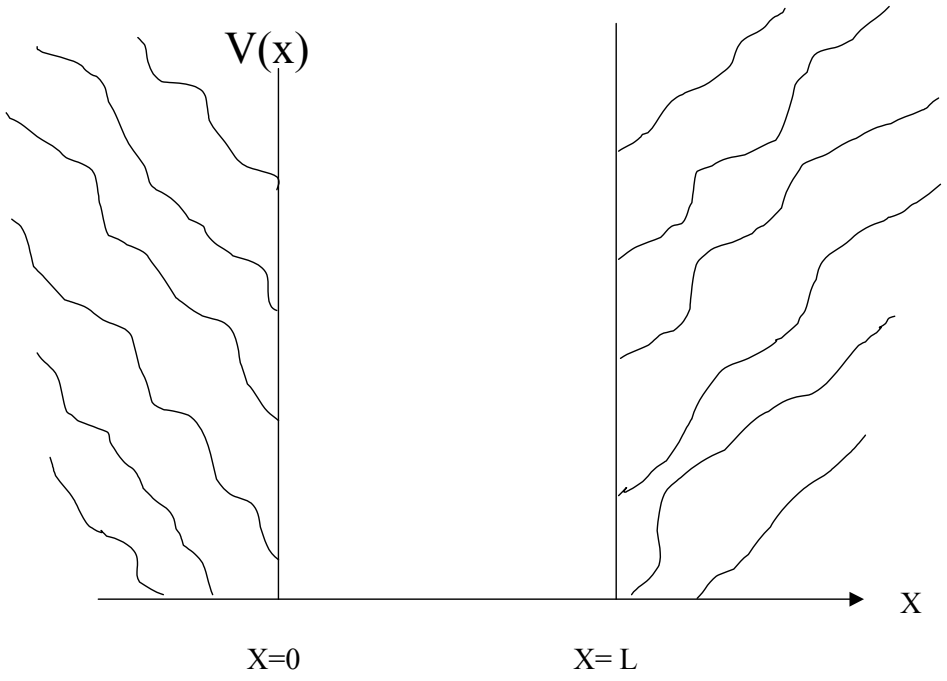
Spring Term 2003

22.02 Introduction to APPLIED NUCLEAR PHYSICS

Problem Set #2

1. *Particle in 1D box:* Consider a free particle moving in box as shown in figure with infinite potential bounding the box at $x = 0$ and $x = L$.



   a. Solve the energy eigenvalue problem, $\hat{\mathcal{H}}\psi_n = E_n\psi_n$, and give a complete listing of both the normalized eigenfunctions, ψ_n, and the energy spectrum, E_n.

   b. Also for state $\psi = \psi_n$, as in b), write the probability that a position measurement finds the particle within the interval, Δx, about x? Be sure to get your answer dimensionally correct for a probablility.

   c. Now suppose the system is in a *superposition* quantum state:

$$\psi(x) = a_1\psi_1(x) + a_3\psi_3(x)$$

i) What are the possible outcomes of an energy measurement in this case?

ii) Determine a_1 and a_3 if the probability of finding $E = E_1$ is $P_1 = .1$, and the probability of measuring, $E = E_3$ is $P_3 = .9$.

iii) What is the probability of finding the particle at $x = \frac{2}{3}L$? Can you state more specifically what the measurement is?

2. Calculate the de Broglie wavelength of a 10-eV electron, and a 10-MeV alpha particle. Relate the numbers you obtain to characteristic physical dimensions. Then calculate the de Broglie wavelength for a 10-g bullet moving at a speed of 1,000 m/sec. What velocity would the bullet be going if its de Broglie wavelength were 10^{-8} cm? Give the velocity in approximate *atomic displacements per year*. (You may take 10^{-8}cm. to be the unit of atomic displacements.)

3. Liboff, problem: 7.42

4. A neutron of energy 20 Mev is incident on a square barrier of height 40 Mev and width, 10 F (Fermi). What is the tunneling probability for the neutron to penetrate the barrier? (*You do NOT have to do a complete detailed estimate for this problem. Just estimate the tunneling probability and put in the numbers).*