IBH Physics – U6

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: -

Autumn Term

Topic 9 Wave Phenomena, Topic 10 Fields, Topic 11 Electromagnetic Induction: -

The defining equation of SHM. Energy changes. The nature of single-slit diffraction. Young's double-slit experiment. Modulation of two-slit interference pattern by one-slit diffraction effect. Multiple slit and diffraction grating interference patterns. Thin film interference. The size of a diffracting aperture. The resolution of simple monochromatic two-source systems. The Doppler effect for sound waves and light waves. Gravitational fields. Electrostatic fields. Electric potential and gravitational potential. Field lines. Equipotential surfaces. Potential and potential energy. Potential gradient. Potential difference. Escape speed. Orbital motion, orbital speed, and orbital energy. Forces and inverse-square law behaviour. Electromotive force (emf). Magnetic flux and magnetic flux linkage. Faraday's law of induction. Lenz's law. Alternating current (ac) generators. Average power and root mean square (rms) values of current and voltage. Transformers. Diode bridges. Half-wave and full-wave rectification. Capacitance. Dielectric materials. Capacitors in series and parallel. Resistor-capacitor (RC) series circuits. Time constant.

Topic 12 Quantum and nuclear physics, Option topic Relativity: -

Photons. The photoelectric effect. Matter waves. Pair production and pair annihilation. Quantization of angular momentum in the Bohr model for hydrogen. The wave functions. The uncertainty principle for energy and time and position and momentum. Tunnelling, potential barrier and factors affecting tunnelling probability. Rutherford scattering and nuclear radius. Nuclear energy levels. The neutrino. The law of radioactive decay and the decay constant. Reference frames. Galilean relativity and Newton's postulates concerning time and space. Maxwell and the constancy of the speed of light. Forces on a charge or current. The two postulates of special relativity. Clock synchronization. The Lorentz transformations. Velocity addition. Invariant quantities (spacetime interval, proper time, proper length, and rest mass). Time dilation. Length contraction. The muon decay experiment. Spacetime diagrams. Worldlines. The twin paradox. Total energy and rest energy. Relativistic momentum. Particle acceleration. Electric charge as an invariant quantity. Photons. MeV c–2 as the unit of mass and MeV c–1 as the unit of momentum. The equivalence principle. The bending of light. Gravitational redshift and the Pound–Rebka–Snider experiment. Schwarzschild black holes. Event horizons. Time dilation near a black hole. Applications of general relativity to the universe as a whole

Knowledge, understanding & Skills

Autumn Term – Topic 9 Wave Phenomena, Topic 10 Fields, Topic 11 Electromagnetic Induction - Demonstrate knowledge, understanding, and application of:- Solving problems involving acceleration, velocity and displacement during simple harmonic motion, both graphically and algebraically. Describing the interchange of kinetic and potential energy during simple harmonic motion. Solving problems involving energy transfer during simple harmonic motion, both graphically and algebraically. Describing the effect of slit width on the diffraction pattern. Determining the position of first interference minimum. Qualitatively describing single-slit diffraction patterns produced from white light and from a range of monochromatic light frequencies. Qualitatively describing two-slit interference patterns, including modulation by one-slit diffraction effect. Investigating Young's double-slit experimentally. Sketching and interpreting intensity graphs of double-slit interference patterns.

Solving problems involving the diffraction grating equation. Describing conditions necessary for constructive and destructive interference from thin films, including phase change at interface and effect of refractive index. Solving problems involving interference from thin films. Solving problems involving the Rayleigh criterion for light emitted by two sources diffracted at a single slit. Resolvance of diffraction gratings. Sketching and interpreting the Doppler effect when there is relative motion between source and observer. Describing situations where the Doppler effect can be utilized. Solving problems involving the change in frequency or wavelength observed due to the Doppler effect to determine the velocity of the source/observer. Representing sources of mass and charge, lines of electric and gravitational force, and field patterns using an appropriate symbolism. Mapping fields using potential. Describing the connection between equipotential surfaces and field lines. energy of a point charge. Solving problems involving potential energy. Determining the potential inside a charged sphere.

