

**PHY 6645 - Quantum Mechanics I - Fall 2011**  
**Homework set # 8, due October 19**

1. Let  $H(\lambda)$  be the Hamiltonian of a system which depends explicitly upon a parameter  $\lambda$ . Consider the eigenvalues  $E_n(\lambda)$  and eigenstates  $|E_n(\lambda)\rangle$  of  $H(\lambda)$ . Show that

$$\langle E_n(\lambda) | \frac{dH}{d\lambda} | E_n(\lambda) \rangle = \frac{dE_n}{d\lambda} \quad , \quad (0.1)$$

for all  $n$ .

2. Show that the free particle one-dimensional Schrödinger equation is invariant with respect to Galilian transformations. Do this by showing that, when the transformation  $x' = x - vt$ ,  $t' = t$  is applied, the transformed wavefunction  $\psi'(x', t') = f(x, t)\psi(x, t)$ , with  $f(x, t)$  a phase factor, is a solution with respect to the primed variables if  $\psi(x, t)$  is a solution with respect to the unprimed ones. Find the phase factor  $f(x, t)$ , and show that the travelling wave solution  $\psi(x, t) = Ae^{i(xt - \omega t)}$  transforms as expected.

3. Problems 7.3.1, 7.3.4 and 7.3.6 in Shankar's book.