IBS 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.

"Everything is theoretically impossible, until it is done" **– Robert A. Heinlein**

Students will learn: - Term 1: -

Topic A - Space,Time and Motion

- A5 Galilean and Special Relativity

Topic D - Fields

- D1 Gravitational Fields
- D2 Electric Fields
- D4 Induction

Students will learn: - Term 2: -

Topic E - Nuclear and Quantum Physics

- E1 Structure of the Atom
- E3 Radioactive decay
- E2 Quantum Physics

What does excellence look like?

Students should understand:

- reference frames
- that Newton's laws of motion are the same in all inertial reference frames and this is known as Galilean relativity
- that in Galilean relativity the position x' and time t' of an event are given by $x' = x - vt$ and $t' = t$
- that Galilean transformation equations lead to the velocity addition equation as given by $u' = u - v$
- the two postulates of special relativity
- that the postulates of special relativity lead to the Lorentz transformation equations for the coordinates of an event in two inertial reference frames (see data book)
- that Lorentz transformation equations lead to the relativistic velocity addition equation
- that the space–time interval Δs between two events is an invariant quantity as given by $(\Delta s)^2 = (c\Delta t)^2 - (\Delta x)^2$
- proper time interval and proper length

Knowledge, understanding & Skills

An inertial reference frame is non-accelerating.
The derivation of the Lorentz transformation equations and the relativistic velocity addition equations are not required.
The derivation of the time dilation and length contraction equations is not required.
The time axis on space–time diagrams will be labelled ct.
The discussion of world lines of moving particles will be limited to constant velocity.
Time dilation, length contraction and simultaneity can be visualized using space–time diagrams.
The scales on the time axes ct and ct′ and on the space axes x and x′ of two inertial reference frames moving relative to one another are not the same and are defined by lines of constant space–time interval.

For calculations involving orbital motion the orbits will be assumed to be circular.
Newton's universal law of gravitation should be extended to spherical masses of uniform density by assuming that their mass is concentrated at their centre.
Determination of the resultant gravitational field strength will be restricted to points along a line joining two bodies.
Sketching and interpretation of gravitational field lines is required.
Gravitational potential is defined as being zero at infinity.
Problems may include, but are not limited to, determining the:
speed to maintain orbit
changes in energy when a satellite changes orbit
energetics of a satellite going into orbit
around a non-rotating planet starting from rest on its surface
energy conditions for an orbiting satellite to escape the gravitational influence of a planet.
Gravitational fields will include the radial fields around point or spherical masses and the (assumed) uniform field close to the surface of massive celestial bodies and planetary bodies.
The orbital motion of a satellite around a planet is restricted to a consideration of circular orbits.
An ability to map fields using potential is required.

What does excellence look like?

Students should understand:

- time dilation as given by $\Delta t = \gamma \Delta t_0$
- length contraction as given by $L = L_0\ \gamma$
- the relativity of simultaneity
- space–time diagrams
- that the angle between the world line of a moving particle and the time axis on a space–time diagram is related to the particle's speed
- that muon decay experiments provide experimental evidence for time dilation and length contraction.
- that the gravitational potential energy Ep of a system is the work done to assemble the system from infinite separation of the components of the system
- the gravitational potential energy for a two-body system where r is the r separation between the centre of mass of the two bodies
- that the gravitational potential Vg at a point is the work done per unit mass in bringing a mass from infinity to that point
- the work done in moving a mass m in a gravitational field as given by $W = m\Delta V_g$
- equipotential surfaces for gravitational fields
- the relationship between equipotential surfaces and gravitational field lines
- the escape speed v_{esc} at any point in a gravitational field
- the orbital speed $v_{orbital}$ of a body orbiting a large mass
- the gravitational field strength g as the gravitational potential gradient
- the qualitative effect of a small viscous drag force due to the atmosphere on the height and speed of an orbiting body.
- the electric potential energy E_p in terms of work done to assemble the system from infinite separation
- the electric potential energy for a system of two charged bodies
- that the electric potential is a scalar quantity with zero defined at infinity
- that the electric potential V_e at a point is the work done per unit charge to bring a test charge from infinity to that point
- the electric field strength E as the electric potential gradient as given by
- the work done in moving a charge q in an electric field as given by $W = q\Delta V_e$
- equipotential surfaces for electric fields
- the relationship between equipotential surfaces and electric field lines.
- magnetic flux Φ as given by $\Phi = BA \cos \theta$
- that a time-changing magnetic flux induces an emf ε as given by Faraday's law of induction
- that a uniform magnetic field induces an emf in a straight conductor moving perpendicularly to it as given by $\varepsilon = BvL$
- that the direction of induced emf is determined by Lenz's law and is a consequence of energy conservation
- that a uniform magnetic field induces a sinusoidal varying emf in a coil rotating within it
- the effect on induced emf caused by changing the frequency of rotation.
- the relationship between the radius and the nucleon number for a nucleus and implications for nuclear densities
- deviations from Rutherford scattering at high energies
  the distance of closest approach in head-on scattering experiments
- the discrete energy levels in the Bohr model for hydrogen
- that the existence of quantized energy and orbits arise from the quantization of angular momentum in the Bohr model for hydrogen.

