Physics 321, Fall 2014 Exam 2

RULES

You may use an equation sheet.

Problems

1: SHORT ANSWER (no calculations)

A) There are two generic solution types for Schroedinger's equation that depend only on the total energy of the system.

a) Describe these two types. One word is sufficient to explain each one.

b) Describe the primary difference in the solution types and the shortcoming of the solutions for one type.

B)

a) What are determinate states of an operator?

b) What condition is required of a wave function to return a determinate state of an operator?

c) What are determinate states of the Hamiltonian operator.

d) What is true of repeated measurements of physical quantities that are not determinate states of an operator representing an observable quantity?

2: Non-commuting operators are those for which $[\hat{A}, \hat{B}] \neq 0$

Consider operators $\hat{s}_x = \frac{\hbar}{2}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$, $\hat{s}_y = \frac{\hbar}{2}\begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$, $\hat{s}_z = \frac{\hbar}{2}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$ and $\hat{s}^2 = \frac{3}{4}\hbar^2\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$

Calculate $[\hat{s}^2, \hat{s}_z]$, $[\hat{s}_y, \hat{s}_x]$, $[\hat{s}_y, \hat{s}_z]$ and $[\hat{s}_x, \hat{s}_z]$. If they commute then these observables may be simultaneously measured on the same system without changing the system.

Which sets of operators above can be simultaneously measured on a system without changing the system? Which operators from the above are hermetian?

3: Calculate the eigenvalues and the properly normalized eigenvectors of $\hat{s}_x$.

4: A particle with energy E passes over a step potential with height V beginning at x=0. (see board) Write down the system of equations that describe how you would solve for the reflection and transmission coefficients. For both the case $E < V$ and $E > V$. Sketch the wave function in each region. DO NOT ATTEMPT TO SOLVE THIS SYSTEM.

5: The hermite polynomials for part of the solution for the harmonic oscillator potential. They are related by the recursion relationship $H_{n+1}(x) = 2xH_n(x) - 2nH_{n-1}(x)$. If $H_0 = 1$ and $H_1 = 2x$, calculate $H_2(x)$.

6: For the harmonic oscillator in state $\psi_2(x) = (\frac{m\omega}{\pi\hbar})^{1/4} * \frac{1}{\sqrt{2^2 2!}} H_3(x) * e^{-x^2/2}$ calculate $< x >$ and $< x^2 >$. Depending on how you attempt this you will either have a chance to get the answer during the test or no chance.