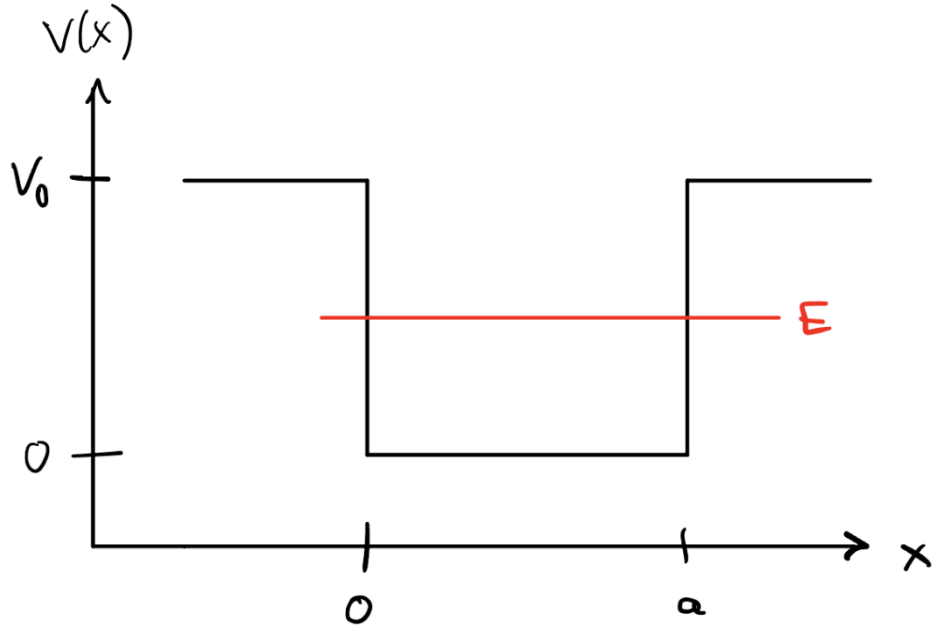
Which of the following statements are correct about a particle **with $E < V_0$** interacting with the finite box shown in the plot below?

Select all that apply.



a) The particle's wavefunction is zero outside the box.
b) The particle's wavefunction must be normalizable.
c) The particle is in a bound state.
d) The particle is in an unbound state.
e) The particle has discrete allowed energies.

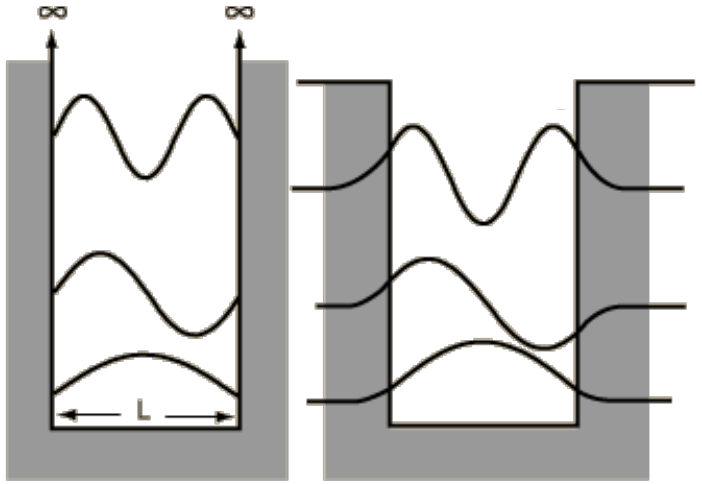
CHM 305 The Quantum World

Lecture 10: The Harmonic Oscillator

McQuarrie Ch. 5

Last lecture…

We found wavefunction solutions for several problems involving potentials with finite walls



