Physics definitions

Making measurements

- **Length**: measure between two points of an object.
- **Least count**: the minimum measurement that can be measured with a device
- **Micrometer screw gauge:** it has two scales. Main scale which is on the shaft and the fractional scale which is on the rotating barrel. The main scale is read to the nearest 0.5mm and the fractional scale has 50 divisions, so one complete turn represents 0.50mm. Used for measuring very small thicknesses.
- **Displacement method for measuring volume:** fill a measuring cylinder partially with water and measure the volume. Then put the irregular object into the cylinder and record the change in volume. Subtract both the volumes and thus find the volume of the irregular shaped objects.
- **Mass**: of an object is the amount of matter that makes up the object.
- **Volume**: the space occupied by three dimensional objects
- **Density**: the ratio of mass to volume of a substance (or) the amount of mass that is concentrated
- $\boldsymbol{D = \frac{m}{V}}$
- **Density of water**= 1000kg/m^3 or 1kg/dm^3 or 1g/cm^3
- **Analogue clock**: time is found by checking where the hands of the clock are pointing on the scale
- **Digital clock:** it gives a direct reading of the time in numerals.
- **Period of a pendulum**: time taken for one swing of a pendulum from left to right and back again

Describing motion

- **Speed**: the distance travelled by an object per unit time $\boldsymbol{S = \frac{d}{t}}$
- **Average speed**: total distance divided by total time taken $s_{avg} = \frac{total\ distance}{total\ time}$
- **Light gates**: a peg on a trolley breaks the first beam of infrared radiation, which starts the timer and after moving a known distance it breaks another beam of infrared radiation, which stops the timer. Then the distance travelled by the trolley is divided by the time taken to move from one ray to another to get the speed of the trolley.
- **Interrupt card**: a card of fixed length starts and stops the timer by breaking the same piece of radiation once and accordingly speed can be calculated.
- **Slope of distance time graphs gives speed**
- **Area under speed time graph gives distance**

- **Slope of speed time graph gives acceleration**
- **Acceleration**: the rate of change of an object's velocity (or) change in speed per unit time. $a = \frac{v-u}{t}$
- **Deceleration**: negative acceleration (when an object is decelerating)
- **Acceleration of free fall:** it has a value of 9.81 m/s^2 near the surface of the earth
- **Velocity**: an object's speed in a particular direction (vector quantity)

  $\boldsymbol{s = ut + \frac{1}{2} at^2}$

  $\boldsymbol{v^2 = u^2 + 2as}$

Forces and motion

- **Mass**: amount of matter in an object and the object's resistance to motion measured in kilograms
- **Weight**: is the force of gravity on mass measured in newton **W = mg**
- **Friction**: a force that opposes motion caused by contact of the two surfaces. It acts in the opposite direction to the object's movement.
- **Force**: the action on a body by another body that causes its velocity or shape or direction of travel to change **(F = ma)**
- **Newton (N):** the force required to give a mass of 1 kg an acceleration of 1 m/s2

- **Resultant force:** is a single force that has the same effect as two or more forces
- **Weight of 1 kg mass = 10 N**
- **Gravitational force per unit mass = 10 N/kg**
- Greater the mass of an object, the smaller the acceleration it is given by a particular force
- **Inertia of rest:** opposition to change in state of rest to the state of motion
- **Inertia of motion:** opposition to change in state of motion to the state of rest
- **Inertia of direction:** opposition to change in existing direction ● **Newton's laws of motion:**
  1. **First law / Law of inertia**: every object continues to be in a state of rest or uniform motion unless and until it is compelled by a net external force
  2. **Second law of motion:** acceleration of a body is directly proportional to the direction of force applied and it is inversely proportional to the mass of the object. $\boldsymbol{Ft = (v - u)m}$
  3. **Third law of motion:** every action has an equal and opposite reaction
- **Momentum**: of a body is the product of the body's mass and velocity **(P=mv)**

Turning effects of forces

- **Pivot**: the fixed point about which an object will turn
- **Turning effect**: can be increased by using a big force and applying force as far from the pivot as possible.
- **Moment of a force**: is the quantity that tells us the turning effect of a force about its pivot. It can be maximised by the force acting 90 degrees to the object, by using a big force and applying the force as far from the pivot as possible.
  $p = F\ x\ d$ **(perpendicular distance from pivot to force)**
- **Equilibrium**: if an object is in equilibrium, then the forces on it must be balanced (no resultant force) and the turning effect of forces must also be balanced (no resultant turning effect which is total clockwise moment = total anticlockwise moment)
- **Principle of moments:** the idea that an object is balanced when anticlockwise moments equal clockwise moments.
- **Contact force:** is the sum of all the downward forces acting on a beam
- **Centre of mass/gravity:** the point on an object where it is assumed that the mass/weight of the object is concentrated.
- **For an object to be stable,** it should have a low centre of mass and a wide base.
- A lamina is hung on a pin and a line is drawn across a plumb line when the lamina stops moving. It is repeated on more sides of the irregular object and the point where the lines coincide, it is assumed as the centre of mass.

Forces and matter

- **Forces used for deforming objects**: tensile forces, compressive forces, bending forces and torsional forces.
- **Load**: weights hung to springs for experimental purposes
- **Inelastically deformed:** occurs when a spring becomes permanently stretched as the load is increased way too much and it will not return to its original length.
- **Extension**: this is the quantity which measures the increase in length of the spring as the force stretching the spring increases.
- **Length of stretched spring = original length + extension**
- **Limit of proportionality / elastic limit:** the point at which the graph slopes up steeply. Beyond this point, if the string is stretched, it will be permanently damaged.
- **Hooke's law:** the extension of a spring is proportional to the load applied to it, provided the limit of proportionality is not exceeded.

- **F = kx** (F is the load, k is the spring constant of the spring and x is the extension of the spring)
- In the spring, the bigger the load, the bigger the extension and not the spring.
- **Pressure**: is the force acting per unit area at right angles to the surface.

