Definitions and Concepts for OCR (B) Physics A-level

Module 6: Field and Particle Physics

6.1: Fields

6.1.1: Electromagnetism

Dynamo: A device that converts mechanical power into electrical power with a direct current.

Eddy Currents: Small closed loops of current within a conductor or magnet. In a transformer these currents act against the magnetic flux that generates a current in the secondary coil, making the transformer less efficient and heating the core.

Electrical Conductance: The inverse of resistance. A measure of how well an object conducts electricity.

Electromagnetic Induction: When a current carrying conductor moves relative to a magnetic field an EMF is induced in the conductor.

Faraday's Law: The magnitude of an induced EMF is directly proportional to the rate of change of magnetic flux linkage.

Flux Lines: Magnetic fields are represented by lines of magnetic flux.

Ideal Transformer: A hypothetical transformer where no power is lost through using it. It is 100% efficient.

Induced E.M.F: The voltage produced if the magnetic flux through a coil is changed.

Induced Pole: A pole that only exists due to other poles, currents or movement.

Lenz's Law: The direction of an induced current is such that it opposes the change that created it.

Magnetic Field: Also known as B-field (when through a vacuum/air). A region of space in which magnetic materials and moving electric charges feel a force.

Magnetic Flux: A measure of the total magnetic field passing through a given area. Given by the product of the magnetic flux density and the area. Can be visualized as the net number of flux lines passing a given area.

Magnetic Flux Density: The force per unit current per unit length on a current-carrying wire placed at 90º to the field lines. Can also be seen as the amount of magnetic flux per unit area on a plane perpendicular to the flux's direction.

Magnetic Flux Linkage: The magnetic flux of a coil found by the product of the magnetic flux and number of turns of a coil.

Permeance: A magnetic equivalent to electrical conductance, can be seen as dependent on the dimensions and nature of the magnetic medium.

Transformer: A device used to increase or decrease voltage by using two sets of coils with different numbers of turns wrapped around a magnetic core. The transformer is step-up if the number of turns on the secondary coil is greater than the number on the primary coil (voltage increases). The transformer is step-down if the number of turns on the secondary coil is fewer than the number on the primary coil (voltage decreases).

Uniform Field: A field in which all of the field lines are parallel and equally spaced – field strength is equal in all areas of the field.

6.1.2: Charge and Field

Electric Field: A region surrounding a charged object which causes a force to be exerted on any charged object placed within the field.

Electric Potential Energy: Energy due to an object with charge being positioned within an electric field. Equal to the work done on a given charge in bringing it from infinity to that point in the field for a point charge. The electric field has to be produced by at least another charged object- the EPE is proportional to the product of the two charges and inversely proportional to their separation.

Electric Potential: The work done per unit charge on a positive test charge in bringing it from infinity to that point in the field. Expressed by:

$$V = k\frac{q}{r}$$

Electrical Charge: A property of matter which causes things to feel a force when placed in an electric field. Charge is current times time but you can think of -1 C as a discrete number, $1/(1.6 \times 10^{-19})$, of electrons.

Electronvolt: The kinetic energy gained by one electron that is accelerated through a potential difference of 1 volt. Equal to 1.6×10^{-16} J.

Equipotential Surface: A surface of constant potential. No work is done by the field when an object moves along an equipotential.

Inverse Square Law: Followed by all point sources that spread their influence in all directions equally and infinitely. By considering the consequence of an expanding sphere of influence, the strength of the source for a given area is inversely proportional to the square of the distance

away from that source.

Point Charge: A model of an object with charge. A spherically symmetrical charged conductor is equivalent to a point charge at its centre.

Radial Field: A field in which the field lines are all directed towards a single point (e.g. the centre of a planet or a point charge).

Uniform Field: A field in which all of the field lines are parallel and equally spaced – field strength is equal in all areas of the field.

6.2: Fundamental Particles

6.2.1: Probing Deep into Matter

Antiparticle: Every particle has a corresponding antiparticle with the same mass but opposite quantum numbers and charges.

Cosmic Rays: High-energy nuclei that travel at relativistic speeds through space.

Electron: A stable negatively charged subatomic particle with a relative charge of -1 and a negligible mass (relative mass of 1/2000).

Energy Level: The discrete values of energy a given particle or system is able to take on.

Gluon: The exchange particle for the strong nuclear force in quark interactions.

Hadron: A type of particle that includes those made up of two or more quarks held together by the strong force (mesons and baryons only).

Lepton: A type of particle that doesn't undergo strong interactions. Examples are electrons, muons and neutrinos.

Lepton Number: Lepton number is conserved in all interactions. Electrons, muons, taus, and all neutrinos each have a lepton number of -1, and their antiparticles each have a laptop number of +1.

Line Spectrum: A spectrum containing isolated lines that show the emission or absorption of discrete frequencies or energies. Its plural is "line spectra".

