YEAR 2022-2023 First TERM

'An ambitious curriculum that meets the needs of all'

Medium Term Planning - Topic: Particle Physics

Curriculum Intent

In addition to working further on objectives from Year 12 Physics, pupils will be taught, following National Curriculum guidelines, the following this term:

3.2.1.3 Particles, antiparticles and photons

Content	Opportunities for skills development
For every type of particle, there is a corresponding antiparticle. Comparison of particle and antiparticle masses, charge and rest energy in MeV. Students should know that the positron, antiproton, antineutron and antineutrino are the antiparticles of the electron, proton, neutron and neutrino respectively. Photon model of electromagnetic radiation, the Planck constant. $E = hf = \frac{hc}{\lambda}$ Knowledge of annihilation and pair production and the energies involved. The use of $E = mc^2$ is not required in calculations.	**AT i** Detection of gamma radiation. **MS 1.1, 2.2** Students could determine the frequency and wavelength of the two gamma photons produced when a 'slow' electron and a 'slow' positron annihilate each other. The PET scanner could be used as an application of annihilation.

3.2.1.4 Particle interactions

Content	Opportunities for skills development
Four fundamental interactions: gravity, electromagnetic, weak nuclear, strong nuclear. (The strong nuclear force may be referred to as the strong interaction.) The concept of exchange particles to explain forces between elementary particles. Knowledge of the gluon, Z^0 and graviton will not be tested. The electromagnetic force; virtual photons as the exchange particle. The weak interaction limited to β^- and β^+ decay, electron capture and electron–proton collisions; W^+ and W^- as the exchange particles. Simple diagrams to represent the above reactions or interactions in terms of incoming and outgoing particles and exchange particles.	**PS 1.2** Momentum transfer of a heavy ball thrown from one person to another.

Skills/Assessment Objective Links

3.2.1.5 Classification of particles

Content	Opportunities for skills development
Hadrons are subject to the strong interaction. The two classes of hadrons: • baryons (proton, neutron) and antibaryons (antiproton and antineutron) • mesons (pion, kaon). Baryon number as a quantum number. Conservation of baryon number. The proton is the only stable baryon into which other baryons eventually decay. The pion as the exchange particle of the strong nuclear force. The kaon as a particle that can decay into pions. Leptons: electron, muon, neutrino (electron and muon types only) and their antiparticles. Lepton number as a quantum number; conservation of lepton number for muon leptons and for electron leptons. The muon as a particle that decays into an electron. Strange particles Strange particles as particles that are produced through the strong interaction and decay through the weak interaction (eg kaons). Strangeness (symbol s) as a quantum number to reflect the fact that strange particles are always created in pairs. Conservation of strangeness in strong interactions.	**AT k** Use of computer simulations of particle collisions. **ATI** Cosmic ray showers as a source of high energy particles including pions and kaons; observation of stray tracks in a cloud chamber; use of two Geiger counters to detect a cosmic ray shower.

3.2.1.6 Quarks and antiquarks

Content	Opportunities for skills development
Properties of quarks and antiquarks: charge, baryon number and strangeness. Combinations of quarks and antiquarks required for baryons (proton and neutron only), antibaryons (antiproton and antineutron only) and mesons (pion and kaon only). Only knowledge of up (u), down (d) and strange (s) quarks and their antiquarks will be tested. The decay of the neutron should be known.	

3.2.1.7 Applications of conservation laws

Content	Opportunities for skills development
Change of quark character in β^- and in β^+ decay. Application of the conservation laws for charge, baryon number, lepton number and strangeness to particle interactions. The necessary data will be provided in questions for particles outside those specified. Students should recognise that energy and momentum are conserved in interactions.	

3.2.1.1 Constituents of the atom

Content	Opportunities for skills development
Simple model of the atom, including the proton, neutron and electron. Charge and mass of the proton, neutron and electron in SI units and relative units. The atomic mass unit (amu) is included in the A-level Nuclear physics section. Specific charge of the proton and the electron, and of nuclei and ions. Proton number Z, nucleon number A, nuclide notation. Students should be familiar with the ${}^{A}_{Z}X$ notation. Meaning of isotopes and the use of isotopic data.	

