Theoretical neuroscience: Exercise 3
Date: 14/11/19

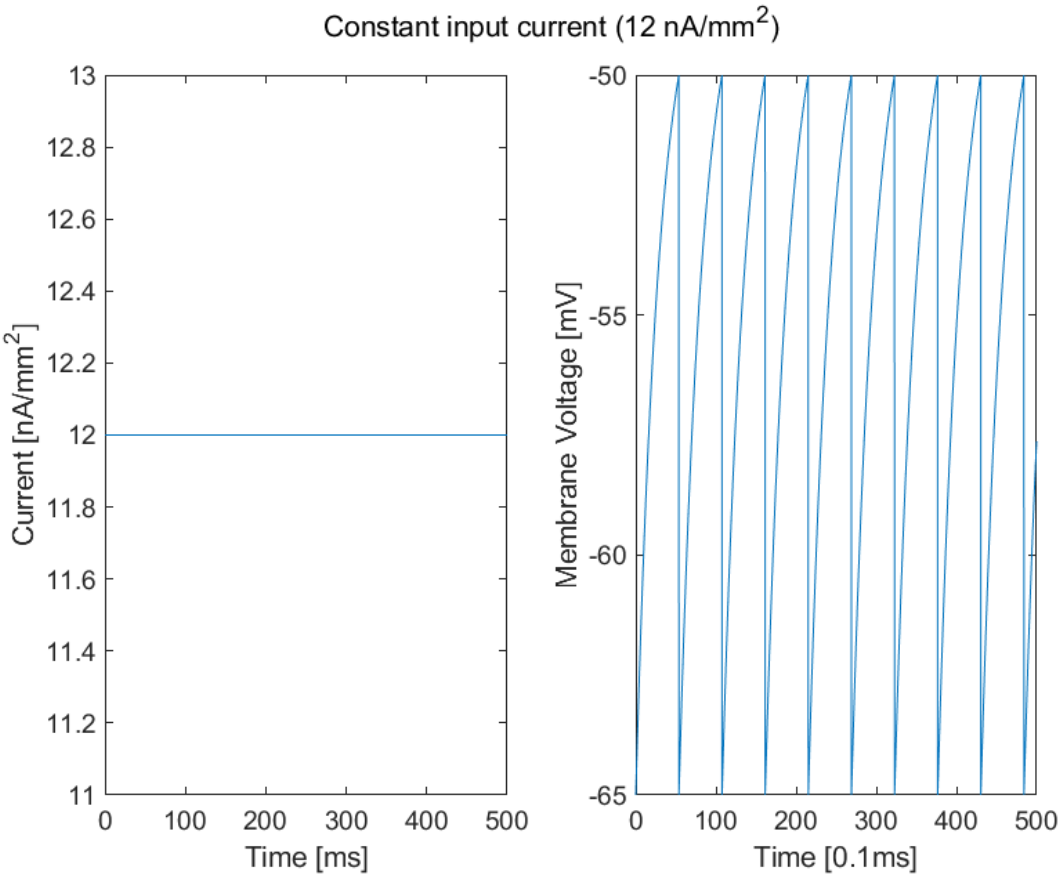

Figure 1: Given a constant input current, we can observe the membrane voltage constantly reaching threshold and spiking. There is, however, no change in inter-spike time.

