Contents

Chapter 1 Measurement

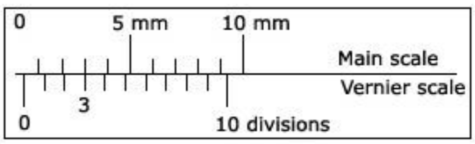
*A physical quantity is a quantity that can be measured. It consists of a numerical magnitude and a unit.

Base Quantity	SI Unit	Symbol for SI unit
Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Electric Current	Ampere	A
Thermodynamic temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	Mole	mol

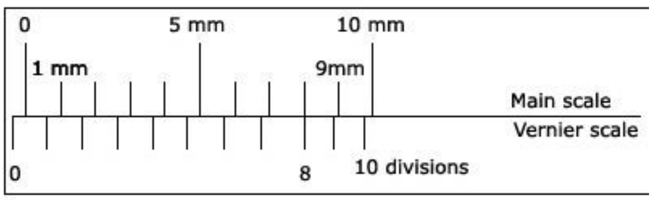
Factors	Prefix	Symbol
10^9	Giga	G
10^6	Mega	M
10^3	Kilo	k
10^{-1}	Deci	d
10^{-2}	Centi	c
10^{-3}	Mili	m
10^{-6}	Micro	μ
10^{-9}	Nano	n

Radius of a hydrogen nucleus 10^{-15}m, size of an atom 10^{-10} m, width of human hair 10^{-4}m, diameter of wire 10^{-3}m, radius of the earth 10^{6}m.

Positive Error

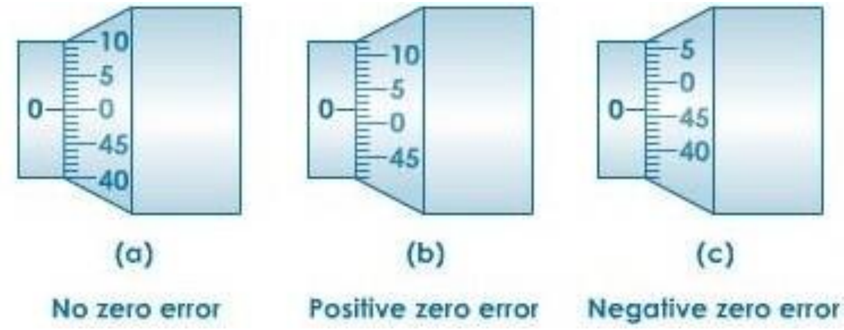


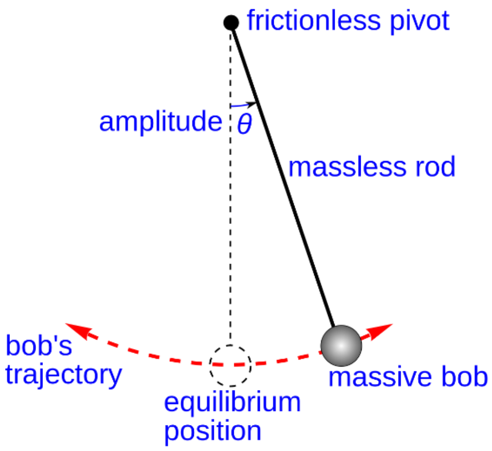
Nagative Error



When it is a positive zero error, read the Vernier scale from left to right, and take that value and deduct it from the value of from the main scale.

When it is a negative zero error, read the Vernier scale from right to left, and take that value and add it to the value of from the main scale.





*Each complete to-and-fro motion is one oscillation.

Where the bob moves from its initial position in the picture, to the opposite end and then back to its starting position.

*The period of a simple pendulum is the time taken for one complete oscillation.

Intervals does not equate to the amount of oscillations.

Chapter 2 Kinematics

*Scalar quantities are physical quantities that have only magnitude.

*Vector quantities are physical quantities that have both magnitude and direction. Examples include…

Scalar	Vector
Distance	Displacement
Speed	Velocity
Mass	Acceleration
Energy	Force
Time	

*Speed is the distance travelled per unit time. [SI Unit: m/s]

Average Speed = $\frac{Total\ Distance\ Travelled}{Total\ time\ taken}$

*Velocity is the rate of change in displacement. [SI Unit: m/s^2]

Average Velocity = $\frac{Total\ Displacement}{Total\ time\ taken}$

When finding velocity, always choose a direction that will be 'positive' first.

*Acceleration is the rate of change in velocity. [SI Unit: m/s^2]

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

Acceleration = $\frac{Change\ in\ Velocity}{Time\ taken}$

When an objects acceleration is decreasing, it can be known as deceleration or retardation.

Uniform acceleration occurs when the change in velocity for every unit of time is the same or constant.

Uniform acceleration = $\frac{Change\ in\ Velocity}{Time\ taken}$ =$\frac{Final\ Velocity - Initial\ velocity}{Time\ at\ final - time\ at\ initial}$

Non-uniform acceleration is the opposite of Uniform acceleration.

Key things to note on graphs.

*The gradient of a displacement-time graph is the object's velocity.

*The gradient of a velocity-time graph is the acceleration of the object.

*Area under velocity-time graph is the object's displacement.

Explanation of graphs will be required, describe the graphs according to its gradient and talk about the objects motion.

Displacement-Time Graph types. [Talk about Graph's gradient then Velocity]

Object is at rest

[Graph gradient is zero, the object's displacement is constant]

Object is travelling with uniform velocity

[Graph has a constant gradient; displacement increases every X second]

Object is travelling with increasing velocity

[Graph has an increasing gradient, velocity is increasing]

Object is travelling with decreasing velocity

[Graph has a decreasing gradient, velocity is decreasing]

Velocity-Time Graph types. [Talk about velocity then acceleration]

1. Object is at rest
   [The velocity remains at 0, object has 0 acceleration]
2. Object is travelling at uniform velocity
   [Velocity stays at X, object has 0 acceleration]
3. Object is travelling with uniform acceleration or deceleration
   [The velocity increases or decreases at a constant rate of X, gradient is positive or negative and constant, acceleration or deceleration is constant]
4. Object is travelling with increasing acceleration.
   [Velocity is increasing at an increasing rate, gradient is positive and increasing, the acceleration is increasing.]
5. Object is travelling with decreasing acceleration.
   [Velocity is increasing at a decreasing rate, gradient is positive and decreasing, acceleration is decreasing.]

Acceleration of gravity on earth is 10m/s^2 unless stated otherwise.

Acceleration of objects due to gravity does not depend on their mass or size in a vacuum. (Where there is no air resistance.)

The characteristics of Air Resistance

- Always opposes the motion of moving objects
- Increases with speed of objects
- Increases with surface area of objects
- Increases with density of air

The higher the terminal velocity, the greater the weight of the object

An object falling through a vacuum will have constant acceleration as gravity that is pulling it remains constant.

Chapter 3 Forces

*A force is either a push or a pull that one object exerts on another object. It can produce, slow down, speed up, stop and change the direction of motion. [SI Unit: N (Newton)]

There are 2 types of forces

Contact Forces	Non-Contact Forces
Normal Reaction The force that the surface exerts against the object that is pressing it.	Gravitational Force The pull exerted by the earth's gravity on an object.
Friction The force that opposes the motion between 2 surfaces.	Electric Force Attractive or repulsive forces between electric charges.
Tension The pull exerted by a stretchable material on an object attached to it.	Magnetic Force The attractive or repulsive forces of opposite and similar poles respectively.

When adding vectors that are parallel, choose a direction that will be positive.

Forces in the opposite direction of the positive one, will be negative.

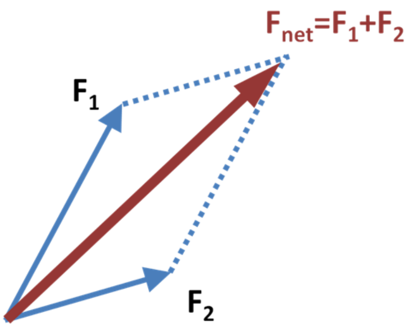
The addition of all forces acting on an object in parallel will be the resultant force.

Addition of non-parallel vectors is by using the graphical method stated above.

Consider 2 force 5N and 3N that are pulling in two different directions.

Set up a ratio of the length to the force and:

Draw the forces on a graph paper with arrows, and the complete the diagram by forming a parallelogram by using dotted lines, the diagonal line from the angle opposite to the object is the resultant force, according to the scale, its length is the magnitude.



Make sure to include the angle formed by the forces, the direction of the forces, the magnitude of the forces on the diagram.

Forces can

1. Move bodies from rest
2. Increase speeds of moving bodies
3. Decrease speeds of moving bodies
4. Change direction of moving bodies

*Newton’s First Law of Motion

States that every object will continue in its state of rest or uniform motion in a straight line unless a resultant force acts on it.

An object is stationary when the forces acting on it are equal for example, the book’s weight and the tables exerting normal reaction. The resultant force is then 0.

*Newton’s Second Law of Motion

States that when a resultant force acts on an object of constant mass, the object will accelerate in the direction of the resultant force. The product of mass and acceleration of the object gives the resultant force.

(Force, N) = (Mass, kg) x (Acceleration, ms^{-2})

F = ma

This law indicates that

1) A resultant force on an object produces an acceleration
2) Doubling resultant force can double acceleration
3) Doubling mass will halve the objects acceleration

One Newton N is essentially Kg m/s^2

*Newton’s Third Law of Motion

States that if body A exerts a force on body B, body B will exert and equal on opposite force on body A.

Hence, every action has an equal and opposite reaction that acts on mutually opposite bodies.

