National Course Specification: course details

Higher Physics: Particles and Waves

The left hand column below details the waves content in which students should develop knowledge and understanding. The middle column contains notes, which give further details of the content.
The right-hand column gives suggested contexts in which knowledge and understanding and skills can be developed.

Content	Notes	Contexts
1. The Standard Model		
a) Orders of magnitude.	The range of orders of magnitude of length from the very small (sub-nuclear) to the very large (distance to furthest known celestial objects).	The scale of our macro world compared to astronomical and sub-nuclear scales.
b) The Standard Model of Fundamental Particles and Interactions.	The evidence for the sub-nuclear particles and the existence of antimatter. Fermions, the matter particles, consist of Quarks (6 types) and Leptons (Electron, Muon and Tau, together with their neutrinos). The force mediating particles are bosons (Photons, W and Z Bosons, and Gluons). Description of beta decay as the first evidence for the neutrino.	Combinations of quarks forming hadrons. Gravity, electromagnetic, strong and weak forces. LHC at CERN. PET scanner.
2. Forces on charged particles		
a) Electric fields around charged particles and between parallel plates.	Examples of electric field patterns include single point charges, systems of two point charges and the field between parallel plates. No calculation of electric field strength required.	Hazards, e.g. lightning, static electricity on microchips.
b) Movement of charge in an electric field, p.d. and work, electrical energy.	The relationship between potential difference, work and charge gives the definition of the volt. Calculating the speed of a charged particle accelerated in an electric field.	Precipitators. Xerography. Paint spraying. Ink jet printing. Electrostatic propulsion.
c) Charged particles in a magnetic field.	A moving charge produces a magnetic field. The direction of the force on a charged particle moving in a magnetic field should be described for negative and positive charges (right hand rule for negative charges). No calculations required.	

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d) Particle accelerators.	Basic operation of particle accelerators in terms of acceleration, deflection and collision of charged particles.	Accelerators include linear accelerator, cyclotron and synchroton. Medical applications of cyclotron. Accelerators used to probe structure of matter.
3. Nuclear Reactions		
a) Fission and fusion.	Nuclear equations to describe radioactive decay and fission and fusion reactions. Mass and energy equivalence, including calculations. Coolant and containment issues in nuclear fusion reactors.	Energy available from chemical and nuclear sources. Magnetic containment of plasma. Joint European Torus (JET) ITER tokamak
4. Wave Particle Duality		
a) The photoelectric effect and wave particle duality.	Photoelectric effect as evidence for the particulate nature of light. Photons of sufficient energy can eject electrons from the surface of materials. The threshold frequency is the minimum frequency of a photon required for photoemission. The work function is the minimum energy required to cause photoemission. The maximum kinetic energy of photoelectrons can be determined.	Light meters in cameras, channel plate image intensifiers, photomultipliers.
5. Interference and diffraction		
a) Conditions for constructive and destructive interference. b) Interference of waves using two coherent sources.	Coherent waves have a constant phase relationship and have the same frequency, wavelength and velocity. Constructive and destructive interference in terms of phase between two waves. Maxima and minima are produced when the path difference between waves is a whole number of wavelengths or an odd number of half wavelengths repectively. Investigations which lead to the relationship between the wavelength, distance between the sources, distance from the sources and the spacing between maxima or minima.	Interference patterns with microwaves, radio waves, sound, light and electrons. Holography. Industrial imaging of surfaces-curvature and stress analysis. Lens blooming. Interference colours (jewellery, petrol films, soap bubbles).

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c) Diffraction grating using light.	Monochromatic light can be used with a diffraction grating to investigate the relationship between the grating spacing, wavelength and angle to the maxima. A white light source may be used with a grating to produce dispersion. Compare the dispersion produced by gratings and prisms.	Interferometers to measure small changes in path difference. Use a spectroscope/ spectrometer/spectrophotometer to examine spectra from a number of light sources.
6. Refraction of light		
a) Refraction. b) Critical angle and total internal reflection.	Refractive index of a material as the ratio of the sine of angle of incidence in vacuum (air) to the sine of angle of refraction in the material. Refractive index of air treated as the same as that of a vacuum. Investigations should include situations where light travels from a more dense to a less dense substance. Refractive index as the ratio of speed of light in vacuum (air) to the speed in the material. Also as the ratio of the wavelengths. Variation of refractive index with frequency. Investigating total internal reflection, including critical angle and its relationship with refractive index.	Optical instruments using lenses. Dispersion of high power laser beams due to hot centre with lower refractive index. Design of lenses, dispersion of signals in optical fibres, colours seen in cut diamonds. Semicircular blocks. Reflective road signs, prism reflectors (binoculars, periscopes, SLR cameras). Optical fibres for communications, medicine and sensors.
7. Spectra		
a) Irradiance and the inverse square law.	Investigating irradiance as a function of distance from a point light source. Irradiance as power per unit area.	Galactic distances and Hubble's Law. Application to other e-m radiation (e.g. gamma radiation) Comparing the irradiance from a point light source with a laser.

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b) Line and continuous emission spectra, absorption spectra and energy level transitions.	The Bohr model of the atom. Electrons can be excited to higher energy levels by an input of energy. Ionisation level is the level at which an electron is free from the atom. Zero potential energy is defined as equal to that of the ionisation level, implying that other energy levels have negative values. The lowest energy level is the ground state. A photon is emitted when an electron moves to a lower energy level and its frequency depends on the difference in energy levels. Planck's constant is the constant of proportionality. Absorption lines in the spectrum of sunlight as evidence for the composition of the Sun's upper atmosphere.	Line and continuous spectra, eg from tungsten filament lamp, electric heater element, fluorescent tube, burning a salt in a Bunsen flame. Discharge lighting, laboratory and extraterrestrial spectroscopy, the standard of time. Lasers.