Physics 252 – **Modern Physics**
Homework Assignment #4

Due Friday, February 16, 2007 at the beginning of class.

Reading: Feynman, chapters 3 and 4.

1. For a particle in a one-dimensional box of size L, find the amplitude for the state of lowest energy. Label the position by $-L/2 < x < L/2$. What is the probablility that a particle in this lowest-energy state is found between $L/4 < x < L/2$?

2. Consider the scattering experiment we discussed in the case where the amplitude $f(\theta) = Ae^{i\theta}$, where A is independent of θ. Find and sketch $P(\theta)$, the probability that one of the particles ends up at angle θ, for (a) distinguishable particles (b) fermions (c) bosons.

3. Calculate the conditions for destructive interference in the double-slit experiment by finding where the two terms in the amplitude $\langle s|x\rangle = \langle s|1\rangle\langle 1|x\rangle + \langle s|2\rangle\langle 2|x\rangle$ cancel. You can assume here that each slit is very narrow: all the electrons going through a given slit go through a single point. In this homework set, take the amplitude for a free particle of definite momentum $\vec{p}$ to be
$$\langle \vec{r}_2|\vec{r}_1\rangle = Ae^{i\vec{p}\cdot(\vec{r}_1-\vec{r}_2)/\hbar}$$
where A is a constant.

4. In this and the next two problems, consider neutrons of momentum p scattering elastically at angle θ off a crystal consisting of planes a distance d apart. In class, we studied the case where the amplitude for a given neutron to scatter off a given plane is some small number a. Here, let's instead say that there's a 50% probability the neutron scatters off a given plane. Thus half the neutrons scatter off the first plane, half of the remaining neutrons (so a quarter of the original neutrons) scatter off the second plane, and so on. What values of a result in this? (Remember that a is in general a complex number.)

5. Write an expression for the probability amplitude of the scattered wave. You can leave it in terms of A, p, a and the distances from the source and detector to the various planes (just draw a picture with your distances labeled).

6. Now simplify the previous problem by neglecting the scattering from all but the first two planes. Compute the probability of finding a scattered particle at angle θ. What are the maximum and minimum probabilities possible?