Assignment 1: Review of circuits in Engineering and Neuroscience
Professor: Eric Schwartz – EC500

Outline and review: The engineering(physics) method of circuit analysis assigns positive voltages V_0 to batteries, but the voltage drop across a battery depends on the direction of ”stepping” across the battery. This was gone over in class, and is summarized on the wiki link ”Multi-loop Circuits”.

If one steps from the negative side to the positive side of a battery, the voltage difference is V_0, (remember that we subtract the ”after” voltage from the ”before” voltage to get the voltage ”change”). If we step across the battery from the positive side to the negative side, the voltage is $-V_0$. If we step across the resistors in the direction of the current we (arbitraily) assigned, then the voltage change is negative. If we step across the battery against the direction of the current we arbitrarily assigned, then the voltage change is positive. Note that the physical direction of the flow of (positive) current is always from higher to lower voltage. So, there are two kinds of ”directions” involved: the first is the way you ”walk” around the loop, which is either clockwise or counterclockwise. The final answer will be the same (of course), but the intermediate results will have their signs flipped. The other kind of direction is that which you arbitarily assigned to the edges of the circuit.

Unfortunately, the method of circuit analysis taught in Neuroscience contexts (e.g. Kandel and Schwartz) uses a different set of conventions. If you learned this way, then you need to make sure that you are not confused by any of this. To make sure do this: write out a simple circuit with one battery and one resistor. You know in advance that the solution will be $|I| = V_0/R$. You can solve this simplest form of circuit by choosing from the set of two directions for the current (i.e. physical or anti-physical), and two directions of”walking” around the circuit: clockwise or anticlockwise. Also, you could choose two ways to hook up the battery of voltage V_0. This gives eight possible solution configurations. If you feel totally on top of this problem, then go on to solve the homework problem below. If you are at all shaky about these issues, then work out all eight ways of solving this circuit, and make sure they all agree with physical intuition. Do not hand in this preliminary exercise.

Problem Page 12 of Chapter 7 of Kandel and Schwartz(4th Edition,

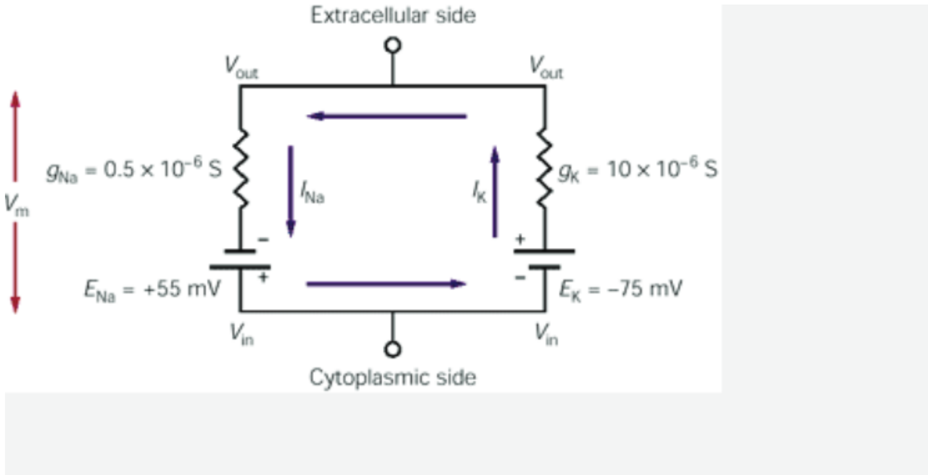

Figure 7-11 This electrical equivalent circuit omits the Cl^- pathway and Na^+-K^+ pump

Figure 1: Simplifed Neuron Equivalent Circuit from Kandel and Schwartz.

available on the wiki) presents a simple version of a "Neural Equivalent" circuit (Figure 7-11), composed of a sodium conductance, a potassium conductance, a sodium "battery" and a potassium "battery".

The values of the conductances and batteries are given in the figure, reproduced below, but the potassium battery is given as $-75mV$. Solve this circuit to find the membrane voltage, which is the difference in potential between the cytoplasmic and extracellular side (or $V_{intracellular}$ and $V_{extracellular}$. The result is about $-69mv$

Write out the solution method used in Kandel-Schwartz, as shown in equations 7-1 through 7-3.

Now, solve this circuit using engineering style circuit analysis, where all batteries are specified by positive numbers , i.e. b_{Na} is $+55mv$ and b_K is $+75mv$ and currents are treated vectorially (as done in class, and summarized in the readings on the wik).

Indicate where the sign differences in the solutions occur, even though the end results are the same. Briefly comment on this state of affairs.