Notre Dame University-Louaize
Faculty of Natural & Applied Sciences
Department of Sciences

PHS 213 – Modern Physics
Exam III - Summer 2011
Duration: 90 minutes (1h30)

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1. Find the energies E_n, in eV, of the energy levels $n = 4, 5, 6$, for an electron in a one-dimensional infinite potential well (rigid box) of width $a = 0.2$ nm. Sketch these energy levels and their wave functions ψ_n. **(25 pts)**

2. For an electron in a solid, $\omega = \omega_{max}.(1 - \cos ak)$.
   a- Calculate the group velocity.
   b- Calculate the phase velocity.
   c- Show that $v_g = 2.v_p$ for small k. (hint: $\cos\theta = 1 - \theta^2/2$ for small θ). **(20 pts)**

3. Consider a particle in the second excited state ($n = 3$) of a rigid box (infinite potential well) of length a.
   a- Write down and sketch the probability distribution $|\psi(x)|^2$.
   b- What are the most probable positions, x_{mp}?
   c- Find the probability of finding the particle in the interval $[0 ; a/3]$. **(30 pts)**

4. The wave function $\psi_0(x)$ of the ground state of a harmonic oscillator is $\psi_0(x) = A_0 e^{-x^2/2b^2}$.
   With $b = \sqrt{\hbar / m\omega}$.
   a- Show that the normalization constant A_0 for this wave function is

$$A_0 = (\pi b^2)^{-1/4}$$

$-\lambda x^2$

Hint: $\int_{-\infty}^{\infty} e^{-\lambda x^2} dx = 2\sqrt{\frac{\pi}{4\lambda}}$

   b- Verify that this wave function is a solution of the Schrödinger equation with $E = ½\,\hbar\omega$.
   (25 pts)

Good Luck!!