Department of Physics
University of California San Diego

Quantum Universe (4E)
Prof. V. Sharma
Quiz # 4 (May 27, 2005)

$$\lambda = \frac{h}{p} \quad ; \quad \Delta x.\, \Delta p \geq \frac{h}{4\pi} \quad ; \quad \Delta E.\, \Delta t \geq \frac{h}{4\pi}$$

Time Dep. S. Eq: $-\frac{\hbar^2}{2m}\frac{d^2\Psi(x,t)}{dx^2} + U(x)\Psi(x,t) = i\hbar\frac{\partial\Psi(x,t)}{\partial t}$

Time Indep. S. Eq: $-\frac{\hbar^2}{2\mathrm{m}}\frac{d^2\psi(x)}{dx^2} + U(x)\psi(x) = E\ \psi(x)$

Particle in box of length L: $\psi_n(0<x<L) = \sqrt{\frac{2}{L}}\sin\left(\frac{n\pi x}{L}\right)$ & $E_n = \frac{n^2\pi^2\hbar^2}{2mL^2}$

Planck's constant h = 6.626×10^{-34} J.s=4.136×10^{-15}eV.s

1 eV = 1.60×10^{-19} J

Electron mass = 9.1×10^{-31} Kg = 0.511 MeV/c^2

Energy in Hydrogen atom $E_n = \frac{-ke^2}{2a_0}\left(\frac{1}{n^2}\right) = \left(\frac{-13.6\text{ eV}}{n^2}\right)$

$$\sin\alpha\sin\beta = \frac{1}{2}\left(\cos(\alpha-\beta) - \cos(\alpha+\beta)\right)$$

$$\int \sin^2 x\, dx = \ = -\frac{1}{2}\cos x \sin x + \frac{1}{2}\mathrm{x} \ = \ \frac{1}{2}x - \frac{1}{4}\sin 2x$$

Please consult the proctor if you don’t understand any part of the questions

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Problem 1: Lazy "R" Us ! [8 pts]

Consider a particle of mass m moving in a one-dimensional box with rigid walls (infinite potential) at x = - L/4 and x = L/4. (a) Draw this potential form (b) Find the normalization constant , the complete wavefunctions and probability densities for state n = 1 , n = 2 & n = 3. (c) Neatly sketch the wavefunctions and probability densities in each case. Indicate the locations of the walls.

Problem 2: Episode II: Attack Of The Clones [12 pts]

A free particle of mass m with wave number k_1 is traveling in the right direction. Its energy $E = \frac{\hbar^2 k_1^2}{2m} = 2V_0$. At x=0, the potential step jumps from zero to $-V_0$. and remains at this value for all positive x. (a) draw the potential (b) does the particle slow down or speed up in region x>0? (c) What is the wave number k_2 of the particle in x>0 ? (d) Calculate the reflection coefficient R at the potential step. (e) What is the transmission coefficient T? (f) If one million such particles with wave number k_1 are incident on the potential step, how many particles are expected to continue along the positive x direction ? (g) How does this answer compare with the classical prediction?