Computational Neuroscience Coursework 1

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Question 1

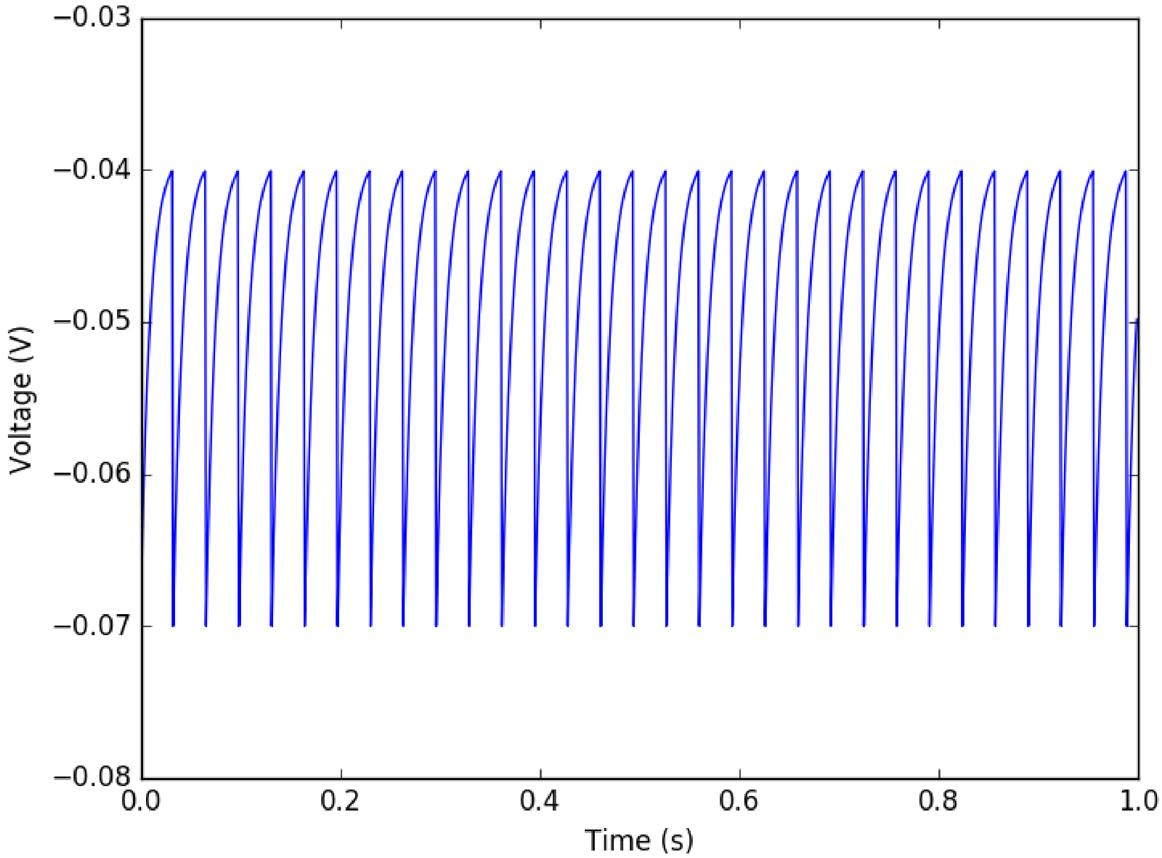

Figure 1: Internal neuron voltage against time for simulating a single neuron, showing thirty spikes over the course of 1 s.