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

- **High pressure**: large force acting on a small area
- **Low pressure**: small force acting on a large area
- **Pa = N/m^2 (1 pascal is equal to a force of 1 N by an area of 1 m^2)**
- **Atmospheric pressure:** the pressure due to the air column above the earth's surface

Energy transformations and energy transfers

- **Energy stores:** kinetic energy, gravitational potential energy, chemical energy, nuclear energy, strain/elastic energy and internal energy
- **Energy transfers:** light energy, heat/thermal energy, sound energy and electrical energy.
- **Internal energy** is the energy stored in a hot object whereas the energy radiating out of a hot object is thermal energy.
- **Energy can be transferred by** a force, by electricity, by heating and by waves.
- **Principle of conservation of energy:** in any energy conversion, the total amount of energy before and after the conversion is constant
- **Low-grade energy**: energy wasted as heat and sound
- **Efficiency**: the efficiency of an energy conversion is the fraction of the energy that ends up in the desired form.

$$Efficiency = \frac{useful\ energy}{energy\ input} \times 100$$

- $\boldsymbol{Eg = mgh}$**:** energy possessed by a body due to its position/h from ground
- $\boldsymbol{Ek = \frac{1}{2}mv^2}$:energy possessed by a body due to virtue of its motion

Energy resources

- **Solar panels:** they are used to collect thermal energy from the sun by absorbing the sun's rays and later convert it into electrical energy for domestic use.
- **Solar cells/photocells:** used to absorb sunlight and produce electricity
- **Wind and wave power:** winds are produced by the warmth of the sunlight heating a few parts of the atmosphere which causes the air to heat and expand

and move around as winds. These winds can be used in turbines and windmills for producing energy.

- **Biomass fuels:** wood, animal dung and biogas.
- **Fossil fuels:** oil, coal and gas.
- **Nuclear fuels:** uranium, plutonium (radioactive materials)
- **Nuclear fission:** a procedure in which inside a nuclear reactor, the radioactive decay is speeded up of radioactive elements so that the energy they stored is released much more quickly. Nuclear fuel is cheap, concentrated energy resource however setup and close down costs are high. Nuclei are split apart to produce energy
- **Nuclear fusion:** occurs when two energetic hydrogen atoms collide and fuse up and form an atom of helium. Nuclei are fused to produce energy.
- **Water power:** used for hydroelectricity and water wheels. Water stored behind the dam walls is released to turn turbines which make generators spin. This is safe, clean and reliable but also causes wildlife, habitat and shelter loss.
- **Geothermal energy:** water is pumped down underground into radioactive rocks where it gets hot and steam produced comes back up to generate electricity.
- **Renewable resources:** sources of energy which won't run out and can be regenerated. Eg: wind, solar, biomass
- **Non-renewable**: sources of energy which are present in limited amounts and have to be used carefully. Eg: coal, oil, gas
- **Comparing energy resources by:** cost, reliability, scale and environmental impact.

Work and power

- **Doing work:** is the means of transferring energy from you to the object with the help of a force.
- **Work done:** is the amount of energy transferred. **(work done = energy transferred)**. Greater the force and distance moved in the direction of force, the work done is increased.
- $W = F \times d$ **(moved in the direction of the force)**
- **1 J = 1N x 1m = 1Nm**
- **Joule**: 1 joule is the energy transferred or the work done by a force of 1 newton when it moves through a distance of 1m in the direction of the force. 1J=1Nm
- **G.p.e / work done = mg * h**
- **1 kJ=1000J, 1MJ=1 000 000J**
- **Power**: the rate at which work is done or energy is transferred. The more work you do in a lesser time, make you more powerful.

- Power can be increased by lifting heavier objects and doing that fast.
- **Watt**: the power when 1 J of work is done in 1 second. **1 W = 1 J/s** and 1 J=1Nm

- **1kW=1000W, 1MW=1,000,000W**

The kinetic model of matter

- **Melting point:** the temperature at which pure substances change into a liquid from solid state
- **Boiling point:** the temperature at which a liquid changes into a gas. It occurs throughout the liquid.
- **Evaporation**: a process in which a liquid changes to a gas over a range of temperature and takes place only on the surface of the liquid.
- **Freezing point:** the temperature at which a liquid changes into a solid state. Freezing point and melting point of a substance are the same.
- **Brownian motion:** the erratic movement of small particles when observed from a microscope. It is caused by gas/liquid particles colliding larger molecules of smoke, for example, with high speeds causing the larger particles to move around.

Thermal properties of matter

- **Thermal expansion**: occurs when solids, liquids and gases expand when they are heated. Uses of expansion are in rivets, loosening metal lids, bimetallic strips and fitting steel tyres onto their wheels.
- **The two types of thermometers** are liquid in glass (mercury in thin column of the thermometer expands with increase in temperature) and liquid crystal (each segment shows a particular temperature).
- **Thermal equilibrium:** is achieved when energy is not being transferred between two objects. Eg: the thermometer is in the same temperature as the water and the water is no more transferring its energy.
- **Internal energy:** is the total energy of all the particles
- **thermal/heat energy:** energy radiated out of an object in the form of heat
- **Temperature**: is a measure of the average kinetic energy of the individual particles.
- **Calibration of the thermometer:** is a process where the thermometer is marked from 0 to 100 degree celsius to give it a proper scale.
- The scale on a thermometer is **linear** if the marks are evenly spaced out. It is usually found in a mercury in glass thermometer as mercury expands at a steady rate when it is heated.

- The thermometer can be made **sensitive** by making the tube containing mercury very narrow.
- Mercury thermometers can also have a wide **range** of temperatures to get more accurate readings and the opportunity to measure a wider range of temperatures.
- **Thermistors**: are resistors whose resistance changes by a large amount over a narrow temperature range. But their resistance changes in a non-linear way and the range is narrow.
- **Thermocouple**: a device that gives out an output voltage that depending on the temperature. They are made from pieces of wires made up of two different metals. A wire of metal X is joined at each end to wire of metal Y to form two junctions. The ends of the thermocouple are joint to a sensitive voltmeter. Then one of the junctions is placed in melting ice whereas the other is placed in the object whose temperature is to be measured. The greater the voltage produced, the greater the difference in the temperatures between the two junctions. They are used for measuring rapidly changing temperatures and high temperatures as well.

