Problem Set #4

Due Monday, March 31 by 5pm to Dickinson 104

Unless otherwise indicated, all problems come from "Quantum Physics: A Fundamental Approach to Modern Physics"

1. For a particle in an infinite box:
    a. Write down and sketch the probability distribution $|\psi|^2$ for the second excited state (n=3) of a particle in a rigid box of length a.
    b. What are the most probable positions, x_{mp}?
    c. What are the probabilities of finding the particle in the intervals [0.50a, 0.51a] and [0.75a, 0.76a]? (*Hint: For a narrow interval, you don't need to do the full integral - the probability of finding a particle in that interval is* $\approx |\psi(x)|^2 \Delta x$)
2. An electron is trapped in a one-dimensional infinite well of width 0.132 nm. The electron is in the n=10 state.
    a. What is the energy of the electron?
    b. What is the uncertainty in its momentum? (*Hint: For small values, Δp~p.)*
    c. What is the uncertainty in its position?
    d. How do these results change as n→∞? Is this consistent with classical behavior?
3. Using whatever plotting package you want:
    a. Generate a plot of probability vs. position of the first 5 energy states of the particle in an infinite box. All five probabilities should be overplotted (i.e. they should all be on the same plot).
    b. Using your plot, determine/estimate (from the plot only):
        i. The most likely location(s) to detect a particle for each of these energies.
        ii. The average position of a particle for each of these energies.
        iii. the probability that the particle is found between 0 and ¾L for the n=3 energy state (i.e. the second excited state).
    c. For the n=4 and n=5 energy states, confirm with math your graphical estimates from part (b)ii.
4. Problem 3.5 *(For the last question of this one, your answer should be in terms only of m, L, and constants).*
5. Problem 3.11