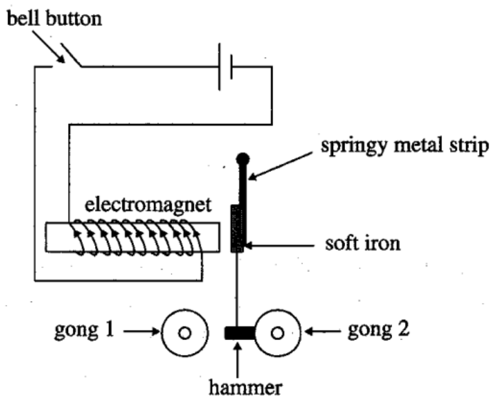



Split-ring commutator is used to change the direction of the direct current flowing in the coil at every 180° turn by the coil to allow the coil to rotate continuously.

**95. Describe the applications of the magnetic effects of a current in an electric bell and a circuit breaker.**

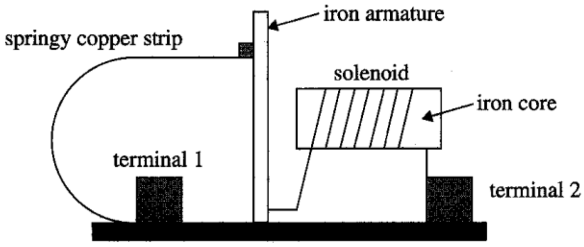
**Electric bell**

When the bell button is switched on, the iron core in the solenoid is magnetised and attracts the soft iron. As soft iron moves forward to the electromagnet, the hammer strikes gong 1.When the bell button is released, the electromagnet losses it magnetism and the springy metal strip pulls the soft iron and the hammer back to the original position to hit gong 2.

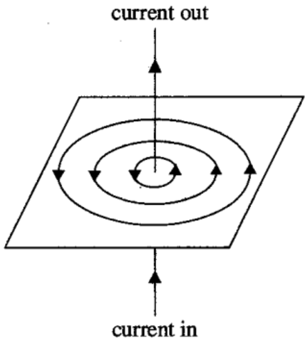



**Circuit breaker**

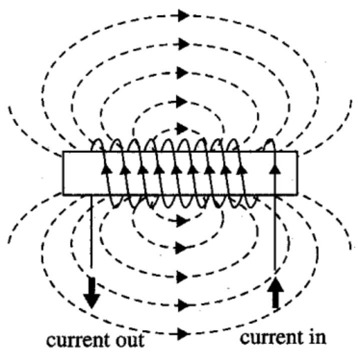
The circuit breaker is designed to switch off the current in a circuit when it becomes excessive. The current flows along the springy copper strip, through the iron armature and solenoid. The electromagnet will attract the iron armature if the current is large enough, thus breaking the circuit.




**96. Draw the pattern of the magnetic field, due to the currents in straight wires and in solenoids and state the effect on the magnetic field of changing the magnitude and/or direction of the current.**




Magnetic field pattern of
straight current-carrying wire




Magnetic field pattern
of solenoid

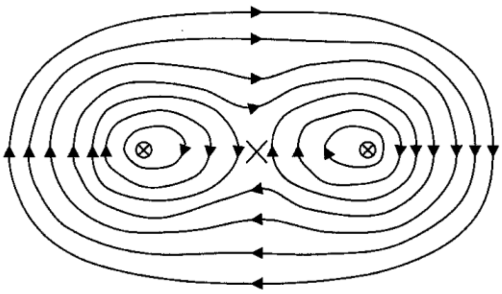
When the current increases, the magnetic field strength increases. It will be shown by magnetic field lines that are more closely packed and a bigger region of magnetic field.

When the direction of current is reversed, the direction of the magnetic field is reversed without a change in the magnetic field strength.

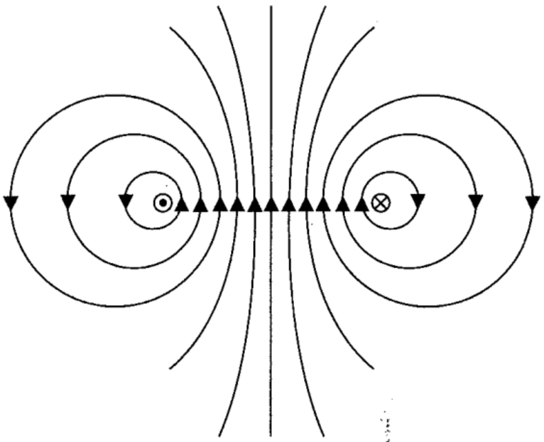
**97. Describe the field patterns between currents in parallel conductors and relate these to the forces which exist between the conductors.**

When two parallel current-carrying conductors are placed close togethers, the magnetic field created by the two conductors will interact and create a force on each conductor.

