An introduction to the 1st project

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1^{st} question

1- Write a function named ode_euler which will implement a method to solve the sample differential equation. The first argument of this function shoul be a function handle to a differential equation (see the follwoing example for a sample example of f=X^2+1)

$$\frac{df}{dx} \approx \frac{f(x+\Delta x)-f(x)}{\Delta x} \Rightarrow f(x+\Delta x) \approx f(x) + \Delta x * \frac{df}{dx}.$$

2nd question

2- Write a function n_prime(t, V) that calculates the derivative of n at the point t given that the membrane potential is V.
Hint: Note that you have to modify the first line of ode_euler() so that it takes an additional input argument, V, and line 24, so that feval() takes three arguments, a function handle such as @n_prime and two additional input arguments, t and V, to the function referred to by the function handle

$$\alpha_n = \frac{0.01(10 - v_m)}{\left[\exp\left(\frac{10-v_m}{10}\right) - 1\right]}$$

$$\beta_n = 0.125 \exp\left(\frac{-v_m}{80}\right)$$

$$\tau_n(V) = \frac{1}{\alpha_n(V) + \beta_n(V)}$$

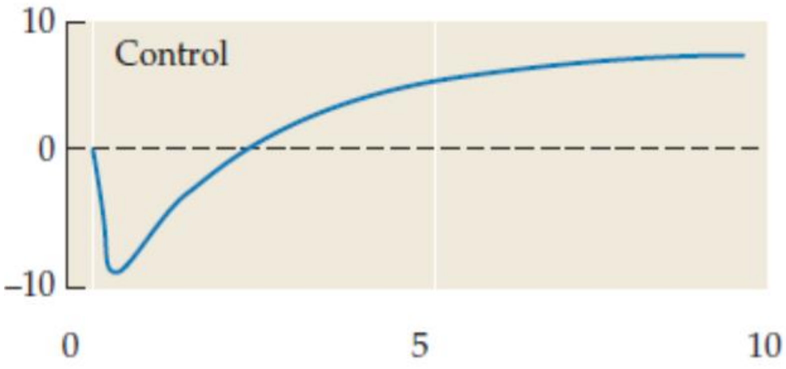
$$n_\infty(V) = \frac{\alpha_n(V)}{\alpha_n(V) + \beta_n(V)}$$

$$\frac{dn}{dt} = \alpha_n(V)(1-n) - \beta_n(V)n$$

$$n(t) = n_\infty - (n_\infty - n_0)e^{-t/\tau_n}$$

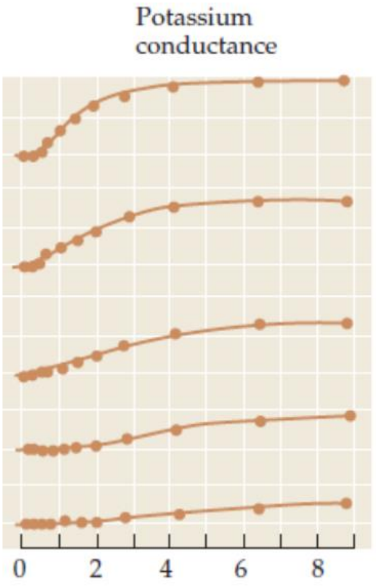
3rd question

3- Write a function called K_v(t, V) that takes a time interval t and a holding potential V and returns the current response of a K^+ channel over the time range specified by t.



4th question

4- Use K_v to plot the current response of a K^+ channel when the membrane potential is clamped to –30 mV. Repeat this for holding potentials from –40 mV to 70 mV in 10 mV increments, and plot the solutions on the same graph.



