Physics 404
Fourth Homework Assignment
Due Wednesday May 16th

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: Chapter 6, Problem 6.3
a) Suppose you started out with a million muons (at rest). How many would still be around 2.2×10^{-5} seconds later?

b) What is the probability of a π^- lasting longer than 1 second (express your answer as a power of 10)?

Problem 2: Chapter 6, Problem 6.6
As an application of the Golden Rule, consider the decay of $\pi^0 \rightarrow \gamma + \gamma$. Unfortunately we don't know the amplitude M, however, it must have the dimensions of mass times velocity and there is only one mass and one velocity available. Moreover, the emission of each photon introduces a factor of $\sqrt{\alpha}$ (the fine structure constant) into M. On this basis, estimate the lifetime of the π^0. Note: don't expect to get very close to the experimental value.

Problem 3: Chapter 6, Problem 6.8
Consider elastic scattering, $a + b \rightarrow a + b$, in the lab frame (b initially at rest) assuming the target is so heavy ($m_b c^2 >> E_a$) that its recoil is negligible. Determine the differential scattering cross section. [Hint: In this limit the lab framd and the CM frame are the same.]

Problem 4: Chapter 6, Problem 6.12a.
a) Draw all the lowest-order diagrams for $A + A \rightarrow A + A$. (There are 6 of them).

Problem 5: Chapter 6, Problem 6.15a.
a) Determine the lowest order amplitude, M, for $A + B \rightarrow A + B$. (There are two diagrams.)
Problem 6: Relativistic Kinematics Problem
The "crystal ball" detector determines the energy and direction of a π^0 by measuring in coincidence the two photons emitted in the decay. Suppose a π^0 is traveling with

an energy of E_π in the lab frame. Then it decays into two photons ($\gamma's$). Suppose the photons have the same energy, E_γ in the lab frame. Find an expression for the angle between the two photons in terms of the energy of the pion E_π and the mass of the pion m_π.

Problem 7: Root Programming Problem:
Write a computer program in root that will find the best fit to the electron-positron cross section at the Z_0 resonance:

C.M. Energy (Gev)	σ (nb)
88.480	5.24 ± 0.08
89.466	10.15 ± 0.12
90.227	18.12 ± 0.15
91.242	30.21 ± 0.06
91.967	24.55 ± 0.19
92.966	14.38 ± 0.14
93.716	9.99 ± 0.11

Fit the data with a Lorentzian peak plus a constant background. Use the root program TMinuit to carry out the fit. Your program should display the values of the Z_0 mass and width, plus their errors. Then it should graph the data and the best fit Lorentzian curve.