

Physics 570B, Spring 2011
Assignment 05
Due Tuesday, Feb. 22

1. Think a little more about *Baym* problem 3-12, which was on last week's homework. Since we said that the particles were well inside the tubes during the time the potential difference was applied, we needed to require that they had reasonably well defined wave packets. (This was so that we could see that they did not feel any significant effect from electric fields near the ends of the tubes.) Suppose that the potential is applied to tube A, while tube B is held at $V = 0$. During the time that the potential difference is applied, what is the phase velocity of the particles in tube A? What is the group velocity? Which of these is relevant to the question about the shift of the interference pattern? What does the other velocity tell you?
2. Write the matrices representing J_x , J_y and J_z (\vec{J} = angular momentum) in the representation with $j = 3/2$. Use the basis where J_z is diagonal.
3. Consider the generators of the $j = 1$ representation of rotations Find the unitary matrix that performs the change of basis from the "Cartesian" basis where we first wrote the generators in class into the basis of eigenstates of L_z .
4. (Another problem from *Sakurai*) The wave function of a particle in a spherically symmetric potential $V(r)$ is given by

$$\Psi(\vec{x}) = (x + y + 3z) f(r) \tag{1}$$

- (a) Is Ψ an eigenfunction of L^2 ? If so, what is the l -value? If not, what are the possible values that we may obtain when L^2 is measured?
 - (b) What are the probabilities for the particle to be found in various m_l states?
5. Use $L_- Y_{l,-l}(\theta, \phi) = 0$ and $L_z Y_{l,-l}(\theta, \phi) = -l\hbar Y_{l,-l}$ to get an explicit form for $Y_{l,-l}$. You do not need to worry about normalization.
 6. Consider a particle with orbital angular momentum one and spin $3/2$. Find all of the "coupled states", or eigenstates of the total angular momentum and its z component, in terms of the "uncoupled states", or eigenstates of L_z and S_z . Explain your work, and don't do it by just looking up coefficients in a table.