

Optics Definitions

Reflection is the bouncing of light off an object

Laws of Reflection of Light:

1. The incident ray, the normal at the point of incidence and the reflected ray all lie in the same plane.
2. The angle of incidence is equal to the angle of reflection ($i = r$)

A **Real Image** is an image formed by the actual intersection of light rays.

A **Virtual Image** is formed by the apparent intersection of light rays.

The apparent movement of one object relative to another due to the motion of the observer is called **parallax**.

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

Laws of Refraction of Light:

1. The incident ray, the normal at the point of incidence and the refracted ray all lie in the same plane.
2. The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant
$$\left(\frac{\sin i}{\sin r} = n \text{ where } n \text{ is a constant} \right)$$

The **Refractive Index of a Medium** is the ratio of the sine of the angle of incidence to the sine of the angle of refraction *when light travels from a vacuum into that medium*.

Snell's law of refraction states that the ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant .

When light travels from a denser to a rarer medium the angle of incidence whose corresponding angle of refraction is 90° is called the **critical angle** (C) for those two media.

Total Internal Reflection: When light going from a denser to a rarer medium strikes the second medium with an angle of incidence greater than the critical angle, it does not enter the second medium. It is all reflected back in the denser medium.

Optical Fibre is a very thin transparent rod (usually of glass) through which light can travel by total internal reflection.

A **short-sighted** person can see nearby objects clearly but cannot bring distance objects into focus

A **long-sighted** person can see distant objects clearly but cannot bring nearby objects into focus

Mechanics Definitions

Displacement is distance in a given direction.

Speed is the rate of change of **distance** with respect to **time**.

Velocity is the rate of change of **Displacement** with respect to **time**.

Acceleration is the rate of change of **Velocity** with respect to **time**.

A **Scalar Quantity** is one which has *magnitude only*.

A **Vector Quantity** is one which has both *magnitude and direction*.

A **Force** is that which can cause an acceleration.

The Newton is that force which gives a mass of 1 kg an acceleration of 1 ms^{-2} .

Friction is a force which opposes the relative motion between two objects.

The **mass** of a body is a measure of how difficult it is to accelerate that body.

The **weight** of an object is the force of the Earth's gravity acting on it.

Momentum is the product of Mass times Velocity.

Newton's First Law of Motion states that every object will remain in a state of rest or travelling with a constant velocity unless an unbalanced external force acts on it.

Newton's Second Law of Motion states that the rate of change of an object's momentum is directly proportional to the force which caused it.

Newton's Third Law of Motion states that if an object A exerts a force on an object B, then B will exert an equal but opposite force on A.

The Principle of Conservation of Momentum states that in any collision between two objects, the total momentum before impact equals total momentum after impact provided no external forces act on the system.

The **Density** of a substance is a measure of its mass per unit volume.

Pressure is defined as Force per unit Area.

Archimedes' Principle states that when an object is immersed in a fluid, the upthrust it experiences is equal to the weight of the displaced fluid.

The Law of Flotation states that the weight of a floating object is equal to the weight of the fluid it displaces.

Boyle's Law states that at constant temperature, the volume of a fixed mass of gas is inversely proportional to its pressure.

Newton's Law of Gravitation states that any two objects in the universe are attracted to each other with a force that is directly proportional to the product of their masses, and inversely proportional to the square of the distance between them.

Conditions for Equilibrium of an object under Coplanar Forces.

If an object is in equilibrium then:

1. The vector sum of the forces in any direction is zero. (forces up = forces down)
2. The sum of the moments about any point is zero.

The Moment of a Force is equal to the force multiplied by the perpendicular distance between the force and the fulcrum.

Two parallel forces with the same magnitude acting in opposite directions is called a **couple**.

Work is defined as the product of **Displacement by Force** (in the direction of the displacement).

Energy is the ability to do work.

The Principle of Conservation of Energy states that Energy cannot be created or destroyed but can only be converted from one form to another.

The **kinetic energy** of a body is the energy that body has due to its motion.

The **potential energy** of a body is the energy it has due to its position in a force field.

Power is the rate at which work is done.

Or

Power is the rate at which energy is converted from one form to another.

Angular Velocity is the rate of change of angle with respect to time.

The force, acting in towards the centre, required to keep an object moving in a circle is called **Centripetal Force**.

If a body is moving in a circle the acceleration it has towards the centre of the circle is called **Centripetal acceleration**.

