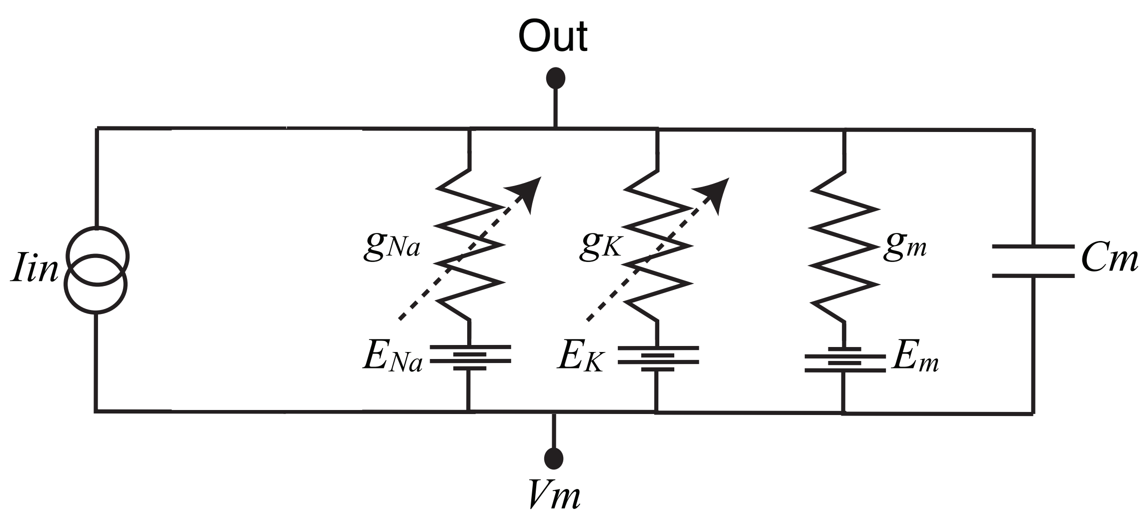
Introduction to Computational Neuroscience
Lab 1: Model Neurons: Neuroelectronics

In this lab you will simulate a single compartment neuron in Matlab using the parallel conductance model shown below. The geometry of the neuron is a sphere 10 um in diameter. All the Matlab files are provided except for the Na and synaptic current.

In main.m, the parameters for the simulation are specified in the structure p. You will modify the parameters of the model by setting the appropriate fields in p. All conductances are in S per area (cm^2) and all currents are in mA per cm^2 (except for Iin).

The code for creating the plots are in main.m and you can modify these as necessary.

All conductances are initially set to zero except for the passive membrane conductance g_m.



1) Passive model

Set the parameters of the simulation to generate a 250 msec 0.5 pA current pulse. Plot the time course of the current injection and the membrane potential.

From the response of the membrane potential, what is the estimated membrane time constant?

From the passive membrane parameters, what is the actual membrane time constant (use the eye-ball method)?

Change the sign of the current injection and plot Vm. Is the effect of the current injection depolarizing or hyperpolarizing? What is the membrane time constant for the negative current injection (use the eye-ball method)?

2) Effects of a voltage-dependent K conductance K_{DR}

Add in the delayed rectifier K conductance by setting the maximal conductance to 4 mS / cm^2.

Plot Vm in response to a 250 msec 0.5 pA current pulse.

What is the membrane time constant now (use the eye-ball method)? Explain why it changed.

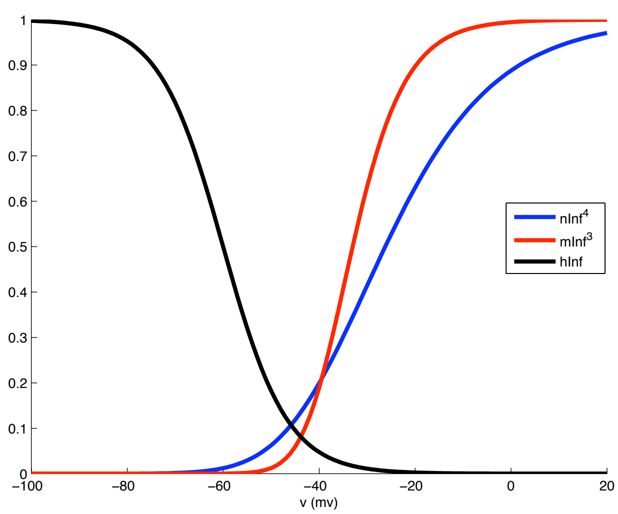
What is is the membrane time constant for a negative current injection of –0.5 pA (use the eye-ball method)? Is it different? If so, explain why.

3) **Add in a voltage-dependent Na conductance to produce action potentials**

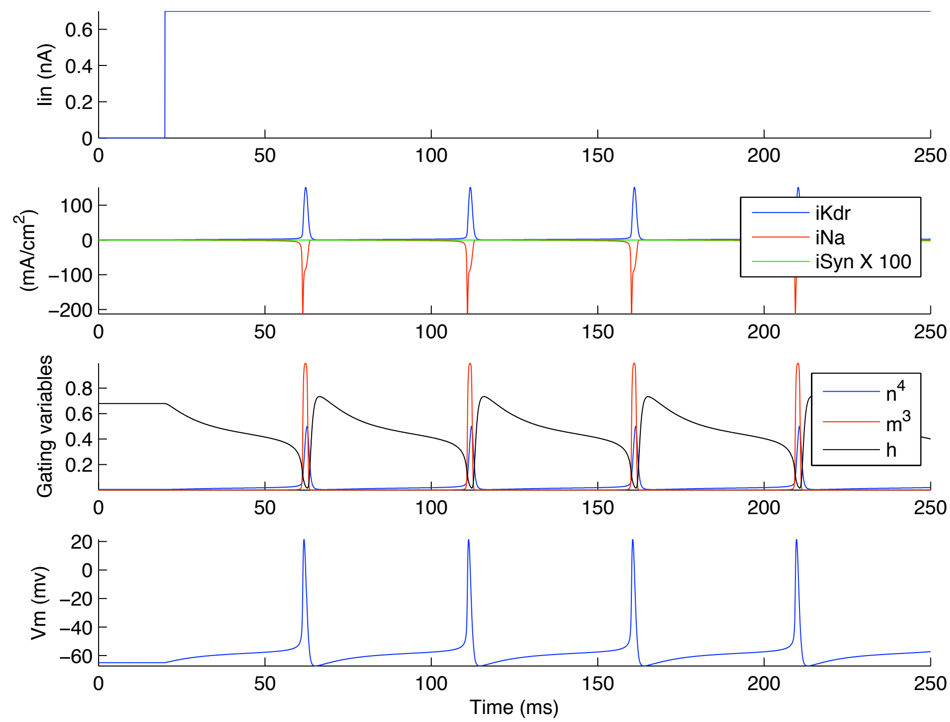
Using Kdr.m as a guide, modify the function Na.m to produce the voltage-dependent Na current:

$i_{NA} = g_{Na}Bar\ m^3\ h\ (Vm - E_{Na})$

where m and h are H&H-like time and voltage dependent gating variables. The taus are already specified in Na.m and the steady-state activation are shown below. Fit the steady-state curves below by eye. Use the mainPlotGaitngFunction.m to generate the plot below.



Next, set the maximal Na conductance to around 80 mS/cm^2. Inject a depolarizing current to produce a few action potentials similar to the ones below. You may have to adjust the maximal Na conductance to get your action potentials looking good.



Adjust the injected current to produce three or four action potentials as shown above and hand in this plot. Your model may not be exactly the same as shown here because your steady state activation functions will likely be a little different than those above.