Thermal/heat energy transfers

- **Thermal energy:** is energy being transferred from a higher temperature to a lower temperature and it requires a temperature difference to be transferred.
- Metals are good conductors of heat and it can be proven by the metal rods and wax experiment. Water is a bad conductor of heat and it can be proven by the ice cubes separated by wire and heating the mouth of the test tube experiment. **Diamond is the best conductor whereas glass wool is the worst.**
- In non-metals/insulators, the atoms on the hot end gain energy and transfer it to their neighbours which eventually makes the hot end cold and the cold end hot.
- In good conductors, electrons flow, transferring the heat.
- **Conduction**: the flow of heat through matter from higher temperature to lower temperature without the movement of the matter as a whole.
- **Convection**: is the flow of heat in liquids/gases (fluids) from regions of higher temperature to regions of lower temperature with the movement of the fluid as a whole.
  Hot air rises because when air is heated, it becomes less dense as it expands which causes it to float upwards and that causes cool air to descend.
- **Convection current:** is a movement of a fluid that carries energy from a warmer place to a cooler one.
- **Radiation**: is the flow of heat from one place to another by means of electromagnetic waves. It doesn't require a medium.

- **Infrared radiation is produced by** warm/hot objects and it is in the form of electromagnetic radiation. It travels through empty space and air in the form of waves and travels in straight lines. It also warms the objects that absorbs it and is invisible to the naked eye but can be detected by nerve cells in the skin.
- Matt black surfaces readily absorb radiation and emit it as well. (best absorbers, best emitters and the worst reflectors)
- Shiny or white surfaces are the best reflectors, worst absorbers and the worst emitters.
- **Insulation** is required to keep energy in something that is hotter than its surroundings. Insulation in houses can be provided by double glazed windows having vacuum between the glass panels (only radiation can pass through as conduction and convection need an medium) and building of cavity walls with an air gap or foam filled between the two layers of bricks which stops convection currents from flowing, but minimal conduction takes place.
- **Energy can be retained in the house** by the use of thick curtains, draught excluders, loft and underfloor insulating materials, double and triple glazing of windows, cavity walls and foam or rockwool in wall cavity.
- In **vacuum flasks**, glass is used as it is a good insulator but sometimes steel is used for added strength. The gap between double walls is vacuum to avoid heat loss by conduction and convection, silvering reduces loss by radiation and the stopper prevents heat loss by convection and evaporation.
- **Thermal capacity**: is the amount of heat energy required to increase the temperature of the object by 1 degree celsius. It is also equal to the amount of heat energy an object will give out when cooled by 1 degree celsius.

  E = thermal capacity * T

  Thermal capacity = m * c (m=mass and c= specific heat capacity)
- **E = m*c*change in t**
- **Specific heat capacity (c):** is the amount of thermal energy needed to raise the temperature of a mass of 1kg by 1 degree celsius. Unit: J/kg degree celsius

  Change in energy= mass*specific heat capacity*change in temperature

Waves and sound

Ripple tank: is a shallow glass-bottomed tank containing a small amount of water. Light from above, shining through the water creates a shadow of the ripples on the floor below, helping us see the pattern in which ripples form.

- **Ripples are produced by** something that moves up and down (vertically, usually wooden bars or spherical dippers) but the ripples move out horizontally.
- **Waves**: disturbance in medium that transports energy and momentum

- **Wavelength**: of a wave is the distance from one crest to another or from one trough to another. It is measured in meters.
- **Amplitude (A):** of a wave is the maximum distance that the surface of the water is displaced from its undisturbed level (or) the height of the crest. It is measured in meters.
- **Frequency (f):** of a wave is the number of waves sent out each second (or) the number of waves per second passing a point. It is measured in Hz. **1 Hz = 1 wave or ripple per second** $f = \frac{1}{T}$
- **Period (T):** of a wave is the time taken for one complete wave to pass a point. It is measured in seconds. It is measured from crest to crest.
- $T = \frac{1}{f}$
- **Wave speed:** is the rate at which the crest of a wave travels along (or) the speed at which it transfers energy from one place to another
- **Transverse waves:** are waves in which particles carrying the wave move from side to side, perpendicular to the direction in which the wave is moving. Eg: light, ripples on water and electromagnetic waves.
- **Longitudinal waves:** are those waves in which the particles carrying the wave move back and forth, along the direction in which the wave is moving. Eg: sound **Compressions** are areas of the sound waves where the air particles are closer together and the air is dense.

  Rarefactions are areas of the sound wave where the particles are farther from each other and the density of the air is less.
- **Mechanical waves** need a medium and **non-mechanical** don't need a medium.
- **When waves enter one medium from another**, the wavelength and velocity keep changing but the frequency remains constant.
- **wavefront**: a surface containing points affected in the same way by a wave in a given time. The separation of the wavefronts of the ripples is equal to their wavelength.
- **Refraction** occurs when the speed of light changes when it is travelling from one medium to another.
- When a glass plate is submerged in water, the area where the glass plate is present is shallow, so the waves travel slowly here and where the glass plate is not present, it is deep and waves travel fast in those regions.

  Diffraction: occurs when ripples in the water encounter a slit/opening in a barrier and they spread out into the space beyond the barrier. When the width of the gap is equal to the wavelength, diffraction is the greatest.
- **Types of musical instruments:** percussion, stringed and wind.
- **Speed of sound in air = 330 m/s or 1200km/h**
- **Sound travels 1 km in about 3 s.**

- **Echo**:is the reflection of sound when it hits a hard surface and reflects. **s=2d/t**
- **Time of flight method:** can be used to measure the speed of sound in a lab. Two microphones should be arranged in a straight line at a suitable distance apart. Each microphone should be connected to a timer. When a student bangs two blocks of wood together, the first microphone senses this and sends the signal to timer to start the timer and the second microphone, a split second later, senses the sound made and stops the timer. So now, distance of the microphones can be divided by the time displayed on the timer, to obtain the speed of sound.
- **Speed of sound in solids > liquids > gases**
- **Oscilloscope**: it produces a trace on the screen which is the up and down motion of the sound wave. A microphone detects sound waves and sends electrical impulses to the oscilloscope.
- **Higher pitch is due to higher frequency**
- **Louder sounds are produced due to greater amplitudes**
- **Sounds**: are vibrations that travel through air and other mediums and are produced by vibrating objects.
- Crests in a sound wave are compressions and troughs on a sound wave are rarefactions. Sound waves also represent the changes in air pressure as the sound travels from its source.