Question 2

As we're modelling the neuron with a constant injected current I_e, we can solve the integrate and fire model for t, and constrain the equation such that at $t = 1$, $V(t) = V_T$ and at $t = 0$,

$V(t) = V_r$.

$$V(t) = E_L + R_m I_e + [V(0) - E_L - R_m I_e]\, e^{-t/\tau_m} \tag{1}$$
$$V(1) = V_T = E_L + R_m I_e + [V_r - E_L - R_m I_e]\, e^{-1/\tau_m} \tag{2}$$
$$(V_T - E_L)\, e^{1/\tau_m} + E_L - V_r = I_e \left(R_m e^{1/\tau_m} - R_m\right) \tag{3}$$
$$I_e = \frac{(V_T - E_L)\, e^{1/\tau_m} + E_L - V_r}{R_m e^{1/\tau_m} - R_m} \tag{4}$$

Therefore using the values outlined in Q1 for the variables in equation (4) to compute I_e, we find that the minimum value that I_e can be to at least cause a single spike in a one second simulation is 3.0 nA.

Question 3

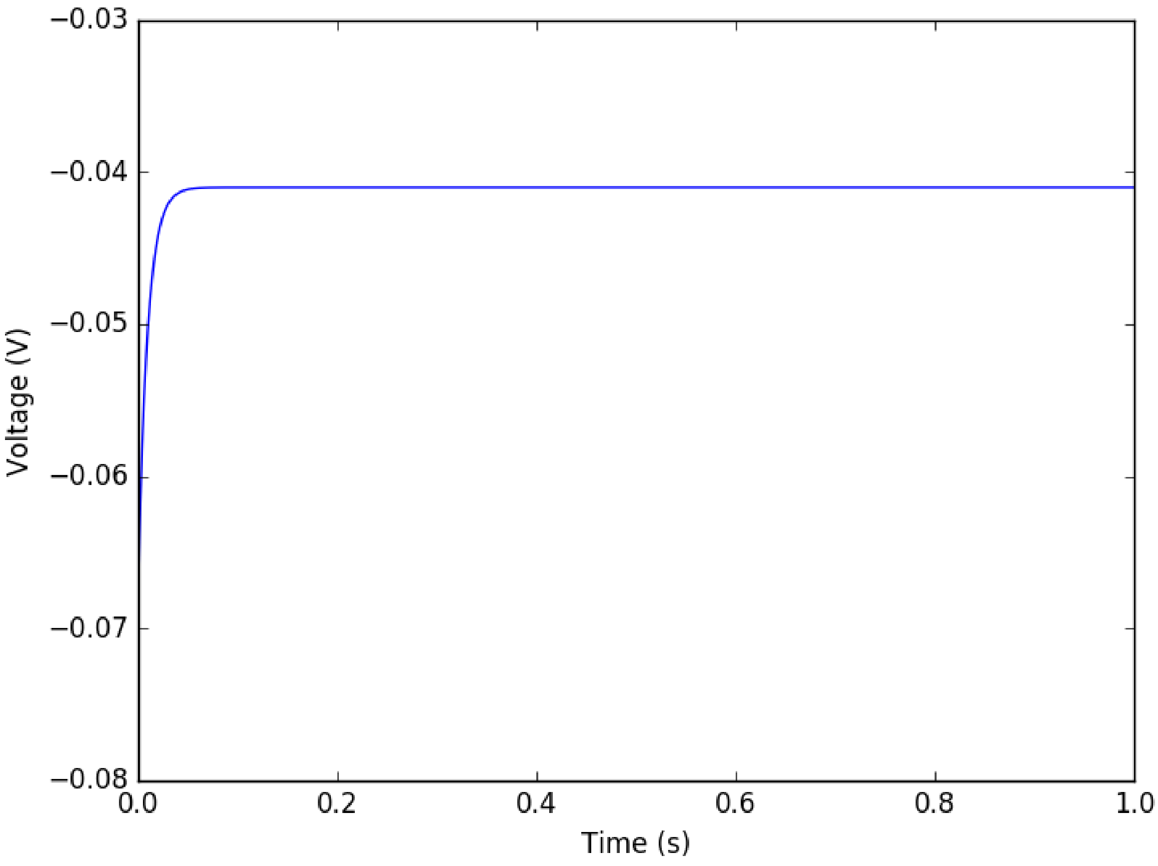

Figure 2: Simulation of a neuron for 1 s with an input current of amplitude I_e which is 0.1 [nA] lower than the minimum current computed in question 2.

