Tutorial 3

(1) Draw a Feynman diagram using as few vertices as possible (i.e. leading order) for the process:
$\gamma+\gamma \rightarrow \gamma+\gamma$.

(2) State which of the following reactions/decays can take place. State the force or forces which can mediate the process if that information is not written next to the process. If the processis forbidden state a conservation law which forbids it.

$(i)\ \Lambda^0 \rightarrow p+\pi^-$ $(ii)\ p \rightarrow \Sigma^+ + \pi^0$

$(iii)\ \Omega^- \rightarrow \Xi^0 + \pi^-$ (strong) $(iv)\ e^- + \gamma \rightarrow e^-$

$(v)\ e^+ + e^- \rightarrow K^+ + K^-$ $(vi)\ \pi^+ + p \rightarrow \Delta^{++}$

(3) The Υ consists of a $b\bar{b}$ and has a mass around 9460 MeV/c^2 and a lifetime $\sim 10^{-20}$s.With this information what can you deduce about the mass of of the B-meson with quark content $u\bar{b}$?

(4) At the Minos experiment, a beam of muon neutrinos is fired 750km from the Fermilab Laboratory in Chicago to the SOUDAN mine in Minnesota. The purpose of the experiment is to see if any are lost via conversion to electron neutrinos. Sketch the expected energy spectrum of muon neutrinos at the SOUDAN detector if :

$\sin^2(2\theta) = 0.9$; $\Delta m^2 = 0.003\ \frac{\text{eV}}{c^2}$.

Assume that there exist only two types of neutrinos (electron and muon) and that the neutrinos have energies between 1-5 GeV and have a flat energy distribution (like a "top hat") in Chicago.

5 The potential between two nucleons in a nucleus as a function of the distance between the nucleons is given below.
Sketch how the force between the nucleons depends on distance apart.
Estimate the force between the nucleons at a separation of 1.2 fm.