Light

- **Speed of light = $3x10^8$ m/s**
- Light changes direction only when it hits a shiny surface or travels from one medium to another. (reflection and refraction)
- **Reflection**: occurs when a light ray strikes a shiny surface and bounces back in a straight line. The angle of incidence is equal to the angle of reflection (law of reflection). The incident ray, reflected ray and the normal all lie on the same plane.
- **Real image**: is an image which can be formed/captured on a screen
- **Virtual image**: is an image which can't be caught/captured on a screen
- **The object reflected on a plane mirror is:**
    1. The same size as the object
    2. Left-right inverted
    3. Virtual
    4. Same distance behind the mirror as the object is in front
- **Refraction**: is the bending of light rays when they enter one medium from another, due to the change in speed. The two laws of refraction are; the incident ray, refracted ray and the normal all lie on the same plane at the point of

incidence. The ratio of sin of angle of incidence to sin of angle of refraction is constant for a pair of media.
If light is perpendicular (90 degrees) to the medium it is entering, refraction doesn't take place.

- **Refractive index:** is the quantity that tells us by how much light slows down while entering particular media.
- **n = speed of light in vacuum($3x10^8$) / speed of light in the material**
- **Snell's law:** it relates the sin of angle of incidence with the angle of refraction and also the refractive index, because as the refractive index increases, so does the ray's bending. $n = \frac{\sin i}{\sin r}$ $n = \frac{1}{\sin i}$ (critical angle)
- **Total internal reflection (TIR):** occurs when light entering a semicircular glass block reflects internally with no refracted ray produced. It is " total " because all the light is reflected, it is " internal " because it happens inside the glass and " reflection " because the ray is reflected. For TIR to happen the angle of incidence should be greater than the critical angle or equal to it.
- **Critical angle:** the angle of incidence in the denser medium (glass) for which the angle of refraction in rarer medium (air) is 90 degrees or more.
- **Optical fibres:** use total internal reflection to transport telephone messages and electronic signals in the form of a flashing laser light. The optical fibres are made up of high purity glass, so that the light inside the fibre is not absorbed and only TIR takes place without any refraction. Optical fibres are used in telecommunications and endoscopes.
- **Converging lenses (convex):** such lenses are thicker/fatter in the middle compared to the sides and they make parallel rays of light converge at one point called the principal focus Eg: magnifying glasses
- **Diverging lenses (concave):** such lenses are thinner in the middle,
- **Principal axis:** is a horizontal line passing through the centre of the lens. All the light rays passing through the lens are parallel to the principal axis.
- **Optical centre:** the centre of the lens situated on the principal axis.
- **Principal focus:** points on either side of the lens, on the principal axis, where all the light rays passing through the lens converge.
- **Focal length:** is the distance measured in between the optical centre and the focal point on the principal axis. A fat lens has a shorter focal length compared to a thin one.
- **Characteristics of light:**
    1. Light is a transverse wave
    2. It travels in a straight line
    3. Speed of light in vacuum is $c = 3x10^8$ m/s
    4. It can travel through vacuum, despite the lack of air molecules

5. Light carries energy with it / transfers energy but the matter through which its moving doesn't change position.

- **An image formed by a converging lens is:**
    1. Real
    2. Inverted
    3. Reduced in size
    4. Nearer to the lens than the object
- **An image formed by a magnifying glass is:**
    1. Virtual
    2. Upright
    3. Magnified (bigger than the object)
    4. Further from the lens than the object

    (object has to be closer to the lens than the principle focus)

Spectra

- **Spectrum of colours:** is produced when white light passes through a prism. The range of colours produced are VIBGYOR
- **Red light:** refracted the least, travels the fastest, least refractive index, most temperature, least frequency, most wavelength
- **Violet light:** refracts the most, travels the slowest, has the highest refractive index, least temperature, most frequency, least wavelength
- **Infrared radiation:** is the invisible form of radiation which is present beyond the red end of the spectrum
- **Ultraviolet radiation:** is the invisible form of radiation which is present beyond the violet end of the spectrum.
- **Electromagnetic spectrum:** is the ordered arrangement of wavelengths of electromagnetic waves;

  Radio waves, microwaves, infrared, ROYGBIV, ultraviolet, X ray, gamma rays
- **Properties of electromagnetic waves:**
    1. All the electromagnetic waves are transverse
    2. They travel at the speed of light approximately 3. They are non-mechanical (can travel through vacuum)
- **Uses of electromagnetic waves:**
    1. **Radio waves:** are used to broadcast radio and television signals.

2. **Microwaves**: are used in satellite television broadcasting. They are also used to transmit mobile phone signals between masts. It has to be made sure no microwaves are leaking out of the microwave ovens used for domestic purposes.
3. **Infrared radiation:** is used in remote control for devices such as televisions and DVD players. It is used in security alarms to send out infrared radiation and check if they are reflected back, which happens in the presence of an intruder.
4. **Ultraviolet radiation:** is used in sunbeds, fluorescent lamps and sterilisation of food by killing the microbes. Overexposure to tanning lamps/sunbeds can cause skin cancer and cell damage.
5. **X rays**: can penetrate solid materials which is why they are used in security scanners in airports. They are also used in hospitals and clinics to see inside the patient's body without performing surgery. Since bones absorb the radiation they appear as shadows. To avoid the danger caused by X rays, the equipment can be enclosed in a metal case, which will absorb the X rays.
6. **Visible light:** is used in optical fibres (telecommunications and medical purposes).