Neutrino: A subatomic particle that has no charge and a negligible mass. There are three known types: the electron neutrino, the muon neutrino and the tau neutrino.

Neutron: A neutral subatomic particle with no charge and a relative mass of 1.

Nuclear Equation: An equation to show the reactants and products in nuclear fission and

fusion, and radioactive decay. All balanced nuclear equations conserve mass/energy, charge, and lepton number at least.

Nuclear Model: A model of the atom where there is a positively charged nucleus at the centre of the atom consisting of neutrons and protons which makes up almost all of the atom's mass, most of the atom is empty space, and electrons are distributed outside of the nucleus.

Nucleon: A term to refer to the particles that make up the nucleus: protons and neutrons.

Nucleus: The dense positively charged core at the centre of the atom consisting of only protons and neutrons making up almost all of the atom's mass.

Particle Accelerator: A machine that propels particles to very high speeds/energies. Used to produce high-energy beams for scattering.

Positron: The antiparticle of the electron.

Proton: A stable positively charged subatomic particle with a relative charge of +1 and a relative mass of 1.

Quantum Behaviour: Quanta have a certain probability of arrival at any given point. Quantum behaviour models a ray of light as taking every possible path between where it's emitted and detected. The probability is obtained by combining amplitude and phase for all possible paths.

Quark: Fundamental particle that interacts with other quarks via the strong interaction, it will change flavour via the weak interaction and annihilate with antiquarks to form photons via the electromagnetic interaction. They come in 6 flavours: up, down, charm, strange, top, bottom. A proton has a quark composition of up up down (uud), and a neutron has one of up down down (udd).

Relativistic Mechanics: Mechanics that are only accurate/compatible with the theory of relativity.

Relativistic Factor: Also known as the 'Lorentz Factor'. The factor by which time, length, and relativistic mass changes for objects moving at relative velocities.

Relativistic Speeds: Speeds nearing the speed of light.

Scattering: When particles change direction of motion due to (indirect, or direct) collisions. A lot of nuclear and atomic physics knowledge has been gained from observing scattering experiments.

Stationary/Standing Wave: A wave that stores energy instead of transferring it. They are formed by a propagating wave being reflected back on itself causing two waves of the same wavelength and similar amplitude travelling in opposite directions. They superpose and form a stationary/standing wave.

6.2.2: Ionising Radiation and Risk

Absorbed Dose: How much ionising radiation (energy) a mass has absorbed. Usually measured in grays as energy per unit mass.

Activity: The number of nuclei that decay per second for a given radioactive source, measured in Becquerels (Bq).

Alpha Particle/α-particle: Equivalent to a helium-4 nucleus: a particle consisting of 2 protons and 2 neutrons.

Atomic Mass Unit (amu): The unit of mass that relative mass is based upon. Equal to one twelfth of an atom of carbon-12.

Beta Particle/β-particle: A high energy and speed electron (β^-) or positron (β^+).

Binding Energy: Also known as 'separation energy'. The minimum total energy required to split a nucleus or system of particles into its individual constituents.

Chain Reaction: When the fission of one nuclei produces neutrons that cause fission in another nuclei.

Decay Constant, λ: The probability of a nucleus decaying per unit time.

Effective Dose: For the whole body, the total effect of radiation, taking into account both absorbed dose and organ sensitivity. Usually measured in sieverts.

Gamma Ray/γ-ray: Electromagnetic radiation emitted during the radioactive decay of a nucleus. It is the shortest wavelength category for EM radiation and has the highest photon energy.

Half-life, $T_{1/2}$: The time taken for half of the radioactive nuclei in a given sample to decay.

Ionising Radiation: Radiation with enough energy as to be able to remove electrons from atoms to form ions.

Ionising Power: How ionising a given type of radiation is.

Isotope: A form of an element with the same number of protons but different numbers of neutrons.

Nuclear Fission: The splitting of a large nucleus to produce smaller nuclei, fast moving neutrons and energy.

Nuclear Fusion: The fusing of two smaller nuclei to form a single nuclei while producing a large quantity of energy. Very high temperatures and pressures are needed as well as high magnetic fields to contain the fusing plasma.

Nuclear Power: Power generated by fission or fusion in nuclear reactors.

'Nuclear Valley': The qualitative variation of binding energy as proton and neutron number varies.

Nucleon Number: Number of protons and neutrons.

Penetrating Power: How far a given type of radiation can travel in a substance- dependent on ionising power. High ionising power = low penetrating power.

Proton Number: Also known as 'atomic number'. Number of protons only.

Quality Factor (*Q* Factor): Also known as 'radiation weighting factor'. It is a relative measure of risk of radiation for different organs. It is the factor that the absorbed dose is multiplied by to calculate the effective dose.

Risk: The possibility of harm to be caused.