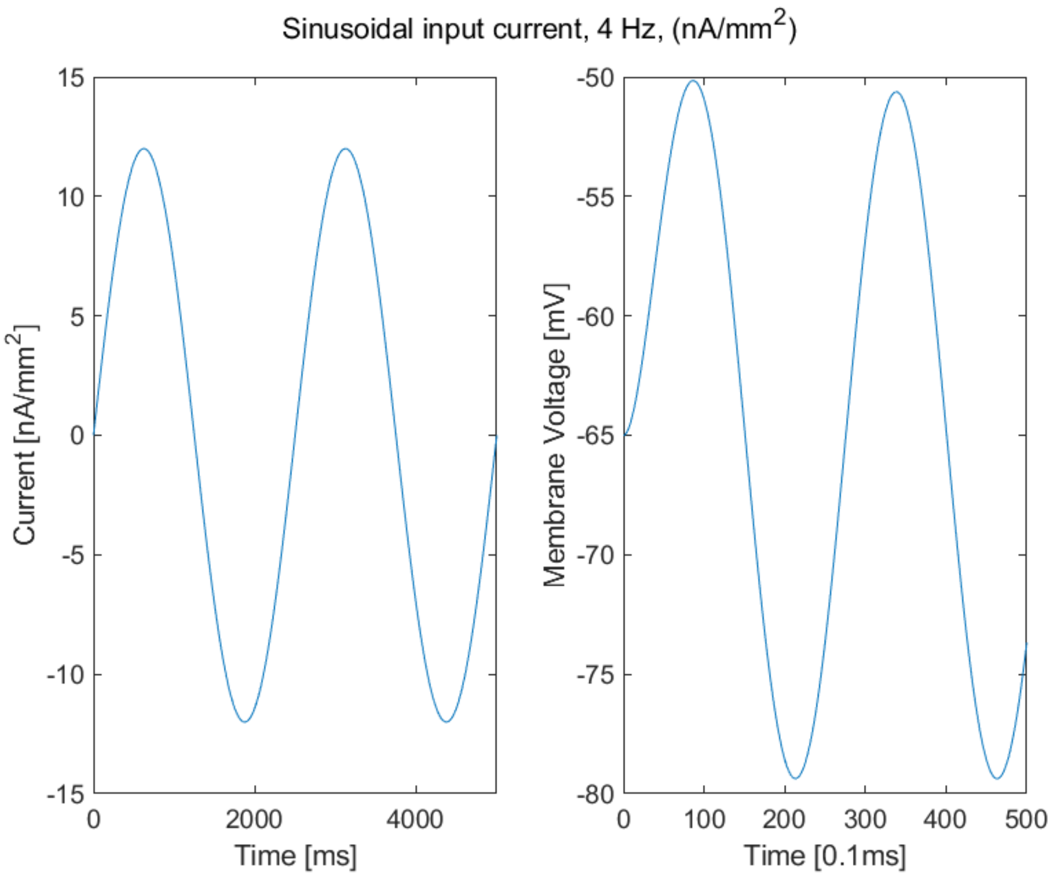

Figure 2: The low frequency sinusoidal input current does not allow the membrane voltage to reach threshold and therefore, no spiking is observed.

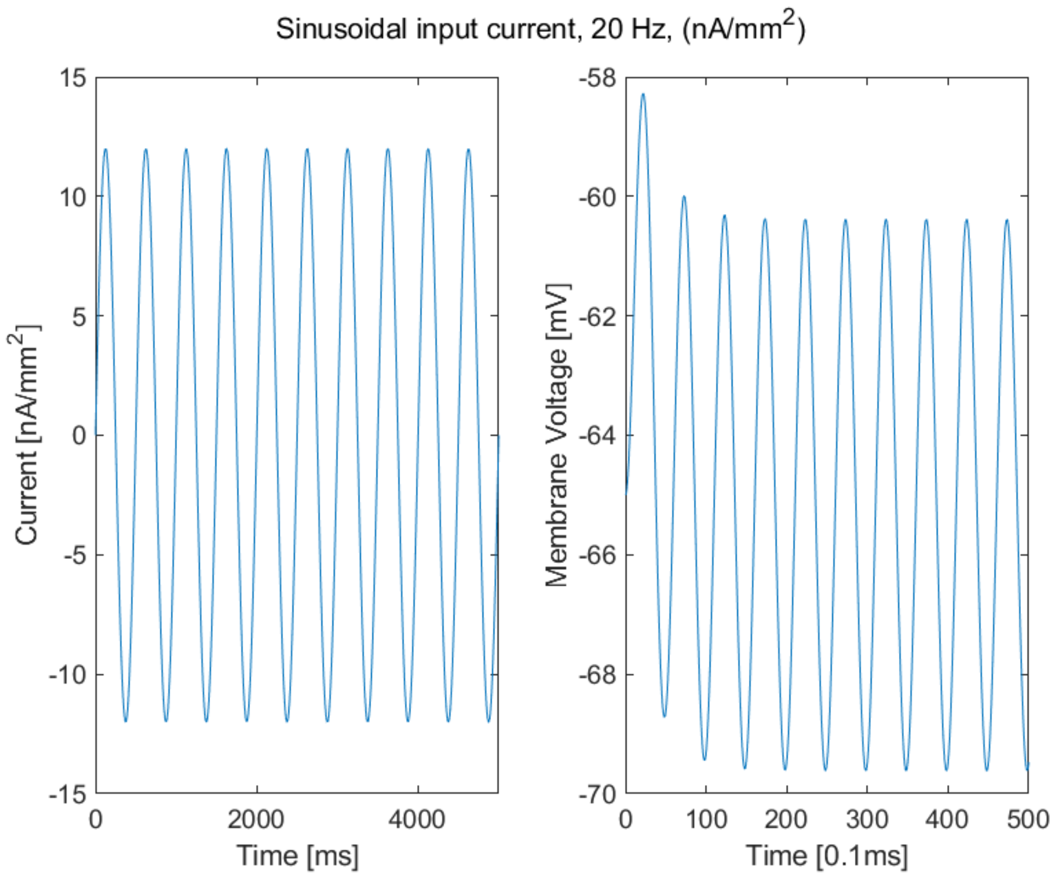

Figure 3: The medium frequency sinusoidal input current does not allow the membrane voltage to reach the threshold and therefore, no spiking is observed.

