PHYS 6107, Homework 3, Due Friday 02/06/09 at 5pm

1. Derive Eq. (3.58) and redo exercises 3.8, 3.9.

2. Read section 4.5 (The Enthalpy) and redo exercise 4.7 and 4.8.

3. A building at temperature T is heated by an ideal heat pump which uses the atmosphere at temperature T_o as heat sources. The pump consumes power W and the building loses heat at a rate $\alpha(T-T_o)$. What is the equilibrium temperature of the building?

4. For a simple magnetic system, if temperature T is held constant, it is found that if magnetic field increase from H to H+dH, the entropy changes by
$$dS = \frac{-CH\,dH}{T^2} \quad .$$
Use one of the Maxwell relations to calculate how the magnetization M depends on T.

5. A random variable x can have any value in the interval (0,a). It has uniform distribution function P(x) given by
$$P(x) = \begin{cases} C & \text{if } \cdot < x < a \\ 0 & \text{if } x < 0 \text{ or } x > a \end{cases} \quad .$$
What is the value of the constant C? Calculate the mean, variance, skewness and curtosis of this distribution.

6. The lattice gas is a very simplified model of gas. In this model the total volume available to the gas is divided into V cells. Each cell is very small so that it can either be empty or occupied by one particle. The total number of particles is N << V.
   a. Calculate the number of microscopic states Ω (V,N) of this systems.
   b. Calculate the entropy per particles S/N in the thermodynamic limit ($N \to \infty$).
   c. Obtain an expression for the equation of state P/T. Write an expansion of P/T in terms of the density N/V.
   d. The gas is brought into contact with a particle reservoir with chemical potential μ and temperature T. Which thermodynamic potential is extremized in equilibrium? What is the value of N after equilibrium? Assuming the particles are non-interacting.

7. Redo exercise 6.2 (this exercise shows that the hardest step in microcanonical ensemble calculation is the proper counting of microstates).
Note: you're allowed to use the identity:
$$\int_{\sum_{i=1}^{n} |x_i| \leq 1} d^n x = \frac{2^n}{n!}$$
to avoid unnecessary derivations.