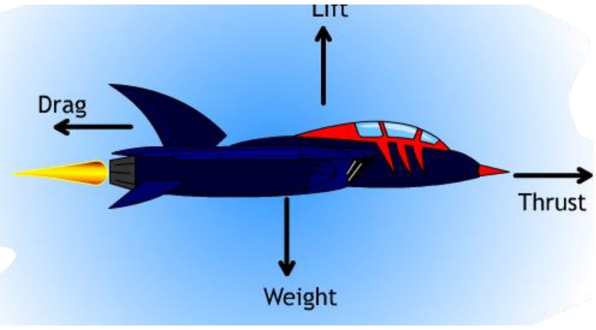
This Law tells us that

1. Forces exist in pairs
2. Action and reaction are equal in magnitude
3. Action and reaction are in opposite directions
4. Action and reaction act on mutually opposite bodies

*Friction is the contact force that opposes the motion between surfaces in contact.

Positive effects of friction	Negative effects of friction
We can walk without slipping Moving vehicles can slow down easily	Cars are less efficient by up to 20% Moving gears in machines will suffer from wear and tear
Enhancement of friction	**Reduction of friction**
1. Treads in tyres 2. Parachute (Air resistance is a type of friction) 3. Chalk powder is used by rock climbers to absorb perspiration and increase their grip	4. Wheels 5. Ball bearings to prevent moving parts from rubbing against each other in machines 6. Lubricants and polished surfaces 7. Bullet trains or hovercrafts

Free-body diagram



Don't forget to include normal reaction from the surface onto objects pressing against it.

Chapter 4 Mass, Weight and Density

*Mass is the amount of matter in a body. [SI Unit: kg]

*Weight is the gravitational force acting on the object.

*Gravitational field is the region where a mass experiences force due to gravitational attraction.

*Gravitational field strength (g) is defined as gravitational force acting per unit mass.

Weight (N) = Mass of object (kg) x Gravitational field (10 m/s^2)

[W = mg] can also be represented by [F = ma]

Mass	Weight
Scalar Quantity	Vector Quantity
Amount of matter	Gravitational force
SI Unit Kg	SI Unit N
Independent of gravity	Dependent on gravity
Measured with beam balance and calibrated electronic balance	Measured with spring balance

*Inertia is defined as the object’s reluctance to change its state of rest or motion due to its mass.

The greater the object’s inertia, the greater it’s mass.

Density is how much mass an object occupies per unit volume. [SI Unit: Kg/m^3]

$$\rho = \frac{m}{v}$$

Density = Total mass / Total volume

Chapter 5 Turning Effect of Forces

*The moment of a force is the product of the force and the perpendicular distance from pivot to the action line of the force.

Moment of a force (N m) = Force (N) x Distance (m)

*The Principle of Moments state that when a body is in equilibrium the sum of clockwise moments about a pivot is equal to the sum of anticlockwise movements about the same pivot.

For an object to be in equilibrium its resultant force on the object must be zero as well as the object's resultant movement.

*The centre of gravity is defined as the point on the object where its whole weight appears to act.

*The stability of an object is a measure of its ability to return to its original position after it has been slightly displaced.

Stability of the object can be increased by keeping the centre of gravity as low as possible and keeping the base area as wide as possible.

There are 3 types of equilibrium

Stable	Unstable	Neutral
Cone on its base Line of action through its weight still lies within its base after tilting The moment of weight about its contact point returns the cone to its original position	Cone on its tip Line of action through its weight lies outside its base after tilting The moment of weight about its contact point causes the cone to be toppled	Cone lying horizontally on the floor Line of action through its weight and its contact force coincide The moment about the contact point is 0, it stays in the position it is displaced

Chapter 6 Energy, Work and Power

*Energy us defined as the capacity to do work.

*Kinetic energy is the energy of a body due to its motion.

*Potential energy is the stored energy in a system.

*Chemical potential energy is the energy stored in a substance due to the position of the atoms or electrons in the substance.

*Elastic potential energy is the energy stored in a body due to elastic deformation.

*Gravitational potential energy is the energy stored in an object due to its height above the ground.

*Electrical energy is the energy of an electric charge due to its position and motion.

*Light is an electromagnetic wave visible to the eye. Made up of electric and magnetic fields oscillating at a certain range of frequency within the electromagnetic spectrum.

*Thermal energy is the energy stored in a body due to its temperature.

*Nuclear energy is the energy released during a nuclear reaction.

*Principle of Conservation of Energy states that energy cannot be created or destroyed. Energy can be converted from one form to another. The total energy in an isolated system is constant.

Based on the Principle of Conservation of Energy:

Total Energy input = Useful energy output + Wasted Energy Input

Efficiency can be calculated by:

Efficiency = $\frac{Useful\ energy\ output}{Total\ energy\ input} X\ 100\%$

*Work done by a constant force on an object is the product of the force and the distance moved by the object in the direction of the force.

Work done by a constant force =

Constant force X Distance moved by the object in the direction of the force

Work done (J) = Constant Force (N) X Distance travelled in force direction (m)

$$W = F \times s$$

When a body of mass (m) moves at speed (v), its kinetic energy (E) is given by

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

$$Energy = \frac{1}{2} Mass \times Speed$$

Where: Mass is in Kg and Speed in m/s

Gravitational potential energy is given by $E = mgh$

Gravitational potential energy (J) =

Mass (kg) Gravitational Field Strength (m/s^2) Height (m)

*Power is defined as the rate of work done or rate of energy conversion.

$P = W$ or $P = \frac{E}{t}$

Power (W)= Work done (J) or Energy (J) / Time taken (s)

Chapter 7 Pressure

*Pressure is defined as the force acting per unit area.

$$P = \frac{F}{A}$$

Pressure (Pa or Nm^{-2}) = Force (N) X Area (m^2)

The amount of pressure inside a body of liquid increases in depth, due to the increasing weight of liquids above it as depth increases. The lower the depth the greater the pressure.

Thus, $\rho = hpg$

Pressure (Pa)=Height (m) Density (Kg/m^3) Gravitational field strength

Pressure in liquid column = Height of liquid column X Density X Gravity

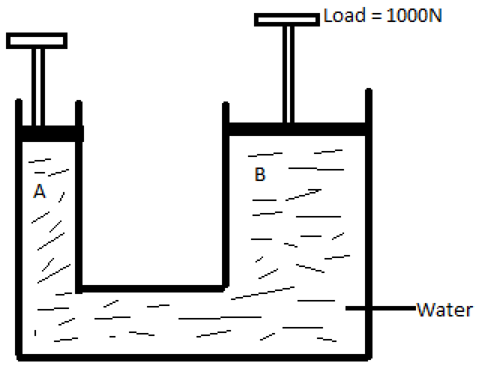
In liquids, pressure is not dependent on the volume, cross-sectional area, or the shape of the volume.

Hydraulic presses lift heavy things with little effort.

When a force acts on piston A, pressure is applied to the liquid beneath it.

The same pressure is transmitted equally to every part of the liquid.

Thus, the pressure beneath piston 2 is equal to pressure beneath piston 1.



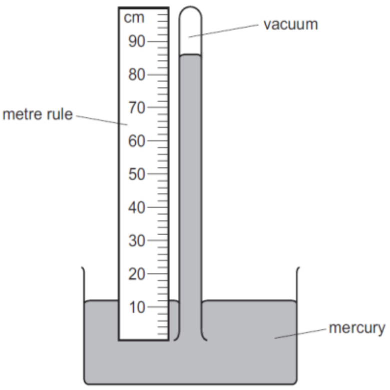
$F \times D$ (At a) = $F \times D$ (At B)

Applications of Atmospheric pressure

When sucking the air out of the straw, air pressure in the straw is lowered, as a result the atmospheric pressure is greater than the pressure in the straw, and as it pushes against the liquid at the surface of the cup, it forces the water up into the straw and into the mouth.

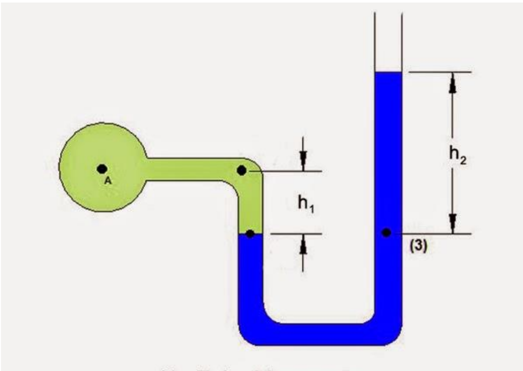
Suction cups that do not have air in them are held against the wall due to atmospheric pressure being greater than the pressure inside the cup.

Measuring Atmospheric pressure using a simple mercury barometer



The pressure on the surface is equal to the atmospheric pressure.

The atmospheric pressure at sea level is the density of the mercury multiplied by the height of the barometer above the surface of the mercury, multiplied by the gravitational field strength.



U - Tube Manometer

Pressure exerted by gas = Atmospheric pressure + hpg

Don't forget that P1V1 = P2V2 is also applicable

Chapter 8 Heat

*Temperature refers to how hot or cold an object is.

*Heat refers to the amount of thermal energy that is being transferred from a hotter to a cooler region.

Steps taken to construct a temperature scale

1. Choose a suitable thermometric substance, which are substances that vary continuously and linearly with temperature, which are thermometric properties.

Thermometric properties	Examples of thermometers
Volume of a fixed mass of liquid	Mercury and alcohol-in-glass thermometers
Electrical resistance of a piece of metal	Resistance thermometer
Electrical voltage or electromotive force	Thermocouple thermometers

2. Choose a lower and upper fixed point, that are easily obtainable and reproducible.
3. Divide the interval between the 2 fixed points into a suitable number of equal parts to obtain a scale.

X = $\frac{X(v)-0(v)}{100(v)-0(v)}$

Y = Unknown temperature

X(v) = Physical property of the thermometric substance at unknown temperature

0(v) = Physical property of thermometric substance at 0°C

100(v) = Physical property of thermometric substance at 100°C

Chapter 9 Kinetic Model of Matter

Solid	Liquid	Gas
Fixed shape and volume High density Incompressible	Fixed volume but not fixed shape High density Incompressible	No fixed shape or volume Low density Compressible

*The kinetic model of matter states that the tiny particles that make up matter are always in continuous random motion.

Brownian motion is haphazard random motion of particles, that results from constant bombardment from particles from all sides.

