KING SAUD UNIVERSITY. DEPARTMENT OF PHYSICS AND ASTRONOMY

MODERN PHYSICS (351 PHYS)

PROBLEM SET 5

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PROBLEM (1)

Discuss why the following functions cannot be a wavefunction

1. $f(x) = -x^4 + x^2 - 2$
2. $g(x) = \sin(x/2)$ if $x \in [-\pi, \pi]$
3. $h(x) = \begin{cases} 1 & \text{if } -1 < x < 1 \\ 2 & \text{if } 0 < x < 2 \end{cases}$

PROBLEM (2)

Compute the following commutators

1. $[x^2, p]$
2. $[xp, 2x]$
3. $[ix - p^2, -x^2 + 2p]$

PROBLEM (3)

Given the wavefunction

$$\psi(x) = N\cos(2\pi x/L)$$

Defined over $x \in [-L/4, +L/4]$ Find the normalisation constant N, then compute $\langle x \rangle$ and $\langle p \rangle$.

PROBLEM (4)

Given the wavefunction

$$\psi(x) = Ne^{-\xi x^2/2}$$

Compute the uncertainty in position for this system Δx
Provided that

$$\int_{-\infty}^{+\infty} x^{2n} e^{-\lambda x^2} = \frac{1 \cdot 3 \cdots (2n-1)}{(2\lambda^n)} \times \sqrt{\frac{\pi}{\lambda}}$$

PROBLEM (5)

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 (6)

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 (7)

Which of the following formulas describes the shortest wavelength in the Balmer series?

1. $4hc/E_R$
2. $4hc/3E_R$
3. $3hc/4E_R$
4. $3hc/E_R$

Where $E_R = 13,6\,eV = hc/R$