Question 4

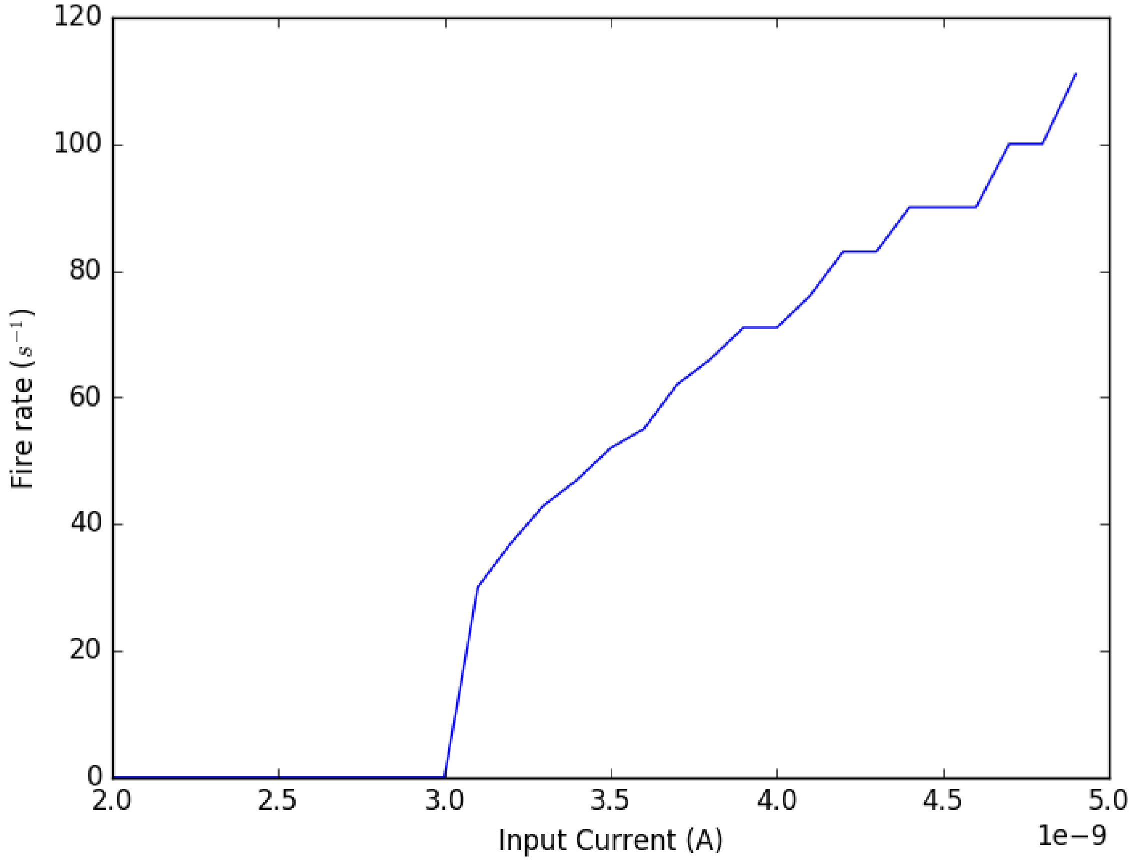

Figure 3: Fire rate per second plotted against input current to the neuron.

