Higher Physics
Particles and Waves
Key Definitions

Word/Term	Definition
Electrical Charge	A physical property of matter measured in coulombs (C). Charge can be either positive or negative.
Electric Field	A region of space around a charge where another charge will experience a force.
Work Done	A type of energy measured in joules (J). For a charged particle moving in the opposite direction to a uniform electric field, it is equal to the change in electrical potential energy. For a charged particle moving in the same direction as a uniform electric field, it is equal to the change in kinetic energy.
Voltage	The energy given to each coulomb of charge that passes through a power supply.
Volt	If **one joule** of work is done in moving **one coulomb** of charge between two points in an electric field, the potential difference (p.d.) between the two points is **one volt**. 1 volt = 1 joule per coulomb
Magnetic Pole	There are two magnetic poles: north and south.
Magnetic Field	A region of space around a magnet where another magnet will experience a force.
Left Hand Grip Rule	Used to determine the direction of the magnetic field around a current-carrying conductor (wire).
Fleming's Right Hand Rule	Used to find the direction of the force on a charge moving in a magnetic field.
Particle Accelerator	Used to accelerate charged particles, such as electrons or protons, to very high energies and speeds. They play a role in the study of matter and fundamental particles.
Particle Detector	Placed around the collision point to record and reveal the particles that emerge from the collision.

Word/Term	Definition
Cathode Ray Tube	Electrons are produced by a heated cathode and accelerate between the plates of the anode. The electron beam is deflected by the magnetic field produced by the deflection coils, and a tiny flash of light is produced when the electrons strike a phosphorescent screen.
Linear Accelerator (LINAC)	Consists of hollow metal tubes placed in a vacuum. Charged particles are accelerated across the gaps between the tubes. They do not accelerate within the tubes.
Cyclotron	Consists of two D-shaped, hollow metal structures (‘dees’), placed in a vacuum. Between the two metal ‘dees’, charged particles are accelerated due to the electric field produced by a large potential difference that is applied to the ‘dees’. The particles do not accelerate when inside the ‘dees’. In the ‘dees’, the path of the charged particles is changed by a magnetic field.
Synchrotron	A linear accelerator that is bent into a ring so that the charged particles gain energy and therefore speed each time they go round. Electromagnets keep the particles travelling in a circular path and the beam pulses are synchronised.
Large Hadron Collider	The world’s largest scientific instrument. Consists of a series of particle accelerators used to collide two beams of sub-atomic particles at very high energies. Special detectors are then used to analyse the particles created in the collision.
Order of Magnitude	Powers of 10 used to describe and compare the sizes of objects that are either very large or very small.
Standard Model	A model used for classifying (sorting) fundamental particles and their interactions.
Fundamental Particle	A particle that is not made up from any other particles; it is in its simplest form. Also known as a matter particle or fermion.
Antimatter Particle	Every fundamental matter particle has a corresponding antimatter particle. They have the same mass but opposite charge to their corresponding matter particle. Also known as an antiparticle.
Lepton	A type of fundamental particle. There are six leptons: the electron, muon and tau, each paired with an associated neutrino (electron neutrino, muon neutrino and tau neutrino).

Word/Term	Definition
Neutrino	First discovered in radioactive beta decay experiments. A type of matter particle with zero charge and essentially zero mass.
Beta Decay	A type of radioactive decay in which a beta particle (electron) is emitted from the nucleus of an atom. A neutron decays to give a proton, electron and anti-neutrino.
Quark	A type of fundamental matter particle. There are six types of quark: up, down, charm, strange, top and bottom. Each quark has its own charge, expressed as a fraction of the magnitude of charge on an electron (either +2/3e or –1/3e). They never exist alone but combine to form hadrons.
Antiquark	Since quarks are fundamental particles, they have their own antiparticles called antiquarks. They have the same magnitude of charge as the quark but with opposite sign.
Composite Particle	A particle that is made up of other particles; it is not a fundamental particle.
Hadron	A composite particle that is made up of quarks. There are two types of hadrons: baryons and mesons.
Baryon	A type of hadron that consists of 3 quarks (e.g. a proton or neutron). They are stable particles. Protons are made up of two up quarks and a down quark. Neutrons are made up of two down quarks and an up quark.
Meson	A type of hadron that consists of 2 quarks in a quark-antiquark pair (e.g. a pion). They are unstable and have a short lifetime.
Fundamental Forces	There are four fundamental forces of nature - the strong nuclear force, weak nuclear force, electromagnetic force and gravitational force.
Force Mediating Particle	Each force has an associated force mediating particle (also known as a force carrier). They are bosons (not fermions).
Strong Nuclear Force	A short range force responsible for holding protons and neutrons together in the nucleus. Its force carrier is the **gluon**.

