

PHYSICS

P1. Electricity

P1.1 Electrostatics:

- Know and understand that insulators can be charged by friction.
- Know and understand that charging is caused by gain or loss of electrons.
- Know and understand that like charges repel and unlike charges attract.
- Understand applications and hazards associated with electrostatics, including the role of earthing.

P1.2 Electric circuits:

- Know and recognise the basic circuit symbols and diagrams, including: cell, battery, light source, resistor, variable resistor, ammeter, voltmeter, switch, diode.
- Understand the difference between alternating current (ac) and direct current (dc).
- Understand the difference between conductors and insulators, and recall examples of each type.
- Know and be able to apply: $\text{current} = \frac{\text{charge}}{\text{time}}$, $I = \frac{Q}{t}$
- Know and understand the use of voltmeters and ammeters.
- Know and be able to apply: $\text{resistance} = \frac{\text{voltage}}{\text{current}}$, $R = \frac{V}{I}$
- Recall and interpret $V-I$ graphs for a fixed resistor and a filament lamp.
- Know the properties of NTC (negative temperature coefficient) thermistors, LDRs (light-dependent resistors) and ideal diodes.
- Know and understand the current and voltage rules for series and parallel circuits.
- Calculate the total resistance for resistor combinations in series.
- Understand that the total resistance of a parallel combination is less than that of any individual resistor.
- Know and be able to apply: $\text{voltage} = \frac{\text{energy}}{\text{charge}}$, $V = \frac{E}{Q}$
- Know and be able to apply: $\text{power} = \text{current} \times \text{voltage}$, $P = IV = I^2R$
- Know and be able to apply: $\text{energy transfer} = \text{power} \times \text{time}$, $E = VIt$

P2. Magnetism

P2.1 Properties of magnets:

- a. Know and be able to use the terms *north pole*, *south pole*, *attraction* and *repulsion*.
- b. Know the magnetic field pattern around a bar magnet (including direction).
- c. Understand the difference between soft and hard magnetic materials (e.g. iron and steel).
- d. Qualitatively understand induced magnetism.

P2.2 Magnetic field due to an electric current:

- a. Know and understand the magnetic effect of a current.
- b. Know the magnetic field patterns around current-carrying wires (including direction) for straight wires and coils/solenoids.
- c. Know and understand the factors affecting magnetic field strength around a wire.
- d. Understand the difference between permanent magnets and electromagnets.

P2.3 The motor effect:

- a. Know that a wire carrying a current in a magnetic field can experience a force.
- b. Know the factors affecting the direction of a force on a wire in a magnetic field (including the left-hand rule).
- c. Know the factors affecting the magnitude of the force on a wire in a magnetic field.
- d. Know and be able to apply $F = BIL$ for a straight wire at right angles to a uniform magnetic field.
- e. Know and understand the construction and operation of a dc motor, including factors affecting the magnitude of the force produced.
- f. Understand applications of electromagnets.

P2.4 Electromagnetic induction:

- a. Know and understand that a voltage is induced when a wire cuts magnetic field lines, or when a magnetic field changes.
- b. Know the factors affecting the magnitude of an induced voltage.
- c. Know the factors affecting the direction of an induced voltage.
- d. Understand the operation of an ac generator, including factors affecting the output voltage.
- e. Interpret the graphical representation of the output voltage of a simple ac generator.
- f. Understand applications of electromagnetic induction.

P2.5 Transformers:

- a. Know and understand the terms *step-up transformer* and *step-down transformer*.
- b. Know and use the relationship between the number of turns on the primary and secondary coils, and the voltage ratio: $\frac{V_p}{V_s} = \frac{n_p}{n_s}$
- c. Know that a consequence of 100% efficiency is total transfer of electrical power, and that this gives rise to the following relationship: $V_p I_p = V_s I_s$. Know and use this relationship to solve problems.
- d. Understand power transmission, including calculating losses during transmission and the need for high voltage.

