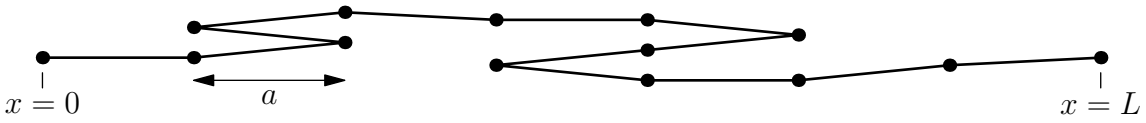
M99T.2—Polymer Chain

Problem

As a model of rubber, consider a polymer of N molecules of length a, connected end to end. One end of the molecular chain is fixed at $x = 0$. Assume the molecules may be oriented only parallel to the x-axis, and that the energies of all the configurational states are equal. The chain is kept at fixed temperature T by contact with a heat bath.



a) What is the entropy of the chain when one of its ends is at $x = 0$ and the other end is at $x = L$.

b) What is the tension in the chain when it is stretched to length L, with $L \ll L_{max} (= Na)$?

c) For N large, how much work is required to stretch the chain from its rest configuration to length $L \leq L_{max}$?

d) During the stretching process - does the heat bath absorb, or yield, heat? (Explain your answer.)