This week we have a short problem set in compensation for having Exam 1.

1. **Upload your topics to the drop box on D2L.** (5 points)

   Please upload your special topics of interest from HW#2 or any other topics that you’ve more recently thought of to the Week4 dropbox on our D2L site. If you have already done so, then you’ve earned your 5 points. Otherwise, please do it.

2. **Guessing about a possible harmonic oscillator wave function.** (20 points)

   Taken all together, a sketch suggests that one possible function with all these features would be a Gaussian:

   \[ \psi(x) = Ae^{-\frac{x^2}{2\sigma^2}} \]

   Here, I’ve given the wave function a normalization constant that we’d need to find. Also, the wave function has a parameter for the width of the Gaussian. **We imagine** that the Gaussian width is a completely **UNKNOWN** parameter that will need to be adjusted to match the Gaussian to the physics of the problem.

   a) Plug the Gaussian into the SHO Schrödinger Equation. Do a little algebra to get the energy isolated on one side and all the other items on the other side. Looks like a mess doesn’t it. It also looks like the energy depends upon position in the well… is that right?? Since when would the energy eigenvalue be a function of position?? Ah, but wait!! Remember that the width of the Gaussian is a completely adjustable parameter. What could you set it to so that the energy is independent of position?

   Write down how the width parameter of the Gaussian is related to the particle mass and natural frequency of the well, so that the energy eigenvalue is not dependent upon position. (5 points)

   b) Now state how the energy must depend upon the width parameter. Comment on how this equation compares to the energy we expect for the infinite potential well ground state. Do these two results look at all similar? Why should they (or why not)? (5 points)
c) Now substitute your result for the width, part a), into the energy equation from part b) and say how the energy depends upon natural frequency of the potential well. Have you found a wave function that works and if so, which one? (5 points)

d) The wave function above is a particular guess. However, it’s not the only guess we might have made. For example, notice that it is a symmetric function in the well. Recall that in the infinite potential well case, we found a whole set of symmetric functions in the well, but also a full set of antisymmetric functions.

Use the same type of arguments we used above to argue about what the shape of an antisymmetric function might be like. Now GUESS a form that is antisymmetric AND that satisfies the required asymptotic behavior of a SHO wave function. Use e.g., Mathematica to plot a picture of your example of an antisymmetric SHO wave function. (5 points)