Physics 3374/6351 Professor Scalise
Homework Assignment #6 Fall 2024

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1. Read Schroeder chapter 6. Did you read all the pages?
2. Work out the two exam problems that you omitted and any problems that you answered incorrectly.
3. In regard to the Maxwell speed distribution, you might wonder why all the molecules in a gas in thermal equilibrium don't have exactly the same speed. After all, when two molecules collide, doesn't the faster one always lose energy and the slower one always gain energy? And if so, wouldn't repeated collisions eventually bring all the molecules to some common speed? Describe an example of an elastic billiard ball collision in two dimensions in which this is not the case: the faster ball gains energy and the slower ball loses energy. Include numbers and be sure that your collision conserves both energy and momentum.
4. (a) Derive the Maxwell speed distributions in one and two dimensions.
   (b) What is most likely speed in each case?
   (c) What is average speed in each case?
   (d) What is root-mean-square speed in each case?
5. A thick coin has equal probability of landing on its head (H), its tail (T), or its side (S). If three distinguishable thick coins are flipped,
   (a) How many microstates are there? Show them explicitly.
   (b) How many macrostates are there? Show them explicitly.

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1. Find $(\partial V/\partial T)_{Pn}$ for the van der Waals gas, whose equation of state is
$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT,$$
where n is the number of moles.
2. Treat the problem of N paramagnetic atoms in an external magnetic field B in contact with a heat bath at absolute temperature T classically, that is not quantum mechanically. Each atom has magnetic dipole moment μ, but the angle θ that the spin makes with the external magnetic field can take any real value between 0 and π.
   (a) In the absence of an external magnetic field, what is the probability that the angle for a single spin lies between θ and $\theta + d\theta$?
   (b) Find the partition function Z.
   (c) Find the average magnetization M as a function of absolute temperature.
   (d) Compare to the answer for a quantized spin-$\frac{1}{2}$ from lecture.

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