Effects of temperature on molecular motion

When the temperature of the air increases, the average kinetic energy of the air molecules increases, the faster-moving air molecules bombard the smoke particles more vigorously and frequently.

Pressure-temperature relationship of a gas

A rise in the temperature of the air causes an increase in the average speed of the air molecules, which would then bombard the inner surface of the container more vigorously and more frequently, the average force per collision between the air molecules and the wall increases, and since the volume of the container is fixed, the pressure inside increases.

Pressure-volume relationship of gas

A decrease in volume would mean that the number of molecules per unit volume increases, which causes the gas molecules to collide more frequently with inner surface of the container and would result in a greater force, as pressure is equal to force over area, the pressure increases.

Volume-temperature relationship of gas

A rise in temperature of gas causes an increase in the average speed of the gas molecules, which causes the molecules to collide more vigorously and frequently with the inner surface, as the average force per collision between air molecules and the wall increases, the pressure increases, and when the pressure increases above atmospheric pressure the volume of the container increases as the piston is pushed up, the gas pressure would then decrease.

Chapter 10 Transfer of Thermal Energy

*Thermal energy always flows from a region of higher temperature to a region of lower temperature. Net flow of thermal energy occurs only when there is a difference in temperature.

*Conduction is the transfer of thermal energy through a medium without any flow of the medium.

1. The particles at the heated end of the rod vibrate vigorously about their fixed positions, and collide with neighbouring particles, causing them to vibrate more vigorously, which in turn cause them to collide with other particles, transferring kinetic energy
2. Eventually particles at the cooler end are set into vigorous vibration, and the rod at the end becomes hot
3. Thermal energy is transferred without the transfer of particles

In metals,

1. There is another process that takes place ‘free electron diffusion’, where free electron particles at the hot end also absorb heat and gain kinetic energy
2. The free electrons move at greater speeds towards cooler regions of the rod, in the process they collide with atoms and cause them to vibrate more vigorously thus, kinetic energy is transferred
3. Thermal energy is transferred via the motion of the free electrons

*Convection is the transfer of thermal energy by means of convection currents in a fluid (gas or liquid) due to a difference in density.

In a kettle, the water at the bottom is heated by the stove, which in turn causes it to expand, its expansion decreases its density and causes it to rise, while the cooler more dense water at the top begin to sink towards the heat source, the difference in densities of water at different regions sets up a convection current.

*Radiation is the transfer of thermal energy in the form of electromagnetic waves such as infrared radiation.

Factors that affect the rate of emission and absorption of infrared radiation

1. Colour and Texture of the surface

Dull and black surfaces are better emitters and absorbers then shiny and silver surfaces

2. Surface temperature
   The higher the objects temperature relative to the surrounding temperature, the higher the rate of emission of infrared radiation (A hot object loses heat faster than a less hot object)
3. Surface area
   The larger the surface area the greater the rate of infrared radiation emission and absorption

Applications of conduction

Good conductors of heat are used to for cooking utensils, soldering iron rods, and in heat exchangers.

Poor conductors of heat are used for handles and table mats to reduce heat gain.

They are also used for clothing in cold weather and double-glazed windows to prevent heat loss.

Vacuum flask

Chapter 11 Thermal Properties of Matter

Internal energy is:

Internal kinetic energy, which is due to the motion of the particles and is related to temperature.

Internal potential energy which due to the stretching and compressing of interatomic or intermolecular bonds as particles move, amount is determined by the forces between particles and how far apart they are.3

*Heat capacity is the amount of thermal energy required to raise the temperature of a substance by 1 K.

C = Heat capacity (J/K)

Q = Thermal energy required (J)

T = Change in temperature (K)

C = Q/T

*Specific heat capacity is defined as the amount of thermal energy required to raise the temperature of a unit mass (1 kg) of a substance by 1 K.

c = Specific heat capacity (J/kg K)

m= Mass (kg)

c = Q/T x m

Melting is when a substance in solid state changes to liquid state upon heating, without a change in temperature of the substance.

1. The particles in a solid are held together by strong bonds, and the particles are packed closely together, with internal potential energy less than that of liquids.
2. Thermal energy is absorbed to break the strong bonds between particles. And the particles move out from their fixed position and are further apart from each other.
3. The state changes from solid to liquid

Solidification is when a substance changes from liquid to solid state.

1. The intermolecular bonds between liquid particles are weaker than those in a solid, the particles are also further apart and have a greater internal potential energy

2. Thermal energy is released to form strong intermolecular bonds, the particles are held in fixed positions and are closer to each other.
3. The state changes from liquid to solid

Boiling is the process in which a substance absorbs energy to change its state from liquid to gas, without a change in temperature.

Condensation is the process in which a substance losses energy to change its state from gas to liquid, without a change in its temperature.

*Latent heat is the energy released or absorbed by a substance during a change in state, without a change in temperature.

*Latent heat of fusion, L_f, is the amount of thermal energy required to change a substance from solid state to liquid state, without a change in temperature.

*Specific latent heat of fusion, l_f, of a substance is the amount of heat energy required to change a unit mass (1 kg) of the substance from solid to liquid state, without a change in temperature.

Lf = latent heat of fusion (J)

lf = specific latent heat of fusion (J/kg) m = mass (kg)

$$L_f = l_f \times m$$

Thermal energy required = Specific latent heat of fusion x Mass

*Latent heat of vaporisation L_v, is the amount of thermal energy required to change a substance from liquid to gaseous state, without a change in temperature.

*Specific latent heat of vaporization l_v, of a substance is the amount of thermal energy required to change a unit mass (1 kg) of the substance from liquid to gaseous state, without a change in temperature. (L_v = l_v x m) Uses same formula as above

Boiling	Evaporation
Occurs only at boiling point	Occurs at any temperature
Relatively fast	Relatively slow
Takes place throughout the liquid	Takes place at the surface of the liquid
Bubbles are formed	No
Temperature remains constant	Temperature may change
External heat source required	No

Evaporation causes cooling, when evaporation occurs, water molecules with greater kinetic energy escape from the skin surface, leaving molecules with less kinetic energy behind, resulting in a decrease in temperature.

Factors that affect rate of evaporation

1. Temperature
2. Increased humidity decreases rate
3. Increased surface area of liquid increases rate
4. Increased pressure increases rate
5. Increased movement of air increases rate
6. Increased boiling point of liquid increases rate

Notes:

A mug with lower heat capacity will be able to reduce heat loss from the content more efficiently than a mug with higher heat capacity. As the mug with lower heat capacity takes less heat away to raise its own temperature by 1 K.

Chapter 12 Light

*The first law of reflection states that the incident ray, reflected ray and the normal at the point of incidence all lie in the same plane.

*The second law of reflection states that the angle of incidence is equal to the angle of reflection.

Regular reflection

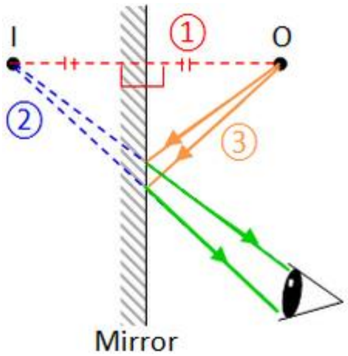
1. Occurs only on smooth surfaces
2. Law of reflection holds true for each individual ray
3. The reflection of all parallel incident rays, and normal of all points of incidence are parallel

Diffused reflection (Irregular)

1. Occurs only on rough surfaces
2. The law of reflection holds true for each individual ray
3. Parallel incident rays are reflected in different directions as the surface is uneven
4. The normal of the points of incidence are not parallel to one another

Characteristics of a plane mirror image

1. The image is of the same size as the object
2. Its distance from the mirror is equal to the distance of the object from the mirror
3. It is laterally inverted
4. It is upright and virtual



If the object and image is not a dot, remember to use dotted lines to mark out their horizontal lengths.

*Refraction is the bending of light as light passes from one optical medium to another.

*The first law of refraction states that the incident ray, the normal and the refracted ray all lie in the same plane.

*The second law of refraction states that, for 2 given media, the ratio of the sine of the angle of incidence i to the sine of the angle of refraction r is a constant. (Known as Snell's Law)

When a light ray passes from a medium of lower optical density to a medium of greater optical density, the light ray bends towards the normal, if the opposite situation occurs for the light ray, it will bend away from the normal.

(When light is travelling from vacuum or air to medium)

Principle of reversibility can be used is i is from an optically denser medium.

$\frac{\sin i}{\sin r} = n$ or constant (refractive index)

$\frac{Speed\ of\ light\ in\ vaccum\ or\ air}{Speed\ of\ light\ in\ medium} = n$ (refractive index)

$\frac{Real\ depth}{Apparent\ depth} = n$

*The critical angle c is defined as the angle of incidence in an optically denser medium for which the angle of refraction in the optically less dense medium is 90°.

*Total internal reflection is the complete reflection of a light ray inside an optically denser medium at its boundary with an optically less dense medium.

$$\sin c = \frac{1}{n}$$

Optical fibres utilize total internal refection to transmit data

Telecommunications industry use them as compared to copper wires, they

1. Have higher carrying capacity for information over long distances
2. Have less signal degradation
3. Are lightweight and less costly

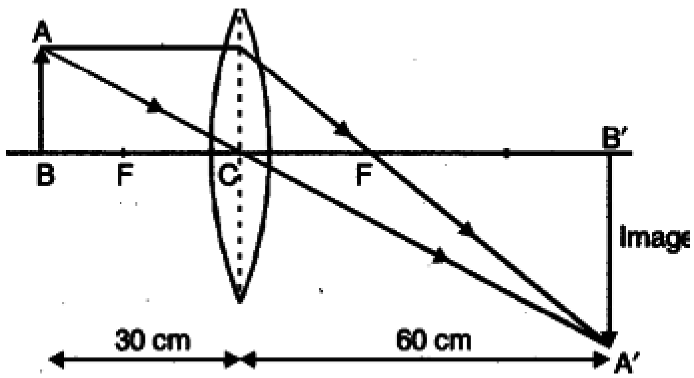
In the medical industry optical fibres as used in endoscopes.

