PHYSICS

P1. Electricity

P1.1 Electrostatics:

a. Know and understand that insulators can be charged by friction.

b. Know and understand that charging is caused by gain or loss of electrons.

c. Know and understand that like charges repel and unlike charges attract.

d. Understand applications and hazards associated with electrostatics, including the role of earthing.

P1.2 Electric circuits:

a. Know and recognise the basic circuit symbols and diagrams, including: cell, battery, light source, resistor, variable resistor, ammeter, voltmeter, switch, diode.

b. Understand the difference between alternating current (ac) and direct current (dc).

c. Understand the difference between conductors and insulators, and recall examples of each type.

d. Know and be able to apply: $\text{current} = \frac{\text{charge}}{\text{time}}$, $I = \frac{Q}{t}$

e. Know and understand the use of voltmeters and ammeters.

f. Know and be able to apply: $\text{resistance} = \frac{\text{voltage}}{\text{current}}$, $R = \frac{V}{I}$

g. Recall and interpret *V*–*I* graphs for a fixed resistor and a filament lamp.

h. Know the properties of NTC (negative temperature coefficient) thermistors, LDRs (light-dependent resistors) and ideal diodes.

i. Know and understand the current and voltage rules for series and parallel circuits.

j. Calculate the total resistance for resistor combinations in series.

k. Understand that the total resistance of a parallel combination is less than that of any individual resistor.

l. Know and be able to apply: $\text{voltage} = \frac{\text{energy}}{\text{charge}}$, $V = \frac{E}{Q}$

m. Know and be able to apply: power = current × voltage, $P = IV = I^2R$

n. Know and be able to apply: energy transfer = power × 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:

a. Interpret force–extension graphs.
b. Understand elastic and inelastic extension, and elastic limits.
c. Know and be able to apply Hooke's law ($F = kx$), and understand the meaning of the limit of proportionality.
d. Understand energy stored in a stretched spring as: $E = \frac{1}{2}Fx = \frac{1}{2}kx^2$

P3.4 Newton's laws:

a. 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'.
b. Understand mass as a property that resists change in motion (inertia).
c. Know and understand Newton's second law as: force = mass × acceleration
d. 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:

a. Know and understand the difference between mass and weight.
b. Know and be able to apply gravitational field strength, *g*, approximated as $10\,\text{N kg}^{-1}$ on Earth.
c. Know and be able to apply the relationship between mass and weight: $w = mg$
d. Understand free-fall acceleration.
e. Know the factors affecting air resistance.
f. Understand terminal velocity and the forces involved.

P3.6 Momentum:

a. Know and be able to apply: momentum = mass × velocity, $p = mv$
b. Know and be able to use the law of conservation of momentum in calculations in one dimension.
c. Know and be able to apply: force = rate of change of momentum

P3.7 Energy:

a. Know and be able to apply: work = force × 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 °C and specific heat capacity, c, is measured in $\text{J kg}^{-1}\,^{\circ}\text{C}^{-1}$.

P5. Matter

P5.1 States of matter:

a. Know the characteristic properties of solids, liquids and gases.

b. Know and be able to apply particle models of solids, liquids and gases.

c. 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:

a. Be able to explain pressure and temperature in terms of the behaviour of particles.

b. Understand and be able to apply the effect of pressure (P) on gas volume (V) at constant temperature, i.e. PV = constant.

P5.3 State changes:

a. Understand the terms *melting point* and *boiling point*.

b. Know and understand the terms *latent heat of fusion* and *latent heat of vaporisation*.

c. Know and be able to apply specific latent heat calculations.

P5.4 Density:

a. Know and be able to apply: density $= \frac{\text{mass}}{\text{volume}}$, $\rho = \frac{m}{V}$

b. Understand the experimental determination of densities.

c. Be able to compare the densities of solids, liquids and gases.

P5.5 Pressure:

a. Know and be able to apply: pressure $= \frac{\text{force}}{\text{area}}$

b. Know and be able to apply: hydrostatic pressure = $h\rho g$, where h is the height, or depth, of the liquid.

P6. Waves

P6.1 Wave properties:

a. Understand the transfer of energy without net movement of matter.

b. Know and understand transverse and longitudinal waves.

c. Know and understand the terms: *peak*, *trough*, *compression* and *rarefaction*.

d. Recall examples of waves, including electromagnetic waves and sound.

e. Know and be able to use the terms: *amplitude*, *wavelength*, *frequency* and *period*.

f. Know and be able to apply: frequency $= \frac{1}{\text{period}}$, $f = \frac{1}{T}$

g. Know and be able to apply: wave speed $= \frac{\text{distance}}{\text{time}}$

h. Know and be able to apply: wave speed = frequency $\times$ wavelength, $v = f\lambda$

P6.2 Wave behaviour:

a. Know and understand reflection at a surface.

b. Know and understand refraction at a boundary.

c. Know and understand the effect of reflection and refraction on the speed, frequency, wavelength and direction of waves.

d. Know and understand the analogy of reflection and refraction of light with that of water waves.

e. Know and understand the Doppler effect.

P6.3 Optics:

a. Draw and interpret ray diagrams to describe reflection in plane mirrors.

b. Know and be able to apply: angle of incidence = angle of reflection

c. Draw and interpret ray diagrams for refraction at a planar boundary.

d. Know and be able to interpret angle of incidence and angle of refraction.

e. 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:

a. Understand the production of sound waves by a vibrating source.

b. Understand the need for a medium.

c. Understand qualitatively the relation of loudness to amplitude and pitch to frequency.

d. Know and understand longitudinal waves.

e. Understand that reflection causes echoes.

f. Recall that the range of human hearing is 20 Hz to 20 kHz.

g. 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.