The time taken for a satellite to go once around the central body is called the periodic time or simply the **period (T)** of the orbit.

Hooke's Law states that when an object is stretched the restoring force F is directly proportional to the displacement – provided the elastic limit is not exceeded.

Heat and Temperature

The **Temperature** of an object is a measure of the hotness or coldness of that object.

A **Thermometric Property** is any physical property that changes measurably with temperature.

No two types of thermometers will give exactly similar readings at all temperatures. *This is because different thermometric properties do not change proportionally with the same change in degree of hotness.*

The **heat capacity** of an object is the heat energy needed to change its temperature by 1K

The **Specific Heat Capacity** of a substance is the heat energy needed to change one kilogram of the substance by one Kelvin.

The **Specific Latent Heat (l)** of a substance is the amount of heat energy needed to change the state of 1kg of that substance without a change in temperature.

The **Specific Latent of Fusion (l_f)** is the amount of heat energy need to change 1 kg of the substance from a solid to a liquid without a change in temperature.

The **Specific Latent of Vaporisation (l_v)** is the amount of heat energy needed to change 1 kg of the substance from a liquid to a gas without a change in temperature.

Conduction is the movement of heat energy through a substance by the passing on of molecular vibration from molecule to molecule, without any overall movement of the substance.

Convection is the transfer of heat through a fluid by means of circulating currents of fluid caused by the heat.

Radiation is the transfer of heat energy from one place to another in the form of electromagnetic waves.

The **U-value** of a structure is the amount of heat energy conducted per second through 1m^2 of that structure when a temperature difference of 1K is maintained between its ends.

The average amount of the Sun's energy falling per second perpendicularly on 1 metre squared of the Earth's atmosphere is the **solar constant**. Its value is about 1.35 kWm^{-2} .

Waves and Wave Motion

A **travelling mechanical wave** is a disturbance carrying energy through a medium without any overall motion of that medium.

A **Transverse wave** is a wave where the direction of vibration is perpendicular to the direction in which the wave travels.

A **Longitudinal Wave** is a wave where the direction of vibration is parallel to the direction in which the wave travels.

Refraction is the changing of direction of a wave as it travels from one medium to another.

Diffraction is the spreading of waves around an obstacle.

Interference occurs when two waves combine to produce a wave of a different amplitude.

Constructive interference occurs when two waves combine to produce a wave of greater amplitude.

Destructive interference occurs when two waves combine to produce a wave of lower amplitude.

Coherent Sources are sources which have the same frequency and are in phase with each other.

A **Polarised wave** is a wave which vibrates in one plane only.

Stationary waves are formed when two periodic travelling waves of the same frequency and amplitude travelling in opposite directions meet.

The Doppler Effect is the apparent change in the frequency of a wave due to the motion of the observer or the source of the wave.

The **natural frequency** of an object is the frequency at which the object will vibrate if free to do so.

Resonance is the transfer of energy between two objects which have the same natural frequency.

The **Sound Intensity** at a point is the rate at which sound energy is passing through unit area.

The **threshold of hearing** is the smallest sound intensity detectable by the average human ear at a frequency of 1 KHz.

The **frequency limits of audibility** are the highest and lowest frequencies that can be heard by a normal human ear. The range is **20 Hz – 20,000 Hz**.

Overtones are frequencies which are multiples of the fundamental frequency.

A **diffraction grating** consists of a piece of transparent material on which a very large number of parallel lines are engraved.

Dispersion is the separating of white light into its different colours.

Electricity Definitions

Any substance through which electric charge cannot flow is called an **insulator**

Any substance through which electric charge can flow is called a **conductor**

Coulomb's Law states that the force between two point charges is proportional to the product of the charges and inversely proportional to the square of the distance between them.

An **electric field** is any region of space where a static electric charge experiences a force other than the force of gravity

The **Electric Field Strength (E)** is the force per unit charge.

The **Potential Difference** (p.d.) between two points is the work done in bringing a charge of one Coulomb from one point to the other.

The Volt: The potential difference between two points is one volt if one Joule of work is done when bringing a charge of one Coulomb from one point to another.

The **potential at a point** refers to the work done in bringing unit charge from that point to earth.

The **Capacitance** of a conductor is the ratio of the charge on a conductor to its potential.

Current is a flow of charge.

A voltage when applied to a circuit is an **emf**.

