Curriculum for Excellence

Higher Physics

Success Guide

Electricity

Our Dynamic Universe

Particles and Waves

Electricity

Key Area – Monitoring and Measuring A.C.

Monitoring alternating current signals with an oscilloscope

Candidates should use their understanding of Physics to:

Use a multimeter to correctly measure current, voltage and resistance.			
Describe A.C. in terms of direction of current.			
Use an oscilloscope to measure the peak voltage of an A.C. supply and describe the waveform produced.			
Determine the frequency of an A.C. supply from an oscilloscope reading or a graph.			
Identify the peak voltage on an oscilloscope trace.			
Describe and determine the root mean square voltage and current of a supply.			

Key Area – Current, Potential Difference, Power and Resistance

Candidates should use their understanding of Physics to:

Use a wide variety of relationships involving potential difference, current, resistance and power to analyse circuits.			
Apply above relationships in complex calculations that require multiple steps to complete.			
Investigate circuits involving potential dividers that can be used for taking measurements and to set and control voltages.			
Perform calculations such as the output of a potential divider when a load is connect across the output.			
Apply their understanding of potential divider circuits to calculations that determine the potential difference and resistance across different components.			

Key Area – Electrical Sources and Internal Resistance

Candidates should use their understanding of Physics to:

Define the terms electromotive force (EMF), internal resistance and terminal potential difference.			
Analyse a circuit to determine the point at which the maximum power is transferred.			
Explain the phenomenon of internal resistance with reference to ‘ideal supplies’, ‘short circuits’, and ‘open circuits’.			
Determine internal resistance and electromotive force using graphical analysis.			

Key Area – Capacitors

Candidates should use their understanding of Physics to:

Describe the principles of a method to show the relationship between the charge on a capacitor and the potential difference across the capacitor.			
Explain the term 'capacitance' in terms of charge on the capacitor and the potential difference across it (this can be used to define the Farad).			
Apply the information gathered from a charge vs. potential difference graph to determine the total energy stored by a charged capacitor.			
Use the relationships between energy, charge, capacitance and potential difference (not to be confused with the work done by a charge moving in a field, W=QV).			
Analyse data gathered from investigations into capacitor charging and discharging to show the variation of current and potential difference against time.			
Describe the effect of resistance and capacitance on charging and discharging curves.			

Key Area – Conductors, Semiconductors and insulators

Candidates should use their understanding of Physics to:

Categorise solids into conductors, semiconductors or insulators by their ability to conduct electricity.			
Describe the conduction and valence bands in conductors, semiconductors and insulators.			
Describe the movement of charge carriers in conductors and semiconductors with reference to energy bands.			
Explain why there is no movement of charge carriers in insulators at room temperature with reference to energy bands.			
Explain the movement of charge carriers in a semiconductor with reference the energy of the electrons, including thermal energy.			

Key Area – p-n junctions

Candidates should use their understanding of Physics to:

Describe the process of manufacturing p-type and n-type semiconductors with reference to doping.			
Describe the electrical properties of a p-n junction with reference to majority charge carriers (potential barrier and depletion layer could be used at this level).			
Explain the production of an EMF when photons are incident on a suitable semiconductor junction (photovoltaic effect).			
Explain the production of photons when current is passed through a suitable p-n junction (LEDs).			

Our Dynamic Universe

Key Area – Motion (Equations and Graphs)

The laws that allow us to predict the motion of all objects in the universe.

Candidates should use their understanding of Physics to:

Define acceleration as the change in velocity per unit time.			
Describe the principles of the method for measuring acceleration using $v = u + at$. (two lights gates)			
Describe the principles of the method for measuring acceleration using $v^2 = u^2 + 2as$.			
Describe the principles of the method for measuring acceleration using $s = ut + ½at^2$. (g by free fall from rest using timer)			
Describe the link between an object's displacement-time graph, velocity-time graph and acceleration-time graph.			
Draw an acceleration-time graph using information obtained from a velocity-time graph for motion with a constant acceleration.			
Determine an object's displacement, velocity or acceleration using its motion-time graphs.			
Plot and Interpret the motion graphs for bouncing objects and objects thrown vertically.			
Use the terms "constant velocity" and "constant acceleration" to describe motion represented in graphical or tabular form.			
Carry out calculations using the equations of motion for objects moving with constant acceleration in a straight line.			