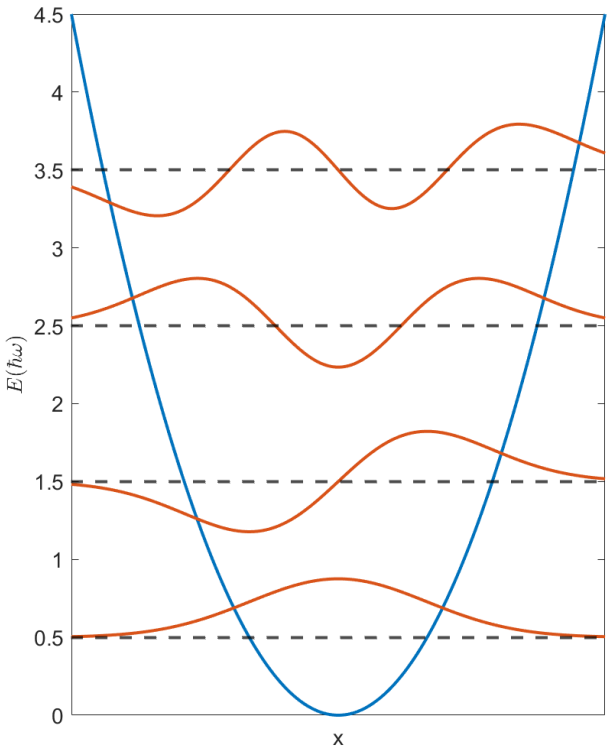
- Particle in a finite box
- Particle hitting a finite step
- Particle tunneling through a finite barrier
- How quantum tunneling is important to chemistry

Road map for today: a new model system

- Briefly lay out what we know about the classical harmonic oscillator
- Introduce the quantum harmonic oscillator, and its relevance to molecular vibrations
- Write down the Schrödinger equation for this system, and examine the resulting wavefunctions and energy eigenvalues
- Learn about some nice properties of these wavefunctions



$$V(x) = \frac{1}{2}kx^2$$



Practice Problem #1: quantum HO solutions

Consider the quantum HO wavefunction with quantum number $n = 0$:

$$\psi_0(x) = \left(\frac{\alpha}{\pi}\right)^{1/4} e^{-\alpha x^2/2}$$

Where $\alpha = \sqrt{\frac{k\mu}{\hbar^2}}$.

Show that this wavefunction solves the Schrödinger equation

$$\hat{H}\psi_n(x) = -\frac{\hbar^2}{2\mu}\frac{d^2\psi_n(x)}{x^2} + \frac{kx^2}{2}\psi_n(x) = E_n\psi_n(x)$$

and find the corresponding energy eigenvalue E_0.

Practice Problem #2: Even and odd functions

Determine whether the following functions are even, odd or neither:

