Physics Definitions Book

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Section A — Mechanics

Measurement and Scalars

Scalar — a quantity that has magnitude only (e.g. speed, mass, temperature).

Vector — a quantity that has both magnitude and direction (e.g. velocity, force, displacement).

Density — the mass per unit volume of a substance.

Motion

Distance — the total path length travelled, regardless of direction.

Displacement — the straight-line distance from start to finish in a specified direction.

Speed — the distance travelled per unit time.

Velocity — the displacement per unit time; it has both magnitude and direction.

Acceleration — the rate of change of velocity, or the change in velocity per unit time.

Momentum — the product of an object's mass and its velocity.

Inertia — the tendency of an object to resist any change in its state of rest or uniform motion. A more massive object has greater inertia.

Newton's First Law — an object remains at rest or moves at constant velocity unless acted on by a resultant external force.

Newton's Second Law

— the resultant force on an object equals its mass multiplied by its acceleration ($F = ma$).

Newton's Third Law — when object A exerts a force on object B, object B exerts an equal force on object A in the opposite direction.

Conservation of momentum — the total momentum of a closed system remains constant provided no external forces act on it.

Statics

Weight— the gravitational force acting on a mass; $W = mg$.

Gravitational field strength(g) — the gravitational force per unit mass at a point. At Earth's surface, $g = 10$ N kg^{-1}.

Moment of a force — the product of the force and the perpendicular distance from the pivot to the line of action of the force.

Principle of moments — for an object in rotational equilibrium, the sum of the clockwise moments about any pivot equals the sum of the anticlockwise moments about the same pivot.

Centre of gravity — the single point through which the total weight of an object appears to act.

Hooke's Law — the extension of a spring is directly proportional to the applied force, provided the elastic limit is not exceeded.

Elastic limit — the maximum force (or extension) beyond which a spring will not return to its original length when the force is removed.

Energy, Work, and Power

Work— the energy transferred when a force moves an object in the direction of the force; $W = Fd$.

Kinetic energy — the energy an object possesses because of its motion.

Gravitational potential energy — the energy stored by an object as a result of its position above a reference level in a gravitational field.

Power — the rate at which energy is transferred, or the rate of doing work.

Efficiency — the ratio of useful energy output to total energy input, usually expressed as a percentage.

Principle of conservation of energy — energy cannot be created or destroyed; it can only be transferred from one form to another.

Hydrostatics

Pressure — the force acting per unit area perpendicular to a surface.

Archimedes' Principle — when an object is fully or partially submerged in a fluid, it experiences an upthrust equal to the weight of fluid it displaces.

Upthrust (buoyancy) — the upward force exerted by a fluid on a submerged or floating object.

Law of flotation — a floating object displaces its own weight of fluid.

Section B — Thermal Physics

Temperature — a measure of the average kinetic energy of the particles in a substance.

Heat — the net transfer of internal energy from a hotter body to a cooler body.

Absolute zero — the temperature at which particles have the minimum possible kinetic energy; equal to 0 K or −273 °C.

Specific heat capacity(c) — the energy required to raise the temperature of 1 kg of a substance by 1 K (or 1 °C).

Latent heat — the energy absorbed or released when a substance changes state without any change in temperature.

Specific latent heat(L) — the energy absorbed or released when 1 kg of a substance changes state without a change in temperature.

Specific latent heat of fusion(L_f) — the energy required to melt (or released when freezing) 1 kg of a substance at its melting point.

Specific latent heat of vaporisation(L_v) — the energy required to vaporise (or released when condensing) 1 kg of a substance at its boiling point.

Evaporation — the escape of particles from the surface of a liquid at any temperature; it causes cooling.

Boiling — vaporisation that occurs throughout a liquid at a fixed boiling point when the vapour pressure equals the external pressure.

Conduction — the transfer of thermal energy through a material without bulk movement of the material itself; most effective in solids.

Convection — the transfer of thermal energy through a fluid by the bulk movement of the fluid. Warm fluid expands, becomes less dense, rises, and is replaced by cooler fluid.

Convection current — the circular flow pattern set up in a fluid when a region is heated: the warmer, less dense fluid rises and the cooler, denser fluid sinks to replace it, continuously transferring thermal energy through the fluid.

Radiation — the transfer of thermal energy as infrared electromagnetic waves. It requires no medium and can travel through a vacuum.

Greenhouse effect — the process by which greenhouse gases in Earth's atmosphere (carbon dioxide, methane, and water vapour) absorb the long-wavelength infrared radiation emitted by Earth's surface and re-emit it in all directions, trapping heat that would otherwise escape into space and warming the lower atmosphere. The enhanced greenhouse effect, driven by rising CO,from burning fossil fuels, contributes to global warming.

