

## Homework H7 Solution

**1. Turn in** Go to the “QM demo” from lecture L4 online, and start the “1D quantum applet.” (As always, wait a minute after clicking the link, and hit “Run” when it asks you to run it.) Now solve the time-dependent Schrödinger equation using the program.

a.

**Solution:**

The amount of time it takes to do an oscillation is  $\sim 1$  second. Moving the wavefunction to higher energy, we observe that the period remains constant at  $\sim 1$  second. This directly indicates that the period of oscillation is independent of energy in the case of the Harmonic Oscillator.

We will later show that the energy levels of the harmonic oscillator are  $E_n = \hbar\omega(n + 1/2)$ , and the difference between two levels,  $E_{n+1} - E_n = \hbar\omega$  is indeed constant.

b.

**Solution:**

It is not as nicely behaved as the harmonic oscillator. The shape of the wavepacket is not maintained as it oscillates, and the oscillations do not have a constant period for different energy levels.

The harmonic oscillator or “perfect spring” with  $F = -kx$  is the only oscillator whose frequency is independent of energy. Remember, a while back you found, running the classical simulation, that a molecule vibrates ever more slowly as more energy is put into it, so its frequency decreases at higher energy.