Physics 404
Third Homework Assignment
Due Wednesday April 25th

Choose any 5 of the following 7 problems. The students from Fresno who are going to CERN in the summer need to do the Relativistic Kinematics and the Root programming problems.

Problem 1. (Problem 5.7). Suppose you had three particles, one in state $\psi_a(x)$, one in state $\psi_b(x)$ and one in state $\psi_c(x)$. Assuming that ψ_a, ψ_b and ψ_b are orthonormal, construct the three particle states representing a) distinguishable particles, b) Identical bosons, and c) identical fermions. Hint: you can use the Slater determinant.

Problem 2. (Problem 5.12). Figure out the electron configurations for the first two rows of the Period Table (up to Neon). Check your result with Table 5.1 in Griffiths. For this problem, you don't need to do Nitrogen (it has 3 valance electrons).

Problem 3. (Problem 4.29**). Find the ratio of the cross sections for the following reactions, assuming the CM energy is such that the $I = 3/2$ channel dominates?

a) $\pi^- + p \to K^0 + \Sigma^0$
b) $\pi^- + p \to K^+ + \Sigma^-$
c) $\pi^+ + p \to K^+ + \Sigma^+$

What are the cross section ratios if the CM energy is such that the $I = 1/2$ channel dominates?

Problem 4. (Problem 4.32**) The Σ^{*0} can decay into $\Sigma^+ + \pi^-$, $\Sigma^0 + \pi^0$, or $\Sigma^- + \pi^+$. Suppose you observed 100 such disintegrations, how many of each type would you expect to see?

Problem 5. (Problem 4.33**)
a) An alpha particle is a bound state of two protons and two neutrons. There is no isotope of hydrogen with an atomic weight of 4, that is H^4, nor of lithium, Li^4. What can you conclude about the isotopic spin of the alpha particle?

b) The reaction $d + d \to \alpha + \pi^0$ has never been observed. Explain why.

c) Would you expect Be^4 to exist? How about a bound state of four neutrons?

** means from Griffiths "Introduction to Elementary Particles" book.

Problem 6: Root Programming Problem. Write a computer program that will find the best fit to the data file: data1.txt. Fit the data with two Gaussian peaks plus a constant background. The error in each channel is equal to the square root of the counts. Each Gaussian peak will have 3 parameters (center, width, height), and the background will be just one parameter. Your fit function will have 7 parameters. Use the root program TMinuit to carry out the fit. Your program should display the values of the 7 fitting parameters and their errors.

Problem 7: Relativistic Kinematics Problem. Consider the following process that produces a Λ particle:

$$K^- + n \rightarrow \Lambda + \pi^- \tag{1}$$

where the neutron is the target and starts at rest. If the K^- has just the right momentum, the Λ will be produced at rest. This process is a very nice way to produce a Λ inside the nucleus, Λ hyper-nuclei. Determine the "magic momentum" for the K^-, such that the Λ particle is produced at rest in the above reaction.