

Airdrie Academy Physics Department

*Particles*  
*and*  
*Waves*  
*Study Guide*



## The Standard Model

- 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 standard model of fundamental particles and interactions.
- 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).
- Hadrons are composite particles made of quarks. Baryons are made of three quarks and mesons are made of two quarks.
- The force mediating particles are bosons (photons, W and Z bosons, and gluons).
- Description of beta decay as the first evidence for the neutrino.

## Forces on charged particles

- Fields exist around charged particles and between charged parallel plates.
- Examples of electric field patterns for single point charges, systems of two point charges and between parallel plates.
- Movement of charged particles in an electric field.
- The relationship between potential difference, work and charge gives the definition of the volt.
- Calculation of the speed of a charged particle accelerated by an electric field.
- A moving charge produces a magnetic field.
- The determination of the direction of the force on a charged particle moving in a magnetic field for negative and positive charges (right hand rule for negative charges).
- Basic operation of particle accelerators in terms of acceleration, deflection and collision of charged particles.

## Nuclear reactions

- Nuclear equations to describe radioactive decay, fission and fusion reactions with reference to mass and energy equivalence, including calculations.
- Coolant and containment issues in nuclear fusion reactors.

## 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 of the material is the minimum energy required to cause photoemission.
- Determination of the maximum kinetic energy of photoelectrons.

## Interference and Diffraction

- Conditions for constructive and destructive interference.
- 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.
- Interference of waves using two coherent sources.
- Maxima and minima are produced when the path difference between waves is a whole number of wavelengths or an odd number of half wavelengths respectively.
- The relationship between the wavelength, distance between the sources, distance from the sources and the spacing between maxima or minima.
- The relationship between the grating spacing, wavelength and angle to the maxima.

## Refraction of light

- Absolute refractive index of a material is 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.
- Situations where light travels from a more dense to a less dense substance.
- Refractive index can also be found from the ratio of speed of light in vacuum (air) to the speed in the material and the ratio of the wavelengths.
- Variation of refractive index with frequency.
- Critical angle and total internal reflection.

## Spectra

- Irradiance and the inverse square law.
- Irradiance is power per unit area.
- The relationship between irradiance and distance from a point light source.
- Line and continuous emission spectra, absorption spectra and energy level transitions.
- The Bohr model of the atom.
- Movement of electrons between energy levels.
- The terms ground state, energy levels, ionisation and zero potential energy for the Bohr model of the atom.
- Emission of photons due to movement of electrons between energy levels and dependence of photon frequency on energy difference between levels.
- The relationship between photon energy, Planck's constant and photon frequency.
- Absorption lines in the spectrum of sunlight provides evidence for the composition of the Sun's upper atmosphere.