KING SAUD UNIVERSITY. DEPARTMENT OF PHYSICS AND ASTRONOMY

QUANTUM MECHANICS (453 PHYS)

PROBLEM SET 2

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PROBLEM (1)

A quantum system at $t = 0$ given by the state $\Psi = 2N\psi_1 + 3N\Psi_2$. Where ψ_1, ψ_2 the eigenstates of the Hamiltonian, with eigenvalues E_1 and E_2, respectively. Write the time evolution of this system.

PROBLEM (2)

Compute the ground state and 1st excited state energy for an electron in an infinite well of width 1 Å. What would the energies be in the particle was a proton ?

PROBLEM (3)

Repeat the previous calculations for a well width of 10^{-5} Åor $1fm$. If the atom and the nucleus were approximated by the well's in the previous problem and this one, respectively, use these computations to argue that electrons could not exist inside the nucleus.

PROBLEM (4)

An electron trapped in an infinite well of width $4nm$, centred at $x = 3$.

1. What is the probability per nm of finding the electron at $x = 1nm$?
2. compute $\langle x \rangle$ and $\langle p^2 \rangle$.
3. find the uncertainty in momentum Δp.

PROBLEM (5)

The ground state for a particle in a stationary state infinite well is equal to $3eV$. Whilst the normalised state for a particle made of the following superposition.

$$\Psi = \frac{1}{\sqrt{3}}\psi_1 + i\sqrt{\frac{2}{3}}\psi_2$$

Compute $\langle E \rangle$ and ΔE for the state Ψ.

PROBLEM (6)

The ground state energy of a quantum simple harmonic oscillator (SHO) is $2eV$. (a) What is a frequency ν of this oscillator ? (b) Calculate the 3rd excited state ennergy.

PROBLEM (7)

A quantum SHO having the following state, at $t = 0$.

$$\Psi = N(\phi_0 + \sqrt{2}\phi_2) \tag{0.1}$$

1. Find N such that Ψ is normalised.
2. Write the time evolution of this system $\Psi(t)$.
3. What is $\langle E \rangle$ at the time $t = \pi/\omega$
4. compute $\langle x \rangle$ at some given time t.