Electricity

- **Two types of static electricity**: positive charge and negative charge
- Like charges repel and unlike charges attract. (opposites attract)
  - Static electricity arises from electric charges.
- **Charging** is caused by the force of friction, because when two substances are rubbed with each other, friction causes transfer of electrons which leaves one positively charged and the other negatively charged. Charge is measured in coulombs (C).
- **Electric field**: Charged objects have electric fields around them and any object placed in that field, will experience the force.
- **Charge : Q = ne** (n= number of e, e= $1.6\text{x}10^{-19}$
- **Electric field lines**: direction of force on unit charge (negative/positive)
- **Electron charge** = $-1.6\text{x}10^{-19}$ C
- **Proton charge** = $+1.6\text{x}10^{19}$
- **Methods of charging**: frictional/rubbing method, Contact method, Earthing method and induced/induction method
- Electric circuits can be used to transport energy and contain devices to transform energy.
- **Cell**: provides push in the electrical circuit for electricity to flow

- **Battery**: is a combination of cells/ two or more cells connected end to end
- **Direct current (DC)**: current that flows in the same direction all the time (positive to negative terminal of the battery)
- **Short circuit**: is caused when two metal wires come in contact with each other. It can be avoided by insulating wires with plastic/polymers.
- Electric charge travels around the circuit
- **Current**: is the flow of electric charge (or) the rate at which electric charge passes a point in a circuit. In a metal current is a flow of e.

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

- **Ammeter**: is used to measure electric current in the units amps. The two types are analogues and digital. It is connected in series. Red is positive (current flows in) and black is negative (current flows out).
- **Trip switches/ fuse**: are used to cut out current if the current passing in a circuit gets too large.
- **Resistance**: is the opposition a substance offers to the flow of electric current. Greater the resistance, smaller is the current. It is measured in " ohms " . Longer and thinner wires have more resistance than shorter and wider ones.
- **Resistance of a wire is proportional to its length** $(R \propto l)$
- **Resistance of a wire is inversely proportional to its area** $R \propto \frac{1}{A}$

$$R = \frac{V}{I}$$

- **Ohm's law**: states that, at constant temperature and fixed dimensions, current through a conductor is proportional to the potential difference across its ends. **V = IR.**
- **Voltage/ Potential difference**: is the work done in moving a unit of positive electric charge from one point to another. The unit is volts.
- **Voltmeter**: is connected in parallel and is used to measure the difference in electric potential across a resistor/p.d. across a resistor.
- **e.m.f (electromotive force)**: work done to move a unit charge across the circuit and it drives the electric charge. It is a voltage and not a force. (or) energy supplied by a source in driving charge around a complete circuit.
- **Current-voltage characteristic**: is a graph with the x-axis representing p.dV/V, as this is what we vary and the y-axis represents current I, because this is the value that varies as we change V.
- **Ohmic resistor**: a resistor which has a current-voltage characteristic which shows that current is proportional to voltage.

- **A filament lamp** acts an ohmic resistor until its filament stays cool, but at high temperatures,as the filament starts getting hot, it acts as an excellent **resistor**,due to which increasing p.d. doesn't increase the current.
- A negative current can be achieved by connecting the voltmeter the other way around.
- **Power rating of an appliance:** shows the rate at which the appliance transforms energy, and indicates the maximum power the appliance draws from the mains supply when it is operating at full power. They are indicated in watts (W) or kilowatts (kW).
- **Power**: is the rate at which energy is transferred from place to place or transformed from one form to another. $P = \frac{E}{t}$
- The rate at which a cell or power supply transfers energy to a circuit depends on both the e.m.f of the supply and the current it pushes round the circuit. $P = IV$
- **Energy transformed:** $E = IVt$
- **Circuit components:**
    1. **Resistor**: can be used to control the amount of current in a circuit. It has two terminals so that current can flow in from one terminal and then out from the other. High resistance resistors are made from carbon (graphite) or metal alloys.
    2. **Variable resistor/potentiometer:** is used to alter the current flowing in a circuit. Such resistors are used for volume control in stereos and radio systems.
    3. **Light-dependent resistor (LDR):** is a type of variable resistor whose resistance depends on the amount of light falling on it. In the dark, an LDR has a very high resistance because it is made up of a material that does not normally conduct well and in the light it has a very low resistance. They are used in circuits to detect light, as current flows in the circuit when light is shone on it.
    4. **Thermistor**: is a type of resistor whose resistance depends on the environment's temperature. The resistance changes by a large amount over a narrow range of temperature. A few resistor's resistance decrease as they are heated and such ones are used in temperature probes(NTC thermistor). For other thermistors, their resistance increases with the temperature. They are used in circuits where overheating has to be prevented because the resistance increases in the circuit with the temperature, and thus current flowing will be reduced and other components in the circuit won't burn out. NTC thermistor stands for negative temperature

coefficient and their resistance decreases with the increase in temperature.

- **Combined resistance (series):** $R_t = R_1 + R_2 + R_3$
- **Combined resistance (parallel):** $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
- - **For resistors in series:**
    1. The combined resistance is equal to the sum of all the resistances
    2. The current is the same at all points around the circuit
- **For resistors in parallel:**
    1. The effective resistance is less than the resistance of either resistor
    2. The current from the source is greater than the current through either resistor.
- **Earthing** is a process carried out so that the chances of electric shocks decreases by connecting the metal case of any wire to the earth wire.
- **Each cable has a live, neutral and earth wire. The earth wire is not insulated (covered with plastic).**
- **Fuse**: contains a thin section of wire, designed to melt and break if the current gets above a certain value. The fuse should have a current rating just above the rating of the appliance when the current is flowing normally.
- **Trip switches:** can be used instead of fuses. If the current flowing through a trip switch is too high, it trips, breaking the whole circuit.
- **All formulae:**
    1. Q = ne (e = 1.6×10^{-19})
    2. Q = It
    3. V = $\frac{w}{Q} = \frac{work\ done}{charge}$
    4. V = IR
    5. R = $\frac{rL}{A}$ (r = resistivity)
    6. $R_s = R_1 + R_2$
    7. $\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$
    8. P = VI = $I^2 R = \frac{V^2}{R}$

