Physics 321, Fall 2014 Exam 1

Dr. Jared Workman, Friday

RULES

You may use an equation sheet. This sheet may NOT have solutions to problems but may contain any formulae or integrals you choose to include.

Problems

1: SHORT ANSWER - No calculations although formulas may need to be written

A) In quantum mechanics an observable quantity is represented by what?

B) Write down the generic formula for calculating the expectation value of a generic observable quantity. Write it out explicitly for kinetic energy (use the correct form for the energy operator) use a generic ψ to represent the wavefunction.

C) What does the expectation value tell you about a particular system, is the expectation value always an observable measurement of a system?

D) What is the distinction between the expectation value and the most probable value? Are both always possible outcomes of the measurement of a system?

E) What exactly is Schröedinger's Equation solving for? What needs to be done to the solution to make it physically meaningful?

2:

At time $t = 0$ a particle is represented by the wave function $\psi = A\frac{(x)^{1/2}}{a}$ on the interval $x\epsilon[0, a]$.

A) Normalize this wave function and find A

B) Determine $< x >$, $< x^2 >$, and σ_x

C) What it the probability that a measurement of this system will find this particle between a/2 and a?

3:

A particle starts out in the state $\psi = \frac{1}{\sqrt{(2)}}\psi_2 + \frac{1}{\sqrt{(4)}}\psi_4 + \frac{1}{\sqrt{(4)}}\psi_6$ where the functions are the basis functions for the infinite square well.

A) What are the possible measurement for momentum and energy (be careful to write down momentum and energy explicitly).

B) What is the expectation value for energy?

4:

Assuming you are using the infinite square well basis functions - A particle starts out at $\psi(x, 0) =$

A for $x \epsilon [0, a]$.

A) Find the normalization constant.

B) Find the expansion coefficients (C_n) for this state.

C)Write down the general solution for $\Psi(x,t)$ for this state

5:

Show explicitly that the solutions for the infinite square well are not eigenfunctions of the momentum operator.

6:

The Schroedinger equation is an energy equation. It says the $i\hbar\frac{\partial\psi}{\partial t} = (\frac{\hat{p}^2}{2m} + V)\psi$ If we equate the operator $\hat{E} = i\hbar\frac{\partial}{\partial t}$ where $\hat{E}$ is not to be confused with number E this essentially says that $\hat{E}\psi = \hat{H}\psi$. This is a non-relativistic energy equation. By rewriting this as $\hat{E}\psi = \hat{p}^2c^2 + m^2c^4$ we make the equation relativistic. Using the correct forms for operators write out the new, relativistically correct Schroedinger's equation. You have now 'derived' the Klein-Gordon equation.

Equations

$sin^2(\theta) = \frac{1-cos(2\theta)}{2}$

$cos^2(\theta) = \frac{1+cos(2\theta)}{2}$

$\int x \cdot sin(x)dx = sin(x) - x \cdot cos(x)$

$\int x \cdot cos(x)dx = x \cdot sin(x) + cos(x)$

$\int x^2 sin(x)dx = (-x^2 + 2)cos(x) + 2xsin(x)$

$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$