BME/ECE 4784 Modeling Project
Phase I: Hodgkin Huxley Model
Due: September 29th, 2014

Project Description: You will develop a computational model using the Hodgkin Huxley neuron model (see attached original paper). At the end of this phase of the modeling project, you will be able to translate a set of equations into a functioning computational model and use the model to answer questions about the biophysics of the cell.

Tools: You are allowed to use Julia, MATLAB, Python, C/C++, or SPICE for this assignment. If you wish to use a tool/framework other than these, please contact Yogi for approval.

Deliverables: The following deliverables should be turned in by 5PM on the due date above.

1. *Report:* The documentation needs to have the following three sections.
   (a) Include a summary statement (no more than 2 paragraphs) describing how the model and the biology correlate (ie why are certain elements used to represent channels? why is the membrane represented as capacitor?).
   (b) Include a link to your GitHub repository.
   (c) A detail description of the framework you choose to use for your model (include software version) and how your code should be run need to be included in the documentation.
   (d) Answers to the question and requested figures with proper figure captions and axis labels with units (on next page).
2. Code:
   (a) All students will be **required** to use a GitHub (github.com) repository for development of their models.
   (b) The commit history for this repository will be used to assess the effort put into this model.
   (c) All code must be commented.
   (d) How to run your code must be thoroughly documented in the documentation section (see above).

Grading: This phase of the project will count for 10% of your grade (out of full 30% for the project) and will be out of 100 points. 60 points are allocated to the Report and 40 points are allocated to your Code. Late submissions will result in a loss of 5 points per day.

Submitting Projects: Upload a PDF of your Report to T-Square by 5PM on the due date above. Late submissions will result in a loss of 5 points per day.

Asking for Help: I am here to help you learn - so please do not hesitate to ask for help. Requests for help 48 hours prior to the project deadline will not be acknowledged - so please start early and ask for help early. When asking for help, please provide the following:

1. what framework are you using?
2. what is the specific issue you are stuck on?
3. update your repository with your latest code to enable fast turn around times

Standard simulation parameters, constants, and equations to use: All standard constants, equations, and simulation parameters are listed on the next page. Please pay attention to units. Please use Eulers method to solve the system (see recitation notes from 2014.09.10 for more information).

Simulation parameters:

- Total simulation time: $100\ ms$

Constants:

- $\bar{g}_K$ = $36\ mS/cm^2$
- $\bar{g}_{Na}$ = $120\ mS/cm^2$
- $\bar{g}_L$ = $0.3\ mS/cm^2$
- E_K = $-12\ mV$
- E_{Na} = $115\ mV$
- E_L = $10.6\ mV$
- V_{rest} = $-70\ mV$

Equations:

Gating variables:

- α_m = $0.1*((25-V_m)/(exp((25-V_m)/10)-1))$
- β_m = $4*exp(-V_m/18)$
- α_n = $.01*((10-V_m)/(exp((10-V_m)/10)-1))$
- β_n = $.125*exp(-V_m/80)$
- α_h = $.07*exp(-V_m/20)$
- β_h = $1/(exp((30-V_m)/10)+1)$

Currents:

- I_{Na} = $m^3*\bar{g}_{Na}*h*(V_m-E_{Na})$
- I_K = $n^4*\bar{g}_K*(V_m-E_K)$
- I_L = $g_L*(V_m-E_L)$
- I_{ion} = $I-I_K-I_{Na}-I_L$

Derivatives:

- dV_m/dt = I_{ion}/C_m
- dm/dt = $\alpha_m*(1-m)-\beta_m*m$
- dn/dt = $\alpha_n*(1-n)-\beta_n*n$
- dh/dt = $\alpha_h*(1-h)-\beta_h*h$

Euler's method:

- y_{n+1} = $y_n+h^*f(t_n,y_n)$

Questions to answer: Your written report should include figures (along with the written descriptions) for each of the following questions. *Example* figures are provided below.

1. Simulate a steady-state neuron with the resting membrane potential described above and provide figures for the membrane potential and g_{Na}/g_K for the duration of the simulation (hint: this is a steady-state simulation - so nothing should happen and the membrane potential should not deviate from rest - at all.)

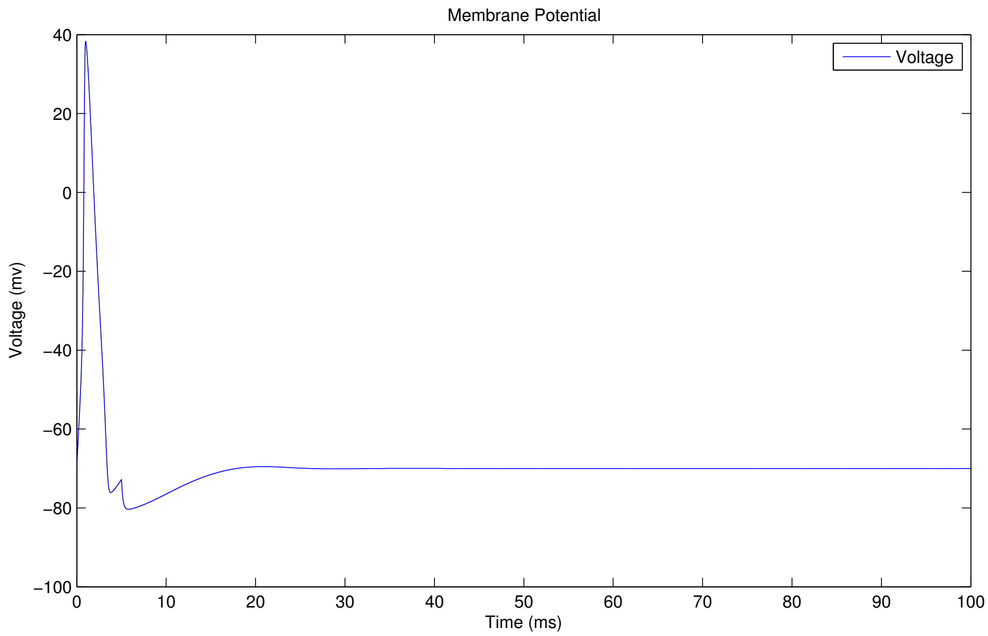
2. Neurons die when not stimulated. To prevent your model neuron from dying, you decide to stimulate the model neuron with a step pulse of 5 μA/cm^2 for 0.5 ms. How does the model respond (provide figures of membrane potential and channel conductances)? Explain your results in 3-5 sentences.

3. You just drank a 5 hour energy or had a few espresso shots. Your neurons are hyper. Now, instead of there being a step pulse to simulate your model neuron, you provide a constant current of μA/cm^2 for the duration of the simulation. How does the model respond (provide figures of membrane potential and channel conductances)? Explain your results in 3-5 sentences.

4. Describe your experience designing this model in 3-5 sentences. What points were difficult? What was easy? What did you learn from this process?

Example figures:

1. **Membrane potential.**



2. **Conductances.**