Homework for the gamma & beta models

1. Implement the PING model. You might begin with the ING code we developed in class. Extend this code to include both a P-cell and I-cell, and the appropriate synapses.
    a. **Simulate the model** and plot the P-cell and I-cell voltages versus time. Describe the dynamics and confirm the model produces activity consistent with a gamma rhythm. The time between spikes should be approximately 25 ms (corresponding to a 40 Hz rhythm)
    b. **Compute the spectrum of the P-cell voltage** from the simulated data and plot the results.
    c. **Compute the spike spectrum from the I-cell voltage** from the simulated data and plot the results.

    Now, do some experiments:

    d. **Block the inhibitory synapses.** Plot the P-cell and I-cell voltages versus time. Describe how the voltages change versus the results in (a).
    e. **Block the excitatory synapses.** Plot the P-cell and I-cell voltages versus time. Describe how the voltages change versus the results in (a).
    f. **Increase the inhibitory synaptic time constant.** Plot the P-cell and I-cell voltages versus time. Describe how the voltages change versus the results in (a).

2. **(Advanced & Optional).** Implement the sparse PING model and simulate the dynamics. Can you produce activity consistent the expected dynamics (e.g., the P-cells fire sparsely, the I-cells fire on each cycle, and the population dynamics are consistent with the gamma rhythm).

3. In this challenge, the goal is to update the HH equations to include a new (slow) current and produce bursting activity. To do so, start with the [HH code available here](). Update the HH model to include the **g_K-"M" current** listed in [Table A2 of this publication]().

In the code you'll create, we'll use the variable **B** to define the gate for this current.

a. Plot the **steady-state function** and **time constant** for this newly included g_K-"M" current.

   HINT: in [Table A2 of this publication] the authors provide the forward rate function ($\alpha[V]$) and backward rate function ($\beta[V]$) for this current. Use these functions to compute the steady-state function and time constant, and plot both versus V.

b. Update the HH model to **include this new current**.

   HINT: Update the HH model to accept three inputs:

   ```
   HH(I0, T0, gB0)
   ```

   where **`gB0`** is the maximal conductance of the new current.

   HINT: Update the HH model to return six outputs:

   ```
   return V,m,h,n,B,t
   ```

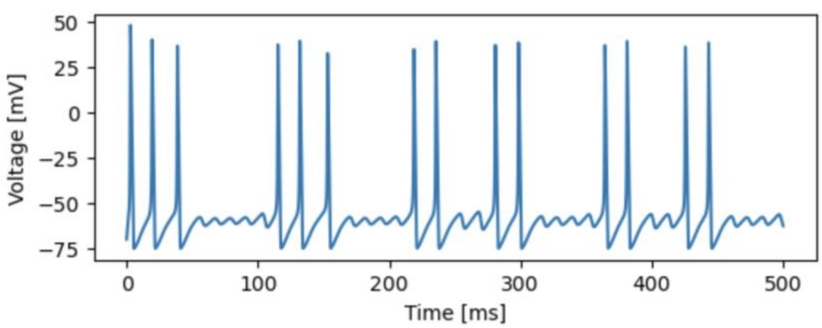
   where *B* is the gate variable of the new current.

c. **Find parameter settings** so that the model produces bursting activity.

   HINT: Fix **`I0=10`** and **`T0=500`** and vary the maximal conductance of the new current, **`gB0`**, until you find a value that supports bursting in the voltage.

   HINT: Plot the voltage V and the new current gate B to visualize how the dynamics behave.

   HINT: You might create a plot of V that looks like this,



d. Compute the spectrum to characterize the dominant rhythms.

   HINT: Be sure to carefully define T.