5^{th} question

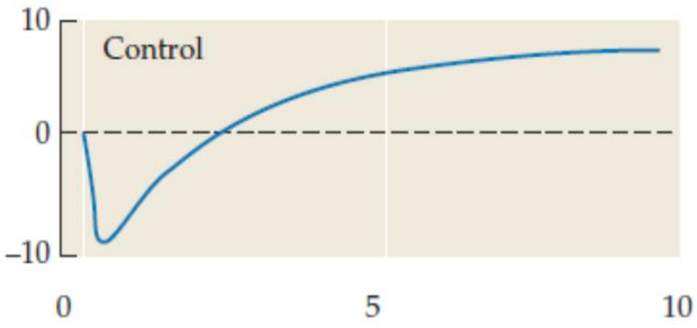
5- Write functions m_prime(t, V) and h_prime(t, V) that calculate the derivative of m and h at the point t given that the membrane potential is V. This will be completely analogous to the code for n_prime.

$$\frac{dm}{dt} = \alpha_m(V)(1 - m) - \beta_m(V)\mathrm{m}$$

$$\frac{dh}{dt} = \alpha_h(V)(1 - h) - \beta_h(V)h$$

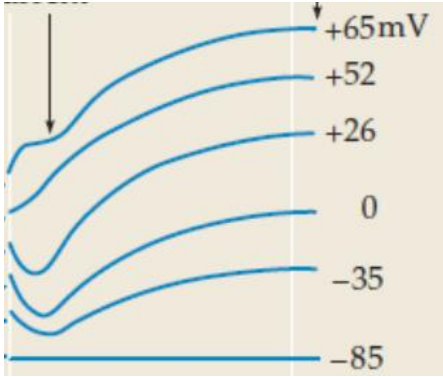
6th question

6- Write a function called Na_v(t, V) that takes a time interval t and a holding potential V, and returns the current response of a Na^+ channel over the time range specified by t. Hint: Na^+ should call ode_euler twice, once with the inputs @m_prime, t, m_o, and V and another with the inputs @h_prime, t, h_o, and V



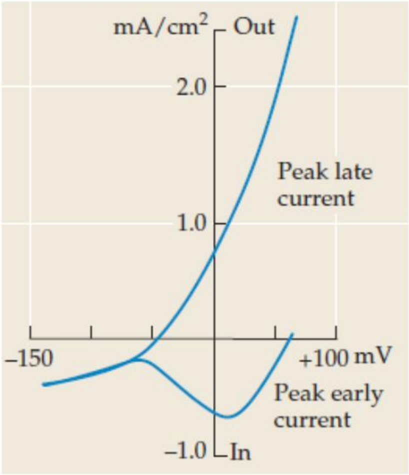
7th question

7- Use Na_v to plot the current response of an Na^+ channel when the membrane potential is clamped to –30 mV. Repeat this for holding potentials from –40 mV to 60 mV in 10 mV increments, and plot the solutions on the same graph.



8th question

8- Plot peak current for different voltages and determine peak late current and peak early current.



9th question – part a

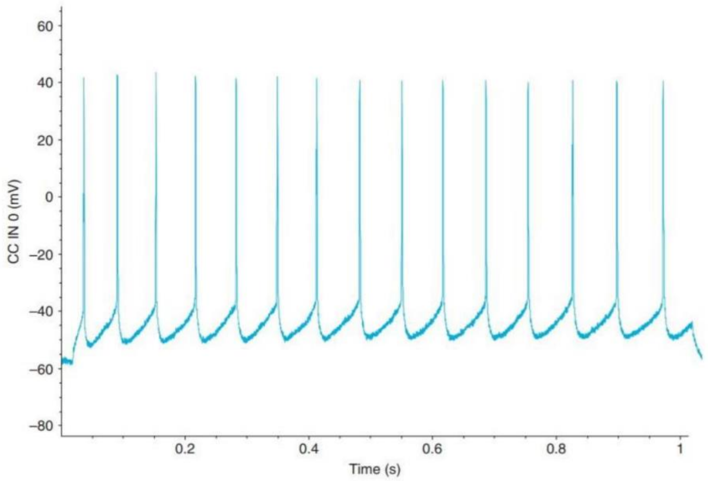
9-

a) Write a function hodgkin_huxley(t, I_inj) that takes a time series t and a constant representing injected current and returns the value of V at every point in t.

$$C_m \frac{dV_M}{dt} = -\bar{g}_{Na} mh(V_M - E_{Na}) - \bar{g}_K n(V_M - E_K) - g_L(V_M - E_L) + I_{inj}$$

9th question – part b

b) Indicate how the action potential generated by this model compares to the following image.



