IB Standards of Physics Required

TOPIC	LEARNING OUTCOMES
Measurements	• Describe the use of rules and measuring cylinders to determine a length or a volume. • Describe the use of clocks and devices for measuring an interval of time. • Describe the use of a mechanical method for the measurement of a small distance measure and describe how to measure a short interval of time (including the period of a pendulum).
Distance, speed and acceleration	• Define speed and calculate speed from $\frac{\text{total distance}}{\text{total time}}$ • Plot and interpret a speed/time graph • Recognise from the shape of a speed/time graph when a body is (a) at rest, (b) moving with constant speed, (c) moving with changing speed • Calculate the area under a speed/time graph to determine the distance travelled for motion with constant acceleration • Understand that acceleration is related to changing speed • State that the acceleration of free fall for a body near to the Earth is constant. • Distinguish between speed and velocity • Recognise linear motion for which the acceleration is constant and calculate the acceleration. • Recognise motion for which the acceleration is not constant. • Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity).

Forces	• State that a force may produce a change in size and shape of a body. • Plot extension/load graphs and describe the associated experimental procedure. • Describe the ways in which a force may change the motion of a body. • Find the resultant of two or more forces acting along the same line. • State Hooke's Law and recall and use the expression $F = kx$. • Interpret extension/load graphs. • Recognise the significance of the term 'limit of proportionality' for an extension/load graph. • Recall and use the relation between force, mass and acceleration (including the direction). • Describe, qualitatively, motion in a curved path due to a perpendicular force ($F = mv^2/r$ is *not* required).

Turning Forces	• Describe the moment of a force as a measure of its turning effect and recognise everyday examples • Describe, qualitatively, the balancing of a beam about a pivot. • Describe an experiment (involving vertical forces) to verify that there is no net moment on a body in equilibrium. • Apply the idea of opposing moments to simple systems in equilibrium. • State that, when there is no resultant force and no resultant turning effect, a system is in equilibrium. • Describe an experiment to determine the position of the centre of mass of a plane lamina. • Describe qualitatively the effect of the position of the centre of mass on the stability of simple objects.
Vectors and Scalars	• Demonstrate an understanding of the difference between scalars and vectors and give common examples. • Add vectors by graphical representation to determine a resultant. • Determine graphically a resultant of two vectors.

Work, Energy and Power	• Relate work done to the magnitude of a force and distance moved. • Demonstrate an understanding that an object may have energy due to its motion or its position, and that energy may be transferred and stored. • Give examples of energy in different forms, including kinetic, gravitational, chemical, strain, nuclear, internal, electrical, light and sound. • Give examples of the conversion of energy from one form to another and of its transfer from one place to another. • Use the terms kinetic and potential energy in context. • Recall and use the expressions k.e.= $\frac{1}{2}mv^2$ and p.e. = mgh. • Apply the principle of energy conservation to simple examples. • Recall and use work done = Fd = energy transformed. • Describe energy changes in terms of work done. • Relate power to work done and time taken. • Recall and use the equation $P = E/t$ in simple systems. • Describe how electricity or other useful forms of energy may be obtained from chemical energy stored in fuel • water, including the energy stored in waves, in tides and in water behind hydroelectric dams • geothermal resources

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Reflection of light	• Describe the formation, and give the characteristics, of an optical image by a plane mirror. • Use the law angle of incidence = angle of reflection. • Draw simple ray diagrams
Refraction of at plane surfaces	• Describe an experimental demonstration of the refraction of light. • Use the terminology for the angle of incidence *i* and angle of refraction r • Describe the passage of light through parallel- sided transparent material • Recall and use definition of refractive index *n* in terms of speed. • Recall and use the equation sin i/sin $r = n$. • Describe internal and total internal reflection. • Understand the meaning of critical angle. • Describe the action of optical fibres.
Refraction in Converging Lenses	• Describe the action of a thin converging lens on a beam of light. • Use the terms principal focus and focal length. • Draw ray diagrams to illustrate the formation of a real image by a single lens. • Draw ray diagrams to illustrate the formation of a virtual image by a single lens. • Use and describe the use of a single lens as a magnifying glass.

