BM4040 Mechanobiology

Problem set 5

Instructions

• You are not expected to submit answers to these problems.

Questions

- 1. Two dice are rolled, each of which can generate a number between 1 and 6. Consider this a statistical system.
 - (a) How many microstates are there for this system? How many macrostates are there?
 - (b) What is the density of states, Ω , for each macrostate?
 - (c) What is the probability of each macrostate if the dice are rolled many times?

Now suppose that the "fair" dice are substituted with a pair of "loaded" dice. In the loaded dice there is a small weight placed under the 1 spot. This makes the probability of getting a 6 slightly higher than 1/6, and the probability of getting a 1 slightly lower than 1/6. Assume that the amount of this bias is a small number, ϵ . Now, what is the probability of each macrostate?

- 2. Consider 100 people in a building. Every time a person moves up one floor, it takes them 1 k_BT of energy. Assume that given enough time the people distribute themselves according to Boltzmann's distribution.
 - (a) How many people are on each floor on average?
 - (b) How tall does the building need to be to accommodate this average distribution of people?
 - (c) How tall would it need to be if there were 10 people? And if there were 1000 people?
- 3. Consider a mechanosensitive ion channel that can be in one of two states: open or closed. Define the energy of the channel using a configuration parameter σ that can be equal to 0 (closed) or 1 (open). The energy is

$$U = \sigma \varepsilon_{\text{open}} + (1 - \sigma) \varepsilon_{\text{closed}} + \tau \Delta A$$

where $\varepsilon_{\text{open}}$ and $\varepsilon_{\text{closed}}$ are the energies of the channel in the open and closed configurations, τ is the tension applied to the channel, and ΔA is the change in area of the channel in going from closed to open.

- (a) Write the expression for the partition function.
- (b) Calculate the probability of the channel being in an open state.
- (c) Estimate the average energy.

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