Boyle's Law

— for a fixed mass of gas at constant temperature, the pressure is inversely proportional to the volume (

$P1V1 = P2V2$).

Charles' Law — for a fixed mass of gas at constant pressure, the volume is directly proportional to the absolute (kelvin) temperature.

Pressure Law — for a fixed mass of gas at constant volume, the pressure is directly proportional to the absolute (kelvin) temperature.

Section C — Waves and Optics

Wave — a transfer of energy from one place to another by means of a disturbance, without any net transfer of matter.

Transverse wave — a wave in which the particles of the medium oscillate perpendicular to the direction of wave travel (e.g. light, water waves).

Longitudinal wave — a wave in which the particles of the medium oscillate parallel to the direction of wave travel, producing compressions and rarefactions (e.g. sound).

Amplitude(A) — the maximum displacement of a particle from its equilibrium position.

Wavelength(λ) — the distance between two successive points that are in phase (e.g. crest to crest).

Period(T) — the time taken for one complete oscillation.

Frequency(f) — the number of complete oscillations per second; measured in hertz (Hz).

Reflection — the bouncing back of a wave when it meets a boundary.

Refraction — the change in direction of a wave when it passes from one medium into another in which its speed differs.

Diffraction — the spreading out of a wave as it passes through a gap or around an obstacle.

Principle of superposition — when two waves overlap, the resultant displacement at any point is the sum of the individual displacements.

Constructive interference — when two waves meet in phase so that crests reinforce crests, producing a larger amplitude.

Destructive interference — when two waves meet out of phase so that crests cancel troughs, reducing the amplitude.

Echo — a sound reflection heard as a distinct repetition of the original sound.

Ultrasound — sound with a frequency above the upper limit of human hearing, approximately 20 000 Hz.

Pitch — the perceived highness or lowness of a sound; determined by frequency.

Loudness — the perceived intensity of a sound; determined by amplitude.

Refractive index(n) — the ratio of the speed of light in a vacuum to the speed of light in the medium.

Critical angle(C) — the angle of incidence (in the denser medium) at which the refracted ray travels exactly along the boundary between the two media.

Total internal reflection — the complete reflection of a ray back into the denser medium when the angle of incidence exceeds the critical angle; only possible when light travels from a denser to a less dense medium.

Dispersion — the separation of white light into its component colours when it passes through a medium (such as a glass prism) in which different wavelengths travel at slightly different speeds.

Real image — an image formed where light rays actually converge; it can be projected onto a screen.

Virtual image — an image formed where light rays appear to diverge from but do not actually meet; it cannot be projected onto a screen.

Converging (convex) lens — a lens that is thicker in the middle and brings parallel rays to a real focus.

Diverging (concave) lens — a lens that is thinner in the middle and spreads parallel rays apart, as though they come from a virtual focus.

Focal length(f) — the distance from the optical centre of a lens to its principal focus.

Magnification — the ratio of image size to object size, equal to image distance divided by object distance.

Section D — Electricity and Magnetism

Electric charge — a fundamental property of matter; exists as positive or negative.

Law of electrostatics — like charges repel; unlike charges attract.

Electric field — a region in which a charged object experiences a force.

Electric current— the rate of flow of electric charge; $I = Q/t$.

Conventional current — the direction of current flow defined as from the positive terminal to the negative terminal of a source (opposite to electron flow).

Electromotive force (EMF) — the energy transferred per unit charge by a source as it drives charge around a complete circuit.

Potential difference (p.d.) — the energy transferred per unit charge between two points in a circuit as charge flows between them.

Resistance — the opposition to the flow of electric current in a conductor.

Ohm's Law — for a metallic conductor at constant temperature, the current is directly proportional to the potential difference across it.

Ohmic conductor — a conductor that obeys Ohm's Law; its resistance remains constant regardless of the current.

Non-ohmic conductor — a conductor whose resistance changes with current or temperature (e.g. a filament lamp or a diode).

Conductor — a material with many free electrons that allow charge to flow easily (e.g. metals).

Insulator — a material with very few free electrons; charge cannot flow easily through it.

Semiconductor — a material with electrical conductivity between that of a conductor and an insulator; its conductivity increases with temperature.

Series circuit — a circuit in which components are connected end-to-end in a single loop; the same current flows through each component.

Parallel circuit — a circuit in which components are connected across common junction points; the p.d. across each branch is the same.

Electrical power — the rate at which electrical energy is transferred.

