Phys 451 **Winter 2026**

Worksheet #8

(Friday, January 23, 2026)

Name

Questions (5 pts):

A quantum harmonic oscillator is in a state described by the following wavefunction: $|\Psi(t)\rangle = 1/\sqrt{2}\,(|0\rangle + e^{-i2\omega t}|2\rangle)$, where $|n\rangle$ are eigenstates of the Hamiltonian.

(a) What is the expectation value of the position operator X in this state?

$\langle \Psi(t)|X|\Psi(t)\rangle =$

(b) **If you have time:** generalize your observation to an arbitrary state $|\Psi(t)\rangle =$ norm. factor * $(c_n e^{-in\omega t}|n\rangle + c_m e^{-im\omega t}|m\rangle)$. Under what conditions is $\langle X\rangle(t) \neq 0$?