PHY 341 HW Ch.2b

Do problems 2.11, 2.14; plus the following:

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

$$\Psi(x,0) = A(i\psi_0(x) + \frac{1}{2}\psi_1(x)).$$

(a) Find A that makes $\Psi(x,0)$ normalized. Do it the easy way.
(b) Construct the wave function $|\Psi(x,0)|^2$ and $|\Psi(x,t)|^2$. Find the oscillation frequency.
(c) Calculate $\langle x \rangle$, $\langle p \rangle$, $\langle E \rangle$ at $t=0$. Results from HW **q2-2** may be helpful.
(d) 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
(a) Generate a computer graph of the probability density $|\psi_0|^2$ of the ground state of the SHO. You can follow the sample SHO code at `https://jwang.sites.umassd.edu/p341/`. Again use atomic units (a.u.). Mark the turning points on the graph.
(b) Numerically calculate the probability of finding the particle in the classically forbidden region. Follow the Python code discussed in class.
(c) [bonus] Do the same for an excited state, e.g., $n = 2$. Compare with and comment on the results relative to the ground state.

q2-7
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.
(A) position, $\langle x \rangle$

(B) momentum, $\langle p \rangle$

(C) energy, $\langle E \rangle$

(D) potential energy, $\langle V \rangle$

(E) kinetic energy, $\langle T \rangle$