Quantum Mechanics

January 21, 2017

Work 2 (and only 2) of the 3 problems. Please put each problem solution on a separate sheet of paper and your name on each sheet.

Problem 1

Consider an electron in a uniform magnetic field in the positive z-direction. The measurement of the magnetic moment of the electron has shown that the spin of the electron is along the $+x$ direction. For a later time compute the quantum mechanical probabilities to find the electron in the following states (in units where $\hbar = 1$):

a.) $S_x = +1/2$

b.) $S_x = -1/2$

c.) $S_x = +1/2$

Problem 2

Particle in a Box: A particle of mass m is confined to a one-dimensional box in the interval $0 < x < L$ along the x-axis. The box has infinitely high walls at $x = 0$ and $x = L$. There is zero probability for the particle to be found outside of the interval $0 < x < L$. The particle is in the ground state in this one-dimensional box.

a.) What is the probability to find the particle in the interval $0 < x < \frac{L}{2}$?

b.) What is the probability to find the particle in the interval $\frac{L}{2} < x < L$?

c.) What is the probability to find the particle in the interval $\frac{L}{4} < x < \frac{3L}{4}$?

An infinitely high barrier is quickly placed at the location $x = \frac{L}{2}$. The particle is now trapped in the smaller interval $0 < x < \frac{L}{2}$.

d.) What is the probability that the particle will be in the ground state in this smaller box?

Problem 3

A monochromatic beam is incident on N slits, which results in an intensity pattern as a function of angle on a screen some distance away as shown in the figure below. Each slit has a width D and the distance between the centers of the slits is d. The distance between the screen and the slits is large compared to both d and D. From the figure, deduce the following:

a.) The number of slits N on which the beam is incident.

b.) The ratio d/D.

Explain your reasoning for both.