Solving problems involving the speed required for an object to go into orbit around a planet and for an object to escape the gravitational field of a planet. Solving problems involving orbital energy of charged particles in circular orbital motion and masses in circular orbital motion. Solving problems involving forces on charges and masses in radial and uniform fields. Describing the production of an induced emf by a changing magnetic flux and within a uniform magnetic field. Solving problems involving magnetic flux, magnetic flux linkage and Faraday's law. Explaining Lenz's law through the conservation of energy. Explaining the operation of a basic ac generator, including the effect of changing the generator frequency. Solving problems involving the average power in an ac circuit. Solving problems involving step-up and step-down transformers. Describing the use of transformers in ac electrical power distribution. Investigating a diode bridge rectification circuit experimentally. Qualitatively describing the effect of adding a capacitor to a diode bridge rectification circuit. Describing the effect of different dielectric materials on capacitance. Solving problems involving parallel-plate capacitors. Investigating combinations of capacitors in series or parallel circuits. Determining the energy stored in a charged capacitor. Describing the nature of the exponential discharge of a capacitor. Solving problems involving the discharge of a capacitor through a fixed resistor.

What does excellence look like?

- Be able to plot and interpret graphs of a simple pendulum and a mass-spring system undergoing simple harmonic motion.
- Experimentally collect data using a pendulum or mass spring system to determine displacement, velocity and acceleration
- Use trigonometric functions to describe and calculate changes in motion of oscillators
- Use or build computer simulations to investigate simple harmonic motion
- Explain how x-ray diffraction can be used in crystallography and materials science
- Use the diffraction equation to determine the position of the first minimum in a single slit interference pattern
- Be able to describe the approximate ratios of successive maxima in a single slit interference pattern
- Explain how the phenomenon of diffraction can be applied in practical contexts like CDs
- Observe diffraction patterns using spectroscopes, thin films e.g. soap and microwave gratings
- State and explain the conditions for constructive and destructive interference
- Explain how resolution is important in practical contexts like astronomy, satellite transmission and data storage
- Explain practical applications of the Doppler effect e.g. radar
- Describe gravitational and electric fields as examples of the inverse square law
- Explain the relationship between field lines and equipotentials
- Describe work done moving through fields and explain why no work is done moving along equipotentials
- Recognise that field lines are 2D representations of a 3D phenomenon
- Calculate the escape velocity from a planet considering conservation of energy
- Describe applications of electromagnetic induction like magnetic braking, seismology, transformers, geophones and metal detectors
- Use Lenz's law and Faraday's law to calculate induced EMF
- Explain the use and benefits of the National Grid
- Be able to construct a basic AC generator
- Be able use appropriate equations to calculate power transmission by ideal transformers and explain qualitatively how this differs from real life transformers
- Determine charge and discharge characteristics of different capacitors experimentally
- Measure the RC time constant of a circuit experimentally
- Can explain under what conditions a real gas behaves like an ideal gas
- Explain how the electron microscope and the tunnelling electron microscope rely on the findings from studies in quantum physicsMeasure Planck's constant using LEDs and a voltmeter
- Use probability in calculations for example the Uncertainty Principle
- Compare models of the atom
- Explain how knowledge of radioactivity, radioactive substances and the radioactive decay law are crucial in modern nuclear medicine
- Quantitatively describe relative motion between 2 objects from the frame of reference of each object
- Derive the Lorentz factor by considering the relative motion of a light clock travelling at relativistic speeds relative to an observer on the Earth
- Explain how relativity is used in practical applications like aviation and GPS satellites
- Explain how observations of muon decay give evidence for time dilation and length contraction
- Be able to sketch and interpret Minkowski diagrams
- Use Minkowski diagrams to calculate relative velocities
- Explain how the theory of relativity gives us the idea that nothing can exceed the speed of light
- Calculate the wavelengths of moving photons in pion decay
- Explain how general relativity might be used to explain the fate of the universe
- Explain how Newtonian physics is limited in is description of the details of planetary and celestial motion
- Be able to explain the equivalence principle in terms of a frame of reference in free fall or undergoing constant acceleration

"The important thing is not to stop questioning. Curiosity has its own reason for existence. One cannot help but be in awe when he contemplates the mysteries of eternity, of life, of the marvellous structure of reality. It is enough if one tries merely to comprehend a little of this mystery each day.