Knowledge, understanding & Skills - cont

The radial field around single point charge
inside and outside a single spherical conducting body
The field between two point charges and two oppositely charged parallel plates, including edge effects.
Sketching and interpretation of electric field lines is required.
Magnetic field patterns will be restricted to a bar magnet, a current-carrying straight wire, a current- carrying circular coil and an air-core solenoid.
Sketching and interpretation of magnetic field lines is required.
The determination of the direction of the magnetic field based in the current direction in a current-carrying straight wire is required.
Work done in electric fields can be expressed in both joules and electronvolts.
A range of permittivity values for Coulomb's law are required.
Electric potential is defined as being zero at infinity.
No work is done in moving charge or mass on an equipotential surface.
Equipotential surfaces should be recognized:
for a point charge
for a collection of up to four point charges
inside and outside a solid charged conducting sphere
inside and outside a hollow charged conduction sphere
between two opposite charged parallel plates

Examples of production of an induced emf should include:
time-varying magnetic fields
coils rotating within a uniform magnetic field
relative motion between a conductor and a magnetic field (for example, a magnet oscillating on a spring above a conducting coil, or a coil moved in or out of the region of a magnetic field).
A quantitative treatment of induced emf will be restricted to straight conductors moving at right angles to magnetic fields and rectangular coils moving in and out of fields and rotating in fields.
Only a qualitative treatment of self-induction is required.
A discussion of inductance and resistance-inductor (RL) circuits is not required.
Recall of chemical symbols is not required.
Only a qualitative approach to the Geiger–Marsden–Rutherford experiment is required for standard level.
Rutherford's simple energy conservation considerations can be used to determine the distance of closest approach.
For scattering experiments, energy values will be low enough so as only to consider the particle being repelled by the electric force.
An interpretation of binding energy curves is required.
Nuclear masses will be expressed in kg, in $MeVc^{-2}$ and in (unified) atomic mass units u.
Real-life contexts for this topic should include the choice of isotope in medical use, leaks in underground pipes, thickness of materials, and radioactive dating based on the penetration of the decay particle and half-life.
The weak nuclear force is not considered in this course.
An application of the radioactive decay equations for arbitrary time intervals is required for additional higher level.
The determination of the half-life of a nuclide is required.

A discussion of which features of the photoelectric effect cannot be explained using the classical wave theory of light is required.
A description of a scattering experiment including the location of minimum intensity for the diffracted particles based on their de Broglie wavelength is required.
The derivation of the Compton formula is not required

What does excellence look like?

Students should understand:

- the evidence for the strong nuclear force
- the role of the ratio of neutrons to protons for the stability of nuclides
- the approximate constancy of binding energy curve above a nucleon number of 60
- that the spectrum of alpha and gamma radiations provides evidence for discrete nuclear energy levels
- the continuous spectrum of beta decay as evidence for the neutrino
- the decay constant λ and the radioactive decay law as given by $N = N_0e^{-\lambda t}$
- that the decay constant approximates the probability of decay in unit time only in the limit of sufficiently small λt
- the activity as the rate of decay as given by $A = \lambda N = \lambda N_0e^{-\lambda t}$
- the relationship between half-life and the decay constant
- the photoelectric effect as evidence of the particle nature of light
- that photons of a certain frequency, known as the threshold frequency, are required to release photoelectrons from the metal
- Einstein's explanation using the work function and the maximum kinetic energy of the photoelectrons as given by $E_{max} = hf - \Phi$ where Φ is the work function of the metal
- diffraction of particles as evidence of the wave nature of matter
- that matter exhibits wave–particle duality
- the de Broglie wavelength for particles
- Compton scattering of light by electrons as additional evidence of the particle nature of light
- that photons scatter off electrons with increased wavelength
- the shift in photon wavelength after scattering off an electron (Compton equation)

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 up.

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 paper

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.

"Time and space are finite in extent, but they don't have any boundary or edge. They would be like the surface of the earth, but with two more dimensions."
— **Stephen W. Hawking, Black Holes and Baby Universes and Other Essays**