10th question – part a

10-

a) Plot V versus t for injected currents of 5, 10, and 15 A/cm2.

10th question – part b

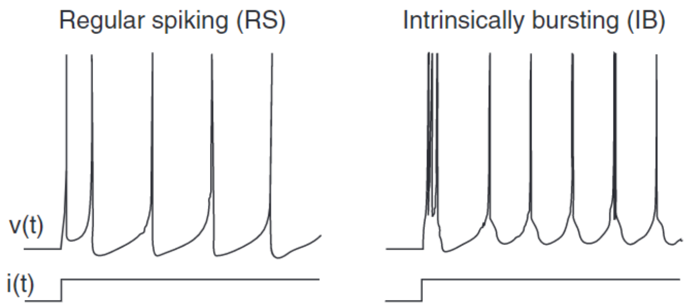
b) Determine what happens to the frequency of firing as the injected current increases.

11^{th} question

11- So far we have learned about regular spiking and in this question we want to simulate bursting type. model for this kind of spiking is a two-dimensional system of ordinary differential equations which is shown below. The parameter a controls the rate of recovery of u, and b controls the sensitivity of recovery to subthreshold fluctuations of the membrane potential. Plot voltage changes in time for injected current I that shows bursting behavior. (assume a=0.02 and b=0.2)

$$\frac{dv}{dt} = 0.04v^2 + 5v + 140 - u + I$$

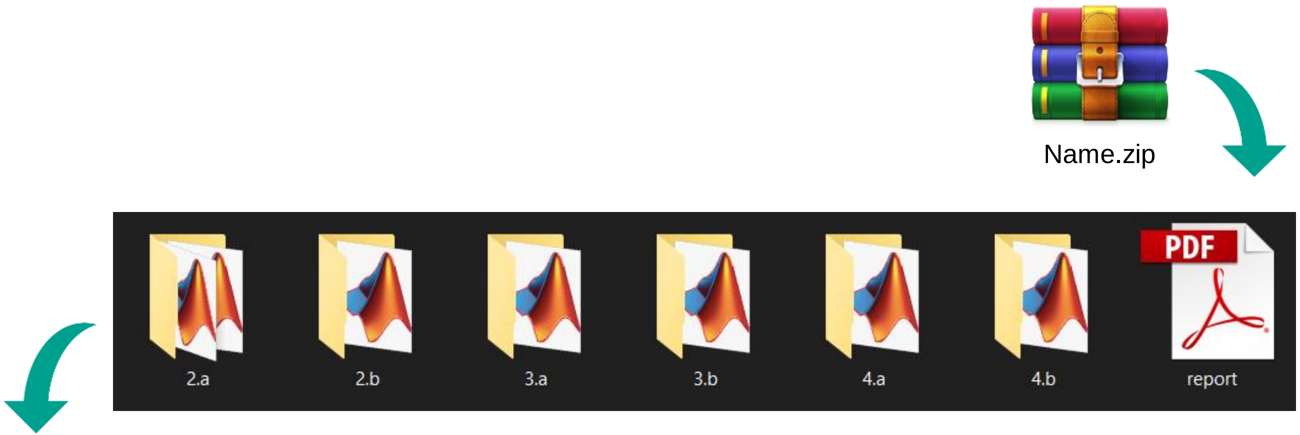
$$\frac{du}{dt} = a(bv - u)$$

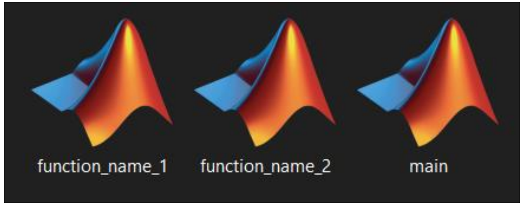


12th question

12- Show your great ideas.

what you are supposed to send





Report: output figures, codes, explanation

Code: write comments

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