3.2.1.2 Stable and unstable nuclei

Content	Opportunities for skills development
The strong nuclear force; its role in keeping the nucleus stable; short-range attraction up to approximately 3 fm, very-short range repulsion closer than approximately 0.5 fm. Unstable nuclei; alpha and beta decay. Equations for alpha decay, β^- decay including the need for the neutrino. The existence of the neutrino was hypothesised to account for conservation of energy in beta decay.	**AT i** Demonstration of the range of alpha particles using a cloud chamber, spark counter or Geiger counter. **MS 0.2** Use of prefixes for small and large distance measurements.

Spiritual, moral, social, and cultural development

SMSC: Listening to each other and valuing each person's contributions in discussions, working together in lessons to problem solve and achieve a shared goal. Learning about different scientists and learning how their understanding of the world evolved.
PSHE/British Values: Working together in practical and problem-solving work. The practical work in this section requires two people to work together to take the measurements whilst holding the equipment in place.
Skills Builder: development of practical skills through the numerous practical activities.

Numeracy

Constant numerical development in every lesson. Measuring skills, graph skills, problem solving. Exam questions build on topics with mechanics components frequently brought in.

Literacy

Vocabulary Tier 2: energy, mass, annihilation, conversion, energy levels,
Vocabulary Tier 3: positron, muon, neutrino, antineutrino, hadron, lepton, strong nuclear force, quarks, pair production.
Reading: Reading of the booklet and questions. Students need to be able to read the methods for practical lessons and ensure they complete them in the right order, using the right equipment.
Writing: Students are exposed to a number of questions, both numerical and short and long written answers. Students need to be able to write in a concise way whilst using the key words.
Oracy: Class discussions are incredibly important in physics where students regularly participate in class discussion to discuss abstract concepts. Students need to be able to express their understanding of concepts and theories.

Becoming future ready

Careers/Employability: The students learn about particle physicists which is also followed up with a trip to CERN.

Adaptation

QFT/SEND Provision

Throughout this topic, quality first teaching will provide differentiation:
By product: different learners are asked different questions, different level of detailed responses are expected and the level of scaffolding for the problem solving questions are varied.
By resource: All booklets are the same, however, extra scaffolding and extension may be provided from the new Kerboodle resources.
By Intervention: by providing different levels of supervision and support
By Progressive Questioning: exploring pupils' understanding through interactive dialogue.
By Grouping: according to prior attainment, gender, social preference, preferred learning style.
By Task: Pupils should be involved in the identification of targets which are meaningful to them and in the selection of an appropriate task from the given range.

	By Offering Optional Activities: In class or as homework, to extend learning. This QFT/SEND provision will be explicit within the lesson-by-lesson schemes of work.
Implementation Curriculum Delivery **Learning Outcomes (Knowledge)**	• To be able to: ***Lesson Objectives*** 1. To know about the Plum Pudding Model & Rutherford Model 2. To understand and explain the SNF 3. To explain the properties of the atom. 1. To know the masses and charges of protons, neutron and electrons. 2. To know the definition of an ion and isotope. 3. To know how to calculate specific charge. 1. To know and explain the four fundamental forces. 2. To understand alpha and beta decay. 3. To know why the beta particles have a range of energies. 4. To know about particles and antiparticles. 5. To introduce the eV. 1. To know the conversion from eV and MeV to J. 2. To know that the photon is a packet of wave energy. 3. To know and calculate pair production. 4. To know and calculate annihilation. 1. To apply the knowledge of pair production and annihilation to calculations. 2. To define exchange particles. 3. To draw Feynman diagrams for beta decay. 1. To know & draw the Feynman Diagram for all decays. 2. To introduce the Particle Zoo 1. To know the properties of Hadrons, baryons and mesons. 2. To understand that hadrons are made of quarks. 3. To know which particles are strange 4. To know the properties of leptons. 1. To know the Baryon, Lepton, Charge and Strangeness of all the particles. 2. To determine if the equations can satify the conservation laws. 3. To know when strangeness is conserved. 1. To know the charges and baryon numbers of quarks. 2. To calculate the quark structure of particles given their properties. 1. To know how to draw Feynman Diagrams using quarks. 2. To apply the quark information to exam questions. 1. To know & describe how electrons move up and down in energy levels. 2. To know the energy levels are quoted in MeV and how to convert them to J. • Red denotes interleaving; aspects of knowledge covered previously.
Current learning to be developed	Students will explore this topic further in nuclear physics topic in Year 13.

in the future within:	
Assessment	Refer to assessment maps for formative and summative assessment opportunities.
Impact	Attainment and Progress – Refer to assessment results / data review documentation.