IBS Physics – L6

Curriculum Intent

Physics is the most fundamental science which aims to understand everything from tiny particles to vast galaxies. The aim of all IB programmes is to develop internationally minded people who strive to create a better society.
The course aims for all students to: ·

- Understand that science is only one of eight ways of knowing
- Understand how science is an international pursuit and the benefits and impacts of international collaborations in science.
- Become critically aware, as global citizens, of the ethical implications of the use of science and technology
- To recognise the contributions of all civilisations that led us to our current understanding of the physics
- develop experimental and investigative scientific skills using up to date technology
- develop and demonstrate a deep appreciation of the skills, knowledge and understanding of scientific methods
- promote students' interest in and enthusiasm for the subject, including an interest in further study and careers associated with the subject.

"However difficult life may seem, there is always something you can do and succeed at" – Stephen Hawking

Students will learn: -

Term 1 - <u>Topic B The Particulate Nature of Matter</u>
- B1 Thermal Energy Transfers
- B2 The Greenhouse Effect
- B3 Gas Laws

<u>Term 2 - Topic C Wave Behaviour</u>
- C1 Simple Harmonic Motion
- C2 Wave Model
- C3 Wave Phenomena
- C4 Standing Waves and Resonance
- C5 Doppler Effect

<u>Term 3 - Topic A Space, Time and Motion</u>
- A1 Kinematics
- A2 Forces and Momentum
- A3 Work, Energy and Power

- **<u>Plus</u>** B5 Current and Circuits

What does excellence look like?

Students should understand:
- molecular theory in solids, liquids and gases
- density
- that Kelvin and Celsius scales are used to express temperature
- that the change in temperature of a system is the same when expressed with the Kelvin or Celsius scales
- that Kelvin temperature is a measure of the average kinetic energy of particles
- that the internal energy of a system is the total intermolecular potential energy arising from the forces between the molecules plus the total random kinetic energy of the molecules arising from their random motion
- that temperature difference determines the direction of the resultant thermal energy transfer between bodies
- that a phase change represents a change in particle behaviour arising from a change in energy at constant temperature

Knowledge, understanding & Skills

An elementary explanation of the physical differences between solids, liquids and gases in terms of the molecular model is required.

The conversion of Kelvin and Celsius scales is required.
The terms melting, freezing, boiling, condensing and evaporation should be familiar.
The luminosity of a star can be expressed in watts or in terms of the luminosity of the Sun $L_\odot$.

Problems will include the estimation of equilibrium temperature of a body using energy balance between incoming and outgoing radiation intensity, including albedo, emissivity, and solar or other constants.
Energy balance problems will include energy exchanged between the surface and the atmosphere of a body.
The burning of fossil fuels is a primary cause of the enhanced greenhouse effect.

The assumption of the kinetic model is of an ideal gas.
The differences between an ideal gas and a real gas should be understood.
Gas laws are limited to constant volume, constant temperature, constant pressure and the ideal gas law.
Changes of state of an ideal gas can be represented on pressure–volume diagrams.
A qualitative explanation of the macroscopic properties of an ideal gas in terms of molecular behaviour is required.
Solving problems using the equation of state for an ideal gas and gas laws. Sketching and interpreting changes of state of an ideal gas on pressure–volume, pressure–temperature and volume–temperature diagrams.
Investigating gas laws experimentally.

What does excellence look like?

Students should understand:

- quantitative analysis of thermal energy transfers Q with the use of specific heat capacity c and specific latent heat of fusion and vaporization of substances L as given by $Q = mc\Delta T$ and $Q = mL$
- that conduction, convection and thermal radiation are the primary mechanisms for thermal energy transfer
  conduction in terms of the difference in the kinetic energy of particles
- quantitative analysis of rate of thermal energy transfer by conduction in terms of the type of material
  and cross-sectional area of the material and the temperature gradient
- qualitative description of thermal energy transferred by convection due to fluid density differences
- quantitative analysis of energy transferred by radiation as a result of the emission of electromagnetic waves from the surface of a body, which in the case of a black body can be modelled by the Stefan-Boltzmann law as given by $L = \sigma A T^4$ where L is the luminosity, A is the surface area and T is the absolute temperature of the body
- the concept of apparent brightness b
- luminosity L of a body
- the emission spectrum of a black body and the determination of the temperature of the body using Wien's displacement law as given by $\lambda_{max} T = 2.9 \times 10^{-3}$ mK where λ_{max} is the peak wavelength emitted.
- the conservation of energy emissivity as the ratio of the power radiated per unit area by a surface compared to that of an ideal black surface at the same temperature
- albedo as a measure of the average energy reflected off a macroscopic system
- that Earth's albedo varies daily and is dependent on cloud formations and latitude
- the solar constant S
- that the incoming radiative power is dependent on the projected surface of a planet along the direction of the path of the rays, resulting in a mean value of the incoming intensity being S/4
- that methane CH_4, water vapour H_2O, carbon dioxide CO_2, and nitrous oxide N_2O, are the main
  greenhouse gases and each of these has origins that are both natural and created by human activity
- the absorption of infrared radiation by the main greenhouse gases in terms of the molecular energy levels and the subsequent emission of radiation in all directions
- that the greenhouse effect can be explained in terms of both a resonance model and molecular energy levels
- that the augmentation of the greenhouse effect due to human activities is known as the enhanced greenhouse effect.
- pressure where F is the force exerted perpendicular to the surface
- the amount of substance n
- that ideal gases are described in terms of the kinetic theory and constitute a modelled system used to
- approximate the behaviour of real gases
- that the ideal gas law equation can be derived from the empirical gas laws for constant pressure, constant volume and constant temperature as given by PV/T = constant
- the equations governing the behaviour of ideal gases
- that the change in momentum of particles due to collisions with a given surface gives rise to pressure in gases and, from that analysis, pressure is related to the average translational speed of molecules
- the relationship between the internal energy U of an ideal monatomic gas and the number of molecules or amount of substance