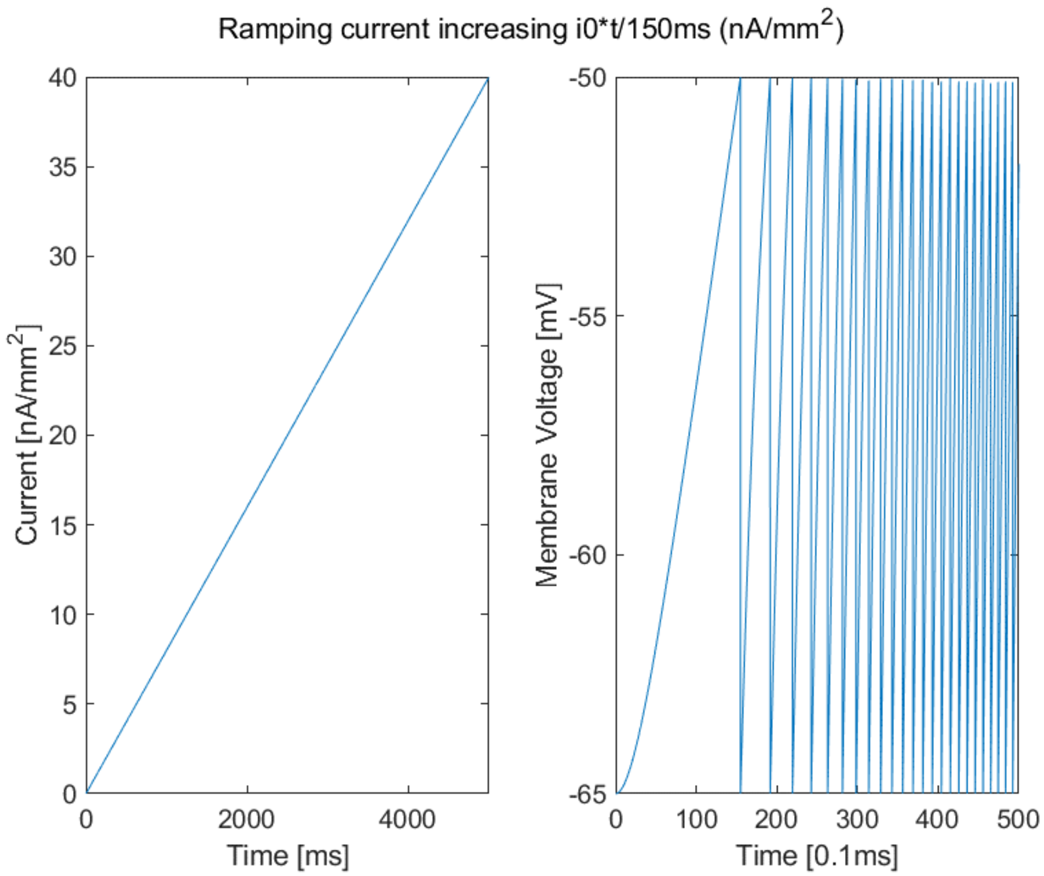

Figure 4: The ramping current has a constantly increasing input and therefore after the membrane reaches threshold, the current continues to increase; consequently, it reaches threshold quicker and quicker. Thus, the inter-spike-intervals are decreasing with time.

Additional task:

$$\frac{dv}{dt} = \frac{1}{\tau_m}\left[\underbrace{r_m \cdot i_e(t) + E_L}_{V_\infty} - V_m(t)\right]$$

$$\Rightarrow \frac{dv}{dt} = \frac{1}{\tau_m}\left(V_\infty - V_m(t)\right)$$

$$\Rightarrow \int_t^{\Delta t + t} \frac{1}{V_\infty - V_m(t)}\, dv = \frac{1}{\tau}\int dt$$

$$\Rightarrow \ln\left|V_\infty - V_m(t)\right|\Big|_t^{t+\Delta t} = \frac{1}{\tau}(t + \Delta t - t)$$

$$\Rightarrow \ln\left|V_\infty - V_m(t+\Delta t)\right| - \ln\left|V_\infty - V_m(t)\right| = \frac{t}{\tau}$$

$$\Rightarrow \ln\left|\frac{V_\infty - V_m(t+\Delta t)}{V_\infty - V_m(t)}\right| = \frac{t}{\tau}$$

$$\Rightarrow \frac{V_\infty - V_m(t+\Delta t)}{V_\infty - V_m(t)} = e^{\frac{t}{\tau}}$$

$$\Rightarrow V_\infty - V_m(t+\Delta t) = \left(V_\infty - V_m(t)\right) e^{\frac{t}{\tau}}$$

$$\Rightarrow V_m(t+\Delta t) = V_\infty - \left(V_\infty - V_m(t)\right) e^{\frac{t}{\tau}}$$

$$\Rightarrow V_m(t+\Delta t) = V_\infty + \left(V_m(t) - V_\infty\right) e^{\frac{t}{\tau}}$$