P3. Mechanics

P3.1 Kinematics:

- a. Know and understand the difference between scalar and vector quantities.
- b. Know and understand the difference between distance and displacement and between speed and velocity.
- c. Know and be able to apply: $\text{speed} = \frac{\text{distance}}{\text{time}}$,
 $\text{velocity} = \frac{\text{change in displacement}}{\text{time}}$
- d. Know and be able to apply: $\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$
- e. Interpret distance–time, displacement–time, speed–time and velocity–time graphs.
- f. Perform calculations using gradients and areas under graphs.
- g. Know and be able to apply: $\text{average speed} = \frac{\text{total distance}}{\text{total time}}$
- h. Know and be able to apply the equation of motion: $v^2 - u^2 = 2as$

P3.2 Forces:

- a. Understand that there are different types of force, including weight, normal contact, drag (including air resistance), friction, magnetic, electrostatic, thrust, upthrust, lift and tension.
- b. Know and understand the factors that can affect the magnitude and direction of the forces in 3.2a.
- c. Draw and interpret force diagrams.
- d. Qualitatively understand resultant force, with calculations in one dimension.

- P3.3 Force and extension:
- Interpret force–extension graphs.
 - Understand elastic and inelastic extension, and elastic limits.
 - Know and be able to apply Hooke’s law ($F = kx$), and understand the meaning of the limit of proportionality.
 - Understand energy stored in a stretched spring as: $E = \frac{1}{2}Fx = \frac{1}{2}kx^2$
- P3.4 Newton’s laws:
- Know and understand Newton’s first law as: ‘a body will remain at rest or in a state of uniform motion in a straight line unless acted on by a resultant external force’.
 - Understand mass as a property that resists change in motion (inertia).
 - Know and understand Newton’s second law as: force = mass \times acceleration
 - Know and understand Newton’s third law as: ‘if body A exerts a force on body B then body B exerts an equal and opposite force of the same type on body A’.
- P3.5 Mass and weight:
- Know and understand the difference between mass and weight.
 - Know and be able to apply gravitational field strength, g , approximated as 10 N kg^{-1} on Earth.
 - Know and be able to apply the relationship between mass and weight: $w = mg$
 - Understand free-fall acceleration.
 - Know the factors affecting air resistance.
 - Understand terminal velocity and the forces involved.
- P3.6 Momentum:
- Know and be able to apply: momentum = mass \times velocity, $p = mv$
 - Know and be able to use the law of conservation of momentum in calculations in one dimension.
 - Know and be able to apply: force = rate of change of momentum

P3.7 Energy:

- a. Know and be able to apply: work = force \times distance moved (in direction of force)
- b. Understand work done as a transfer of energy.
- c. Know and be able to apply: gravitational potential energy = mgh , where h is the difference in height of the object.
- d. Know and be able to apply: kinetic energy = $\frac{1}{2}mv^2$
- e. Know and be able to apply: power = $\frac{\text{energy transfer}}{\text{time}}$
- f. Know and be able to use in calculations the law of conservation of energy.
- g. Understand the concepts of useful energy and wasted energy.
- h. Know and be able to apply: percentage efficiency = $\frac{\text{useful output}}{\text{total input}} \times 100$

P4. Thermal physics

P4.1 Conduction:

- a. Know and understand thermal conductors and insulators, with examples.
- b. Know and be able to apply factors affecting rate of conduction.

P4.2 Convection:

- a. Understand and be able to apply the effect of temperature on density of fluid.
- b. Understand and be able to apply fluid flow caused by differences in density.

P4.3 Thermal radiation:

- a. Understand thermal radiation as electromagnetic waves in the infrared region.
- b. Know and be able to apply absorption and emission of radiation.
- c. Know and be able to apply factors affecting rate of absorption and emission of thermal radiation.

P4.4 Heat capacity:

- a. Understand the effect of energy transferred to or from an object on its temperature.
- b. Know and be able to apply: specific heat capacity = $\frac{\text{thermal energy}}{\text{mass} \times \text{temperature change}}$
where temperature is measured in $^{\circ}\text{C}$ and specific heat capacity, c , is measured in $\text{J kg}^{-1}^{\circ}\text{C}^{-1}$.

P5. Matter

P5.1 States of matter:

- Know the characteristic properties of solids, liquids and gases.
- Know and be able to apply particle models of solids, liquids and gases.
- Know and be able to explain properties of solids, liquids and gases in terms of particle motion and the forces and distances between the particles.

P5.2 Ideal gases:

- Be able to explain pressure and temperature in terms of the behaviour of particles.
- Understand and be able to apply the effect of pressure (P) on gas volume (V) at constant temperature, i.e. $PV = \text{constant}$.

P5.3 State changes:

- Understand the terms *melting point* and *boiling point*.
- Know and understand the terms *latent heat of fusion* and *latent heat of vaporisation*.
- Know and be able to apply specific latent heat calculations.