If the currents are in the same direction, the interaction between the two circular magnetic fields will create an attracton between the two wires.



Currents in the same direction



Currents in the opposite direction

If the currents are in the opposite direction, the interaction between the two magnetic fields will create a repulsion between the two wires.

**98. What are the factors affecting the magnitude of the induced e.m.f. in the coil and magnet electromagnetic induction experiment?**

- Number of turns on the coil
- Magnetic field strength of the magnet
- Speed at which the magnet is inserted or withdrawn from the coil

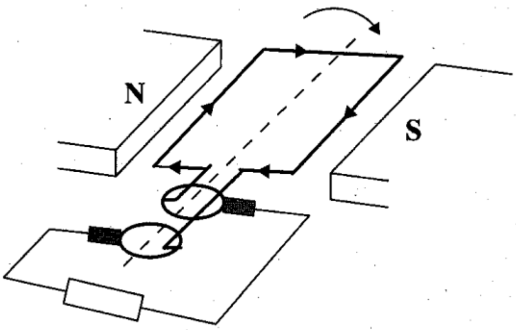
**99. Describe a simple form of a.c. generator (rotating coil or rotating magnet) and the use of slip rings (where needed).**

A simple a.c. generator is an electromagnetic device, which transforms mechanical energy into electrical energy. The simple structure of an a.c. generator basically consists of a coil rotating about an axis between the poles of a permanent magnet.

Coil rotation cuts magnetic field lines resulting in an e.m.f being induced between ends of the coil.

Magnitude of the induced e.m.f. and hence the induced current produced by the generator is increased by strengthening the magnet, increasing number of turns of coils or rotation speed.

When the rotating coil reaches vertical position, the current reverses in the coil, resulting in alternating current generation.




Carbon brushes and slip rings are used to prevent entanglement of the connecting wires and to direct an alternating current flowing to the load.

**100. Describe the structure and principle of operation of a simple iron-cored transformer as used for voltage transformations.**

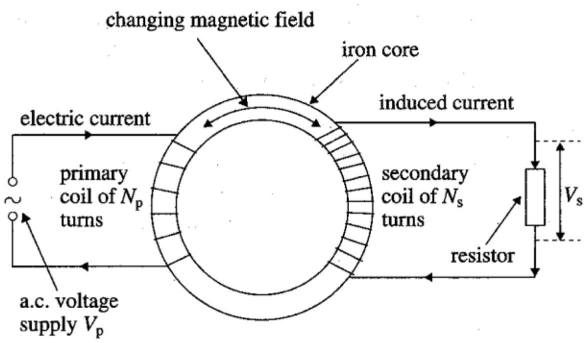
The basic structure of a transformer consists of a primary coil and secondary coil wound on a soft iron core.

Primary coil produces alternating current due to the alternating supply voltage.

The alternating current produces changing magnetic field flowing within the iron core.

The secondary coil experiences changing magnetic field and induces e.m.f.

According to Faraday's law, the e.m.f. generated in a conductor is proportional to the rate of change of magnetic flux linking the circuit.




**101. Describe the energy loss in cables and deduce the advantages of high voltage transmission.**

The electricity generated at the power station is transmitted to the households over long distance cable. Some energy is lost during transmission due to the electrical resistance of the cable. The power lost in the cable is calculated by $P = I^2R$ where $R$ is the resistance on the cables and I is the electrical current flowing through the cables.

$I$ and $R$ have to be minimised in order to reduce transmission loss. Hence, the output a.c. voltage from the generator in the power station is stepped up to a very high voltage by a step-up transformer. The current in the cable is decreased and this will reduce the power loss. The advantage of high voltage transmission is to reduce the heat loss in the transmission cable by allowing a low current to flow through it.

The resistance $R$ is reduced by using cable with large cross-sectional area and using good electrical conductor such as copper.