When light passes through converging lens, it converges at a point, when light passes through diverging lens, it diverges from a its focal point behind the lens.

- Principal axis is the horizontal line passing through the optical centre of the axis
- Optical centre C is the midpoint between the surfaces of the lens on its principal axis
- Focal point F is the point where all rays parallel to the principal axis converge after refraction by the lens
- The plane that passes through the focal point F and perpendicular to the principal axis
- *Focal length f is the distance between the optical centre C and the focal point F

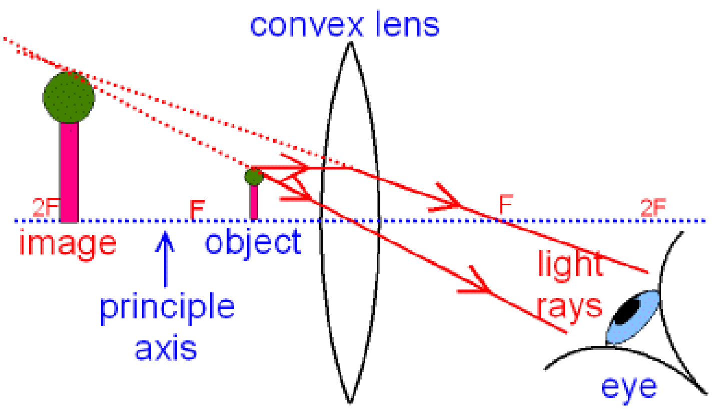
How rays are affected when passing through the lens

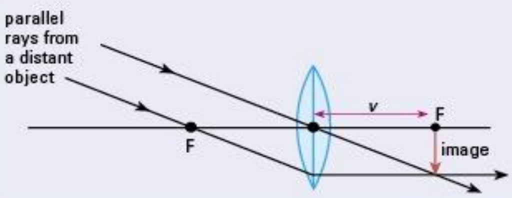
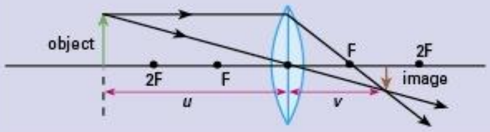
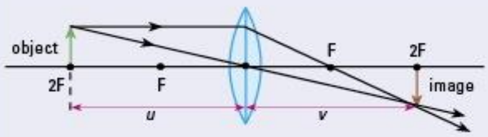
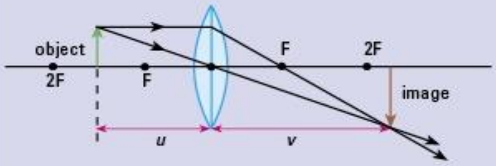
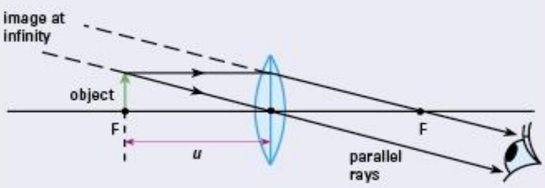
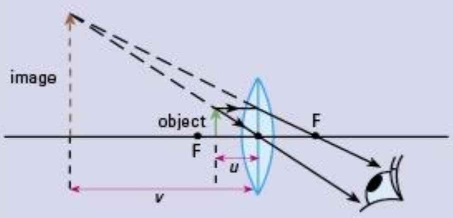
1. Any incident ray that passes through the optical centre of the lens will not refract.
2. Any incident ray parallel to the principal axis will be refracted and will pass through the focal point F.
3. An incident ray that passes through focal point F before passing through the lens will be refracted parallel to the principal axis.



Mark the object with O and the image with I, mark out the focal points and optical centre when drawing ray diagrams.

Label the focal length with f and the distance from the object to the lens with u and use double sided arrows for them. 



Object distance (u)	Ray diagram	Type of image	Image distance (v)	Uses
$u = \infty$		- inverted - real - diminished	$v = f$ - opposite side of the lens	- object lens of a telescope
$u > 2f$		- inverted - real - diminished	$f < v < 2f$ - opposite side of the lens	- camera - eye
$u = 2f$		- inverted - real - same size	$v = 2f$ - opposite side of the lens	- photocopier making same-sized copy
$f < u < 2f$		- inverted - real - magnified	$v > 2f$ - opposite side of the lens	- projector - photograph enlarger
$u = f$		- upright - virtual - magnified	- image at infinity - same side of the lens	- to produce a parallel beam of light, e.g. a spotlight
$u < f$		- upright - virtual - magnified	- image is behind the object - same side of the lens	- magnifying glass

To find the image of the object without knowing the focal point and only knowing one ray that emerges and refracts from the object:

Extend the known ray (dotted lines if going backwards) and draw the ray from the object diagonal to the principal axis, the point of intersection of the 2 rays is the location of the image formed.

To find the focal point of the lens while knowing the above information:

Draw the line from the top of the image, that intersects with the horizontal line from the top of the object at the lens, and the point on the X axis where that ray meets, is the focal point. (For last 2 diagrams)

Chapter 13 Waves

*A wave is a disturbance that transfers energy from one point to another without the transference of matter.

The sources of a wave are vibration or oscillation, and waves transfer energy from one point to another without transferring the medium.

How waves are formed on a rope

1. One end of the rope is at a fixed position
2. The kinetic energy from the hand is transferred to the rope particles by a rope wave, rope particles move up and down as the wave passes through them
3. As the rope wave moves towards the wall, the kinetic energy of rope particles is transferred to the rope particles further away
4. The rope particles further away vibrate up and down and the rope wave moves towards the wall
5. Note that the rope particles vibrate up and down about their rest positions

How waves are formed on water by a dipper

1. The kinetic energy from the vibrating dipper is transferred to the water particles directly below it
2. The water particles move up and down as the ripple passes through them
3. As the circular ripple spreads outwards towards the tank edges, kinetic energy gets transferred to adjacent water particles
4. Causing water particles at other parts to vibrate up and down and the circular ripple continues to spread
5. Note that the water particles vibrate up and down about their rest positions

*Transverse waves are waves that travel perpendicular to the direction of the vibration.

*Longitudinal waves are waves that travel parallel to the direction of the vibration.

*The amplitude A (m) of a wave is the maximum displacement of a point from its rest position.

*The wavelength λ (m) of a wave is the shortest distance between any 2 points in a phase.

Points along a wave are in phase if they have the same direction of motion, speed and displacement from their rest position.

*The period T (s) of a wave is the time taken to produce one complete wave.

*The frequency f (Hz) of a wave is the number of complete waves produced per second.

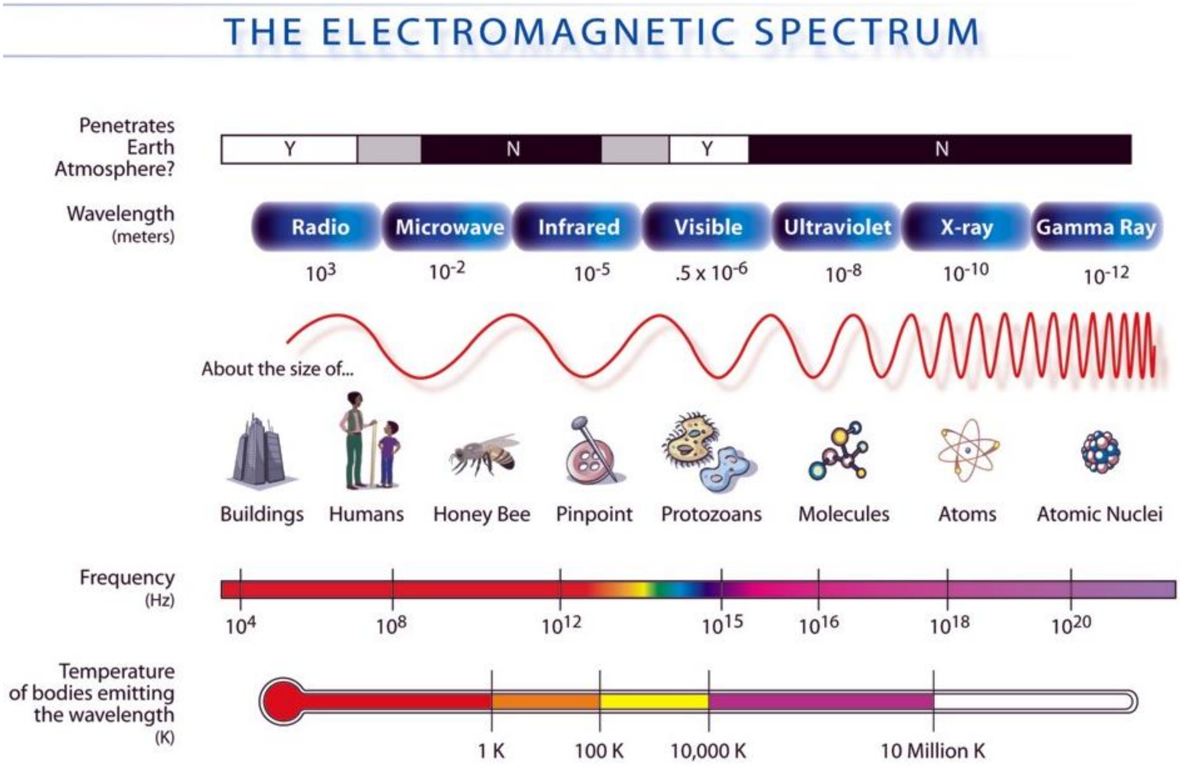
$$f = \frac{1}{T}$$

*Wave speed v (m/s) is the distance travelled by a wave per second.

$$v = f\lambda$$

*A wavefront is an imaginary line on a wave that joins all adjacent points in one phase.

Chapter 14 Electromagnetic Waves



Electronic waves go from lower frequencies and longer wave lengths (Radio waves, microwaves) to higher frequencies and shorter wave lengths.