Knowledge, understanding & Skills

Advantages and disadvantages of difference sources of electrical energy are required.
Refer to the Physics data booklet for the electrical circuit symbols that are required.
Alternating current (ac) circuits are not required.
Unless otherwise stated, ammeters and voltmeters will be considered as ideal. In cases where non-ideal meters are used, the resistance will be constant.
A metal conductor at a constant temperature will be considered an ohmic device.
Variable resistors will be limited to thermistors, light-dependent resistors (LDR) and potentiometers.
The significance of the minus sign in the defining equation for simple harmonic motion should be understood.
Energy changes during simple harmonic motion (kinetic, potential and total) should be described qualitatively.
A quantitative approach to energy changes during simple harmonic motion is required at higher level only. Radians are used for phase angle calculations.
Problems will involve describing the motion of particles of a medium when a wave passes through it for both transverse and longitudinal waves. This will be in terms of displacement with respect to the position along the wave and with time.
Travelling waves transfer energy, even if there is no resultant displacement of the medium.
Refer to the Physics data booklet for the approximate orders of magnitude of the wavelengths of radio, microwave, infrared, visible, ultraviolet, X-rays and gamma rays.
The wave model should be applied to both mechanical waves and electromagnetic waves.
Problems may involve sketching and interpreting wavefronts and rays. These will be limited to incident, reflected, and transmitted waves.
Interference and diffraction patterns will be limited to those produced at normal incidence.
The effect of slit width on the intensity of the single-slit diffraction pattern should be considered qualitatively.
The discussion of single-slit diffraction will be limited to monochromatic light and rectangular slits.
Multiple slit and diffraction grating patterns produced from white light and a range of monochromatic light wavelengths should be discussed.
The formation of standing waves from the superposition of more than two waves should not be considered.
Pipes will be referred to as open or closed.
End corrections for open pipes are not required.
Boundary conditions for strings include two fixed boundaries, one fixed and one free boundary, and two free boundaries.

What does excellence look like?

- the temperature, pressure and density conditions under which an ideal gas is a good approximation of a real gas
- conditions that lead to simple harmonic motion
- the defining equation of simple harmonic motion as given by $a = -\omega^2 x$
- a particle undergoing simple harmonic motion can be described using time period T, frequency f, angular frequency ω, amplitude, equilibrium position, and displacement
- the time period in terms of frequency of oscillation and angular frequency
- the time period of a mass–spring system
- the time period of a simple pendulum as given
- transverse and longitudinal travelling waves
- wavelength λ, frequency f, time period T, and wave speed v applied to wave motion
- the nature of sound waves
- the nature of electromagnetic waves
- the differences between mechanical waves and electromagnetic waves.
- that waves travelling in two and three dimensions can be described through the concepts of wavefronts and rays
- wave behaviour at boundaries in terms of reflection, refraction and transmission
- wave diffraction around a body and through an aperture
- wavefront-ray diagrams showing refraction and diffraction
- Snell's law, critical angle and total internal reflection
- superposition of waves and wave pulses
- that double-source interference requires coherent sources
- the condition for constructive interference as given by path difference = $n\lambda$
- the condition for destructive interference as given by path difference = $(n + 1/2)\lambda$
- Young's double-slit interference as given by $s = \lambda D/d$ where s is the separation of fringes, d is the separation of the slits, and D is the distance from the slits to the screen.
- the nature and formation of standing waves in terms of superposition of two identical waves travelling in opposite directions
- nodes and antinodes, relative amplitude and phase difference of points along a standing wave
- standing waves patterns in strings and pipes
- the nature of resonance including natural frequency and amplitude of oscillation based on driving frequency
- the effect of damping on the maximum amplitude and resonant frequency of oscillation
- the effects of light, critical and heavy damping on the system.
- the nature of the Doppler effect for sound waves and electromagnetic waves
- the representation of the Doppler effect in terms of wavefront diagrams when either the source or the observer is moving
- the relative change in frequency or wavelength observed for a light wave due to the Doppler effect where the speed of light is much larger than the relative speed between the source and the observer
- that shifts in spectral lines provide information about the motion of bodies like stars and galaxies in space.
- that the motion of bodies through space and time can be described and analysed in terms of position, velocity, and acceleration
- velocity is the rate of change of position, and acceleration is the rate of change of velocity
- the change in position is the displacement
- the difference between distance and displacement
- the difference between instantaneous and average values of velocity, speed and acceleration, and how to determine them

