# Homework Set #12

**Due Date:** Before class Friday May 4th

### 1) Neutrino Oscillations                                                      *(5 points)*

In the two flavour approximation, work out the probability for a $\nu_e$ to be detected as a $\nu_\mu$ as a function of mixing angle, mass difference, distance traveled and Energy.

Sketch the probability as a function of L/E.

### 2) Cosmic Rays                                                               *(5 points)*

What ratio of $\nu_e$ and $\nu_\mu$ do you expect in cosmic rays at low energies ?
*(Treat cosmic rays as protons which produce pions.)*

What can cause this ratio to change at higher energies ?

### 3) SNO                                                                       *(5 points)*

SNO measured the $\nu$ flux in three different ways. Draw the corresponding Feynman diagrams and indicate if you would expect a difference in cross section between the different $\nu$ flavours.

### 4) $\nu$ beams                                                               *(5 points)*

  a)  How could you make a beam of $\nu$s ?

  b)  What $\nu$ flavours would be produced ?

  c)  Would you expect this to make more $\nu$ or anti-$\nu$ ?

  d)  How could you enhance the $\nu$ fraction ?

  e)  How about the anti-$\nu$ fraction ?