Properties of electromagnetic waves

1. They are transverse waves that can travel through mediums while transferring energy from one point to another
2. They travel at the same speed as light due to $v = f\lambda$ (wave speed equation) that is applicable to electromagnetic waves
3. When they travel from one medium to another, their wave lengths and speed can change, but not their frequency
4. They obey the laws of reflection and refraction and do not carry electric charges

Effects of absorbing electromagnetic radio waves

Exposure to ionizing radiation (UV radiation, X and Y rays) can damage biological molecules and lead to abnormal patterns of cell division (cancer), deformation of foetus may also occur.

Radio waves

AM radios and submarine communication use the shorter radio wave lengths to work, while FM radio and terrestrial television utilize the longer ones.

Microwaves

Used in microwave ovens, where microwaves penetrate food and cause water molecules to vibrate vigorously and generate heat

Also used for communicating with satellites as they are able to penetrate the atmosphere, and also used in mobile phone networks

Infrared Radiation

Used by remote controllers, ear thermometers and intruder alarm

Visible light

Used by optical sensors for medical purposes and telecommunication

Ultraviolet radiation

Used in the sterilisation of equipment and sunbeds

X rays

Used in radiation therapy to kill cancer cells and in radiography to produce X ray images for diagnosis, X rays are also used in airport security checks

Y/Gamma rays

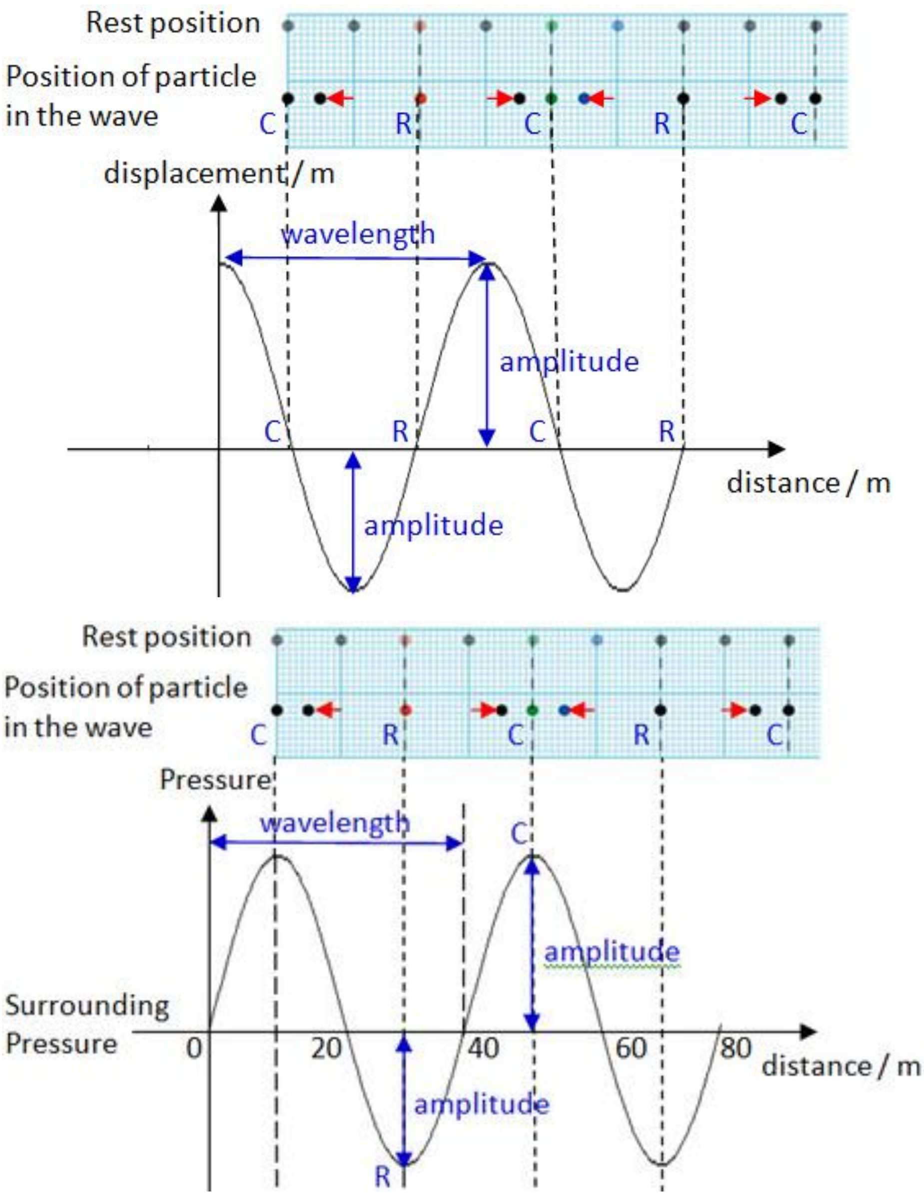
Used in Gamma knife radio therapy where Y rays are directed at brain tumours to kill cancer cells

Chapter 15 Sound

*Sound is a form of energy that is transferred from one point to another as a longitudinal wave.

Description of the formation of sound waves from a tuning fork

1. Layers of air are in undisturbed position
2. When the prongs push outward, a compression is produced, where the air pressure is higher than the surrounding regions
3. When the prongs push inward, a rarefaction is produced, where the air pressure is lower than the surrounding regions
4. Another compression follows, and after a while, a series of compressions and rarefactions are formed



Speed of sound in fastest in solids, followed by liquids, and then gases.

*An echo is the repetition of a sound due to the reflection of sound.

Echoes can be used to measure large distances and detect the location of objects.

*Ultrasound in sound with frequencies above the upper limit of the human range of audibility.

Ultrasound in quality control

1. Ultrasound emerges from a transmitter
2. Ultrasound passes through the concrete slab and is received by a sensor at the bottom of it
3. By comparing the ultrasound emitted and received, the location of defects can be identified

Ultrasound in prenatal scanning

1. Ultrasound pulses are sent into the womb via a transmitter
2. By measuring the time taken for the ultrasound to be reflected, the depth of the reflecting surface within the womb can be derived, forming an image.

*Pitch is related to the frequency of a sound wave the higher frequency, the higher the pitch.

*Loudness is related to the amplitude of a sound wave- the larger the amplitude, the louder the sound.

Chapter 16 Static Electricity

Like charges repel while unlike charges attract.

Charges are measured in coulombs (C).

Electrostatic charging by friction

When a glass rod is rubbed against a piece of silk, some electrons are transferred from the surface of the glass to the silk, as the glass rod loses electrons it becomes positively charged, as the silk gains electrons, it becomes negatively charged.

Electrostatic charging by induction

Charging 2 metals spheres that are touching by induction

Bring a negatively charged rod near to one metal sphere, which would cause its electrons to move to the far ends of the other sphere. Move the 2 spheres apart while keeping the negatively charged rod near the sphere.

Both spheres now have an equal number of opposite charges, the spheres have now been charged by induction.

Charging a single metal conductor by induction

Bring a positively charged rod near a metal conductor on an insulating stand, this would attract the free electrons to move towards the other end of the rod. Without removing the rod, earth the positively charged opposite end and electrons will flow towards it to neutralize the positive charge.

Unearth the conductor without removing the rod, after a while and removing the rod, the negative charges will distribute themselves throughout the negative conductor and it is now negatively charged.

A charged insulator is discharged by heating or providing humid conditions.

A charged conductor is discharged by providing a path for excess electrons to flow away, or electrons to flow towards the conductor, this is also known as earthing.

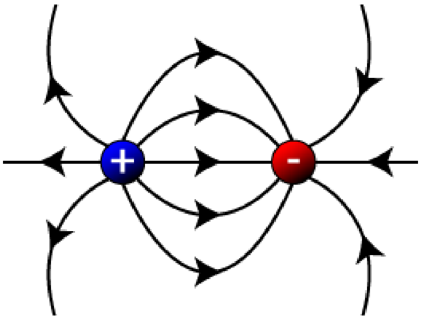
*An electric force is the attractive or repulsive force that electric charges exert on one another.

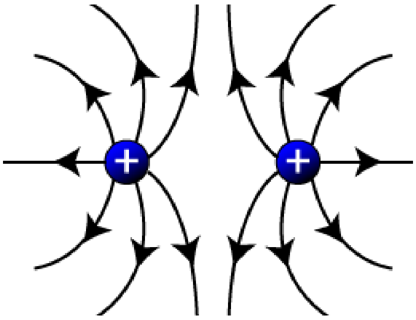
*An electric field is the region in which an electric charge experiences an electric force.

*The direction of an electric field is the direction of the force that would act on a small positive charge.

*The strength of an electric field is indicated by how close the field lines are to one another.

Good conductors of electricity will be able to conduct electrons away easily when charged





There are 2 hazards of electrostatics, lightning and electrostatic discharge. Sudden discharges may occur after friction has accumulated electric charges, this discharge may cause sparks or ignite flammable items, they can also damage electronic equipment.

Electrostatics are utilized in photocopiers, laser printing, electronic precipitators and in spray painting.

Chapter 17 Current Electricity

*Conventional current is in the direction opposite to electron flow.

*An electric current I is the rate of flow of electric charge Q.

$$I = \frac{Q}{t}$$

$$Q = It$$

Q = Charge (C)

I = Current (A)

t = time taken (s)

*The electromotive force (e.m.f.) e of an electrical energy source is the work done by the source in driving a unit charge around a complete circuit. $E = \frac{W}{Q}$

E = Electromotive force (V)

W = Work done (J)

Q = Charge (C)

*When cells are arranged in series, the resultant e.m.f. is the sum of all e.m.f.s of the cells.

*When cells are equal e.m.f. are arranged in parallel, the resultant e.m.f. is equal to that of a single cell.

*The potential difference (p.d.) across a component in an electric circuit is the work done to drive a unit charge through the component.

V = W/Q

V = Potential difference or voltage across a component (V)

W = Work Done (J)

Q = Charge (C)

*The resistance R of a component is the ratio of the potential difference V across it to the current I flowing through it.

