Higher Physics

Particles and Waves

Study Guide

At the end of section **2.1 Forces on Charged Particles** you should be able to :

❑ 1 state that, in an electric field, a charge experiences a force.

❑ 2 state that electric fields exist around charged particles and between charged parallel plates.

❑ 3 sketch electric field patterns for single-point charges and systems of two-point charges.

❑ 4 sketch electric field patterns between two charged parallel plates.

❑ 5 identify the direction of free electric charges in an electric field.

❑ 6 state that an electric field applied to a conductor causes the free electric charges in it to move.

❑ 7 state that work is done when a charge is moved in an electric field.

❑ 8 state that the potential difference (V) between two points in an electric field is a measure of the work done (W) in moving one coulomb of charge (Q) between the two points.

❑ 9 state that if one joule of work is done moving one coulomb of charge between two points, the potential difference between the two points is one volt.

❑ 10 carry out calculations involving the relationship between potential difference, work and charge.

$$W = QV$$

❑ 11 use the conservation of energy principle to calculate the speed of a charged particle in an electric field.

$$QV = \frac{1}{2}mv^2$$

❑ 12 understand that a moving charge produces a magnetic field.

❑ 13 determine the direction of the force on a charged particle moving in a magnetic field.

❑ 14 state the three types of particle accelerator.

❑ 15 state that high energy collisions of charged particles produce other particles.

❑ 16 describe the basic operation of three different types of particle accelerator in terms of acceleration, deflection and collision of charged particles.

Higher Physics

Particles and Waves

Study Guide

At the end of section **2.2 The Standard Model** you should be able to :

- ❑ 1 define the standard model as a model of fundamental particles and interactions.
- ❑ 2 state that the range of orders of magnitude studied in Physics range from the very small to the very large.
- ❑ 3 place objects in order in relation to their relative size.
- ❑ 4 state that fundamental particles are not composed of any other particles.
- ❑ 5 state that all particles are either Fermions or Bosons.
- ❑ 6 name the three generations of Quark pairs.
- ❑ 7 explain that evidence for the existence of quarks comes from high energy collisions between electrons and nucleons.
- ❑ 8 name the three generations of Lepton pairs.
- ❑ 9 describe beta decay as the first evidence for the neutrino.
- ❑ 10 state that Fermions are the matter particles and consist of quarks and leptons.
- ❑ 11 state that hadrons are composite particles made of quarks.
- ❑ 12 state that Baryons are made from three Quarks.
- ❑ 13 state that Mesons are made from two Quarks, one Quark and an anti-Quark.
- ❑ 14 give some examples of sub atomic particles.
- ❑ 15 explain that every particle has an antiparticle and that the production of energy in the annihilation of particles is evidence for the existence of antimatter.
- ❑ 16 state that antimatter is a particle which has the same mass as their equivalent particle but opposite charge.
- ❑ 17 state that bosons are the force mediating particles.
- ❑ 18 state that the Strong and Weak Forces only act over short distances relative to the size of an atom.
- ❑ 19 state that the force mediating particle for the Strong Force is the Gluon.

- ❑ 20 state that the force mediating particles for the Weak Force are the W- and Z- boson.
- ❑ 21 state that the Electromagnetic Force is responsible for all electrical and magnetic phenomena.
- ❑ 22 state that the force mediating particle for the Electromagnetic Force is the Photon.
- ❑ 23 state that the Gravitational Force is responsible for the large scale structure of the Universe.
- ❑ 24 state that the force mediating particle for the Gravitational Force is the Graviton.

Higher Physics

Particles and Waves

Study Guide

At the end of section **2. 3 Nuclear Reactions** you should be able to :

❑ 1 describe how Rutherford showed that:
a) the nucleus has a relatively small diameter compared with that of the atom
b) most of the mass of the atom is concentrated in the nucleus.

❑ 2 state what is meant by alpha, beta and gamma decay of radionuclides.

❑ 3 identify the processes occurring in nuclear reactions written in symbolic form.

❑ 4 state that in fission a nucleus of large mass number splits into two nuclei of smaller mass numbers, usually with the release of neutrons.

❑ 5 state that fission may be spontaneous or induced by neutron bombardment.

❑ 6 state that in fusion two nuclei combine to form a nucleus of larger mass number.

❑ 7 explain, using $E = mc^2$, how the products of fission and fusion acquire large amounts of kinetic energy.

❑ 8 carry out calculations involving the relationship between energy (E) and mass (m) loss for fission and fusion reactions.

$$E = mc^2$$

❑ 9 state that nuclear fusion reactors require charges at a very high temperature (plasma).

❑ 10 state that magnetic fields are used to contain charged particles in nuclear fusion reactors.

❑ 11 state that in a fusion reactor the coolant must be ***contained*** so that it doesn't vaporise and cool the reaction down.

❑ 12 state that in a fusion reactor the coolant must be ***confined*** to ensure that more energy is given out than is absorbed.

Higher Physics
Particles and Waves
Study Guide

At the end of section **2. 4 Inverse Square Law** you should be able to :

- ❑ 1 state that the irradiance at a surface on which radiation is incident is the power per unit area.

- ❑ 2 carry out calculations involving irradiance, the power of radiation incident on a surface and the area of the surface.

$$I = \frac{P}{A}$$

- ❑ 3 describe the principles of a method for showing that the irradiance is inversely proportional to the square of the distance from a point source.

- ❑ 4 carry out calculations involving the relationship between irradiance and distance.

$$I_1 d_1^2 = I_2 d_2^2$$

- ❑ 5 explain that if N photons per second are incident per unit area on a surface, the irradiance at the surface is given by I = Nhf.

