Physics 008: The Quantum World Around Us
Spring 2007
Homework Assignment #2
Due Thursday 2/1/07 **Name:**

1. In DC, license plates are identified by two sets of three numbers (e.g. 056-421). If all the digits are chosen at random, what is the probability that the second set of numbers is the same as the first?

2. Craps is a game played with two dice. One person rolls the dice and others bet on the outcome. Suppose each bet you place costs one dollar. The house pays money back to you when you correctly predict what occurs. Like all gambling ventures, the odds are stacked in favor of the house.

   (a) One bet you can make is that the next roll will be a seven.

   – What is the probability that this will happen? (Show how you reached your answer.)

   – If you win this bet, the house pays you four dollars plus your original dollar. How much should the house pay (in addition to your original dollar) to make it a "fair" bet? (Hint: Suppose you make this bet 36 times. This costs you $36. On average, how many times out of the 36 would you expect to win? How much would the house have to pay you for each win in order for you to break even?)

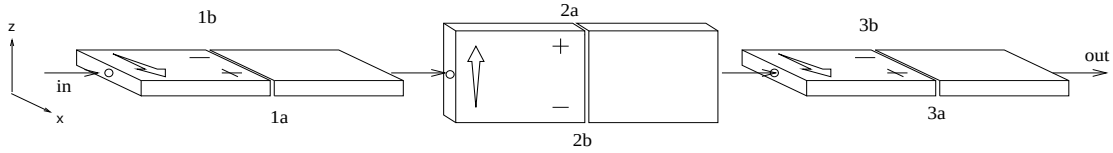
   (b) Another bet you can place is that the roller will roll craps (a 2, 3, or 12) on the next roll.

   – What is the probability of rolling craps? (Show how you reached your answer.)

   – The house pays seven dollars over and above your original dollar, which you keep if you win. How much should the house pay (in addition to your original dollar) to make it a "fair" bet?

Do not attempt the rest of this assignment until after Tuesday's lecture.

3. Atoms with $m_z = +m_B$ are passed through a horizontal analyzer loop, then a vertical analyzer loop, then a horizontal analyzer loop.



What percent of the incoming atoms leave from the output if the following branches are closed? (The atoms are not observed as they pass through the analyzer loops.) Explain your reasoning and also state the axis and the sign of the projection of the output atoms.

(a) 1b

(b) 3a

(c) 3b

(d) 2a

(e) 2b

(f) 2a and 3b

(g) 1b and 3b

(h) 1b and 3a

(i) 1b and 2a and 3a

4 *Short Essay*: You should notice something strange occurred between part (h) and part (i) of the last problem: by placing an additional obstruction in the beam of atoms, the output actually *increased*! Write a paragraph describing how such a counterintuitive result can occur in the quantum-mechanical world. (You may want to begin by explaining what occurred in parts (h) and (i) of question 3.) In fact, it is the atoms that *do not hit* the obstruction that let you know the obstruction is there! This phenomenon is called *quantum seeing in the dark*.