Key Area – Forces, Energy and Power

How objects in the universe get moving.

Candidates should use their understanding of Physics to:

Analyse the forces acting on an object in one plane – balanced and unbalanced forces including frictional forces.			
Define and explain terminal velocity.			
Analyse motion of an object using Newton's first and second laws.			
Analyse situations involving frictional force as a negative vector quantity.			
Analyse situations involving tension as a pulling force exerted by a string or cable on another object.			
Analyse the forces acting on a connected system of objects, for example a train with multiple carriages.			
Calculate the forces acting on an object moving vertically, for example in a lift.			
Interpret a velocity-time graph of a falling object when air resistance is taken into account, including the effect of changing			

the surface area of the falling object.			
Resolve a force into two perpendicular components.			
Identify and calculate forces acting at an angle to the direction of movement, and analyse the resultant motion.			
Resolve the weight of an object on a slope into a component acting down the slope and a component acting at 90° to the slope.			
Analysis of systems of balanced forces with forces acting in two dimensions.			
Use of the law of conservation of energy to identify and explain energy changes in familiar and unfamiliar situations			
Perform calculations, including conservation of energy, on work done, potential energy, kinetic energy and power.			

Key Area – Collisions and Explosions

What happens when mass interacts.

Candidates should use their understanding of Physics to:

Define momentum of an object as a vector quantity that is the product of mass and velocity of the object.			
Define the law of conservation of linear momentum as the total momentum before a collision equalling the total momentum after the collision in the absence of external forces.			
Apply the law of conservation of linear momentum in the following contexts: • Collisions in which the objects move in only one dimension • Explosions where the objects move in only one dimension			
Define an elastic collision as one in which both momentum and kinetic energy are conserved.			
Define an inelastic collision as one in which only momentum is conserved and kinetic energy is converted to other forms			
Explain the equivalence of conservation of linear momentum and Newton's Third Law.			
Define impulse acting on an object as a vector quantity that is the product of the force acting and time of interaction.			
Define impulse as the change in momentum of an object.			
Carry out calculations using impulse and change in momentum.			
Recognise that the force acting during an interaction may not be constant, and that a force-time graph represents the variation of force during an interaction.			
Explain the effects of changing the interaction time between objects on the force acting during the interaction.			
Determine impulse using the area under a force-time graph.			

Key Area – Gravitation

The force that shapes the universe.

Candidates should use their understanding of Physics to:

Resolve the initial velocity of a projectile into horizontal and vertical components.			
Analyse the motion of a projectile using the equations of motion (constant vertical acceleration, constant horizontal velocity).			
Describe projectiles as objects in free-fall with a constant horizontal velocity component.			
Explain the link between satellite motion and projectile motion.			
Understand the factors that affect the gravitational field strength of a planet, natural satellites			
Make qualitative comparisons between the gravitational field strength of planets, natural satellites and stars.			
Calculation of force exerted on a mass placed in a gravitational field (W = mg)			
Use Newton's Universal Law of Gravitation to calculate the gravitational force acting between two objects of known mass.			

Key Area – Special Relativity

A more in-depth look at moving objects.

Candidates should use their understanding of Physics to:

Describe the motion of an object in terms of an observer's frame of reference.			
State that the speed of light in a vacuum is the same for all observers in all reference frames.			
Explain how the constancy of the speed of light led Einstein to derive his theory of Special Relativity.			
Perform calculations with speed of an object, dilated and proper time given an appropriate relationship			
Perform calculations with length of an object, dilated and proper length given an appropriate relationship			
Explain that relativistic effects are only observed when objects are moving with velocities close to the speed of light.			

Key Area – The Expanding Universe

A model of our universe.

