

Optics

Laws of reflection of light

- (i) The incident ray, the normal at the point of incidence and the reflected ray all lie on the same plane.
- (ii) 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.

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

Snell's law of refraction

The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant.

The laws of refraction of light.

- (i) The incident ray, the refracted ray and the normal all lie in the same plane.
- (ii) The ratio of the sine of the angle of incidence to the sine of the angle of refraction is a constant.

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.

Total internal reflection

Total internal reflection occurs when the angle of incidence in the denser of the two media is greater than the critical angle and light is reflected back into the denser medium.

Critical angle

The critical angle corresponds to the angle of incidence in the denser of two media which causes the angle of refraction to be 90° .

Mechanics

Velocity and acceleration

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.

Acceleration due to gravity, g .

It is the acceleration of an object which is in freefall due to the attraction of the earth.

Vectors

A Scalar Quantity is one which has magnitude only.

A vector is a quantity which has both magnitude and direction.

Force, Mass and Momentum

The Newton is the force that gives a mass of 1 kg an acceleration of 1 m s^{-2} .

A force is something which causes an acceleration.

Momentum = 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, and takes place in the direction of the force.

Newton's Third law of Motion states that when body A exerts a force on body B, B exerts a force equal in magnitude (and) opposite in direction to A.

The Principle of Conservation of Momentum states that in any interaction between two objects, the total momentum before the interaction is equal to the total momentum after the collision provided no external forces act.

Friction is a force that opposes the relative motion between two surfaces in contact.

Pressure

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

Pressure is Force per unit Area.

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

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 for a floating object, the weight of the object equals the weight of the fluid displaced.

Gravity

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

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

Moments

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

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.

Work, Energy and Power

Energy is defined as the ability to do work

Work is defined as the product of displacement by force (in the direction of the displacement).

Power is the rate at which work is done.

Potential energy is energy a body has due to its position; kinetic energy is energy a body has due to its motion.

The Principle of Conservation of Energy states that the energy cannot be created or destroyed; it can only be changed from one form to another.

Circular Motion

Velocity is the rate of change of displacement with respect to time.

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

Centripetal Force is the force - acting in towards the centre - required to keep an object moving in a circle.

Simple Harmonic Motion

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.

Temperature and Thermometers

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

Heat is a form of energy

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Temperature is a measure of the hotness of an object.

A thermometric property is a property which changes measurably with temperature.

Different thermometers have different thermometric properties at the same temperature.

Heat

Specific heat capacity is the heat energy required to raise the temperature of 1 kg of a substance by 1 K

Specific latent heat is the heat energy required to change the state of 1 kg of a 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.

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

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.

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

Waves and Wave Motion

The frequency of a wave is the number of waves passing a fixed point per second.

Amplitude corresponds to the height of the wave.

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.

Diffraction is the spreading out of a wave when it passes through a gap or passes by an obstacle.

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

Interference occurs when waves from two sources meet to produce a wave of different amplitude.

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

Coherent sources are waves which have the same frequency and are at in phase.

The Doppler Effect is the apparent change in frequency due to relative motion between source and observer.

Sound

Sound Intensity is defined as power per unit area.

Natural frequency is the frequency at which an object will vibrate if free to do so.

Resonance is the transfer of energy so that a body vibrates at its natural frequency.

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.

Overtone frequencies are multiples of the fundamental frequency.

The wave nature of Light

Dispersion is the splitting up of white light into its constituent colours.

A spectrum refers to the range of colours present in white light.

Monochromatic light is light of one wavelength only.

A diffraction grating consists of a piece of transparent material on which a very large number of opaque (black) parallel lines are engraved.

Complementary colours are pairs of colours consisting of a primary and a secondary colour, such that when combined they give white light.

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

Electricity

Static Electricity

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.

Electric field strength is defined as force per unit charge.

Electric Current

An electric current is a flow of charge.

Potential Difference and Capacitance

Potential difference is the work done in moving a charge of one Coulomb from one point to another.

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

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.

A voltage when applied to a circuit is an emf.

Resistance

The resistance of a conductor is the ratio of the potential difference across the conductor 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 defined as the resistance of a cube of material of side one metre.

Effects of an Electric Current

The kilo-watt hour is the amount of energy used by a 1000 Watt appliance in one hour.

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

A semiconductor is a material whose resistivity is between that of a conductor and that of an insulator.

Doping is the adding of a controlled quantity of an impurity to increase conduction.

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

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

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.

A p-n junction is the region connecting the p-type semiconductor to the n-type semiconductor.

A diode is a device that allows current to flow in one direction only.

Magnets and magnetic fields

A Magnetic Field is any region of space where magnetic forces can be felt.

Current in a Magnetic Field

The Ampere is that current which, if flowing in two infinitely long parallel wires of negligible cross-sectional area 1 m apart in vacuum experience a force of 2×10^{-7} N per metre.

Electromagnetic Induction

Electromagnetic Induction occurs when an emf is induced in a coil due to a changing magnetic flux.

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.

Magnetic flux is the product of magnetic flux density by area.

The Electron

Cathode rays are streams of high speed electrons.

The photoelectric effect is the emission of electrons from the surface of a metal when light radiation of suitable frequency falls on it.

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

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

Thermionic emission is the emission of electrons from the surface of a hot metal.

X-rays are electromagnetic radiation of a high frequency.

Ionisation occurs when an atom loses electrons.

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

The Atom, the Nucleus and Radioactivity

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 number.

An alpha particle is a helium nucleus (composed of 2 protons and 2 neutrons).

Radioactivity / Radioactive decay is the breakup of unstable nuclei with the release of one or more types of radiation.

Ionisation occurs when an atom loses or gains an electron.

The half-life of a material is the time taken for half of the nuclei in the sample to decay.

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

Fission, Fusion and Nuclear Energy

Isotopes are atoms which have the same atomic number but different mass number.

Nuclear fission is the break-up of a large nucleus into two smaller nuclei with the release of energy (and neutrons).

This occurs when at least one neutron gets released during fission causing more fission to occur in another nucleus and this then becomes a self-sustaining reaction.

Nuclear Fusion is the combining of two small nuclei to form one large nucleus with the release of energy.

Particle Physics

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

Antimatter is material/matter/particles that has same mass as another particle but opposite charge.

Pair production involves the production of a particle and its antiparticle from a gamma ray photon.