The resistance of a conductor is the ratio of the Potential Difference across it to the current flowing through it.

Ohm's Law states that the current flowing through a conductor is directly proportional to the Potential Difference across it, assuming constant temperature.

Resistivity is the resistance of a cube of material of side 1 m.

Joules Law states that the rate at which heat is produced in a conductor is proportional to the square of the current, provided its resistance is constant.

Semiconductors and Electromagnetic Induction

A **Semiconductor** is a material whose resistivity is between that of a good conductor and a good insulator.

Intrinsic Conduction is the movement of charges through a pure semiconductor.

Extrinsic Conduction is the movement of charges through a doped semiconductor.

Doping is the addition of a small amount of atoms of another element to a pure semiconductor to increase its conductivity.

An **n-type semiconductor** is a semiconductor in which electrons are the majority charge carriers.

A **p-type semiconductor** is a semiconductor in which holes are the majority charge carriers.

The Ampere is that current which, if flowing in two, infinitely long parallel wires, of negligible cross-sectional area, one metre apart, in a vacuum, experiences a force of 2×10^{-7} N per metre.

The **Coulomb (C)** is the amount of charge that passes any point in a circuit when a current of 1A flows for 1 second.

A **magnetic field** is any region of space where magnetic forces can be felt. The direction of the magnetic field at a point is the direction of the force on a north pole if it were placed at that point.

Magnetic Flux Density (B) at a point in a magnetic field, is a vector whose magnitude is equal to the force that would be experienced by a conductor of length 1m carrying a current of 1A at right angles to the field at that point and whose direction is the direction of the force on a north pole placed at that point.

Magnetic Flux is the product of Flux Density by Area.

The magnetic flux density at a point is 1 **tesla (T)** if a conductor of length 1m carrying a current 1A experiences a force of 1N when placed perpendicular to the field.

Electromagnetic Induction: When a conductor cuts a magnetic flux an emf is induced.

Faraday's Law states that the size of the induced emf is proportional to the rate of change of flux.

Lenz's Law states that the direction of the induced emf is always such as to oppose the change producing it.

If a changing magnetic field in one coil causes an induced emf to appear in a nearby coil there is said to be **mutual induction** between the two coils.

Whenever the current passing through a coil changes, the magnetic field surrounding that coil changes. This changing magnetic field induces an emf in the coil that opposes the changing current (i.e. a back emf). This phenomenon is called **self induction**.

Modern Physics (which means Physics of the last 120 years)

Ionisation occurs when an atom loses electrons.

Thermionic Emission is the giving off of electrons from the surface of a *hot* metal.

Cathode rays are streams of high speed electrons moving from the cathode.

The Photoelectric Effect is the emission of electrons from a metal due to light of a suitable frequency falling upon it.

For a given metal the frequency below which photoemission will not occur is called the **Threshold Frequency**.

The **Work Function** of a metal is the minimum energy needed to remove the loosest electron from the surface of that metal.

A **photon** is a discrete amount (packet) of electromagnetic radiation.

The **Electron Volt** is the energy lost or gained by an electron when it moves through a potential difference of one volt.

X-Rays are high frequency electromagnetic radiation produced when high speed electrons in a cathode ray tube strike a metal target that has a high melting point.

The **Atomic Number** (Z) of an atom tells us the number of protons present in the atom.

The **Mass Number** (A) of an atom tells us the number of protons *plus neutrons* present in the atom.

Isotopes are atoms which have the same Atomic Number but different Mass Numbers.

Radioactivity is the disintegration of unstable nuclei with the emission of alpha, beta or gamma radiation.

The Activity (A) of a radioactive substance is the number of nuclei of that substance decaying per second.

1 **Becquerel** is equal to 1 radioactive disintegration per second.

The **half-life** ($T_{1/2}$) of an element is the time taken for half of the nuclei in a sample to decay.

Or

The **half-life** ($T_{1/2}$) of an element is the time taken for the activity of a sample to decrease to half of its original value.

The **Law of Radioactive Decay** states that the number of disintegrations per second is proportional to the number of nuclei present.

The **Mass Number** of any element expressed in grams contains **Avogadro's No.** of atoms.

Nuclear Fission is the breaking up of a large nucleus into two smaller nuclei with the release of energy.

Nuclear Fusion is the joining together of two small nuclei to form one larger nucleus with the release of energy and neutrons.