Question 5

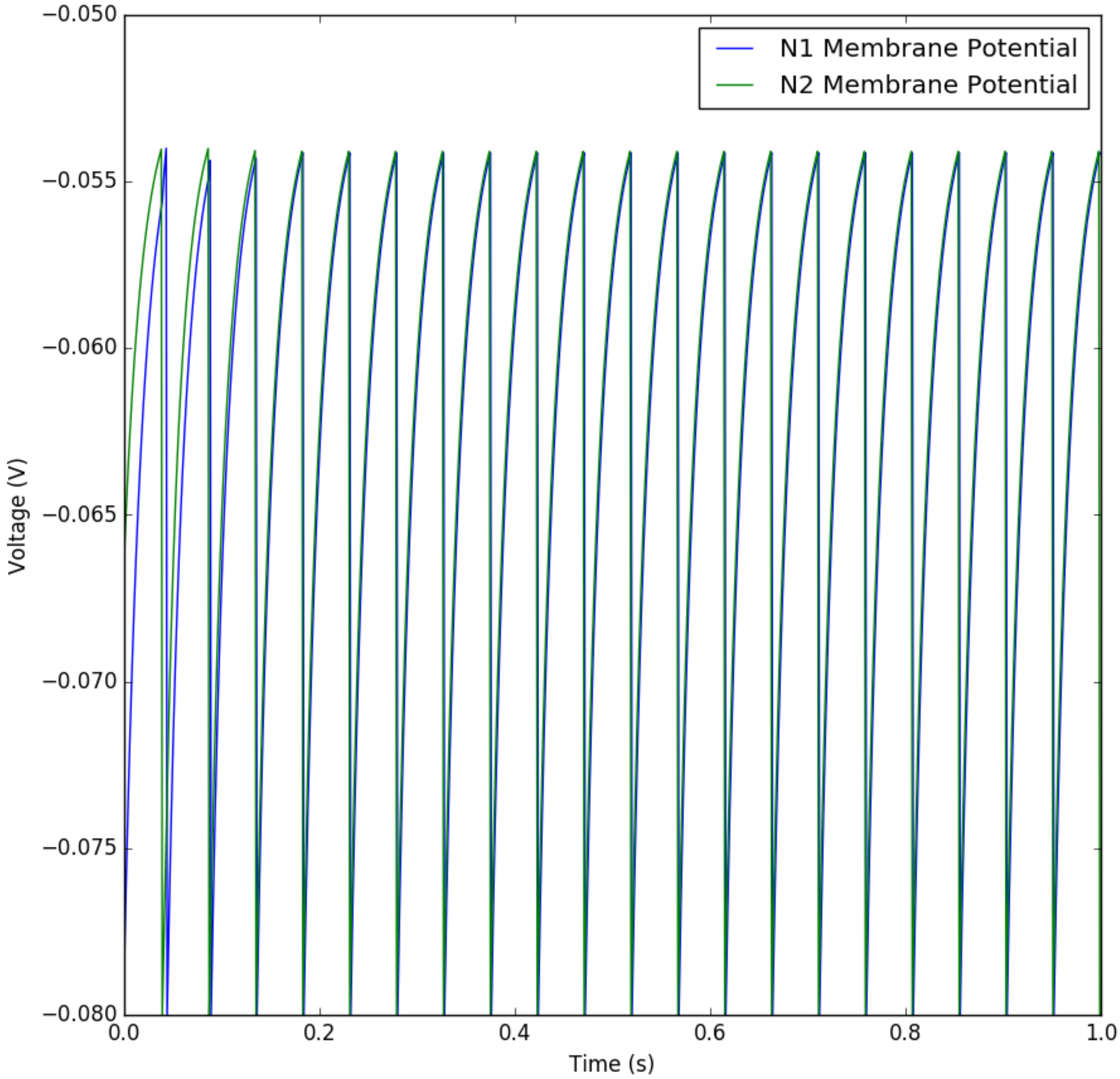

Figure 4: Internal neuron voltage against time for simulating a single neuron, showing thirty spikes over the course of 1 s.