R = V/I

R = Resistance (Ω)

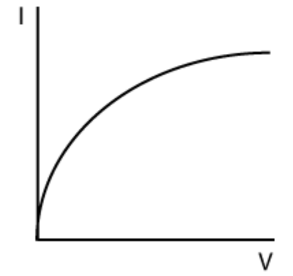
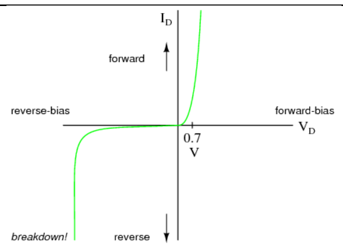
V = Potential difference across a component (V)

I = Current (A)

*Ohm’s Law states that the current passing through a metallic conductor is directly proportional to the potential difference across it, provided that physical conditions (such as temperature) remain constant. V/I = R = Constant

Ohmic conductors are conductors that obey Ohm’s Law and they have a straight line moving in a diagonal direction on their graphs.

Non-ohmic conductors are conductors that do not obey Ohm’s law.

Conductor	Function	I-V Graph	Description
Filament lamp	Converts electrical energy to light and heat		As currents increase, devices generate more heat and the temperature rises and resistance increases
Semiconductor diode	Allows current to only flow in one direction		When p.d. is applied in the forward direction, the current is large as the resistance is lower In the reverse direction, there is almost no current flow, as the resistance is high in the reverse direction (Infinite)

$$R = \frac{\rho l}{A}$$

p (constant) = Resistivity, a fixed property of a material (Ω)

l = Length of wire (m)

A = Cross sectional area (m^2)

Notes:

Chapter 18 D.C. Circuits

*In a series circuit, the current at every point is the same.

*In a series circuit, the sum of the p.d. across each component is equal to the p.d. across the whole circuit.

*In a series circuit, the effective resistance R is the sum of all the resistances.

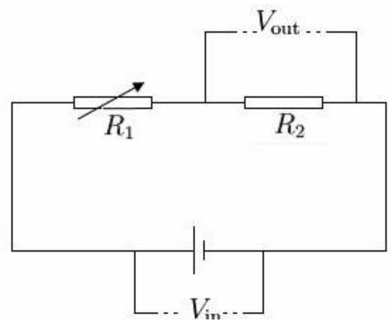
*In a parallel circuit, the sum of the individual current in each of the parallel branches is equal to the main current flowing into or out of the parallel branches.

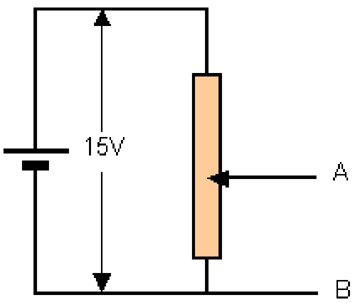
*In a parallel circuit, the p.d. across separate parallel branches is the same.

*The reciprocal of the effective resistance of resistors in parallel, is equal to the sum of the reciprocal of all effective resistances.

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ ….

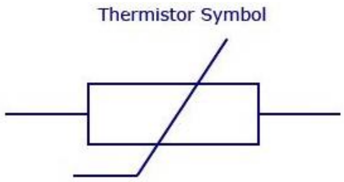
*A potential divider is a line of resistors connected in series. It is used to provide a fraction of the voltage of a source to another part of the circuit.

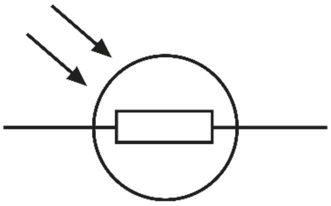




$$V_{out} = \left(\frac{R_2}{R_1 + R_2}\right)V_E$$

*Input transducers are electronic devices that convert non-electrical energy to electrical energy. (Light-dependent resistor)





Thermistors: Resistance decreases as temperature increases, which causes the output voltage to increase.

Light-dependent resistors: Resistance decreases as luminous intensity increases, which causes the output voltage to increase.

Notes:

When the resistance of a resistor varies, and formula $Vout = (R2/R2 + R1) \times Ve$ doesn't properly show the change in voltage, utilise

$V1 + V2 = Ve$ formula.

Chapter 19 Practical Electricity

Electricity energy is converted into thermal energy when electricity passes through heating elements, (which are used due to their high resistivity and high melting point), which cause them to heat up rapidly.

$P = \frac{W}{t}$ or $\frac{E}{t} = VI = I^2R = \frac{V^2}{R}$

I = Q/t

E or W = VQ

$E = Pt = IVt = \frac{V^2}{R}t$

Solar power	Higher efficiency during daytime and minimal cloud cover, excess energy generated fed back to power grid High costs for the manufacture of solar panels Clean form of energy, requires large areas
Hydroelectric	Most efficient sources of electricity, as water flow can be concentrated and easily controlled High costs for construction of the dam, power plant, and maintenance Clean form of energy, construction disrupts ecosystems
Wind power	Efficiency is dependent on wind velocity Cost is reducing due to technological strides and costs mainly go towards maintenance Clean form of energy, causes noise pollution
Nuclear power	High efficiency as small amounts of uranium are required to generate large amounts of energy Additional costs for waste disposal Waste from uranium mining contaminates ground water and surface water sources
Fossil fuel	Efficient, as most countries have well-established technology and distribution systems Cost rising as supplies decline and demands increase Extensive mining negatively impacts ecosystem around it and fuels contribute to air pollution

Electrical hazards

1. Damaged insulation, exposed conducting wires can cause electric shocks if touched
2. Overloaded power sockets, an unusually large current would flow through the wires, which may result in overheating, followed by burning of wires
3. Use of inappropriate wires, thin wires for low power appliances while thick wire for high power appliances, wrong wire is death
4. Damp environments, water in contact with uninsulated electrical wires provides a conducting path for the current to the body

Safety features in home circuitries

*Circuit breakers are safety devices that can switch off the electrical supply in a circuit when unnaturally large currents flow through them.

*Fuses are safety devices that blow when an excessively large current flows through them, to open the circuit and stop the current flow.

*Switches are designed to break or complete circuits, they should be fitted onto live wires.

*The neutral wire (blue) completes the circuit by providing a return path to the supply for the current. (0 V)

*The earth wire (green or yellow) is a low resistance wire that is usually connected to the metal casing of appliances to earth them.

*The live wire (brown) is connected to the power supply and delivers the current to the appliance.

When the live wire touches the metal case due to an electrical fault, the earth wire provides a path towards the ground for the current, which would prevent any touchers from receiving an electric shock.

The large current flowing through the earth wire would also cause a short circuit, while the fuse would blow and cut of the electrical supply.

3 pin plugs have a cartridge fuse to prevent overheating.

2 pin plugs utilise double insulation, where the electric cables are insulated from the internal components, and the internal components are also isolated from the electric cables.

Chapter 20 Magnetism

*Magnetic materials are materials that can be attracted to magnets, while non-magnetic materials are the opposite.

Properties of magnets

1. Magnets have 2 poles, where magnetic effects are the strongest
2. A freely suspended magnet comes to rest in a north-south direction
3. Like poles repel and unlike poles attract

*Magnetic induction is the process whereby an object made of magnetic material becomes a magnet when it is near or in contact with a magnet.

During magnetisation, when a magnet is stroking a magnetic material, the previous magnetic domains pointing in different directions in the magnetic material, begin to point in the same direction, which produce a net magnetisation, as the magnetic domains are no longer cancelling each other out.

Methods of magnetisation

1. Stroking an unmagnetized steel bar, with the north end of a magnet would induce a south pole at where strokes finish, and a north pole at where strokes begin.
2. Electrical method using a direct current, when a large current flows through the coils of a wire, a strong magnetic field is produced, which aligns the magnetic domains in the steel bar, and cause it to become magnetised.

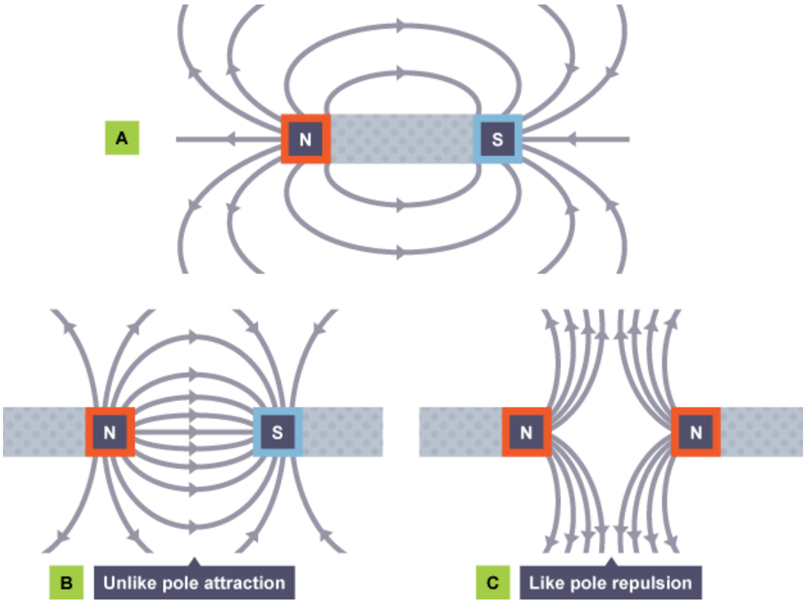
- To determine the poles induced, use the right-hand grip rule, where the steel bar is 'gripped' and the thumb points in the direction of the current, the direction of the thumb is the north pole, while the other end is the south pole.

Methods of demagnetisation (Magnets placed in east-west direction)

1. Heating, the atoms of a magnet vibrate vigorously when heated, causing the magnetic domains to lose their alignment.
2. Hammering a magnet alters the alignment of its magnetic domains.
3. Electrical method using alternating current, connect to the solenoid to an alternating current, and withdraw the magnet while the current is still flowing in the solenoid.

*A magnetic field is the region surrounding a magnet, in which a body of a magnetic material experiences a magnetic force.

