Physics 222 CID ____________

Lab 3 - The Square Well

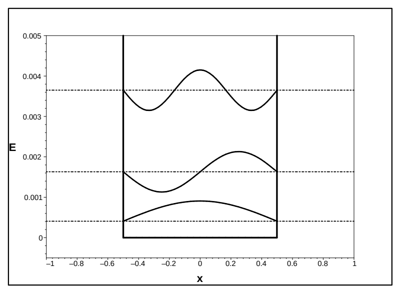
Score ________ / 10

In this lab you will develop intuition for the what the stationary states (or Eigenstates) of 1-dimensional square well potentials are like. You will do this by interacting with a computer program which can numerically calculate stationary-state wavefunctions for a potential which you define. The first thing you should do is to load up the program and read through the on-line help.

The one-dimensional infinite square well

We found in class that the wavefunctions of the stationary states for a 1-dimensional infinite square well are sinusoidal — the three lowest-energy states are shown below. Count the zero crossings in these wavefunctions and determine the energy of these states (in Joules) for a particle of with a mass such that $m/\hbar^2 = 10,000$ S.I. units (i.e. $m = 1.11 \times 10^{-64}$ kg) trapped in a one-dimensional square well potential which is 1 meter wide. Enter these values in the table below.

$n =$	1	2	3
zero crossings			
E_n			



Now approximate a square potential in the simulation with a very deep finite well by entering “`20*(1-squarepulse(2*x))`” for “V(x)” and set “mass/hbar^2” to 10000.0 and n to 0. (Note that in some cases, including the infinite square well, we start labeling the states with $n = 1$. In other cases, such as the harmonic oscillator, we start with $n = 0$ because it makes the equations look nicer. The simulation, however, always labels the ground state as $n = 0$.) Now click on “Recalculate,” and you should see the ground state wavefunction for the infinite square well. Remember that in class we found that the energy of the stationary states for the 1-D infinite square well scaled as n^2, and note that the plot of “E(n)” is, in fact, quadratic! Look at the energy that the simulation calculated for the ground state. I should be the close to the one that you calculated above — it won’t be exact because our potential isn’t really infinite. Now increase “n” in the simulation. The wavefunctions should look like the ones above, and the energies should be similar to the ones you calculated.

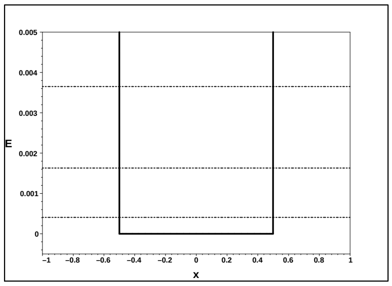
The one-dimensional *finite* square well

Now lets predict what will happen if we make our potential shallower. This will allow the wavefunctions to penetrate into the “classically forbidden” region. This means that the wavefunctions aren’t completely confined to the well — they can “stretch out” a bit into the wall, and will therefore have slightly longer wavelengths.

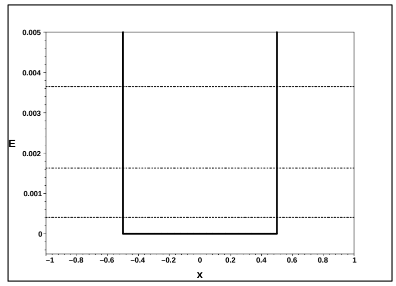
How will the energies of the states change? ____

Sketch what you expect the three lowest stationary-state wavefunctions will look like on the leftmost graph below. Then enter "`0.02*(1-squarepulse(2*x))`" for "V(x)" and click on "Recalculate" to see if you were correct. Sketch the wavefunctions generated by the simulation on the rightmost graph below. Use the simulation to find the energies of the lowest three states and see if your answer to the above question is correct!

Predicted



From Simulation



Finally, answer the following question:

- Do higher or lower energy states penetrate further into the classically forbidden region?

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