Albert Einstein

Knowledge, understanding & Skills

Topic 12 Quantum and Nuclear Physics, Option topic Relativity -

Demonstrate knowledge, understanding, and application of:-

Discussing the photoelectric effect experiment and explaining which features of the experiment cannot be explained by the classical wave theory of light. Solving photoelectric problems both graphically and algebraically. Discussing experimental evidence for matter waves, including an experiment in which the wave nature of electrons is evident. Stating order of magnitude estimates from the uncertainty principle. Describing a scattering experiment including location of minimum intensity for the diffracted particles based on their de Broglie wavelength. Explaining deviations from Rutherford scattering in high energy experiments. Describing experimental evidence for nuclear energy levels.

Solving problems involving the radioactive decay law for arbitrary time intervals. Explaining the methods for measuring short and long half-lives. Using the Galilean transformation equations. Determining whether a force on a charge or current is electric or magnetic in a given frame of reference. Determining the nature of the fields observed by different observers. Using the Lorentz transformations to describe how different measurements of space and time by two observers can be converted into the measurements observed in either frame of reference. Using the Lorentz transformation equations to determine the position and time coordinates of various events. Using the Lorentz transformation equations to show that if two events are simultaneous for one observer but happen at different points in space, then the events are not simultaneous for an observer in a different reference frame.

Solving problems involving velocity addition. Deriving the time dilation and length contraction equations using the Lorentz Equations. Solving problems involving time dilation and length contraction. Solving problems involving the muon decay experiment. Representing events on a spacetime diagram as points. Representing the positions of a moving particle on a spacetime diagram by a curve (the worldline). Representing more than one inertial reference frame on the same spacetime diagram. Determining the angle between a worldline for specific speed and the time axis on a spacetime diagram.

Solving problems on simultaneity and kinematics using spacetime diagrams. Representing time dilation and length contraction on spacetime diagrams. Describing the twin paradox. Resolving of the twin paradox through spacetime diagrams. Describing the laws of conservation of momentum and conservation of energy within special relativity. Determining the potential difference necessary to accelerate a particle to a given speed or energy.

Solving problems involving relativistic energy and momentum conservation in collisions and particle decays. Using the equivalence principle to deduce and explain light bending near massive objects. Using the equivalence principle to deduce and explain gravitational time dilation. Calculating gravitational frequency shifts. Describing an experiment in which gravitational redshift is observed and measured. Calculating the Schwarzschild radius of a black hole. Applying the formula for gravitational time dilation near the event horizon of a black hole.

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 tasks

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

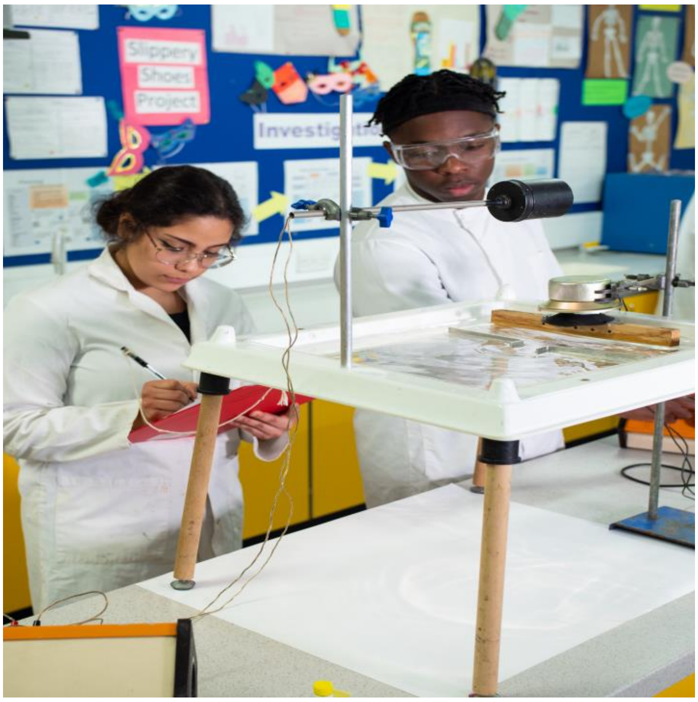
How will we assess impact?

- Peer and self-assessment
- Previous lesson recap quiz
- Check point tasks
- End of topic tests
- Teacher questioning
- Cumulative linear knowledge tests

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.