CH 5: 4-5

Review of Classical Bound States
And
Particle in a Box (infinite well)
Review of Classical Bound States

1. \( K + U = E \)
2. \( K \text{ cannot} \) be negative
3. \( E = 0 \) at the turning points
4. \( E < \) means bound state
A model of a particle in a box

The electric field in each capacitor exerts a force, \( F = (-e)E \), inward on the electron...

...so its potential is higher outside:
\[ U = qV = (-e)(-V_0) = eV_0 \]

\[ U = eV_0 \]

With total energy \( E < eV_0 \), the electron is bound: Its kinetic energy drops to 0 before it can reach a capacitor’s outer plate, and it returns in the opposite direction.
Ideal Particle in a box (infinite well)

\[
\frac{-\hbar^2}{2m} \frac{\partial^2 \psi(x)}{\partial x^2} + U(x)\psi(x) = E\psi(x)
\]

In the box \( U = 0 \),

\[
\frac{-\hbar^2}{2m \psi(x)} \frac{1}{\partial x^2} \frac{\partial^2 \psi(x)}{\partial x^2} = E\psi(x)
\]
Standing waves with quantized $\lambda$ and $k$:

$$k_n = \frac{2\pi}{\lambda_n} = \frac{n\pi}{L}$$

$$\psi_n(x) = \sqrt{\frac{2}{L}} \sin k_n \text{ (inside)}$$

$$\psi(x) = 0 \text{ (outside)}$$

And quantized energy

$$E_n = \frac{1}{2m} \left( \frac{n\pi\hbar}{L} \right)^2$$
1. Shows most likely location of “particle”.
2. Particle is modeled as a wave.
3. But we measure the probability density (or probability).
4. “Particle” is not moving. (These are stationary states.)
Quantum Vs. Classical Particle in a Box

**CLASSICAL**

- Ground state (lowest energy state) is $E = 0$.
- Kinetic energy can be zero.
- Particle (in ground state) is likely to be anywhere in the box.

**QUANTUM**

- Ground state is $E_1 \neq 0$
- Kinetic energy cannot be zero.
- Particle (in ground state) is most likely to be found near the middle.
An electron is confined in an infinite well, in the ground state with an energy of 0.10 eV. (a) What is the well’s length? (b) What is the probability the electron is found in the left 1/3 of the box? (c) What would be its next higher allowed energy? (d) If the electron is confined to a much larger box of $L = 1.0 \text{ mm}$, while its energy remained 0.10 eV, what would be the probability of finding it in the left 1/3 of the box? And what would be the minimum possible fractional increase in its energy?
Ch 5: 23 and 24

- DUE 22OCT15 (SAME AS TEST 2!!)