11th March 2014

Course: Biophysics
Problem Set: 4
Due: 27th March 2014

5.4 *Coasting at low Reynolds*

The chapter asserted that tiny objects stop moving at once when we stop pushing them. Let's see.

a. **Consider a bacterium, idealized as a sphere of radius 1 μm, propelling itself at 1 μm s^{-1}. At time zero, the bacterium suddenly stops swimming and coasts to a stop, following Newton's Law of motion with the Stokes drag force. How far does it travel before it stops? Comment.**

b. **Our discussion of Brownian motion assumed that each random step was independent of the previous one; thus, for example, we neglected the possibility of a residual drift speed left over from the previous step. In the light of (a), would you say that this assumption is justified for a bacterium?**

5.5 *Blood flow*

Your heart pumps blood into your aorta. The maximum flow rate into the aorta is about 500 cm^3 s^{-1}. Assume that the aorta has diameter 2.5 cm, that the flow is laminar (not very accurate), and that blood is a Newtonian fluid with viscosity roughly equal to that of water.

a. **Find the pressure drop per unit length along the aorta. Express your answer in SI units. Compare the pressure drop along a 10 cm section of aorta with atmospheric pressure (10^5 Pa).**

b. **How much power does the heart expend just pushing blood along a 10 cm section of aorta? Compare your answer with your basal metabolic rate, about 100 W, and comment.**

c. **The fluid velocity in laminar pipe flow is zero at the walls of the pipe and maximum at the center. Sketch the velocity as a function of distance r from the center. Find the velocity at the center. [*Hint:* The total volume flow rate, which you are given, equals $\int v(r) 2\pi r \, dr$.]**