Word/Term	Definition
Weak Nuclear Force	A short range force responsible for radioactive beta decay. Its force carriers are the **W and Z bosons**.
Electromagnetic Force	An infinite range force responsible for holding electrons in their orbit around the nucleus. Its force carrier is the **photon**.
Gravitational Force	An infinite range force responsible for holding matter together in planets, stars and galaxies. Its force carrier is the **graviton**, though this is a hypothetical particle.
Higgs Boson	A type of boson associated with a 'Higgs field' which is thought to permeate all of space and therefore give other particles which exist in that field a mass. It explains why some fundamental particles have mass.
Atom	The basic units of matter, made up of positively charged protons, negatively charged electrons and neutral neutrons. It is overall neutral.
Radioactive Decay	When unstable nuclei emit nuclear radiation in the form of an alpha particle, beta particle or gamma ray in an attempt to become more stable.
Isotope	Atoms of the same element with different numbers of neutrons in the nucleus.
Mass Number (A)	Used alongside atomic number to identify a particular isotope. Gives the total number of **protons and neutrons** in the nucleus.
Atomic Number (Z)	Used alongside mass number to identify a particular isotope. Gives the number of **protons** in the nucleus.
Alpha Radiation	An alpha particle consists of 2 protons and 2 neutrons. It is the same as a helium nucleus. It has a relatively large mass and short range in air (3-5 cm). It is positively charged and is absorbed by a single sheet of paper.
Beta Radiation	A beta particle is a fast moving electron. It has a relatively small mass and longer range in air (15 cm). It is negatively charged and is absorbed by 2-3 mm of aluminium.
Gamma Radiation	A gamma ray is a high energy electromagnetic wave. It has no mass and a very long range in air (hundreds of metres). It has no charge and is absorbed by 2-3 cm of lead.

Word/Term	Definition
Nuclear Equation	Used with isotope symbols to describe radioactive decays. In all nuclear equations, both mass number and atomic number are conserved.
Parent Nucleus	The original nucleus before a reaction takes place.
Daughter Nucleus	The product produced in a nuclear reaction.
Alpha Decay	When an alpha particle is emitted from the nucleus of an atom. For an original parent nucleus undergoing alpha decay, its: • mass number (A) will decrease by 4 • atomic number (Z) will decrease by 2
Beta Decay	When a neutron decays into a proton and electron (and anti-neutrino). The electron is fired out of the nucleus as a beta particle, whilst the proton remains within the nucleus. For an original parent nucleus undergoing beta decay, its: • mass number (A) will remain unchanged • atomic number (Z) will increase by 1
Gamma Decay	When a high-energy electromagnetic wave is emitted from the nucleus of an atom in an attempt for it to become more stable. For an original parent nucleus undergoing gamma decay, its: • mass number (A) will remain unchanged • atomic number (Z) will remain unchanged
Lost Mass	Describes the mass difference which arises due to sum of the masses of the particles produced by a reaction being slightly less than the sum of the masses of the particles before the reaction.
Einstein's Mass-Energy Equivalence Principle	According to this principle, lost mass can be turned into energy, but energy can also be turned into mass.
Nuclear Fission	The process in which an unstable, heavy atomic nucleus splits into two or more lighter nuclei (called fission fragments), with energy being released.
Spontaneous Fission	A type of nuclear fission that occurs when the nucleus randomly decays.
Induced Fission	A type of nuclear fission that occurs when the nucleus is bombarded by a neutron, causing it to split.
Chain Reaction	When a nucleus undergoes induced fission, the released neutrons can go on to hit other nuclei, causing further fission reactions, and the cycle repeats. The process may be controlled (nuclear power) or uncontrolled (nuclear weapons).

Word/Term	Definition
Nuclear Fission Reactor	In nuclear power stations, nuclear fission is used to produce heat energy within nuclear fission reactors. This is used to turn water into steam, which drives turbines to generate electricity.
Moderator	Used in nuclear fission reactors to slow down the fast moving neutrons released in fission reactions.
Nuclear Fusion	The process of small nuclei joining together to form a larger nucleus, with energy being released.
Nuclear Fusion Reactor	Where nuclear fusion is used to produce energy. Special conditions of high temperatures and pressures are required to create the plasma in which the fusion reactions can take place.
Plasma	A state of matter in which nuclear fusion reactions can take place.
Plasma Containment	The use of powerful magnetic fields to prevent the high-temperature plasma from physically touching and therefore melting any parts of the reactor.
Irradiance	The power per unit area of electromagnetic radiation incident on a surface.
Point Source	A small, compact source that emits radiation uniformly in all directions. E.g. we can assume that a small bulb is a point source.
Inverse Square Law	Irradiance is directly proportional to the inverse of the distance squared for a point source of light.
Light	An electromagnetic wave that travels at 3×10^{8} ms^{-1}. It reflects, refracts and diffracts.
Wave-Particle Duality	The idea that light can act both like a wave and like a particle without contradiction.
Photoelectric Effect	Provides evidence for the particle nature of light. Photoelectrons are ejected from the surface of a metal when photons of light with sufficient energy are incident on the surface. For photoemission to occur: • the energy of the photons must be greater than the work function of the metal • the frequency of the photons must be greater than the threshold frequency.
Photoelectron	An electron emitted from the surface of a material due to a photon incident on the material.

