The idea behind the project is that you do a serious set of calculations using one or more of the tools you have learned about. You can choose the style and scope to fit your needs. We're expecting something on the order of 1/3 of one of our tutorials, but that's a very rough guide. It’s more important that you get something out of this. That means some careful explanation and some construction on your part -- more than just manipulating equations/code that’s already written for you. Here are some possibilities.

model of a chemical system emphasizing differential equations (phototransduction, olfactory transduction, ...)
model of a neuron emphasizing differential equations (HH or other conductance based model)
model of a motor system (e.g., oculomotor) that implements the Fuchs et al constraints or something like it.
(这些 could be in Matlab or simulink and could build on the tutorial where appropriate)

An application of fourier analysis to image statistics
An application of fourier analysis to sound statistics (e.g., birdsong)
A model of a complex cell
A model of a simple cell
A model of a direction selective simple cell
A model of a direction selective complex cell
Use of convolution to model a bunch of neurons in retina

Implement a threshold crossing model with noise and some kind of 'reset' after a spike (like the Keat et al paper). How do the statistics of the output change as you change the properties of the noise and the reset?

Model the effect of spike timing jitter on the ability to localize sounds in space based on the different in timing between the two ears
Model the effect of spike timing jitter on motion detection

Model jitter inherent in spike generation based on the stochastic properties of Na channels

Analyze a markov chain that describes a real system (e.g., a Na channel, a chemical cascade)

Explain by example the application of singular value decomposition or principal components analysis to a extract spatial and/or temporal weighting functions of neurons (there's an emerging literature on this).

Use PCA to look at the stimuli leading to a spike in the HH model (or using real data we can provide).
Generate a set of data (e.g. mix of spikes of different shapes), embed and noise and see how well PCA picks them out. Determine how many components you can trust.
Extend the mathematical tools in a direction that we have not taught. Do this as a tutorial that would illustrate a neurobiological concept. Examples: brownian motion, time to absorption statistics in absorbing markov chains, systems of ordinary differential equations to describe signal transduction, partial differential equations to solve cable equations (for neurons), application of information theory to spike trains (apparently there's a book around that explores this), use of singular value decomposition in color vision or in neurophysiology.

Model just about anything you want that is in some way neurobiological that makes use of the tools we are covering.

Compute the linear filters associated with a simple model neuron like FitzHugh-Nagumo. How valid is the filter-and-fire approach?

Try adding an additional variable, like some calcium dynamics.

Implement a filter-and-fire neuron with afterhyperpolarization, as for retinal ganglion cells in Keat et al, J. Neuroscience.

Write down the system of equations describing a 2 neuron network and analyse its behavior.