Knowledge, understanding & Skills

Boundary conditions for air in pipes include two closed ends, one closed and one open end, and two open ends. Vibration modes of air in pipes will be discussed in terms of displacement nodes and antinodes. For standing waves in air, pressure nodes and antinodes are not required.
The lowest frequency mode of a standing wave will be referred to as the first harmonic. The terms fundamental and overtone are not to be used in this course.
A determination of the wavelength and the frequency of the nth harmonic given the length of the string or pipe and the speed of the wave is required.
Only a qualitative analysis is required concerning the impact of damping on the frequency response of a driven oscillator.
Knowledge of the useful and destructive effects of resonance is required.
Problems will not include situations where both source and observer are moving.
Problems can involve the determination of the velocity of the source/observer.
The use of the Doppler effect in medical physics and in radars should be considered as examples.

A quantitative approach to projectile motion will be limited to situations where fluid resistance is absent or can be neglected.
The trajectory of projectile motion is parabolic in the absence of fluid resistance, but the equation of the trajectory is not required.
Familiarity with projectiles launched horizontally, at angles above, and at angles below the horizontal is required.
Projectile motion will only involve problems using a constant value of g close to the surface of the Earth. Fluid resistance refers to the effects of gases and liquids on the motion of a body.

Sketches and interpretations of free-body diagrams and a determination of the resultant force are for one- and two-dimensional situations only.
Forces should be labelled using commonly accepted names or symbols.
Newton's first law will be applied to problems involving translational equilibrium.
Examples of Newton's third law will include the identification of force pairs in various situations.
The use of simultaneous equations involving conservation of momentum and energy in collisions is not required.

What does excellence look like?

- the equations of motion for solving problems with uniformly accelerated motion (see data book)
- motion with uniform and non-uniform acceleration
- the behaviour of projectiles in the absence of fluid resistance, and the application of the equations of motion resolved into vertical and horizontal components
- the qualitative effect of fluid resistance on projectiles, including time of flight, trajectory, velocity, acceleration, range and terminal speed.
- Newton's three laws of motion
- forces as interactions between bodies
- that forces acting on a body can be represented in a free-body diagram
- that free-body diagrams can be analysed to find the resultant force on a system
- the nature and use of the following contact forces
- normal force F_N is the component of the contact force acting perpendicular to the surface that counteracts the body
- surface frictional force F_f acting in a direction parallel to the plane of contact between a body and a surface, on a stationary body as given by $F_f \leq \mu_s F_N$ or a body in motion as given by $F_f = \mu_d F_N$ where μ_s and μ_d are the coefficients of static and dynamic friction respectively
- tension
- elastic restoring force F_H following Hooke's law as given by $F_H = -kx$ where k is the spring constant
- viscous drag force F_d acting on a small sphere opposing its motion through a fluid as given by $F_d = 6\pi\eta r v$ where η is the fluid viscosity, r is the radius of the sphere and v is the velocity of the sphere through the fluid
- buoyancy F_b acting on a body due to the displacement of the fluid as given by $F_b = \rho V g$ where V is the volume of fluid displaced
- the nature and use of the following field forces
  - gravitational force F_g is the weight of the body and calculated is given by $F_g = mg$
  - electric force F_e
  - magnetic force F_m
- energy considerations in elastic collisions, inelastic collisions, and explosions
- that linear momentum as given by $p = mv$ remains constant unless the system is acted upon by a resultant external force
- that a resultant external force applied to a system constitutes an impulse J as given by $J = F\Delta t$ where F is the average resultant force and Δt is the time of contact

  that the applied external impulse equals the change in momentum of the system
- that Newton's second law in the form $F = ma$ assumes mass is constant whereas $F = \Delta p/\Delta t$ allows for situations where mass is changing
- the elastic and inelastic collisions of two bodies explosions
- that bodies moving along a circular trajectory at a constant speed experience an acceleration that is directed radially towards the centre of the circle—known as a centripetal acceleration
- that circular motion is caused by a centripetal force acting perpendicular to the velocity
- that a centripetal force causes the body to change direction even if its magnitude of velocity may remain constant
- that the motion along a circular trajectory can be described in terms of the angular velocity ω which is related to the linear speed v by the equation