P5.4 Density:

- Know and be able to apply: $\text{density} = \frac{\text{mass}}{\text{volume}}$, $\rho = \frac{m}{V}$
- Understand the experimental determination of densities.
- Be able to compare the densities of solids, liquids and gases.

P5.5 Pressure:

- Know and be able to apply: $\text{pressure} = \frac{\text{force}}{\text{area}}$
- Know and be able to apply: $\text{hydrostatic pressure} = h\rho g$, where h is the height, or depth, of the liquid.

P6. Waves

P6.1 Wave properties:

- Understand the transfer of energy without net movement of matter.
- Know and understand transverse and longitudinal waves.
- Know and understand the terms: *peak*, *trough*, *compression* and *rarefaction*.
- Recall examples of waves, including electromagnetic waves and sound.
- Know and be able to use the terms: *amplitude*, *wavelength*, *frequency* and *period*.
- Know and be able to apply: frequency = $\frac{1}{\text{period}}$, $f = \frac{1}{T}$
- Know and be able to apply: wave speed = $\frac{\text{distance}}{\text{time}}$
- Know and be able to apply: wave speed = frequency \times wavelength, $v = f\lambda$

P6.2 Wave behaviour:

- Know and understand reflection at a surface.
- Know and understand refraction at a boundary.
- Know and understand the effect of reflection and refraction on the speed, frequency, wavelength and direction of waves.
- Know and understand the analogy of reflection and refraction of light with that of water waves.
- Know and understand the Doppler effect.

P6.3 Optics:

- Draw and interpret ray diagrams to describe reflection in plane mirrors.
- Know and be able to apply: angle of incidence = angle of reflection
- Draw and interpret ray diagrams for refraction at a planar boundary.
- Know and be able to interpret angle of incidence and angle of refraction.
- Know and understand the effect of refraction on wave direction (away from or towards the normal) and speed (increasing or decreasing).

P6.4 Sound waves:

- Understand the production of sound waves by a vibrating source.
- Understand the need for a medium.
- Understand qualitatively the relation of loudness to amplitude and pitch to frequency.
- Know and understand longitudinal waves.
- Understand that reflection causes echoes.
- Recall that the range of human hearing is 20 Hz to 20 kHz.
- Know and understand ultrasound and its uses (sonar and medical scanning).

P6.5 Electromagnetic spectrum:

- a. Know and understand the nature and properties of electromagnetic waves (they are transverse waves and travel at the speed of light in a vacuum).
- b. Recall the component parts of the spectrum (radio waves, microwaves, IR, visible light, UV, X-rays, gamma).
- c. Understand the distinction of the component parts by different wavelengths and/or frequencies.
- d. Recall the order of the component parts by wavelength and/or frequency.
- e. Understand applications and hazards of the component parts of the electromagnetic spectrum.

P7. Radioactivity

P7.1 Atomic structure:

- a. Understand the atom in terms of protons, neutrons and electrons.
- b. Know and be able to apply the nuclear model of atomic structure.
- c. Know the relative charges and masses of protons, neutrons and electrons.
- d. Understand and be able to use the terms *atomic number* and *mass number*.
- e. Know and understand the term *isotope*.
- f. Know and understand the term *nuclide*, and use nuclide notation.
- g. Understand that ionisation is caused by the gain/loss of electrons.

P7.2 Radioactive decay:

- a. Know and understand that emissions arise from an unstable nucleus.
- b. Know and understand the random nature of emissions.
- c. Know and understand the differences between alpha, beta and gamma emission.
- d. Know and understand the nature of alpha and beta particles, and gamma radiation.
- e. Be able to use and interpret nuclear equations.
- f. Know the effect of decay on atomic number and mass number.

P7.3 Ionising radiation:

- a. Know the relative penetrating abilities of alpha, beta and gamma radiation.
- b. Know the relative ionising abilities of alpha, beta and gamma radiation.
- c. Understand qualitatively the deflection of alpha, beta and gamma radiation in electric or magnetic fields.
- d. Know and appreciate the existence of background radiation.
- e. Understand the applications and hazards of ionising radiation.

P7.4 Half-life:

- a. Be able to interpret graphical representations of radioactive decay (including consideration of decay products).
- b. Understand the meaning of the term *half-life*.
- c. Understand and be able to apply half-life calculations.