Physics 410 - 2004
Thermal Physics

Problem Set 1

1. A particle of mass \( m \) is confined in a cubic box of size \( L \). The potential energy has the form

\[
U(x, y, z) = \begin{cases} 
0, & 0 < x, y, z < L \\
\infty, & \text{otherwise}
\end{cases}
\]

Find the 4th, 5th, and 6th energy levels in Fig. 1.2 of the textbook, p. 9 (3 pt). Consider a particle in a square box of size \( L \). Find the lowest 4 energy levels and their multiplicities. (3 pt)

2. Consider the problem of flipping a coin. Prove that the probability that heads turn up \( n \) times if the coin is flipped \( N \) times is

\[
p_n = 2^{-N} \frac{N!}{n!(N-n)!}, \quad n = 0, 1, \ldots, N
\]

(6 pt).

3. The probability density for a classical harmonic oscillator of mass \( m \) and angular frequency \( \omega \) to be at a distance \( q \) from the minimum of the potential energy is

\[
p(q) = C \exp\left[-\frac{m\omega^2q^2}{2k_BT}\right],
\]

where \( T \) is temperature and \( k_B \) is the Boltzmann constant. Find the constant \( C \) (4 pt). Find the probability for an oscillator to be within the interval \((2k_BT/m\omega^2)^{1/2} < q < (3k_BT/m\omega^2)^{1/2}\) (6 pt).

You need to have 20 points out of 22 (2 points are extra credit).