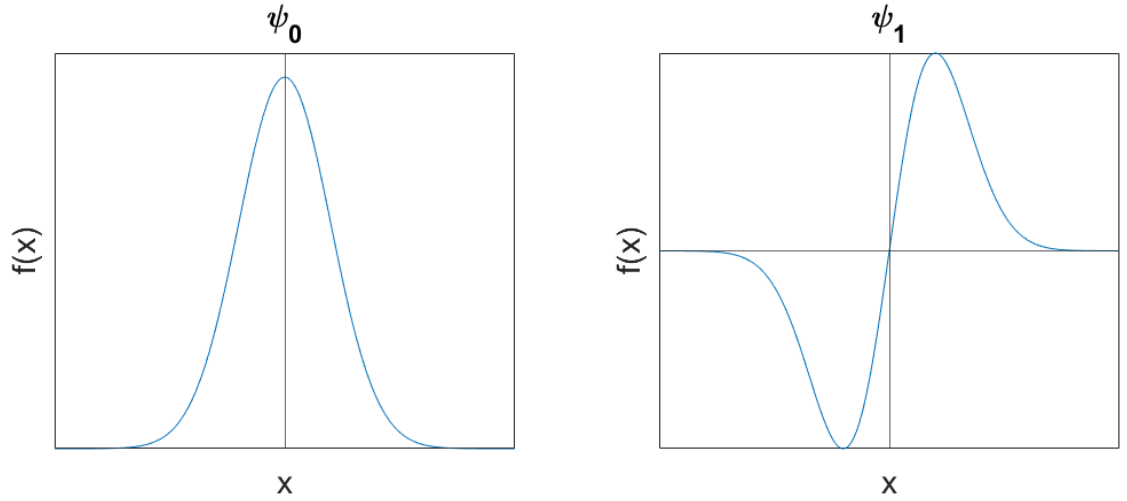
(a) $x \sin(x)$

(b) $e^{-x^2} \cos(x)$

(c) $x^2 \sin(x)$

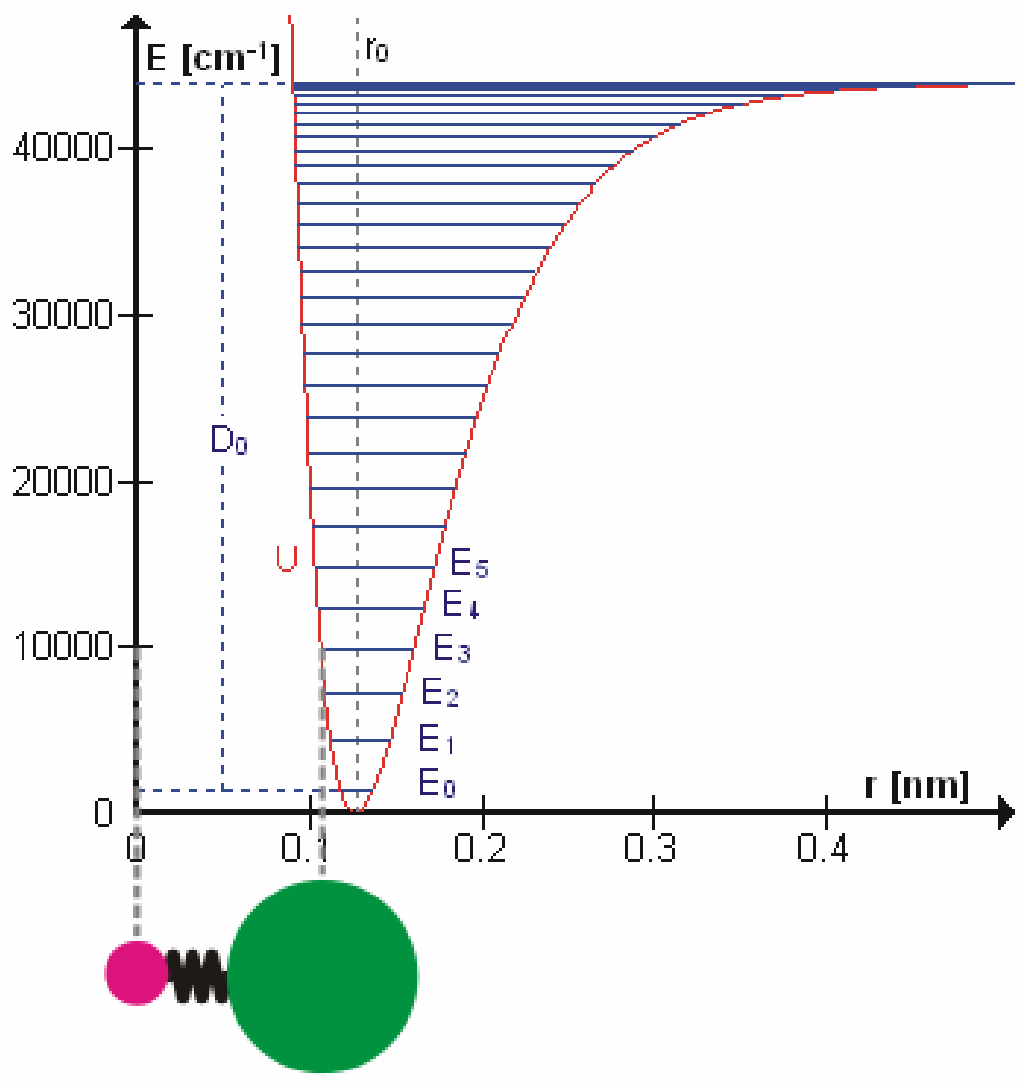
(d) e^{ix}

(e) What about the first two harmonic oscillator wavefunctions?



Wrapping up

- **Next time:** Angular momentum
- **Today's reading:** McQuarrie Ch. 5
- **Before you go:** What is your muddiest point from today's lecture?



https://en.wikipedia.org/wiki/Molecular_vibration