Magnets

- Like poles repel and unlike poles attract.
- North pole of the compass is attracted to the earth's geographical north pole as there is a magnetic south pole nearby.
- **Examples of magnetic materials** are iron, cobalt, steel, nickel, lodestone, ferrite and neodymium.
- **Magnetisation**: is the process by which materials can be made magnetic either by stroking them with a magnet in one direction, or placingthe material in a strong magnetic field produced by an electromagnet, or placing it in a north-south
  direction in a magnetic field and hammering it or inducing it by keeping it close to a magnet which makes it magnetic for a while.
- **Hard magnets** are those which are hard to magnetise but retain their magnetism for a long time and are hard to demagnetise.They are used in loudspeakers, permanent magnets and compass needles. Hard steel is an example.
- **Soft magnets** are those which can be magnetised and demagnetised easily. They are used in radio aerials, transformers and cores for electromagnets.
- **Magnetic fields** come out from the north pole and go into the south pole of a magnet. The closer the magnetic field lines are to each other, the stronger the field.
- **Strength of an electromagnet can be increased by:** increasing the current flow, increasing the number of turns of wire on the coil and add a soft iron core.
- **Electromagnets are used in** electric doorbells, relays, transformers, electric motors and loudspeakers.
- **Maxwell's right hand grip rule:** when a wire carrying current is held, the thumb shows direction of current flow and the curl of fingers show the direction of magnetic field lines. The magnetic field lines are circular and farther from the wire, the greater the distance/space between the circular lines and thus lesser is the magnetic field strength.
- **(.) represents current going out of the plane**
- **(X) represents current going into the plane**
- **Solenoid**: is a length of wire wound to form a coil
- **Electric motor:** in an electric motor there is a coil of wire which has current in it, so it has its own magnetic field. Permanent magnets or electromagnets produce a magnetic field in which the coil is present. The result of this is the turning effect on the coil which causes it to spin around.

- **DC motor consists of:**
    1. A coil of wire which acts as an electromagnet when a direct current flows through it
    2. Two magnets to provide a magnetic field passing through the wire
    3. A split-ring commutator, through which current reaches the coil
    4. Two carbon brushes which are springy wires, press against the two metal sections of the commutator.
- **Working of a DC motor:** (DC motor converts electrical energy into mechanical energy)
    1. A current flows in through the right hand brush (red) and flows out through the left hand brush (green).
    2. Since the current is flowing, the wire acts as an electromagnet. So the part of the wire near the north pole of the wire becomes the north pole and wire near the south pole becomes the south pole. Since the north pole is attracted to the south pole, the wire starts turning in that direction (anticlockwise).
    3. The commutators are used in this stage because, once the north pole gets attracted to the south pole it stops there. To avoid that, the brush connections to the split rings are reversed, so that the electricity flows the other way around.
    4. So now we have north pole on the uppermost side of the coil and thus it turns 180° anticlockwise again. This continues which causes the movement until the electricity is supplied.
- The axle of this setup can be connected to a pulley, a wheel or a pump, to make use of it which are parts of fans and vehicles.
- **Speed of the DC motor can be increased by:**
    1. Increasing number of turns of coil
    2. Increasing strength of the magnet
    3. Passing more current
- **Motor effect** is a force all motors experience. It can be demonstrated using a copper rod and magnet setup. A copper rod is kept on two aluminium rods and in between two magnets separated vertically. When the current flows from the left side, the forces due to the interaction of the magnetic field produced by the magnets and the wire interact, pushing the copper rod ahead. If the connections of the current are reversed or of the magnets with north on the top and south at the bottom, the rod will roll backwards.

  The force can be increased by increasing the current and using magnets with stronger magnetic fields.

- **Fleming's left hand rule:** the thumb finger represents force, the index finger represents magnetic field and the middle finger represents current.
  It is used to predict the direction of the force on a current-carrying conductor in a magnetic field.
- **Generator**: is used to convert mechanical energy into electrical energy which is opposite to the working of the motor. In a generator, an electric motor is connected to a meter and its axle is spinned due to which the meter's reading will show a presence of voltage. It works because the motor is being spun in a magnetic field produced by magnets due to which the current flowing in the coil has been induced.
- **Induced current:** occurs when a coil and the magnetic field move relative to each other and the current flows if it is part of a complete circuit.
- **Induced e.m.f/voltage:** occurs when the generator is not connected to a circuit, due to which there will be induced e.m.f/voltage across its ends, ready to make a current flow around a circuit.
- **Electromagnetic induction:** is the process of generating electricity from motion.
- **Dynamo effect:** occurs when a coil and magnetic field are moving relative to each other and are needed to induce a voltage across the ends of a wire. If the coil is a part of a complete circuit, the induced e.m.f will make an induced current flow across the circuit.
- **galvanometer/centre-zero meter:** used to indicate the direction in which the current is moving.
- **The induced e.m.f can be increased by:**
  1. Use a stronger magnet
  2. Move the coil more quickly relative to the magnet
  3. Use a coil with more turns of wire
- **A.C generator:** alternating current generator, is unlike a d.c in which current flows in one direction. In an a.c generator, alternating current flows back and forth. The frequency of an a.c supply is the number of cycles it produces each second. The graph has time on the x axis and voltage on the y axis. The graph is like that of a sound wave, half the time the voltage is positive and the next half it is negative and keeps alternating that way.
- **Factors that affect the magnitude and direction of induced e.m.f:**
  1. If the magnet is stationary, no e.m.f is induced because there is no cutting of the magnetic field lines.
  2. If the magnet is further from the wire, the e.m.f induced is smaller as the field lines are farther apart and fewer are cut.
  3. If the magnet is moved quickly, a greater e.m.f is produced as the lines are being cut more often and quickly.

4. The use of coil, compared to a single wire, generates a greater e.m.f as each turn of the wire cuts the magnetic field lines.