Kilowatt-hour (kWh)— the energy transferred by a 1000 W device running for one hour; $1\ \text{kWh} = 3.6 \times 10^6\ \text{J}$.

Primary cell — a cell that cannot be recharged; chemical energy is converted to electrical energy until the reactants are exhausted.

Secondary cell — a cell that can be recharged by passing a current through it in the reverse direction.

Magnetic field — a region in which a magnetic material or a moving charge experiences a force.

Induced magnetism — magnetism acquired by a magnetic material when placed near or in contact with a permanent magnet; lost when the external field is removed (soft iron) or retained (hard steel).

Permanent magnet — a magnet made from a hard magnetic material that retains its magnetism after the magnetising force is removed.

Electromagnet — a temporary magnet produced by passing an electric current through a coil wound around a soft-iron core.

Relay — a switch operated by an electromagnet; a small current in the control circuit switches a separate circuit carrying a larger current.

Motor effect — the force experienced by a current-carrying conductor placed in a magnetic field.

Fleming's left-hand rule — a rule for the motor effect (force on a current in a field): hold the left hand with the First finger in the direction of the Field, the Second finger in the direction of the Current, and the Thumb shows the direction of the Thrust (force).

Electromagnetic induction — the production of an EMF in a conductor when the magnetic flux through it changes.

Faraday's Law — the magnitude of the induced EMF is proportional to the rate of change of magnetic flux.

Lenz's Law — the induced current flows in a direction that opposes the change that caused it, in accordance with conservation of energy.

Fleming's right-hand rule — a rule for the generator effect (induced current from motion in a field): hold the right hand with the First finger in the direction of the Field, the Thumb in the direction of Motion of the conductor, and the Second finger shows the direction of the induced Current.

Transformer — a device that uses electromagnetic induction to change the voltage of an AC supply. It consists of two coils wound on a shared soft-iron core.

Step-up transformer — a transformer in which the secondary coil has more turns than the primary; it increases voltage and decreases current.

Step-down transformer — a transformer in which the secondary coil has fewer turns than the primary; it decreases voltage and increases current.

Live wire — carries current to the appliance at mains voltage (brown).

Neutral wire — completes the circuit back to the supply; held at approximately 0 V (blue).

Earth wire — a safety wire that connects the metal casing of an appliance to earth potential, so a fault does not make the casing live (green/yellow).

Fuse — a thin wire that melts and breaks the circuit if the current exceeds a safe value.

Circuit breaker — an automatic switch that trips and breaks the circuit when the current exceeds a rated value; can be reset after the fault is corrected.

Section E — Physics of the Atom

Atomic number(Z) — the number of protons in the nucleus of an atom; determines the element.

Mass number(A) — the total number of protons and neutrons (nucleons) in the nucleus.

Isotopes — atoms of the same element (same atomic number) that have different numbers of neutrons (different mass numbers).

Radioisotope (radioactive isotope) — an isotope of an element that has an unstable nucleus and spontaneously emits radiation as it decays toward a more stable state.

Radioactivity — the spontaneous emission of radiation from an unstable nucleus; it is a property of the nucleus itself, not of any chemical bond.

Radioactive decay — the spontaneous, random disintegration of an unstable nucleus with the emission of radiation.

Alpha particle(α) — a helium-4 nucleus (two protons and two neutrons) emitted during radioactive decay.

Beta particle(β) — a fast-moving electron emitted from the nucleus during radioactive decay when a neutron converts to a proton.

Gamma radiation(γ) — high-energy electromagnetic radiation emitted from a nucleus following alpha or beta decay; it carries no charge and has no mass.

Background radiation — the low-level ionising radiation present at all times from natural sources (cosmic rays, radon gas, rocks, soil) and artificial sources.

Half-life($t_{1/2}$) — the time taken for the activity of a radioactive sample (or the number of undecayed nuclei) to fall to half its initial value.

Activity — the number of nuclear disintegrations per second; measured in becquerels (Bq).

Becquerel (Bq) — the SI unit of radioactivity; 1 Bq equals one nuclear disintegration per second.

Nuclear fission — the splitting of a heavy nucleus into two lighter nuclei, accompanied by the release of energy and two or three neutrons.

Chain reaction — a self-sustaining series of fission reactions in which neutrons released by each fission trigger further fissions.

Nuclear fusion — the combining of two light nuclei to form a heavier nucleus, releasing a large amount of energy.

Mass deficit — the difference between the total mass of the reactants and the total mass of the products in a nuclear reaction; the missing mass is converted to energy.

Mass-energy equivalence— the principle that mass and energy are interconvertible; $\Delta E = \Delta mc^2$.