Word/Term	Definition
Photoemission	The emission of photoelectrons from the surface of a material in the photoelectric effect.
Photon	A particle of light that can also be thought of as a short burst of wave energy.
Electroscope	Consists of a metal plate, metal rod and gold leaf. The deflection of the gold leaf can be used to investigate the photoelectric effect.
Threshold Frequency	The minimum frequency of a photon required to cause the emission of photoelectrons from a metal surface.
Work Function	The minimum energy of a photon required to cause the emission of photoelectrons from a metal surface.
Photoelectric Current	The number of photoelectrons emitted each second from the surface of a material.
Irradiance	The power per unit area of electromagnetic radiation incident on a surface. It can be associated with the intensity or brightness of the incident light.
Interference	Provides evidence for the wave nature of light.
Interference Pattern	Observed when coherent waves overlap.
Coherence	When two or more waves have the same frequency, wavelength and speed. Waves produced from the same source are likely to be coherent. Waves are said to be coherent if they have a **constant phase difference**.
Phase	Describes how ‘in tune’ two waves are when overlapping. Two waves are **completely in phase** when the crest of one matches up with the crest of the other. Two waves are **completely out of phase** when the crest of one matches up with the trough of the other.
Constructive Interference	When two waves of equal amplitude meet **in phase**, they combine to form a wave of **twice the amplitude**.
Destructive Interference	When two waves of equal amplitude meet **out of phase**, they combine to form a wave of **zero amplitude**.
Monochromatic Light	Light of a single frequency (or wavelength).
Interference Fringes	A series of bright and dark bands corresponding to regions of constructive and destructive interference respectively.
Path Difference	The difference in distance travelled by waves from different coherent sources.

Word/Term	Definition
Maximum/Maxima	A point/points of constructive interference.
Minimum/Minima	A point/points of destructive interference.
Order Number (m)	An integer (whole number) value which describes the point on the interference pattern (screen) you are dealing with.
Grating	Consists of many equally spaced slits placed very close together. Light diffracts through each slit. Lets much more light through compared to a double slit, so the fringes produced are **brighter** and **sharper**.
Fringe Spacing	The distance between adjacent fringes of the same type (i.e. bright or dark) in an interference pattern. It can be **increased** by **increasing the wavelength** or **decreasing the slit separation**.
Angular Breadth	The difference in angles of deviation of red light and violet light.
Bohr Model of the Atom	A model of the atom which describes the arrangement of electrons within it. It proposes that electrons are in circular orbits around the nucleus which correspond to energy levels. The electrons can only occupy discrete energy levels; the ground state or an excited state.
Energy Level Diagram	A diagram used to study the movement of electrons between energy levels in the atom.
Ground State	The lowest energy orbit. It is the orbit closest to the nucleus of an atom.
Excited State	An energy level above the ground state. Electrons can move into an excited state when they gain energy.
Electron Transition	The movement of an electron from one energy level to another.
Photon Emission	Occurs when an electron drops from a higher energy level to a lower energy level. Only photons with energies exactly matched to the difference between two energy levels can be emitted.
Photon Absorption	An electron will move to a higher energy level when it absorbs the energy of a photon. Only photons with energies exactly matched to the difference between two energy levels can be absorbed.

Word/Term	Definition
Emission Spectrum	The range of colours emitted by a light source. Consists of two types: continuous and line spectra.
Spectroscope/ Spectrometer	An instrument which spreads light out into its wavelengths, creating a spectrum. Used to view spectra produced by various sources.
Continuous Spectrum	Produced when white light is passed through a grating or prism. All frequencies of radiation (colours) are present (ROY G. BIV).
Line Spectrum	Produced by light from a star or an electrical discharge lamp containing vapour of elements such as sodium or mercury. Consist of bright lines which are produced by electrons making transitions from a higher energy level to a lower energy level. The **number of lines** in the spectrum corresponds to the number of possible transitions.
Absorption Spectrum	Produced when light with a continuous spectrum (e.g. sunlight) passes through a low-pressure gas. They appear as black lines on a continuous spectrum.
Fraunhofer Lines	Absorption lines in the spectrum of sunlight. They provide evidence for the composition of the Sun's outer atmosphere.
Refraction	The change in speed of light as it passes from one medium (material) to another (e.g. from air to glass).
Density	Describes how closely packed the particles in a material are, i.e. how much of its mass fits into a certain volume.
Normal	A dashed line that is drawn perpendicular (at 90˚) to any surface.
Angle of Incidence (i)	The angle measured between the incident ray and the normal.
Angle of Refraction (r)	The angle measured between the refracted ray and the normal.
Absolute Refractive Index	A number greater than or equal to 1 which indicates a material's ability to refract light. It is also the ratio of the speed of light in a vacuum to the speed of light in the medium.
Critical Angle	The angle of incidence which produces an angle of refraction of 90˚.
Total Internal Reflection	Occurs at angles of incidence above the critical angle, when all the light is reflected inside the denser medium. No light escapes.