The arrangement of the magnetic lines of force is called a magnetic field pattern, which can be seen by sprinkling iron or plotting with a compass. (Placing compasses around a magnet.)



Magnetic shielding is where thin sheets of soft magnetic materials are used to divert magnetic fields that are present.

By placing an object in a cylindrical iron container and having it between the north and south pole of 2 different magnets, the magnetic field lines coming out from the magnetics would pass through the iron to form closed loops.

Magnetic material	Soft	Hard
Properties	Easily magnetised and demagnetised	Difficult to magnetise and de-
Example(s)	Iron	Steel, alnico, neodymium
Used to make	Temporary magnets	Permanent magnets

Permanent magnets are used to produce:

1. Magnetic door catches
2. Reed switches (Close a circuit in the presence of a magnet)

Temporary magnets are used for making electromagnets.

Chapter 21 Electromagnetism

*A current carrying conductor produces a magnetic field around it.

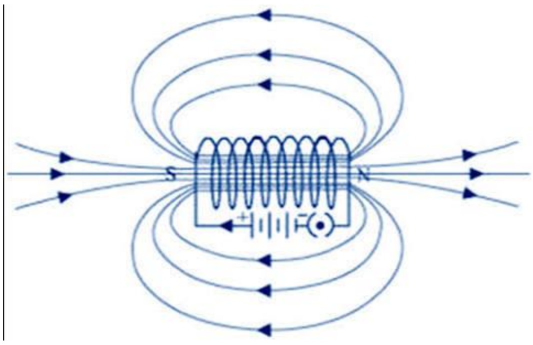
*Right hand grip rule, thumb is direction of current, curl of fingers when viewing from the top determines the flow of the circular magnetic field.

A dot symbol is the current flowing towards you

A cross symbol is the current towards the paper away from you

*The strength of the magnetic field of a current-carrying wire increases when the current is increased.

*The strength of the magnetic field of a flat coil can be increased by increasing the current flowing through the coil.



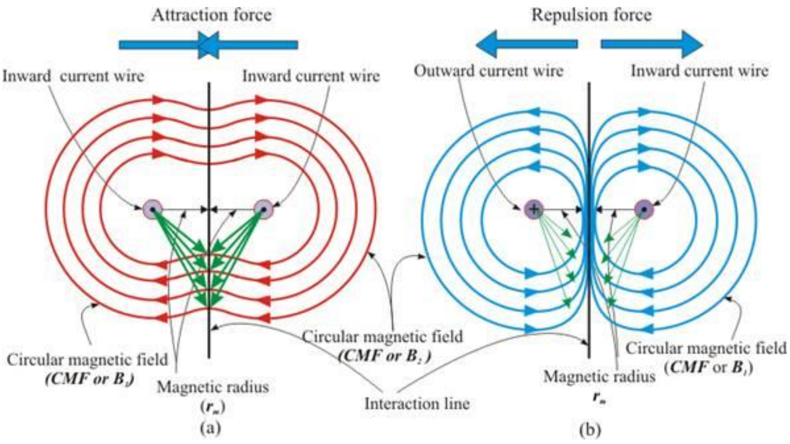
The magnetic field pattern of a solenoid resembles that of a bar magnet, field lines inside the solenoid are stronger.

How to increase strength of magnetic field

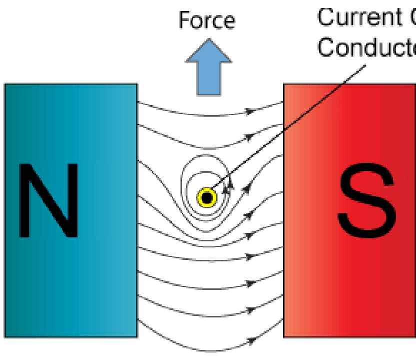
1. Increasing the current flowing through the solenoid
2. Increasing the number of turns per unit length of the solenoid
3. Placing a soft iron core to strengthen and concentrate the magnetic field of the solenoid

*The motor effect occurs when a current-carrying conductor is placed in a magnetic field and the conductor experiences a force.

*The force, current, and magnetic field are all right angles to one another, so in Fleming's left hand rule, the force is represented by the thumb, the magnetic field (From N to S) by the fore finger, and the current by current by the second finger.



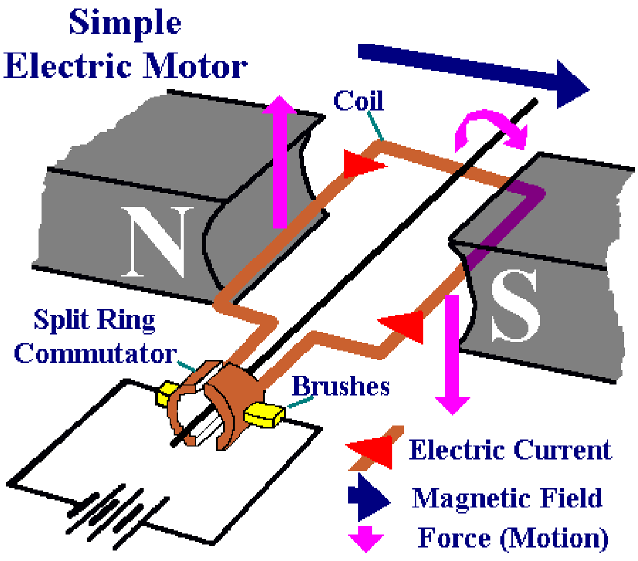
When the question is asking about electric charges in a magnetic field, current direction is determined by the type and direction of the electric charge, the direction of the magnetic field (N-S) is determined by right-hand grip rule on the wires, and using these 2, the force can be found.



The magnetic field produced by the magnets and current carrying conductor act in the same direction and reinforce each other and their combined magnetic field is stronger, however at the other side, the magnetic field of current carrying conductor is in the opposite direction of the fields of the magnets, resulting in a weaker magnetic field, the difference in magnetic field strength of 2 different points causes a net force to be acted on the wire as a result of the combined magnetic field lines.

The turning effect of a current-carrying coil can be increased by:

1. Increasing the number of turns of the wire coil
2. Increasing the current in the coil



When the coil is in a horizontal position a force acts on the 2 sides of the wires, causing it to rotate in a clockwise direction until the vertical position, where the current is cut of as the split ring commutator that is attached to the wires, is not in contact with the carbon brushes, the momentum of the coil carries it pass the vertical condition. When it goes back to the horizontal position again, the direction of the current in the 2 sides the wire are different due to their change in position, and the forces acting on them are thus also different, but the coil still continues to rotate in a clockwise direction.

To increase the turning effect of the coil:

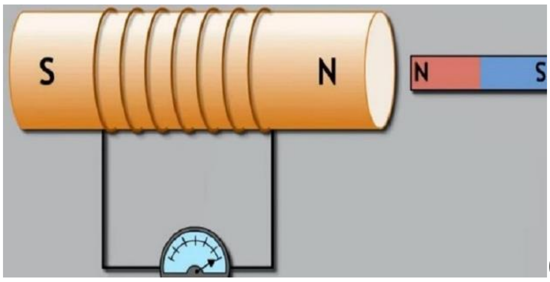
1. Insert a soft iron core into the coil
2. Increase the number of turns in the coil
3. Increase the current of the coil

Chapter 22 Electromagnetic Induction

*Electromagnetic induction is the process through which an induced e.m.f. is produced in a conductor due to a changing magnetic field. (Change in magnetic flux)

*Faraday's Law of electromagnetic induction states that the magnitude of the induced e.m.f. in a circuit is directly proportional to the rate of change of magnetic flux in the circuit.

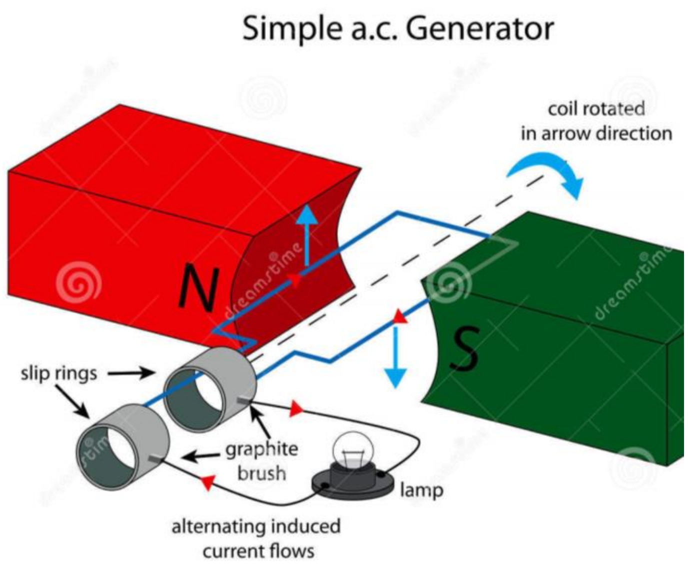
*Lenz's Law states that the direction of the induced e.m.f. and current, is always such that its magnetic effect opposes the motion or change that is producing it.

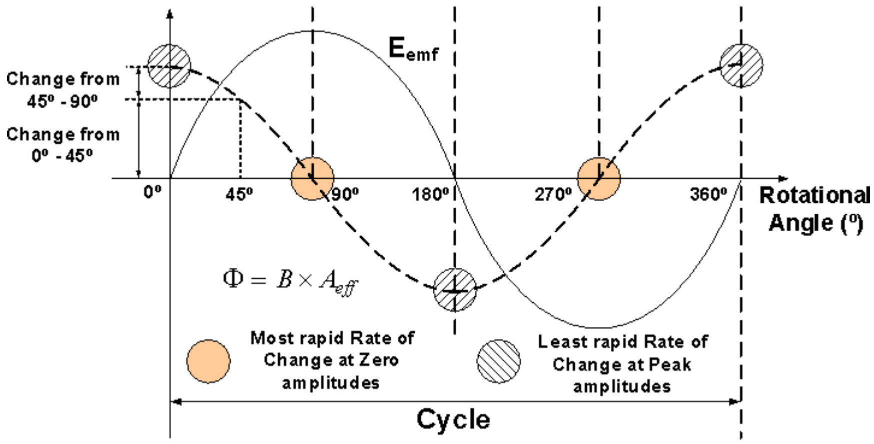


(Faraday's Experiment)

When a north/south pole of a magnet is brought towards right of a solenoid, the galvanometer will be deflected momentarily to the right/left, as the movement of the magnet results in a change in magnetic flux of the solenoid, which induces e.m.f. in the coil and a current that flows towards the galvanometer, the induced current produces a north/south pole on the end of the solenoid to repel the north/south pole on the magnet that is moving towards it.

