Problem Set 3.1

This problem set allows students to practice the material from Labs 3.1, 3.2, and 3.3.

Due: Monday Nov 2nd, 4pm

This is a short one to help prepare for Team Project 2.

You will need to download from Latte the zipped file PS3_1.zip, which contains `neuron.mat` to complete this problem set.

Questions:

1. Time series questions (after Lab 3.1):

   Q1.1: What are the components of a sampled time series?
   a) The value of each sample
   b) The time of each sample
   c) The index number of each sample
   d) All of these

   Q1.2: Which of the following (possibly more than 1 choice) contain sufficient information to specify a time series?
   a) A list of samples
   b) A list of samples and a list of the times the samples were measured
   c) A list of samples, the time of the first sample, and a fixed time that elapsed between samples
   d) A list of sample times

   Suppose a quantity is sampled beginning at time 0 and is sampled at a constant rate of 10,000Hz.
   Q1.3.1: At what time was the 500th sample acquired?
   Q1.3.2: What sample number corresponds to time 0.453 seconds?
   Q1.3.3: What sample number corresponds to time T seconds? (Write an expression.)
   Q1.3.4: How much time elapsed between when the time samples 100 and 200 were acquired, including the time of both sample 100 and 200?

2. Using your knowledge of `for` loops, write a function called **`cumdiff`**, which computes the cumulative sum of differences between successive points. It should have one input (a vector of numbers) and one output (a vector of answers). Example: `cumdiff([1 4 3 5])` is `[3 2 4]` because `4 – 1` is `3` and `(4 – 1) + (3 – 4) = 2` and `(4 – 1) + (3 – 4) + (5-3) = 4`.

3. The file `neuron.mat` has a variable named voltage that is a record of the voltage near a microelectrode in the brain of a tree shrew. The data were acquired at 10000 Hz (10kHz). When the neuron that is nearby to the electrode fires an action potential, the potential appears as a negative-going spike wave in the voltage record.

    Q3.1: Plot the voltage as a function of time for the time range 17s to 21s. Make sure the units on the X axis are time (not samples) and the units on the Y axis are voltage.

    Q3.2: Write a Matlab expression that finds all of the times when the voltage crosses a threshold Vt. That is, write an expression that finds all of the times when the voltage jumps from being greater than a threshold Vt to being less than the threshold Vt. Make sure that for each spike the reported time corresponds to the first sample that is less than Vt (that is, not necessarily the lowest dip of the spike, but rather the onset). These values will be considered the times of the spike events. For this data set, what are good choices for Vt given the amplitude of these spikes?

    Q3.3: Plot the detected events as circles on the record of the voltage, using a different color. Using the zoom tool, verify that your code correctly detects the events and write a comment in your response to indicate successful verification.

    Q3.4: Write a Matlab expression that counts the number of spikes between time T0 and T1. (Hint: think `find` and `length`). If you want a specific T0 and T1 to help you get started, you could first write code that counts the spikes between 17.3586 and 19.3586.

    Q3.5: The variable stim_times is a matrix. Each row of the stim_times matrix contains the stimulus number (column 1), the time of stimulus onset (column 2) and the time of the stimulus offset (column 3). Note that the same stimuli were presented many times. Plot the stimulus onset and offset times that occur during the window 17 sec to 21 sec in some color (maybe as a thick line that stretches from Stim_onset to Stim_offset).

Q3.6: Write a function that calculates the response to the individual stimuli (in terms of spikes per second) and also computes the mean response (average spikes per second). That is, fill in the following function:

slidingwindowfunc.m

```
function [average_response, individual_responses] =
      calculate_responses(spike_times, stim_times)
% compute responses during stimulus presentations
%
%  [AVG_RESPONSE, INDIVID_RESPONSES] =
      CALCULATE_RESPONSES(SPIKE_TIMES, STIM_TIMES)
%
%   This function calculates the mean number of spikes
%   per second fired during presentations of a
%   repeated stimulus. SPIKE_TIMES should contain the
%   times of spikes.  STIM_TIMES should be a matrix;
%   each row of STIM_TIMES should have the onset (column
%   1) and offset (column 2) time of the stimulus
%   presentation.  AVG_RESPONSE is the average response
%  (in spikes per second) that was observed during the
%   stimulus presentation, and INDIVID_RESPONSES is a
%   vector that contains the responses to the individual
%   stimulus presentations.

INDIVID_RESPONSES = [];

for i=1:size(stim_times,1),

  % do something

end;

AVG_RESPONSE = mean(INDIVID_RESPONSES);
```

Q3.7: What is the average response to stimulus number 1 and what are the individual trial responses of this particular neuron to stimulus number 1, in spikes per second?

4. A classic pitfall in statistics. An investigator studying a single potential that was generated at time t=1 wants to evaluate whether the individual potential is significantly different from the background noise. The investigator decides to use a t-test, comparing the "green diamond" points in the graph below to the "red square" points. He obtains a p-value of 8.3524e-05 and concludes that the response is highly significant.

   Q4.1: What's wrong with this analysis? What assumption of the t-test is violated? (Hint: it has nothing to do with whether or not the data are normally distributed.)