Physics 3374/6351 Professor Scalise
Homework Assignment #9 Fall 2022

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1. Read Schroeder section 7.4. Did you read all the pages?

2. For the system on homework #7 of three distinguishable marbles (red, white, and blue) each of mass m which may be found on any step of a staircase whose steps are a distance h apart, now the energy is not specified but the temperature T is.

   (a) What kind of ensemble is this?

   (b) What temperature T of a heat bath will maximize the probability of finding all three marbles on the first step above ground level?

   (c) What is this maximum probability?

3. Show that for a one-dimensional random walk

   (a) the root-mean-square displacement is $\sigma_d = 2\sqrt{Npq}$. Show all the steps.

   (b) If $p = \frac{1}{2}$, find $< d >$, $< d^2 >$, $< d^3 >$, and $< d^4 >$. Show all the steps, not just the answers.

4. (a) The Gaussian approximation to the binomial distribution is excellent for large N and surprisingly good for small N, especially if p is close to $\frac{1}{2}$. To illustrate, calculate the probabilities for $N = 4$, $p = \frac{1}{2}$, and $0 \leq n \leq 4$ both exactly and using the Gaussian approximation. Compare the results.

   (b) What is the probability of getting exactly 70 heads if you toss a fair coin 100 times? (Use the Gaussian.)

   (c) What is the probability of getting at least 70 heads if you toss a fair coin 100 times? (Use the Gaussian.)

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1. Consider an assembly of N distinguishable quantum harmonic oscillators (QHOs) in thermal equilibrium at temperature T. Each QHO is characterized by angular frequency ω.

   (a) What is the mean energy of the assembly?

   (b) What is the heat capacity of the assembly?

   (c) What is the heat capacity in the limit $k_B T >> \hbar\omega$?

   (d) Plot the heat capacity versus temperature.

Bonus: Solve as much of the other class' assignment as you can.