# Physics 8.321, Fall 2002
## Homework #8

Due **Monday, November 4** by 4:30 PM in the 8.321 homework box in 4-339B.

1. Sakurai: Problem 28, Chapter 2 (page 149)

2. Sakurai: Problem 29, Chapter 2 (page 149)

3. Sakurai: Problem 30, Chapter 2 (page 149)

4. Sakurai: Problem 31, Chapter 2 (page 149). Note: in part $a$, the action should be expressed as a function of the initial and final positions. In part $b$ include terms up to order $\Delta t$, but you can drop terms of order $(\Delta t)^2$.

5. Consider a simple harmonic oscillator of frequency $\omega$ which begins in the state

$$|\psi(0)\rangle = c_0 e^{\phi_0 a^\dagger} |0\rangle$$

where $\phi_0 = \alpha + i\beta$ is an arbitrary complex number and $c_0 = \exp\left(-|\phi_0|^2/2\right)$.

   (a) Solve the equation of motion for $|\psi(t)\rangle$.

   (b) Evaluate $\langle x \rangle$, $\langle p \rangle$ as functions of time.

   (c) Describe the wavefunction associated with $|\psi(t)\rangle$ in terms of modulus $\rho(x)$ and phase $S(x)$. Give the physical interpretation of the modulus and phase. Describe qualitatively what happens to the wavefunction over time. Compare with the time-development of a free particle given an initial Gaussian state.

6. Derive the propagator for the simple harmonic oscillator

$$K(x, t; x', t_0) = \sqrt{\frac{m\omega}{2\pi i\hbar \sin\left[\omega(t - t_0)\right]}} \exp\left[\frac{im\omega}{2\hbar \sin\left[\omega(t - t_0)\right]}\left((x^2 + x'^2)\cos\left[\omega(t - t_0)\right] - 2xx'\right)\right]$$