Higher Physics
Particles and Waves
Study Guide

At the end of section **2. 5 Wave Particle Duality** you should be able to :

- ❑ 1 state that the photoelectric effect is evidence for the particle model of light.

- ❑ 2 state that photoelectric emission from a surface occurs only if the frequency of the incident radiation (f) is greater than some threshold frequency (f_o) which depends on the nature of the surface.

- ❑ 3 state that for frequencies smaller than the threshold value, an increase in the irradiance of the radiation at the surface will not cause photoelectric emission.

- ❑ 4 state that for frequencies greater than the threshold value, the photoelectric current produced by monochromatic radiation is directly proportional to the irradiance of the radiation at the surface.

- ❑ 5 state that a beam of radiation can be regarded as a stream of individual energy bundles called photons, each having an energy (E) dependent on the frequency of the radiation (f).

- ❑ 6 carry out calculations involving the relationship between the energy (E), Planck's constant (h) and the frequency of photons (f).

$$E = hf$$

- ❑ 7 state that photoelectrons are ejected with a maximum kinetic energy which is given by the difference between the energy of the incident photon and the work function of the surface.

- ❑ 8 carry out calculations involving the maximum kinetic energy (E_k), the threshold frequency of the material (f_o) and the frequency of the photons (f).

$$E_k = hf - hf_o$$

Higher Physics

Particles and Waves

Study Guide

At the end of section **2.6 Interference and Diffraction** you should be able to :

- ❑ 1 state that interference is the test for a wave.
- ❑ 2 use correctly in context the terms: 'in phase', 'out of phase' and 'coherent', when applied to waves.
- ❑ 3 explain the meaning of: 'constructive interference' and 'destructive` interference', in terms of superposition of waves.
- ❑ 4 state that reflection, refraction, diffraction and interference are characteristic behaviours of all types of waves.
- ❑ 5 state the conditions for maxima and minima in an interference pattern formed by two coherent sources in the form:

$$\boldsymbol{Path\ difference} = \boldsymbol{m\lambda} \text{ for maxima, and}$$

$$\boldsymbol{Path\ difference} = \left(\boldsymbol{m} + \tfrac{1}{2}\right)\lambda \text{ for minima, where m is an integer.}$$

- ❑ 6 carry out calculations using the relationships for maxima and minima in an interference pattern formed by two coherent sources.
- ❑ 7 carry out calculations involving the grating spacing, wavelength, order number and the angle to the maximum.

$$\boldsymbol{m\lambda = \mathrm{d}\sin\theta}$$

- ❑ 8 describe the effect of grating on a monochromatic light beam.
- ❑ 9 carry out calculations involving the relationship between wavelength, order, slit separation and angle for gratings.
- ❑ 10 describe the principles of a method for measuring the wavelength of a monochromatic light source, using a grating.
- ❑ 11 state approximate values for the wavelengths of red, green and blue light.
- ❑ 12 describe and compare the white light spectra produced by: a grating and a prism.

Higher Physics

Particles and Waves

Study Guide

At the end of section **2.7 Spectra** you should be able to :

- ❑ 1 state that electrons in a free atom occupy discrete energy levels (the Bohr model of the atom).
- ❑ 2 draw a diagram which represents qualitatively the energy levels of a hydrogen atom.
- ❑ 3 use the following terms correctly in context: ground state, excited state, ionisation level.
- ❑ 4 state that an emission line in a spectrum occurs when an electron makes a transition between an excited energy level and a lower level.
- ❑ 5 state that an absorption line in a spectrum occurs when an electron in a lower energy level absorbs radiation and is excited to a higher energy level.
- ❑ 6 carry out calculations involving energy level transitions, photon energy and photon frequency.

$$E_2 - E_1 = hf$$

- ❑ 7 explain the occurrence of absorption lines (Fraunhofer lines) in the spectrum of sunlight.

Higher Physics
Particles and Waves
Study Guide

At the end of section **2. 8 Refraction of Light** you should be able to :

- ❑ 1 state that the ratio $\frac{sin\theta_1}{sin\theta_2}$ is a constant when light passes obliquely from medium 1 to medium 2.
- ❑ 2 state that the refractive index of air is treated the same as that of a vacuum.
- ❑ 3 state that the absolute ***refractive index, n***, of a medium is the ratio $\frac{sin\theta_1}{sin\theta_2}$ where θ_1 is in a vacuum (or air as an approximation) and θ_2 is in the medium.
- ❑ 4 describe an experiment to determine the refractive index of a medium.
- ❑ 5 state that when light enters an optically more dense medium the speed decreases, the wavelength decreases but the ***frequency*** remains ***unchanged***.
- ❑ 6 state that the refractive index is the ratio of the speed of light in a vacuum (air) to the speed of light in the material. It is also the ratio of the wavelengths.
- ❑ 7 state that the refractive index depends on the frequency of the incident light.
- ❑ 8 carry out calculations involving the relationships between refractive index, angle, wavelength, speed and frequency.

$$\frac{sin\theta_1}{sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$$

- ❑ 9 explain what is meant by total internal reflection.
- ❑ 10 explain what is meant by critical angle θ_C.
- ❑ 11 describe the principles of a method for measuring a critical angle.
- ❑ 12 derive the relationship between critical angle and absolute refractive index of a medium.
- ❑ 13 carry out calculations involving the relationship between critical angle and absolute refractive index of a medium.

$$sin\theta_c = \frac{1}{n}$$

Higher Physics

Particles and Waves

Study Guide