QUANTUM MECHANICS I

PHYS 516

Problem Set # 3

Distributed: Jan. 26, 2011

Due: Feb. 4, 2011

1. Ballentine, Problem 6.4, pg. 159.

2. Ballentine, Problem 6.6, pg. 159.

3. Coherent States: Ballentine, Problem 6.8, pg. 159.

4. Thermal Energy: $\langle (n + \frac{1}{2})\hbar\omega \rangle_T = ?$

5. Phonons: A one-dimensional lattice consists of N atoms, each of mass m, connected together with $N-1$ identical springs with spring constant k. The mean atom-atom separation is d. Assume "brick wall" boundary conditions: two extra springs attach the first and last atoms to brick walls.

a. What are the normal modes?

b. For each mode, what is the normal mode frequency ω_k?

c. Compute the mean thermal energy at temperature T.

d. Divide this energy into two parts: a part the depends on the mean excitation above the ground state; and a part that depends only on the ground state energy (it is independent of T).

e. What is the mass-density equivalence of the ground state energy density? (Hint: $\rho c^2 = \sum_k \frac{1}{2}\hbar\omega_k / \left[(N+1)d\right]$.)