Q.U.I.N.N.

Quantum Understanding and Interactive Navigation for Newbies

Senior physics worksheet – teacher notes

Introduction

The Standard Model is a key component of Australia's senior secondary curriculum. The Standard Model explains the properties and interactions of elementary particles, providing students with a critical foundation for understanding modern physics.

The senior worksheet provides year 11-12 students with an opportunity to consolidate and reinforce their understanding of The Standard Model. Students can complete this worksheet in consultation with the digital interactive standard model and/or a paper copy, and the Internet for student research.

By completing the worksheet, students achieve the following learning objectives:

- demonstrate understanding of fundamental particles and their properties
- apply Conservation Laws to particle interactions
- analyse Feynman diagrams and particle decay processes
- connect historical experiments to understanding of modern particle physics.

Question-specific guidence

Understanding section (Q1-3)

Q1 Encourage students to use mass values in GeV/c^2. Top quark (173.2 GeV/c^2) is heaviest.

Q2 Key comparison points: electron (charge = -1, affected by EM and weak force) vs neutrino (charge = 0, only weak force).

Q3 Table should include:

- **Photon:** mass = 0, charge = 0, electromagnetic force
- **W±:** mass = 80.4 GeV/c^2, charge = ±1, weak force
- **Z^0:** mass = 91.2 GeV/c^2, charge = 0, weak force
- **Gluon:** mass = 0, charge = 0, strong force.

Particle interactions section (Q4-6)

Q4 Lepton number calculation should show:

- **Before:** $n(0) \rightarrow p^+(0) + e^-(1) + \bar{\nu}_e(-1)$
- **Total lepton number conserved:** $0 = 0 + 1 + (-1)$.

Q5 Baryon number calculation:

- **Before:** $p(1) + \bar{p}(-1) = 0$
- **After:** $\pi^+(0) + \pi^-(0) = 0$.

Q6 Look for conservation of:

- Energy
- Momentum
- Charge
- Lepton number.

Common misconceptions to address

1. Particle/antiparticle charge relationships
2. Conservation law applications
3. Force carrier properties
4. Baryon vs lepton number.

Extension activities

- LHC data analysis using ATLAS or CMS public datasets
- virtual particle detector simulations
- historical timeline of particle discoveries.

EQUS Australian Research Council Centre of Excellence for Engineered Quantum Systems

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