

# Chemical physics of polymer solutions

## Exercise 3

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DNA is a semiflexible polymer having a persistence length  $l_p \simeq 50$  nm. Consider the molecule as a three-dimensional chain containing  $N$  freely-jointed segments of length  $l_p$  each. Suppose that one end of the chain is fixed at the origin and the other end is pulled with force  $f$  in the  $\hat{x}$  direction. The chain is in contact with a thermal bath of temperature  $T$ .

1. Calculate the partition function of the chain. Note that the problem is analogous to that of  $N$  non-interacting dipoles under external field.
2. Find the free energy.
3. Calculate the mean extension of the chain in the direction of pulling,  $\langle x \rangle$ . What is the value of  $\langle x \rangle$  for very small  $f$ ? Compare to Exercise 1, Question 1. What is  $\langle x \rangle$  for very large  $f$ ?
4. What is the force required to get  $\langle x \rangle$  which is one half the total length of the chain at room temperature?