- **Working of an a.c generator:** when the axle is turned, each side of the armature goes through the north and south poles of the magnet and the current reverses every half rotation which produces the graph. The peak is caused by the horizontal section of the wire cutting through the magnetic field. The zero point is caused by the vertical position of the coil, cutting no magnetic field. The negative peak is caused by the horizontal coil cutting through the opposite magnetic field.
- **The voltage generated by the a.c generator can be increased by:**
  1. Turning the coil more rapidly
  2. Using a coil with more number of turns
  3. Using a coil with bigger area
  4. Using stronger magnets
- **Power lines:** are cables slung high above the ground between tall pylons which carry electricity generated in power stations to the modern homes for daily use.
- When this power enters a local distribution centre, the voltage is reduced and the power is sent through more cables to local substations. In the substations, transformers reduce the voltage to the local supply voltage and then it is branched out to various homes and buildings.
- High voltage is used to transfer electricity because by using high voltage, less current is flowing due to which the energy loss is minimum. **Power loss is proportional to the square of the current**
- **Transformer**: is a device used to increase or decrease the voltage of an electric supply. It only changes the size of an alternating voltage and works only with alternating current a.c. Every transformer has three parts;
  1. **Primary coil:** the incoming voltage (Vp) is connected across this coil
  2. **Secondary coil:** this provides the voltage (Vs) to the external circuit
  3. **Iron core**: this links the two coils
- **Step-up transformer:** increases the voltage, so there are more turns on the secondary coil compared to the primary coil.
- **Step-down transformer:** decreases the voltage, so there are more turns on the primary coil compared to the secondary coil.
- **The ratio of the numbers of turns tell us the factor by which the voltage will be changed.** From this: $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

(V_p= voltage across primary coil, V_s= voltage across secondary coil, N_p= number of turns on primary, N_s= number of turns on secondary)

- **For a 100% efficient transformer:** $V_p I_p = V_s I_s$
 (power in to primary coil = power out of secondary coil)

Solar physics

- **Rotation of Earth:**The circular movement of the Earth about its own axis is called as the rotation of the Earth.
- **Average orbital speed:** It is defined using the equation: v = 2??r /T where r is the average radius of the orbit and T is the orbital period
- **Solar system:**Solar system is a single term that includes eight planets and their moons in orbit round the sun. Also included in the solar system are the smaller bodies such as the comets., asteroids, and the meteoroids.
- **Orbital distance:**Orbital distance is the term that tells us the time taken by one object to revolve around the other.
- **Orbital duration[Orbital time}:** Orbital duration is the time taken by one object to completely orbit around the other.
- **gravitational field strength:** Gravitational field strength is a term that indicates the amount of gravitational force that is exerted per unit mass at a particular point.It has a symbol "g"
- **Interstellar clouds of gas and dust:** It is a cloud comprising of dust, plasma and gases present in all the galaxies, including our own.
- **accretion disc:** These are structures that surround the celestial objects such as the stars and the black holes.These structures are made of gas, plasma and dust
- **Planetary data:**It refers to the data that gives us information on the different planets based on researches and explorations
- **Stars:**Stars are massive , self-luminous celestial objects, made of Hydrogen and Helium
- **Proto stars:** A protostar is a young star. .It is formed as a result of accretion in the nebula.
- **Stable stars:**In every star, there is the gas pressure that exerts an outward force from the centre and at the same time , there is gravity that is pulling the atoms of Hydrogen and Helium inwards. When the outward pushing force balances the gravitational force, we call the star as a stable tar.Example of a stable star is the Sun.
- **Sun:**The Sun is a very bright, luminous, celestial and a stable star, situated in the spiral arm of the Milky Way galaxy and at the centre of the Solar System.

- **Galaxy:**The word galaxy encompasses billions of stars along with their solar systems,gas and dust held by their gravity. There are more than a hundred billion galaxies in the universe.
- **Milky way:** Milky way is a spiral galaxy that includes our solar system. It has billions of stars, including our Sun.
- **Universe:** Universe refers to the space, time and matter and all the laws that govern them.
- **Light-year:** One light-year is the distance traveled in (the vacuum of) space by light in one year.
- **Red giants:**These are massive , luminous stars with a very low surface temperature and a high volume , with a reddish-orange hue, in their final stage of stellar evolution and that have exhausted their supply of Hydrogen in their core.Examples: Aldebaran (Alpha Tauri) and Mira (Omicron Ceti).
- **Red super giants: Red super giants are aging giant stars** with a minimum of 15 solar masses. [solar mass refers to the mass of the sun, when used as a unit of mass. One solar mass is equal to 1.989 x 10^{30} kg]
- **Supernova:** Supernova is a powerful and luminous stellar explosion, that happens when a star has reached the end of its life. Example: Kepler's Supernova
- **Nebula:** Nebula is a Latin word for fog or cloud.It consists of interstellar clouds consisting of Helium, Cosmic Dust, ionised gases, hydrogen as well as molecular clouds. [There are in all 5 different types of Nebulae, namely;emission nebulae, reflection nebulae, dark nebulae, planetary nebulae, and supernova remnants.
- **Black hole:**A black hole is a region in the space, in which the effect of gravity is so strong, that it lets nothing escape out f it, not even light.The region appears to be black and circular.[There are approximately 100 billion super massive black holes]
- **Redshift:**Redshift is a phenomenon in which the spectrum of an astronomical object gets displaced towards the longer(red) wavelength.
- **Cosmic microwave background radiation (CMBR):** Cosmic microwave background radiation (CMBR) is the leftover of the cosmic radiation after the big bang.
- **Hubble constant H_o:** Hubble constant is the ratio of the speed at which the galaxy is moving away from the Earth to its distance from the Earth

