## Physics 780.02 Problem Set 1 Due Monday Jan 18, 2010

1) Problem A.4, Page 342, Marin and Shaw. In addition: what is the speed of the  $X^0$  particle (relative to the speed of light) and what is its energy?

2) The  $\omega$  meson (mass = 783 MeV/c<sup>2</sup>) decays to  $\pi^0 \gamma 10\%$  of the time and to  $\pi^+ \pi^- \pi^0 90\%$  of the time.

a) What is the energy of the  $\gamma$  assuming the  $\omega$  meson decays at rest?

b) Consider the second decay mode of the  $\omega$  meson. What is the maximum possible momentum of a decay product assuming the  $\omega$  meson decays at rest? Assume that the pions all have rest mass = 140 MeV/c<sup>2</sup>.

3) A pion ( $\pi$ ) at rest decays into a muon ( $\mu$ ) and a neutrino ( $\nu$ ),  $\pi \rightarrow \mu \nu$ . On average how far will the muon travel (assume in vacuum) before it decays? Assume the mass of a pion is 0.140 GeV/c<sup>2</sup>, the mass of the muon is 0.106 GeV/c<sup>2</sup>, the neutrino is massless and the average lifetime of the muon (in its rest frame) is 2 µsec.

4) Show that a Fermi Energy of 25 MeV lowers the threshold incident <u>kinetic energy</u> for antiproton production by a proton incident on a nucleus to 4.3 GeV.

5) For each of the reactions listed below state whether the reaction is possible within the Standard Model. If the reaction is not possible give a reason.

a) $p + \overline{p} \rightarrow \pi^+ \pi^0$	$b) \Sigma^0 \to \Lambda \pi^0$	c) $\eta \rightarrow \gamma \gamma$
$d) \Sigma^- \to n\pi^-$	$e) e^+ e^- \rightarrow \mu^+ \mu^-$	$f) \mu^- \rightarrow e^- \gamma$
g) $\mu^- \rightarrow e^- \overline{v}_e$	$h)\overline{v}_ep \to ne^+$	i) $ep \rightarrow v_e \pi^0$
$j) \ \overline{p} \rightarrow e^{-} \overline{v_e}$	$k)  \pi^0 \to \gamma \gamma$	$l) \; \Xi^- \to \Lambda \pi^-$

6) Plug Eq. 1.30 into 1.32 and fill in the steps (i.e. do the integrals!) that lead to Eq. 1.35. Compare the differential and total cross section that one gets from a Coloumb potential with what one gets from the Yukawa potential. Note: "Rutherford scattering" is scattering off of a Coloumb potential.

7) What is the order (i.e. power of  $\alpha$ ) of the amplitudes in Figs. 1.4, 1.7, 1.8, 1.10, and 7.5?

8) Write down the Dirac equation and describe each term. Write the Klein Gordon equation and describe each term. Which equation describes: a) an electron, b) a muon, c) a pion, d) a neutrino? Why can't we use just the Schrodinger equation for everything?