

PHY 341 HW Ch.2b

Do problems 2.11, 2.14, 2.15[†] (see below); plus the following:

[†] For 2.15, follow the Python code discussed in class, and carry out the same computation for excited states $n = 1, 2$, and compare them with the ground state ($n = 0$) value.

q2-5

Let $\psi_0(x)$ and $\psi_1(x)$ be the normalized stationary states of the SHO. The wave function $\Psi(x, 0)$ at $t = 0$ is given by

$$\Psi(x, 0) = A(\psi_0(x) - 2\psi_1(x)).$$

- Find A that makes $\Psi(x, 0)$ normalized. Do it the easy way.
- Construct the wave function $|\Psi(x, 0)|$ and $|\Psi(x, t)|^2$. Find the oscillation frequency.
- Calculate $\langle x \rangle$, $\langle p \rangle$, $\langle E \rangle$. Results from HW **q2-2** may be helpful.
- Using a computer code from a similar problem (HW **q2-3**), plot the probability distribution $|\Psi(x, t)|^2$. For convenience, set the units such that $m\omega/\hbar = 1$ (the so called atomic units). In this unit, plot $|\Psi(x, t)|^2$ at $t = 0, 0.25, 0.5, 1, 2$, for $x = [-4, 4]$. Comment on your results.

q2-6

The wave function at $t = 0$ is $\Psi(0) = \sum_{n=0}^{n=10} c_n \psi_n$, where c_n are nonzero constants and ψ_n the stationary states of SHO. At later times t , which of the following is independent of time? Answer each as true or false, and briefly state reason.

- position, $\langle x \rangle$
- momentum, $\langle p \rangle$
- energy, $\langle E \rangle$
- potential energy, $\langle V \rangle$
- kinetic energy, $\langle T \rangle$

q2-7*

- Use a computer to graph the probability density $|\psi_0|^2$ of the ground state of the SHO. You can follow the sample SHO code at <http://jwang.sites.umassd.edu/p341/>. Mark the turning points on the graph. Estimate the probability of finding the particle in the classically forbidden region.
- Do the same for an excited state, e.g., $n = 2$. Compare with and comment on the results relative to the ground state.

<http://jwang.sites.umassd.edu/p341/>