When a north/south pole of a magnet is brought out of its right, the galvanometer will be deflected momentarily towards the left/right, as the movement of the magnet results in a change in magnetic flux of the solenoid, which induces e.m.f. in the coil and a current that flows towards the galvanometer, the induced current produces a south/north pole to attract the north/south pole of the magnet that is moving away from it.





(Follows the dotted line)

For a.c. motors, use Fleming's right hand rule instead of his left rule

1. At the horizontal position the plane of the coil is parallel to the magnetic field where the wires cut across the magnetic field lines at the greatest rate, as there is the greatest change in magnetic flux, the induced e.m.f. is the highest.
2. At the vertical position the plane of the coil is perpendicular to the magnetic field, and the wires do not even cut across the magnetic field, since the rate of change of magnetic flux is 0, the magnitude of the induced e.m.f. is 0.
3. After the coil rotates for half a cycle, it is at the horizontal position again where the plane of coils is parallel to the magnetic field, the wires contrast the 1st step as they move in opposite directions.
4. Continue until back to 1.

We can increase the magnitude of the induced e.m.f. of an a.c. generator by:

1. Increasing the number of turns in the coil
2. Using stronger permanent magnets
3. Increasing frequency of rotation of coil
4. Winding the coil around a soft iron core to strengthen the magnetic flux linking the coil

In graphs, doubling number of coil turns doubles the amplitude of the voltage, while doubling the frequency of rotations, will increase both the amplitude and frequency of curves.

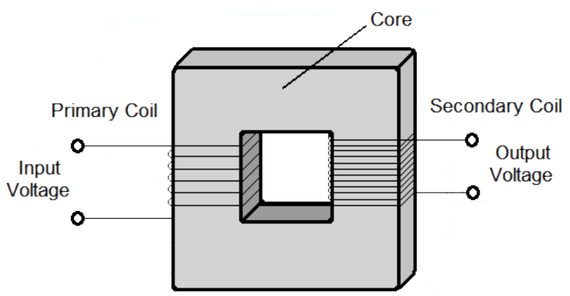
A fixed coil a.c. generator (spinning magnet instead of wire) is favoured as:

1. It does not require carbon brushes which need frequent replacement
2. It is less likely to overheat as it does not utilise slip rings and carbon brushes, which could have eroded connections which increase resistance and generate large quantities of heat
3. It is more compact

*A transformer is a device that can change a high alternating voltage at low current to a low alternating voltage at high current or vice versa.

Transformers are used for

1. Electrical transmission from power stations to households
2. Regulating voltages for proper operation of electrical appliances



1. The input voltage V_p comes from an alternating current generator, which sets up a continuously varying magnetic field in the laminated iron core

2. Due to changes in magnetic flux, e.m.f. Vs is induced in the secondary coil, and as the circuit is closed a current is also induced in the coil

In a step-up transformer the number of turns in the secondary coil is greater than that in the primary coil which results in an output voltage that is higher than the input voltage.

The converse is true for that of a step-down transformer.

Number of primary coils Np, number of secondary coils Ns

$V_p I_p = V_s I_s$

$\frac{Vs}{Vp} = \frac{Ns}{Np} = \frac{Ip}{Is}$

Step-up transformer	Step-down transformer
Ns > Np	Ns < Np
Vs > Vp	Vs < Vp
Is < Ip	Is > Ip

Efficiency = $\frac{useful\ output\ power}{input\ power}\ x\ 100\%$

To curb the problem of Joule heating during the process of electrical transmission from power stations to households:

Voltage should be higher than the current as the greater the voltage, the less the power loss(using a step-up transformer) , and resistance should be kept low (thick power cables as R =p(l/a)) to reduce loss of power due to overheating as P loss = I^2R.

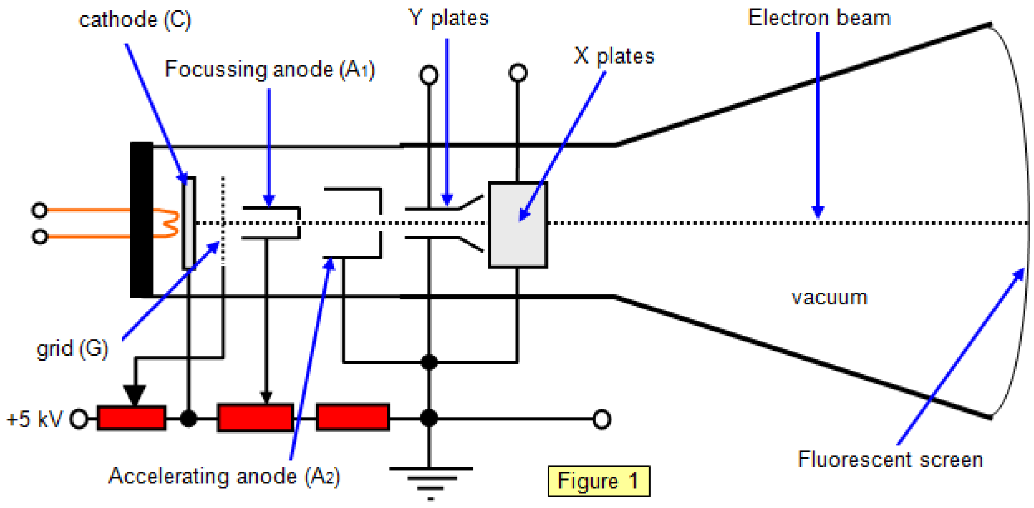
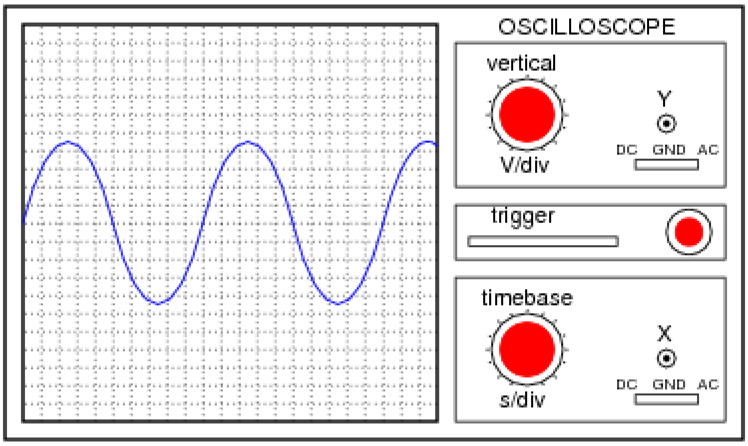


Figure 1

1. Cathode-ray tube, a vacuum glass tube that contains an electron gun, a deflecting system and a fluorescent screen
2. Electron gun, emits a beam if electrons which is produced by the cathode
3. Fluorescent screen, coated with zinc sulfide which glows in proportion to the electrons that strike it
4. Y plates, where the voltage is varied to change the vertical deflection of the electron beam
5. X plates, where the voltage is varied to change the speed of the electron beam

To use the Cathode-ray oscilloscope:

1. Turn it on and connect it to the voltage that is to be studied
2. Adjust the X-shift and Y-shift controls to position the trace at the centre of the screen.
3. Adjust the Y-gain and time base controls to obtain a waveform that can be visualised clearly on the c.r.o screen.



*Y-gain control is the control that amplifies the vertical (Y) deflection of the electron beam by varying the voltage across the Y-plates of the cathode ray tube.

Voltage across the Y-plates is amplified by amplifier circuits in c.r.o..

*Time base control is the control that adjusts how quickly the electron beam sweeps horizontally across the screen by varying the voltage applied across the X-plates of the cathode-ray tube.

An internal circuit applies an alternating voltage across X-plates, which varies the frequency of the time base.

Gain of Y-input determines the sensitivity of the c.r.o. (V/div)

Deflection of the electron beam is measured by divisions (div)

Y-gain x Deflection = Applied voltage

If Y-gain is o.5 V/div and if the electron beam is deflected by 3 div, the applied voltage is 1.5 V.

With an inactive timebase,

The graph is either a single dot (d.c. input or no applied voltage) or a

Single vertical line (a.c. input)

Electrons that are deflected downwards have negative V (reverse voltage)

With an active timebase

The graph is either a horizontal straight line (d.c. input) or a

Series of transverse waves (a.c. input) due to the horizontal sweeping of the electron and its vertical oscillation.

The determine the number of cycles on screen, take the frequency of the a.c. input and divide it by the time base frequency which is usually 25 Hz.

To measure voltage, the time base is first switched off and the voltage to be measured is applied across Y-plate by Y-input terminals. The applied voltage sets up an electric field which would deflect the electron beam passing through, we use the equation above to determine the applied voltage.

Number of complete cycles of a.c. input =

Frequency of a.c./Frequency of the time base (Usually 25 Hz)

Deflection of the electron beam when represented on the graph only moves vertically, for a.c. inputs the electron beam moves vertically towards both positive and negative sides, depending on the magnitude of deflection.

Cathode-ray oscilloscopes can be used for measuring short intervals for time, for example, when a microphone is connected to the Y-input terminals of the c.r.o. , a sound and its echo will be shown as signals on the c.r.o. screen, the number of divisions between the 2 signals can be used to calculate the time taken to travel from the c.r.o. to the wall and back.(Time between sound and echo)

Time base setting is 5 ms/div, so if there are 10 divisions, the time taken would be 5 ms/div x 10 div = 50 ms