Massachusetts Institute of Technology
Department of Physics

8.276 Nuclear and Particle Physics   March 15, 2007

EXAM 1 WILL BE GIVEN IN CLASS ON TUESDAY, 3/20.

IT WILL COVER THE MATERIAL IN PROBLEM SETS 1-4 (ASSIGNED READING THROUGH CHAPTER 8, SECTION 3). IT WILL BE AN OPEN-BOOK EXAM: YOU MAY REFER TO PARTICLES AND NUCLEI, BUT TO NO OTHER BOOKS, NOTES, HANDOUTS, PROBLEM SETS, OR SOLUTIONS.

Reading Assignment for 3/22

Particles and Nuclei, Chapter 11
Optional Reading: Coughlan and Dodd, Chapters 23-25
    Cahn and Goldhaber, Chapter 12

Problem Set #5 (due 3/22)

1. *P&N*, 9-1
2. Explain why observation of the processes $\nu_\mu + e^- \to \nu_\mu + e^-$ or $\overline{\nu}_\mu + e^- \to \overline{\nu}_\mu + e^-$

constitutes unique evidence for neutral currents, whereas observation of
$\nu_e + e^- \to \nu_e + e^-$ and $\overline{\nu}_e + e^- \to \overline{\nu}_e + e^-$ does not.

3. Use four-momentum conservation to show that the maximum angle of emission

of the recoil electron in neutrino-electron scattering is $\sqrt{2m/E}$, where m and E are the electron's mass and energy, respectively.

4. The three leptons e, μ and τ may be assumed to have the same weak

interaction coupling constant. The τ-lepton (mass 1784 MeV/c^2) and the muon (mass 105 MeV/c^2) have decay modes and branching ratios as follows:

$$\mu \to e + \nu + \overline{\nu} \ (100\%)$$

$$\tau \to e + \nu + \overline{\nu} \ (17\%)$$

a) Given that the mean lifetime of the muon is 2.2 x 10^{-6} s, make an estimate of the mean lifetime of the τ-lepton.

b) If τ-leptons with momentum 5 GeV/c are produced in an e^+e^- collider, calculate the mean flight path before decay in the laboratory system. (Hint: consider time

dilation.)