Q.U.I.N.N.

Quantum Understanding and Interactive Navigation for Newbies

Senior physics worksheet

Understanding:

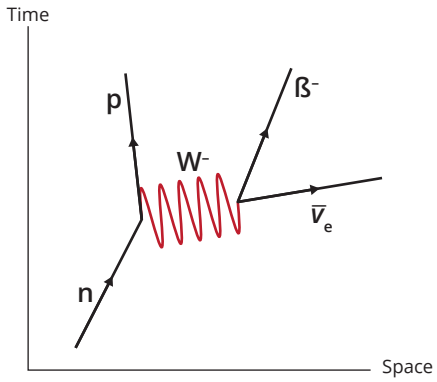
1 Using the standard model, identify the quark that has the largest mass and describe two of its key properties. How does this compare to its corresponding antiquark?

2 Examine the lepton section of the model. Compare and contrast the electron neutrino with the electron in terms of their charge and the fundamental forces they experience. Why is this significant?

3 Study the gauge bosons shown in the model. Create a table comparing the gluon, W/Z bosons, and photon in terms of their mass, charge, and the force they mediate. Which one stands out as unique and why?

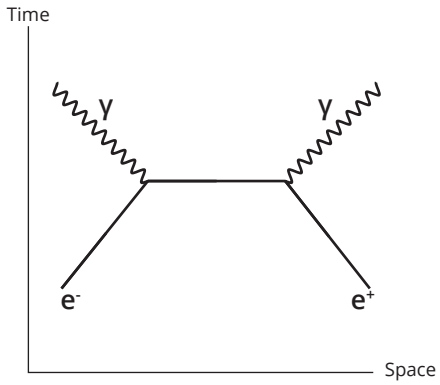
Particle interactions:

4 Using the Feynman diagram provided for neutron beta decay, calculate the lepton number before and after the interaction. Explain why this interaction conserves lepton number.



5 Consider this interaction: $p + \bar{p} \rightarrow \pi^+ + \pi^-$ Calculate the baryon number before and after using $B = nb - n\bar{b}$. Show your working and explain why this interaction is allowed.

6 Examine the electron-positron annihilation diagram. Draw the corresponding diagram for the reverse process (pair production). What symmetries are maintained?



Critical thinking and science as a human endeavor:

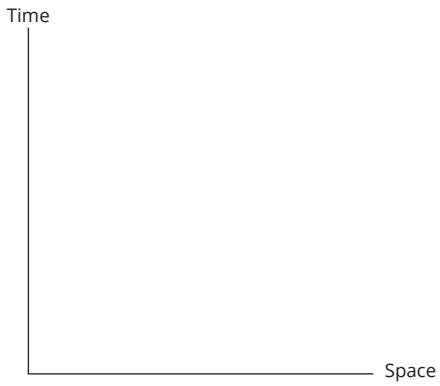
7 Research Chien-Shiung Wu's experiment that disproved the conservation of parity. Using the standard model, explain why this discovery was revolutionary for particle physics.

8 Compare the properties of the Higgs boson shown in the model with the theoretical predictions made by Peter Higgs. What evidence from the LHC confirmed these predictions?

Analysis questions:

9 A particle decay produces a muon, an electron, and their respective neutrinos. Using the standard model reference:

- Write the equation for this interaction
- Show that lepton number is conserved
- Draw the Feynman diagram for this interaction.



10 Study the baryon section of the model. Design an allowed interaction that produces a proton from three quarks:

- List the required quarks
- Calculate the resulting charge
- Explain why the strong force is necessary for this combination.