Knowledge, understanding & Skills

A quantitative approach to collisions and explosions is for one-dimensional situations for standard level students and for two-dimensional situations for higher level students. Situations should involve both uniform and non-uniform circular motion in both horizontal and vertical planes. Analysis of forces on bodies in non-uniform circular motion in a vertical plane at points other than the top or bottom is not required.

Quantitative treatment of problems involving banked surfaces is not required.

Describing the differences between photovoltaic cells and solar heating panels. Sketching and interpreting graphs showing the variation of intensity with wavelength for bodies emitting thermal radiation at different temperatures. Solving problems involving the Stefan–Boltzmann law and Wien's displacement law. Describing the effects of the Earth's atmosphere on the mean surface temperature. Solving problems involving albedo, emissivity, solar constant and the Earth's average temperature. The change in the total mechanical energy of a system should be interpreted in terms of the work done on the system by any non-conservative force.

How can you enhance your learning at home?

- **IB Physics revision**
- **Grade Gorilla**
- **Isaac Physics**
- **Physics Tube**
- **The institute of physics**
- **Physics and maths tutor**
- **Minute Physics**
- **Hyperphysics**

Suggested homework task

- **Learn definitions of key terms**
- **Group and independent research projects**
- **Past examination question practice**
- **Practical activity preparation, simulations and follow up.**

What does excellence look like?

- the principle of the conservation of energy
- that work done by a force is equivalent to a transfer of energy
- that energy transfers can be represented on a Sankey diagram
- that work W done on a body by a constant force depends on the component of the force along the line of displacement as given by $W = Fs \cos \theta$
- that work done by the resultant force on a system is equal to the change in the energy of the system
- that mechanical energy is the sum of kinetic energy, gravitational potential energy and elastic potential energy
- that in the absence of frictional, resistive forces, the total mechanical energy of a system is conserved
- that if mechanical energy is conserved, work is the amount of energy transformed between different forms of mechanical energy in a system, such as:
  the kinetic energy of translational motion
- that power developed P is the rate of work done, or the rate of energy transfer
- efficiency η in terms of energy transfer or power
- the gravitational potential energy, when close to the surface of the Earth as given by $\Delta E_p = mg\Delta h$
- the elastic potential energy
- that cells provide a source of emf
- chemical cells and solar cells as the energy source in circuits
- that circuit diagrams represent the arrangement of components in a circuit
- direct current (dc) I as a flow of charge carriers as given by $I = \Delta q \ \Delta t$
- that the electric potential difference V is the work done per unit charge on moving a positive charge between two points along the path of the current
- the properties of electrical conductors and insulators in terms of mobility of charge carriers
- electric resistance, R, and its origin
- resistivity
- Ohm's law
- the ohmic and non-ohmic behaviour of electrical conductors, including the heating effect of resistors
- the combinations of resistors in series and parallel circuits
- electrical power P dissipated by a resistor
- that electric cells are characterized by their emf ε and internal resistance r as given by $\varepsilon = I(R + r)$
- that resistors can have variable resistance.

How will we assess impact?

- Peer and self-assessment
- Previous lesson recap quiz
- Check point tasks
- End of topic tests
- Teacher questioning
- Cumulative linear knowledge tests
- End of L6 and mid- U6 PPE examinations using unseen exam board papers

ENTRY REQUIREMENTS

To study Standard Level Physics, you will need:

- A grade 5 in GCSE Physics OR a grade 5-5 in Combined Sciences
- In addition, you will need a grade 5 in Maths

International Opportunities

Visits Programmes

- **Community lectures on International themes**
- **International day across the school**
- **Primary research using student cultural diversity**

Within the Curriculum

The Physics IB Standard curriculum is designed to deepen understanding and appreciation of how our International society makes decisions about world scientific issues.

Students are encouraged to research each theme beyond lessons using International research methods and set work to ensure that they can draw on a worldwide knowledge of the skills, techniques and theoretical understanding required for the further study of Physical Sciences at an International level.

"Physics is really nothing more than a search for ultimate simplicity, but so far all we have is a kind of elegant messiness." **Bill Bryson, A Short History of Nearly Everything**