Dispersion of light	• Describe the action on light of a glass prism. • Give a qualitative account of the dispersion of light by a glass prism
Kinetic theory of gases	• State the distinguishing properties of solids, liquids and gases. • Describe qualitatively the molecular structure of solids, liquids and gases. • Relate the properties of solids, liquids and gases to the forces and distances between molecules and to the motion of the molecules. • Interpret the temperature of a gas in terms of the motion of its molecules. • Describe qualitatively the pressure of a gas in terms of the motion of its molecules. • Describe qualitatively the effect of a change of temperature on the pressure of a gas at constant volume. • Relate the change in volume of a gas to change in pressure applied to the gas at constant temperature. • Recall and use the equation pV = constant at constant temperature. • Show an understanding of the random motion of particles in a suspension as evidence for the kinetic molecular model of matter. • Describe this motion (sometimes known as Brownian motion) in terms of random molecular bombardment. • Show an appreciation that massive particles may be moved by light, fast-moving molecules.

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Evaporation	• Describe evaporation in terms of the escape of more-energetic molecules from the surface of a liquid. • Relate evaporation and the consequent cooling. • Demonstrate an understanding of how temperature, surface area and draught over a surface influence evaporation.
Expansion of solids, liquids and gases	• Describe qualitatively the thermal expansion of solids, liquids and gases. • Identify and explain some of the everyday applications and consequences of thermal expansion. • Describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure. • Show an appreciation of the relative order of magnitude of the expansion of solids, liquids and gases.

Thermometers	• Appreciate how a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties. • Recognise the need for and identify fixed points. • Describe the structure and action of liquid-in-glass thermometers. • Demonstrate understanding of sensitivity, range and linearity. • Describe the structure of a thermocouple and show understanding of its use for measuring high temperatures and those which vary rapidly.
Thermal capacity and change of state	• Relate a rise in temperature of a body to an Increase in internal energy. • Show an understanding of the term thermal capacity. • Describe an experiment to measure the specific heat capacity of a substance. • Describe melting and boiling in terms of energy input without a change in temperature. • State the meaning of melting point and boiling point. • Describe condensation and solidification. • Distinguish between boiling and evaporation • Use the term latent heat and give a molecular interpretation of latent heat. • Describe an experiment to measure specific latent heats for steam and for ice.

Transfer of heat	• Describe experiments to demonstrate the properties of good and bad conductors of heat. • Give a simple molecular account of the heat transfer in solids. • Relate convection in fluids to density changes and describe experiments to illustrate convection. • Identify infra-red radiation as part of the electromagnetic spectrum. • Describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation. • Identify and explain some of the everyday applications and consequences of conduction, convection and radiation.
Wave properties	• Describe what is meant by wave motion as illustrated by vibration in ropes, springs and by experiments using water waves. • Use the term wavefront. • Give the meaning of speed, frequency, wavelength and amplitude. • Distinguish between transverse and longitudinal waves and give suitable examples. • Describe the use of water waves to show • reflection at a plane surface • refraction due to a change of speed • (iii) diffraction produced by wide and narrow gaps. • Give the meaning of the term wavefront. • Recall and use the equation $v = f \times \lambda$. • Interpret reflection, refraction and diffraction using wave theory.

Electromagnetic Waves	• Describe the main features of the electromagnetic spectrum and state that all • e-m waves travel with the same high speed *in vacuo.* • State the approximate value of the speed of electromagnetic waves.
Sound	• Describe the production of sound by vibrating sources. • Describe the longitudinal nature of sound waves. • State the approximate range of audible frequencies. • Show an understanding that a medium is required in order to transmit sound waves. • Describe an experiment to determine the speed of sound in air. • Relate the loudness and pitch of sound waves to amplitude and frequency. • Describe how the reflection of sound may produce an echo. • Describe compression and rarefaction. • State the order of magnitude of the speed of sound in air, liquids and solids.