Candidates should use their understanding of Physics to:

Describe the Doppler Effect in terms of the changing frequencies of sound and light for moving objects.			
Use the Doppler Effect equation for calculations involving the sound emitted by moving objects.			
Understand that light from distant galaxies is red-shifted because they are moving away from the Earth.			
Carry out calculations involving the red-shift and the recession velocity of a distant galaxy.			
State that the Doppler Effect equations used for sound cannot be used with light from fast moving galaxies because relativistic effects need to be taken into account.			
State that, for slow-moving galaxies, redshift is the ratio of the velocity of the galaxy to the velocity of light.			

Key Area – The Expanding Universe

A model of our universe.

Candidates should use their understanding of Physics to:

Explain Hubble's Law as the relationship between the recession velocity of a galaxy and its distance from the observer.			
Use Hubble's Law in calculations involving recession velocity and distance from observer.			
Understand how Hubble's Law can be used to estimate the age of the universe.			

Key Area – Expansion of the Universe

A model of our universe.

Candidates should use their understanding of Physics to:

Describe evidence for the expansion of the universe based on the velocities of galaxies and their distance from us.			
Describe a way of determining the mass of our galaxy using measurements of the orbital speed of the Sun and other stars			
Define the term 'dark matter'- mass which cannot currently be detected.			
Explain the evidence for dark matter in terms of measurements of the mass of our galaxy and others.			
Define the term 'dark energy'- something that overcomes the force of gravity			
Explain the evidence for dark energy in terms of measurements of the expansion rate of the Universe.			

Key Area – Big Bang Theory

The Big Bang Theory is a current model for the origin of our universe.

Candidates should use their understanding of Physics to:

Explain that the temperature of a stellar object is related to the distribution of wavelengths of emitted radiation.			
Describe that the peak wavelength emitted is related to the temperature of the object – the greater the temperature, the shorter the wavelength.			
Understand the qualitative relationship between the temperature of a star and the irradiance – the greater the temperature, the greater the irradiance.			
Understand what is meant by the cosmic microwave background radiation .			
Provide evidence to justify the model of the Big Bang for the beginning and evolution of the universe such as the peak wavelength of cosmic microwave background radiation, abundance of light elements the darkness of the sky (Olber's paradox)			

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 and intergalactic distances using orders of magnitude (powers of ten).			
Describe the standard model of sub atomic particles with reference to the following: Fermions, Quarks, (up, down, strange, charm, bottom, and top) Baryons, Mesons, Hadrons, Leptons, Electrons, Positrons, Muons, Taus and Neutrinos.			
Give evidence for the existence of particles in the standard model.			
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 into a radial electric field.			
Describe the motion of a charged particle introduced into 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.			
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.			
Describe the operation of particle accelerators such as a cyclotron. For example, 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.			
Describe the operation of particle accelerators such as a synchrotron where both alternating electric **and** magnetic fields are used to accelerate charges.			
Understand that magnetic fields are used to maintain a fixed radius circular motion in particle accelerators.			
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 α,β & γ radioactive decay.			
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.			
Determine the maximum kinetic energy of a photoelectron, given photon frequency and work function.			

Key Area – Interference and Diffraction

Candidates should use their understanding of Physics 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 patterns produced by a prism and 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.)			
Describe the principles of an investigation where light travels from a more dense to a less dense medium.			
Explain the refractive index as the ratio of the speed of light in vacuum (air) to the speed in the medium.			
Explain the refractive index as the ratio of the wavelength of light in vacuum (air) to the wavelength of light in the medium.			
Carry out calculations using the relationships above.			
Describe 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:

Define Irradiance as power per unit area.			
Carry out calculations using the equation I = P/A.			
Describe the principles of an investigation into the variation of irradiance with distance from a point light source .Comparison with a laser light source may be considered as an alternative or addition.			
Carry out calculations using the relationship $Id^2 = k$.			
Explain how electrons can be excited to higher energy levels by an input of energy and that 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 line and continuous emission spectra 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.			
Describe the Bohr model of the atom using the terms: ionization level; energy levels; ground state; excited state and electrons, based on observations from line spectra.			
Describe how absorption lines in the spectrum of sunlight give evidence of the composition of the Sun’s upper atmosphere.			