Atomic physics

- **A = mass number, Z = proton number, X = element symbol.**
- **Nuclide**: different types of nucleus formed by different combinations of Z and A which gives rise to different elements.
- **Atom**: the smallest particle of a chemical substance that can exist.
- **Proton number + neutron number = nucleon number (Z + N = A)**
- **Isotopes**: have the same proton number but different number of neutrons giving different masses. The isotopes of the same element have similar chemical properties but those with a greater number of neutrons are heavier.
- **Unstable isotopes:** are those isotopes which undergo radioactive decay, emitting radiation as they change from one element to another.
- **Radioactive substances can cause problems:**
    1. By contamination in our body if it gets inside in concentrated amounts.
    2. By getting irradiated, which happens when their radiation hits our body
- **Background radiation**: low levels of radiation present in the atmosphere at all times.
- **Sources of natural background radiation:**
    1. **Ground and buildings:** because they are built from substances found in the ground and the ground contains radioactive substances.
    2. **Radon and thoron in atmosphere:** which seep upwards from the uranium rocks underground.
    3. **Food and drink:** as living things tend to grow by taking in materials from air and ground containing radioactive substances.
    4. **Cosmic rays:** from sun and outer space which are mostly blocked by the earth's atmosphere.
- **Sources of artificial radiation:**
    1. **Medical**: use of X-rays, gamma rays and radiation for destroying cancer cells.
    2. **Fallout from weapons tests:** it happens only if bombs are denoted above ground. Now everything as such is done underground.
    3. **Air travel, TV sets, etc** : since you are high up in the atmosphere, the radiation is stronger compared to on the ground.
    4. **At work**: professions like radiographers and staff in a nuclear power station are more exposed to such radiation.
    5. **Nuclear discharges**: from industries dealing with nuclear substances to use as fuel.
- **Radiation can be detected by:**

1. **Photographic film:** when a radioactive substance is left on a photographic film for a long time, it darkens/blackens the area where it is left.
2. **Geiger counter:** this is a quicker method compared to the photographic film method. The geiger-muller tube is the detector and it is held close to the suspected source of radiation. If any radiation is coming out of the source, it enters the tube which produces an electrical impulse every time it detects any radiation. The electronic counter adds up all these impulses.

- **Radioactive decay:** is the radiation emitted by an unstable nucleus in order to become more stable.
- **Radioactivity**: is the spontaneous disintegration of heavy nuclei by emitting particles and energy to become a stable nuclei.
- **Alpha particle is the same as the helium atom. Beta particle is the same as 1 electron. Gamma ray is the same as the photon of electromagnetic radiation.**
- Alpha (α) particles travel the slowest as they have the most mass whereas gamma rays travel at the speed of light. An atom emits either alpha or beta particles along with gamma rays at the same time.
- When the radioactive substances decay, alpha and beta particles release kinetic energy whereas gamma rays release electromagnetic radiation.
- Alpha particles are the least penetrating (paper can absorb them) but gamma rays are the most penetrating (lead which is very dense, only can absorb it). Beta (β) particles are absorbed by metals.
- **Ionised**: when radiation passes through air it may interact with air molecules, knocking electrons from them which causes the air molecules to become charged. Now, the air molecules are ionised.
- Since radiation from radioactive substances causes radiation of the materials that absorb it, it is often known as **ionising radiation.** Alpha particles are the most ionising and gamma rays are least.
- **In an electric field**, the alpha particles are attracted to the negative charge, the beta particles are attracted to the positive charge and the gamma rays go undeflected as they have no charge.
- **In a magnetic field,** the beta particles get deflected towards the north pole, the alpha particles get deflected to the south pole but the gamma rays go undeflected.
- **Radiation can damage living cells by:**
    1. Intense dose of radiation can cause a lot of ionisation in the cell, killing it **(radiation burns)**

2. The DNA in the cell nucleus gets damaged and the mechanisms that control the cell may break down causing uncontrolled division of the cell **(cancer)**
3. If a gamete is affected by radiation, then the mutations may be passed on **(genetic mutation)**

- **In radioactive decay,** nucleon number and proton number are conserved.
- **An exponential decay graph** is used to display the time it will take a radioactive substance to decay. If the graph is steeper it shows that the substance has a shorter half life.
- **Half-life**: of a radioactive substance is the average time it will take for half of the atoms in a sample to decay.
- **Activity of a sample**: is the number of atoms that decay each second. It is measured in becquerels (Bq).
- **Uses of radioisotopes are related to their:**
  1. Penetrating power
  2. Damage caused to the cells
  3. Detection of tiny quantities 4. Radioactive decay and half life ● **Uses related to penetrating power:**
  1. **Smoke detectors (α particles):** americium-241, a radioactive material is chosen. It emits alpha radiation in the direction of a detector which is connected to an alarm. If the smoke enters and absorbs these radiations, then there is no electric charge from the radiation, so no current flows in the detector and thus the alarm rings.
  2. **Thickness measurements (β particles)**: in plastic and paper industries, beta radiation is passed through bundles of paper/plastic and the radiation that is getting through is calculated by detectors. This ensures uniform thickness.
  3. **Medical diagnosis (γ rays):** the patient is injected with a radioactive substance in the area of the disease. Then the gamma rays being emitted can be used to detect the image of the tissue under study.
  4. **Fault detection (γ rays):** used to find faults in welding, etc. a photographic film of any faults is developed by emitting gamma rays.
- **Uses related to cell damage:**
  1. **Radiation therapy (α or x rays):** it is used in killing cancerous cells by directing the radiation at them. Chemical drugs are used as a combination for cancer cure.
  2. **Food irradiation (γ rays):** it is used to preserve food as the intense gamma rays kill the microbes which cause decay in the food.

3. **Sterilisation (γ rays):** it is used to kill microbes on syringes, scalpels, tampons, sanitary towels and other instruments by tying them in plastic bags and exposing to radiation.

- **Uses related to detectability:**
    1. **Radioactive tracing:** for example in detecting underground water supply by injecting water containing a radioactive substance into the cracks in the ground and monitor using gamma detectors at ground level.
    2. **Radioactive labelling and genetic fingerprinting:** chemicals bond to particular parts of the molecules of interest, so that they can be tracked through a set of reactions.

- **Uses related to radioactive decay:**
    1. **Half-life and radiocarbon dating:** used to calculate how much carbon-14 is left in an organism to calculate how long ago, it was alive.
    2. **Other radioactive dating techniques:** since potassium-40 in rocks decays by beta radiation it turns into argon. So more the amount of argon, older the rock is.