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Electrostatics	• Describe simple experiments to show the production and detection of electrostatic charges. • State that there are positive and negative charges. • State that unlike charges attract and that like charges repel. • Describe an electric field as a region in which an electric charge experiences a force. • Distinguish between electrical conductors and insulators and give typical examples. • State that charge is measured in coulombs. • State the direction of lines of force and describe simple field patterns. • Give an account of charging by induction. • Recall and use the simple electron model to distinguish between conductors and insulators.

	• State that current is related to the flow of charge. • Use and describe the use of an ammeter. • Show understanding that a current is a rate of flow of charge and recall and use the equation $I = Q/t$. • Distinguish between the direction of flow of electrons and conventional current. • State that the e.m.f. of a source of electrical energy is measured in volts. • Show understanding that e.m.f. is defined in terms of energy supplied by a source in driving charge round a complete circuit. • State that the potential difference across a circuit component is measured in volts. • Use and describe the use of a voltmeter. • State that resistance = pd/current and understand qualitatively how changes in p.d. or resistance affect current. • Recall and use the equation $R = V/I$. • Describe an experiment to determine resistance using a voltmeter and an ammeter. • Relate (without calculation) the resistance of a wire to its length and to its diameter. • Recall and use quantitatively the proportionality between resistance and the length and the inverse proportionality between resistance and cross-sectional area of a wire. • Recall and use the equation $P = IV$ and $E = Ivt$.

Current electricity	• Draw and interpret circuit diagrams containing sources, switches, resistors (fixed and variable), lamps, ammeters, voltmeters, magnetising coils, transformers, bells, fuses, relays.
	• Understand that the current at every point in a series circuit is the same.
	• Give the combined resistance of two or more resistors in series.
	• State that, for a parallel circuit, the current from the source is larger than the current in each branch.
	• State that the combined resistance of two resistors in parallel is less than that of either resistor by itself.
	• Draw and interpret circuit diagrams containing diodes and transistors.
	• Recall and use the fact that the sum of the p.d.s. across the components in a series circuit is equal to the total p.d.s. across the supply.
	• Recall and use the fact that the current from the source is the sum of the currents in the separate branches of a parallel circuit.
	• Calculate the effective resistance of two resistors in parallel.
	• State the hazards of: (i) damaged insulation
	  • (ii) overheating of cables
	  • (iii) damp conditions
	• Show an understanding of the use of fuses and/or circuit-breakers.

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Magnets and electromagnetism	• State the properties of magnets. Give an account of induced magnetism. Distinguish between ferrous and non-ferrous materials. • Describe methods of magnetisation and of demagnetisation. • Describe an experiment to identify the pattern of field lines round a bar magnet. • Distinguish between the magnetic properties of iron and steel. • Distinguish between the design and use of permanent magnets and electromagnets. • Describe the pattern of the magnetic field due to currents in straight wires and in solenoids • State the qualitative variation of the strength of the magnetic field over salient parts of the pattern. • Describe the effect on the magnetic field of changing the magnitude and direction of the current. • Describe applications of the magnetic effect of current, including the action of a relay.

Atomic physics	• Show awareness of the existence of background radioactivity.
	• Describe the detection of alpha-particles, beta- particles and gamma- rays.
	• State that radioactive emissions occur randomly over space and time.
	
	• State, for radioactive emissions:
	  • their nature
	  • their relative ionising effects
	  • their relative penetrating abilities.
	• Describe their deflection in electric fields and magnetic fields.
	• Interpret their relative ionising effects
	• State the meaning of radioactive decay, using equations (involving words or symbols) to represent changes in the composition of the nucleus when particles are emitted.
	• Use the term half-life in simple calculations which might involve information in tables or decay curves.
	• Describe how radioactive materials are handled, used and stored in a safe way.
	• Describe the structure of an atom in terms of a nucleus and electrons
	• Describe how the scattering of alpha- particles by thin metal foils provides evidence for the nuclear atom.
	• Describe the composition of the nucleus in terms of protons and neutrons.
	• Use the term proton number (= atomic number), *z,* use the term nucleon number **(**= mass number), *A*, use the term nuclide and nuclide notation
	$^{A}_{Z}X$
	• Use the term isotope

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