BM4040 Mechanobiology

Problem set 4

Instructions

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

Questions

1. Calculate the mean displacement and mean squared displacement of a Brownian particle using the overdamped Langevin equation
$$m\frac{dx}{dt} = f.$$
2. Calculate the mean displacement and mean squared displacement of a Brownian particle using the Diffusion equation
$$\frac{\partial \rho(x,t)}{\partial t} = D\frac{\partial^2 \rho(x,t)}{\partial x^2}$$
where $\rho(x,t)$ denotes the density at position x at time t.
3. Estimate the time it would take oxygen molecules to diffuse in water ($D = 1.8 \times 10^{-5}$ cm^2/sec) at room temperature a distance equal to
   (a) the typical size of a bacterium
   (b) the typical size of a human being

   Verify that the diffusive transport of oxygen from the environment to the lungs is not an alternative to oxygen transport by red blood cells. Do you expect that an oxygen molecule in air diffuses much slower or much faster than in water?
4. A spherical Brownian particle with a radius of $a = 100$ nm and a mass density of 1.8 g/ml is immersed in water, with a viscosity equal to $\eta = 0.001$N-s/m^2. Use relation $\gamma = 6\pi\eta a$ for the friction coefficient to calculate the time m/γ and the diffusive length scale i.e. Dm/γ. Calculate the time at which the mean squared displacement is equal to a^2.