Homework for Chapters 6 and 7

Due: Friday, October 7 before 12:00, midnight
Submit to Derek.Dosdall@carma.utah.edu

Chapter 6: Propagation

1) A cylindrical fiber is represented by the core- conductor model. The upstroke of the transmembrane potential is given by a template function as $V_m(x) = 50 \tanh(x)$ (x in mm). The fiber's radius is a, and the intracellular and extracellular resistances are r_i and r_e. (Note that r_i and r_e are in "unit length" form.) V_m is understood to be the spatial distribution of V_m at one moment during propagation of an action potential. At this time, which is after propagation began, there are no stimuli. Give the mathematical expression for the answer, and plot normalized wave shapes, (wave shapes having peaks scaled to ± 1), for each part below.

a. Plot $V_m(x)$ from x of –4 to 4 mm. Which direction would this action potential be moving?
b. Find and plot $I_i(x)$. At its peak, which is the direction of the current?
c. Find and plot $I_e(x)$. At its peak, which is the direction of the current?
d. Find and plot $I_m(x)$. Interpret the sign of the peaks in relation to the direction of AP movement.

Chapter 7: Stimulation

3) This question is about an idealized spherical cell. Investigation of the response to stimuli of the spherical cell used transmembrane stimulation, with a current source inside the cell and current sink outside. Spherical symmetry was preserved. The cell responded according to the model described in the text. With a long stimulus, the lowest stimulus current that would produce an action potential had magnitude 10 μA/cm^2, and the transmembrane voltage at the end of that stimulus was 20 millivolts. Moreover, the membrane was found to have a time constant of 2.4 msec. Using shorter stimuli, the investigator set a stimulus duration and then carefully tried stimuli of different current magnitudes until the current was found that produced, at the end of the stimulus, the threshold voltage for an action potential. What stimulus current is needed for a stimulus duration of 0.2 msec, if other results were as shown in the table? Give a numerical answer, in μA/cm^2. Please show your work.

Duration (ms)	Current (μA/cm^2)
1	29.346
3	14.015