Curriculum for Excellence
Higher Physics

Learning Outcomes

Particles and Waves

Key Area – The Standard Model

Orders of magnitude and the Standard Model of Fundamental Particles and Interactions

At the end of this topic candidates should be able to:

Understand the concept of atomic distances using correct powers of ten (10^{-10})			
Understand the concept of nuclear distances using correct powers of ten (10^{-15})			
Understand the concept of sub-nuclear distances using correct powers of ten (10^{-18})			
Understand the concept of the scale of our solar system using correct powers of ten (10^{11})			
Understand the concept of the scale of our galaxy using correct powers of ten (10^{21})			
Understand the concept of the scale of the observable Universe using correct powers of ten (10^{29})			
Give evidence for the existence of the following sub-nuclear particles (Fermions, the matter particles, consist of Quarks (6 types) and Leptons (Electron, Muon and Tau, together with their neutrinos). Hadrons are composite particles made of Quarks. Baryons are made of three Quarks and Mesons are made of two Quarks.)			
Describe the following sub-nuclear particles (Fermions, the matter particles, consist of Quarks (6 types) and Leptons (Electron, Muon and Tau, together with their neutrinos). Hadrons are composite particles made of Quarks. Baryons are made of three Quarks and Mesons are made of two Quarks.)			
Explain the evidence for the existence of antimatter.			
Describe the force mediating particles bosons (Photons, W and Z Bosons, and Gluons) in relation to the four fundamental forces (Gravity, electromagnetic, strong and weak forces.)			
Describe how beta decay was the first evidence for the neutrino.			

Key Area – Forces on Charged Particles

At the end of this topic candidates should be able to:

Draw the **radial** electric field diagrams for point charges on their own and diagrams for a combination of point charges.			
Draw the **uniform** electric field diagram that exists between parallel plates.			
Describe the motion of a charged particle introduced in a **radial** electric field.			
Describe the motion of a charged particle introduced in a **uniform** electric field.			
Understand that the volt is a measure of the electrical potential energy given to each coulomb of charge in a **uniform** electric field.			
Understand that there is **work done** by the electric field when moving a charge through the field.			
Understand that this work done by the field is converted into the kinetic energy **gained** by the charge.			
Calculate the speed of a charged particle accelerated in an electric field.			
Understand that a **moving** charge produces a magnetic field.			
To predict the direction of the force on a charged particle moving in a magnetic field.			
Understand that in a linear particle accelerator, charged particles are accelerated by alternating electric fields and can be used for collisions with fixed targets.			
Understand that in a cyclotron, charges are accelerated by an alternating electric field and a magnetic field at right angles is used to produce a circular motion.			
Understand that as the energy of a charge in a cyclotron increases a spiral motion of increasing radius is produced.			
Understand that in a synchrotron both alternating electric **and** magnetic fields are used to accelerate charges.			
Understand that magnetic fields are used to maintain a fixed radius circular motion.			
Understand that a synchrotron can be used for collisions between charges travelling in opposite directions.			

Key Area – Nuclear Reactions
Fission and fusion reactions

At the end of this topic candidates should be able to:

Use nuclear equations to describe radioactive decay. (α,β,γ); fission reactions; fusion reactions			
Explain fission reactions (induced and spontaneous) using the terms: high mass nuclei; neutrons; chain reaction; daughter products; binding energy; mass defect			
Explain fusion reactions using the terms: low mass nuclei; energy; mass defect			
Explain mass/energy equivalence ($E = mc^2$)			
Carry out calculations using $E = mc^2$			
Explain the issues surrounding coolant and containment methods in nuclear fusion reactors.			

Key Area – Wave Particle Duality

At the end of this topic candidates should be able to:

Describe the photoelectric effect and that it is evidence of particle behaviour of light.			
Understand that the minimum energy required to eject an electron from the surface of a metal is the Work Function of the metal.			
Understand that the minimum frequency of a photon that can eject an electron from the surface of a metal is called the Threshold Frequency.			
Understand how to determine the maximum kinetic energy of a photoelectron.			

Key Area – Interference and Diffraction

At the end of this topic candidates should be able to:

Describe the conditions necessary for waves to be coherent.			
Describe the phase conditions necessary for constructive and destructive interference.			
Explain in terms of path differences how maxima and minima are produced during the interference between 2 coherent waves.			
Describe an investigation between 2 coherent sources which leads to the relationship between wavelength, distance between sources, distance from the sources and the spacing between maxima or minima.			
Describe an experiment using multiple coherent light sources that shows the relationship, $d \sin\theta = n\lambda$			
Explain why white light separates into spectra on passing through a diffraction grating.			
Explain the differences in the spectral pattern produced by a prism compared to a diffraction grating.			

Key Area – Refraction
Refraction, critical angle and total internal reflection

At the end of this topic candidates should be able to:

Explain the refractive index of a medium as the ratio of the sine of angle of incidence in vacuum (air) to the sine of angle of refraction in the medium. (Refractive index of air treated as the same as that of a vacuum.)			
Carry out and describe investigations where light travels from a more dense to a less dense medium.			
Explain the refractive index as the ratio of speed of light in vacuum (air) to the speed in the medium.			
Explain the refractive index as the ratio of wavelength of light in vacuum (air) to the wavelength of light in the medium.			
Carry out calculations using the relationships above			
Explain the variation of refractive index with frequency.			
Carry out an investigation to • determine the critical angle of a semi-circular block • show total internal reflection			
Explain the terms “critical angle” and “total internal reflection”			
Carry out calculations using the relationship between critical angle refractive index.			

Key Area – Spectra

Irradiance and the inverse square law.

Line and continuous emission spectra, absorption spectra and energy level transitions.

At the end of this topic candidates should be able to

Explain the term Irradiance as power per unit area.			
Carry out calculations using the equation I = P/A			
Carry out an investigation into how irradiance varies with distance from a point light source and a laser			
Carry out calculations using the relationship $Id^2 = k$			
Describe the Bohr model of the atom using the terms: ionization level; energy levels; ground state; excited state; electrons;			
Explain how electrons can be excited to higher energy levels by an input of energy and ionisation level is the level at which an electron is free from the atom.			
Define • zero potential energy as equal to that of the ionisation level, implying that other energy levels have negative values. • the lowest energy level as the ground state.			
Explain spectra (line, continuous) in terms of photons being emitted when an electron moves from higher energy levels to lower energy levels.			
Explain absorption spectra in terms of photons being absorbed and electrons moving from lower energy levels to higher energy levels			
Explain the relationship between the frequency of photon emitted and the difference in energy levels.			
Carry out calculations using E = hf (h isPlanck‘s constant, the constant of proportionality)			
Describe how the absorption lines in the spectrum of sunlight as evidence of the composition of the Sun’s upper atmosphere.			