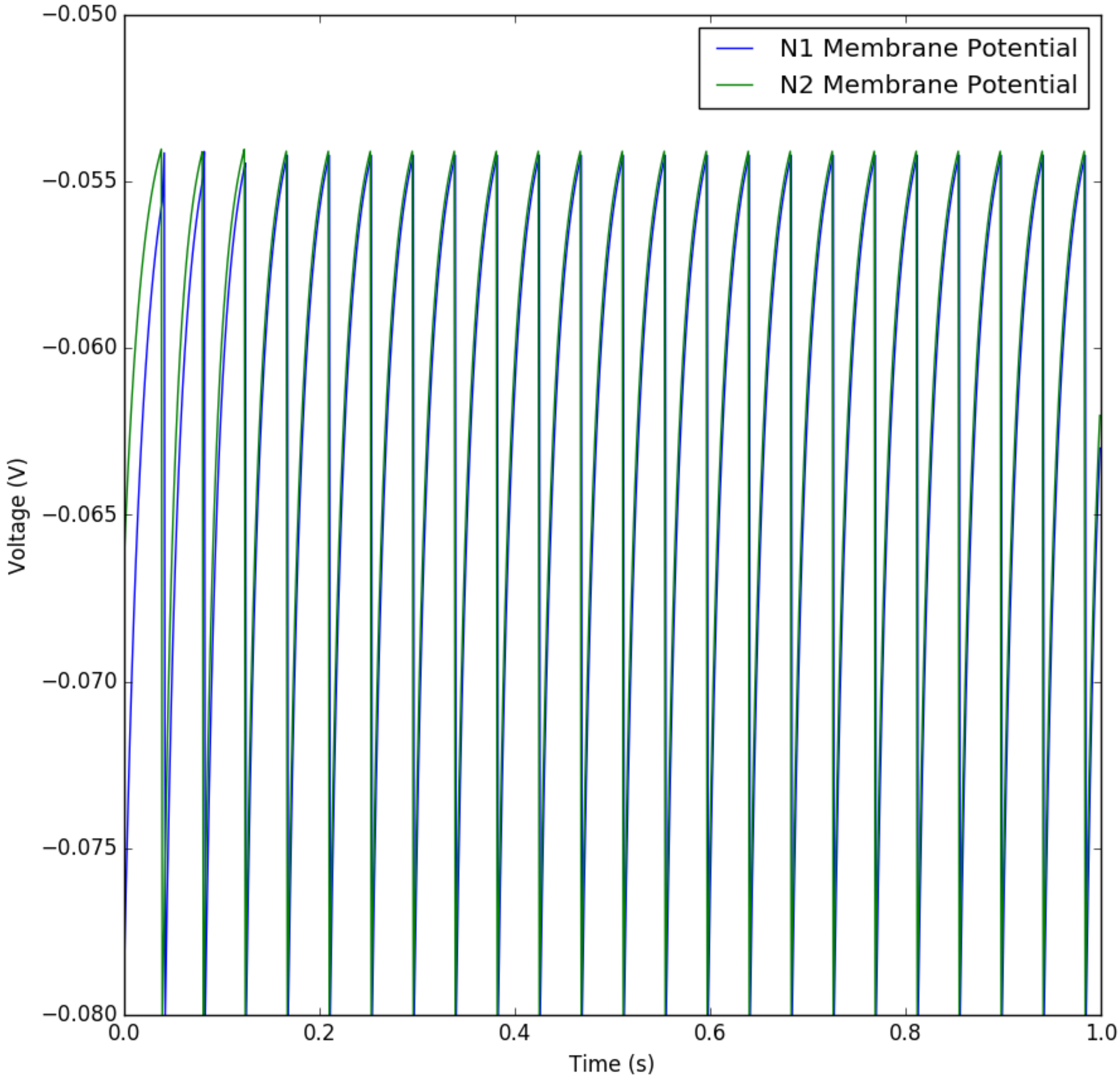

Figure 5: Internal neuron voltage against time for simulating a single neuron, showing thirty spikes over the course of 1 s.

Question 6

Question 7

References