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**Knowledge Rich Curriculum Plan**

Science – Physics

Year 12



| **Science****Year 12 Physics**  | **Unit: Particle Physics** |  |  |
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| **Lesson/Learning Sequence**  | **Intended Knowledge:***Students will know that…* | **Tiered Vocabulary**  | **Prior Knowledge:***In order to know this students, need to already know that…* |
| **Lesson:** **Constituents of the Atom** | * Students will know that atomic mass unit is defined as a mass equal to one twelfth the mass of an atom of carbon-12
* Students will know that protons and neutrons have a mass of 1 amu
* Students will know that specific charge is calculated using the equation:

specific charge = charge ÷ mass* Students will know that specific charge has the unit coulomb per kg
* Students will know that proton number has the symbol Z, and nucleon number has the symbol A
* Students will know that protons and neutrons are nucleons
* Students will know how to calculate specific charge
* Students will know how to determine the mass and charge of subatomic particles and ions using data from the data booklet
* Students will know how to use AZ notation to represent atoms
 | Atomic mass unit: mass equal to one twelfth the mass of an atom of carbon-12 | * ***Students need to already know that the simple model of an atom has a nucleus (containing protons and neutrons) and electrons orbiting the nucleus. Students need to also already know that protons have a relative charge of +1, neutrons have no charge and electrons have a relative charge of -1***
* ***Students need to already know that isotopes are atoms that contain the same number of protons but different number of neutrons***
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| **Lesson:** **Stable and Unstable Nuclei** | * Students will know that within the nucleus there is strong nuclear force, which is a force that helps to keep the nucleus stable
* Students will know that the strong nuclear force is attractive up to 3 fm, and repulsive below 0.5 fm
* Students will know that unstable nuclei undergo alpha and beta decay
* Students will know that during alpha decay a nucleus loses 2 protons and 2 neutrons, resulting in the nucleon number decreasing by 4 and the atomic number decreasing by 2
* Students will know how to write equations representing alpha decay
* Students will know that during Beta minus decay a neutron turns into a proton, an electron and an anti-electron neutrino
* Students will know how to write equations representing beta minus decay
 |  | * ***Students need to already know that repulsive forces would exist between protons***
* ***Students need to already know that unstable nuclei undergo decay***
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| **Lesson:** **Particles, antiparticles and photons** | * Students will know that for every type of particle there is a corresponding antiparticle
* Students will know that an antiparticle has the same mass and opposite charge to its corresponding particle
* Students will know the following examples of antiparticles:

-positron (antiparticle to an electron)-antiproton (antiparticle to a proton)-antineutron (antiparticle to a neutron)-antineutrino (antiparticle to a neutrino)* Students will know that photons are packets of electromagnetic waves.
* Students will know that the energy carried by a photon is given by the equations:

E = hf or E = hc/lambda* Students will know that when a particle and its antiparticle meet they annihilate each other.
* Students will know that during annihilation mass is converted into energy, the particle and antiparticle are transformed into two photons of energy
* Students will know that mass and energy interchangeable, as stated in the equation E = mc(squared)
* Students will know that during pair production energy is converted into mass.
* Students will know that during pair production a single photon of energy is converted into a particle-antiparticle pair.
* Students will know how to calculate energy involved in interactions using the equations stated above
* Students will know how to determine if pair production can take place from a single photon
* Students will know how to determine the wavelength or frequency of a photon that is released during annihilation
 | Antiparticle: a particle that has the same mass and opposite charge to its corresponding particle | * ***Students need to already know that the particles proton, electron, neutron and neutrino exist.***
* ***Students need to already know how to convert between eV and Joules***
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| **Lesson:** **Hadrons** | * Students will know that hadrons are not fundamental particles, as they are made from smaller particles
* Students will know that there are two categories of Hadrons; Baryons and Mesons
* Students will know that Baryons are made from three quarks (they will find more out about this next lesson)
* Students will know that Antibaryons are made from three antiquarks
* Students will know that the only stable Hadron is the proton, all other Hadrons eventually decay into a proton
* Students will know that Mesons are made from a quark and an antiquark
 | Fundamental particle: a particle that is not made form smaller particles | * ***Students need to already know that the nucleons are protons and neutrons***
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| **Lesson:****Quarks** | * Students will know that quarks are fundamental particles.
* Students will know that fundamental particles are particles that aren't made of anything smaller
* Students will know that there are three quarks (up, u, down, d, and strange, s) all which have their own antiquark
* Students will know that quarks have 3 properties; charge, baryon number and strangeness. These properties are detailed in the data booklet
* Students will know how to determine the quark composition of baryons, antibaryons and mesons
* Students will know that the quark composition of a neutron is dud
* Students will know that the quark composition of a proton is duu
* Students will know that when a neutron decays to a proton, a d quark turns into an u quark
* Students will know how to determine changes in quark composition during particle interactions
 | Quark: a fundamental particle that makes up hadrons | * ***Students need to already know that baryons are made of 3 quarks, antibaryons are made of 3 antiquarks and mesons are made of 2 quarks***
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| **Lesson:** **Leptons** | * Students will know that Leptons are fundamental particles
* Students will know that fundamental particles are particles that aren't made of anything smaller
* Students will know that leptons are much lighter than Baryons and Mesons
* Students will know that Leptons don't feel the strong nuclear interaction
* Students will know that electrons, muons and tauons are examples of charged Leptons
* Students will know that electrons, muons and tauons have their own corresponding neutrino.
* Students will know that neutrinos are charge less, almost massless particles.
* Students will know that Leptons have a Lepton number of +1, whilst Antileptons have a Lepton number of -1
 | Lepton: a type of fundamental particle | * ***Students need to already know that fundamental particles are particles that can't be made any smaller***
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| **Lesson:** **Particle Interactions** | * Students will know that there are four fundamental interactions: gravity, electromagnetic, weak nuclear, strong nuclear
* Students will know that exchange particles are used to explain force interactions between particles
* Students will know that electromagnetic forces and gravitational forces have unlimited range
* Students will know that the relative strength of the interactions are ordered, from strongest to weakest, as: Strong nuclear, electromagnetic, weak nuclear, gravitational
* Students will know that strong nuclear force acts between nucleons (hadrons), and the exchange particles are Gluons (between quarks) and Pions (between baryons)
* Students will know that the electromagnetic force acts between charged particles, and has the exchange particle Virtual Photon
* Students will know that the weak nuclear forces acts between all particles, and the exchange particles are W+, W- and Z
* Students will know that gravitational forces act between particles with masses, and the exchange particle is the Graviton
 | Exchange particle (boson): particles that are used to explain force interactions between particles. They conserve energy and charge  | * ***Students need to already know that strong nuclear forces act between nucleons***
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| **Lesson:** **Conservation Laws** | * Students will know that for particle interactions to occur the following conservation laws must be obeyed:

Charge - must be conservedBaryon number - must be conservedLepton number - must be conservedStrangeness - conserved in electromagnetic and strong interactions. Doesn't have to be conserved in Weak interaction* Students will know that during beta plus decay an up quark turns into a down quark
* Students will know that during beta minus decay a down quark turns into an up quark
* Students will know how to apply conservation laws to determine whether a particle interaction will take place
 |  | * ***Students need to already know that baryons have a baryon number of 1***
* ***Students need to already know that leptons have a lepton number of 1***
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| **Lesson:** **The Weak Interaction** | * Students will know that beta decay is an example of weak interaction
* Students will know that beta minus decay occurs in a neutron rich nuclei.
* Students will know that beta minus decay sees a neutron decay into a proton, electron and an anti electron neutrino
* Students will know that charge, Baryon number and Lepton number are conserved during this interaction
* Students will know that beta plus decay occurs in proton rich nuclei
* Students will know that during beta plus decay a proton decays into a neutron, positron and an electron neutrino
* Students will know that Baryon number, Lepton number and charge are all conserved during beta plus decay
* Students will know how to apply the conservation laws to weak interaction
 |  | * ***Students need to already know that during interactions Baryon number, Lepton number and charge need to be conserved***
* ***Students need to already know that during weak interactions strangeness doesn't have to be conserved***
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| **Lesson:** **The Strong Interaction** | * Students will know that strong nuclear force acts alongside electromagnetic force within the nucleus
* Students will know that the combination of electromagnetic force and strong nuclear force results in their being repulsive forces less than 0.7 fm, attractive forces up to 2 fm and then repulsive forces above 2 fm
* Students will know that larger nuclei tend to include more neutrons to help counteract the repulsive electromagnetic forces between the protons.
 |  | * ***Students need to already know that strong nuclear force takes place between hadrons and quarks***
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| **Lesson:** **Particle Diagrams** | * Students will know that Feynman diagrams are used to represent particle interactions
* Students will know that the arrows in Feynman diagrams tell us which particles are present before and after the interaction
* Students will know that the exchange particle is represented using a wavy arrow
* Students will know that the type of particle can't change either side of the diagram
* Students will know how to draw Feynman diagrams to represent different particle interactions
 |  | * ***Students need to already know that in particle interactions Baryon number and Lepton number must be conserved***
* ***Students need to already know that strong nuclear force acts between nucleons (hadrons), and the exchange particles are Gluons (between quarks) and Pions (between baryons)***
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