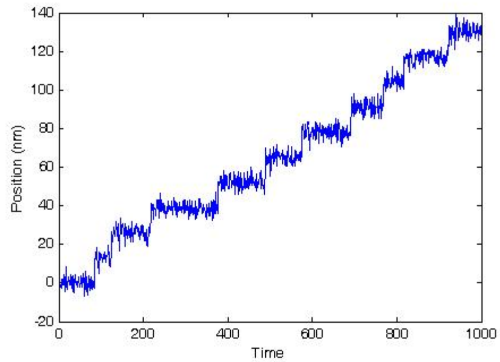
Molecular, Cellular & Tissue Biomechanics, Fall 2006

20.310/2.797J/6.024J/3.053

Problem Set # 4

Problem 1: From the force-clamped stepping trace below, which you can find on the stellar web-page, generate a pairwise difference distribution (1 or 2nm bins will likely work well for this) and plot this out. From this distribution, plot the corresponding spatial frequency and identify the step size. You can obviously see the steps in the trace below so compare your result to what you get by eye.



Problem 2: The following graph shows a plot containing many points where the value of k_{off} as a function of force for receptor ligand bonds for selectin tethers has been determined. According to the points in the graph, determine the length scale of the distance to the transition state δ_{100} for tether unbinding. Assume the unloaded k^0_{off} is 1/s.

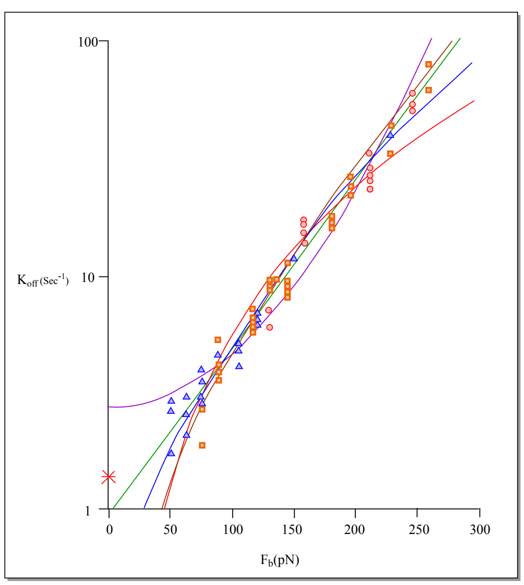
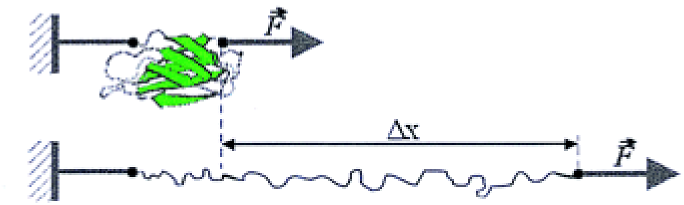


Figure by MIT OCW.

Problem 3: For the protein below, it is observed that the spontaneous zero load unfolding rate is $4x10^{-4}$/s and the refolding rate is 2/s. If you apply a force to unfold the protein (at low loading rates) you notice that for the rate to drop an e fold, you need 15pN. Assuming the reaction coordinate spans a distance of zero representing the folded state to disordered contracted polymer of 2.5nm and assuming an Eyring rate mechanism, draw the corresponding reaction coordinate. What is the distance to the transition state for unfolding? What is the force required to drop the re-folding rate by an e fold?



Problem 4: You performed the following calibration experiments at room temp, 25°C for an optically trapped 0.97μm diameter bead that is free in solution:

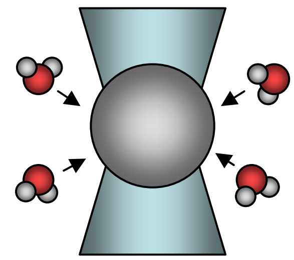


Figure 1

X displacements of the trapped bead, in nm, were gathered for some time in "stationary" water. Fluctuations in position are due to random bombardment of water molecules such as those shown in, figure 1.

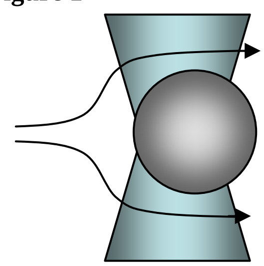


Figure 2

Towards the end of the data acquisition, the fluid chamber surrounding the bead was moved along the "x" direction at a constant velocity of 0.15μm/ms, figure 2.

Data from an actual experiment, BE310_Calib.txt, can be found on the course website.

a) Modeling the optical trap as a Hookean spring, calculate the trap stiffness using the equipartition method, calculate the stiffness using Stokes drag. Compare the two values.

b) Estimate the kinesin stall force from the lower data trace below.