Problem Set

1. Load the data from ps7.mat. This file contains real lfp, position and spiking data taken from a rat running on a U-shaped maze.
lfptimes are the times of the lfpsamples
lfpdata are the lfpdata
spiketimes are the times of spikes
postimes are the times of position samples
posdata are the distances from one endpoint of the track for each postime
speed is the speed of the animal for each postime.

all times are in seconds
the sampling rate of the LFP traces is 1500 Hz.

Make sure you've downloaded the Chronux package and added all of the directories to your path.

a. Plot the first 10000 samples or so of the data.

b. Use the mtspectrumc function to plot a power spectrum for the first 100000 or so points of the data. Use the following code to initialize the params structure:

```
Params = {};
params.Fs = 1500;
params.fpass = [0 150];
params.err = 0;
params.trialave = 0;
```

c. Given that power spectrum, what frequency band stands out as something potentially interesting?

2. a. Plot a spectrogram using mtspecgramc and the same params function for the same chunk of data. You may want to plot the log of the spectrogram to help compensate for the 1/f structure of the data:

```
[S t f] = mtspecgramc(lfpdata, [.5 .25], params);
imagesc(t, f, log(S'));
```

b. The spectrogram provides a measure of the power in each frequency at each time. Take a region in the neighborhood of 6-10 Hz and compute the average power for each time in that region. Using the absolute value of the speed variable, determine whether there is a significant correlation between speed and theta power over time.

3. Assuming that you decided that 6-12 Hz was an interesting frequency range, use matlab's fdatool to design an FIR filter for that range. Try an equiripple FIR filter, select minimum order and specify the filter as follows:

Density: 20
Fs :1500 (this is the sampling frequency)
Fstop1: 4
Fpass1: 6
Fpass2: 12
Fstop2: 14

Leave the magnitudes where they are and click on design filter at the bottom. Note the number of coefficients on the upper left.

a. How do the magnitude specifications relate to the frequency response plotted in the window?

b. What happens to the order of the filter if you increase the magnitude specifications (e.g. change both Astops to 40)?

c. What happens to the order if you make the filter tighter by moving the Fstops closer to the Fpass numbers?

Note that if you wanted to save this filter for later use you would use the Export command from the file menu.

4. Load thetafilter.mat.

a. Use the matlab Filter command to apply this filter to the lfpdata (user all the data). thetafilter.tf.num is A and thetafilter.tf.den is B for use in the Filter command. Plot the first 2-3 seconds of filtered data on top of the real data and zoom in on a section. Does the filter look like a good match for the theta component of the signal? Why or why not? What is going on at the beginning of the trace?

b. Now try the same thing using filtfilt instead of filter. How does this change the correspondence between the filtered signal and the original and why?

5. Use the Hilbert transform to extract the magnitude and phase of the theta band signal for lfpdata .

a. Plot, for a few seconds of data, the magnitude from the Hilbert transform on top of the theta filtered trace. Does it look reasonable?

b. Pick a couple of cycles and plot the phase on top of the signal. Does it look reasonable?

c. Take each spike time and look up the phase of theta for that spike. Plot a histogram of the number of spikes seen at each phase of theta. Is there a relationship between theta phase and spiking?

d. Another way to look at this is to plot the spike triggered LFP. For each spike, take a 1 second sample of raw eeg on each side of the spike and then take the average of those samples. Plot the average with a time axis. Is there structure in the LFP surrounding each spike?

e. Take each spike time and look up the linear position in posdata for that spike. Plot a scatter plot of the spikes where each point's x value is the position and each point's y value is the phase of theta for that spike. Do you see a relationship?

f. Finally, figure out a way to get only those spikes that occur while the animal is moving from negative to positive values of the position variable and repeat. You may find it helpful to plot position vs. phase and position vs. phase + 2 pi. How does position affect the phase of spiking?