Here is a Matlab script that runs a GLM. It is recommended that you run the script step by step (cut and paste), relating each step to the class slides. As you go along, answer the questions posed in red.

```
clear all; close all; clc;

nTRs=480; %number of timepoints in the fMRI timecourse
%define and plot the boxcar function. It is a boxcar model of the neural activation that could be expected from a task-responsive voxel in a block design experiment with two five minute stimulation blocks and two five minute rest blocks.
t=0:.1:1200;
box=[ones(1,3000),zeros(1,3000),ones(1,3000),zeros(1,3001)];
figure(1);plot(t,box);axis([0 1200 0 1.5]); xlabel('sec');

%define and plot the hrf (gamma functions)
T0=0; n=4; lamda=2;
hrf=((t-T0).^ (n-1)).*exp(-(t-T0)/lamda)/((lamda^n)*factorial(n-1));
figure(2)
plot(hrf(1:240)); xlabel('1/10th seconds'); %in 1/10th sec for smooth plot

%convolve the hrf and boxcar and then discretize (Assume that BOLD data was acquired every 2.5 sec, so the twenty minute experiment had 480 time points)
nTRs=480;
B=conv(hrf,box)/10;
tp=0:.1:2400;
for i=1:480
    N(i)=B(i*25);
end;
figure(3)
plot(N); axis([0 480 0 1.5]);

%Generate the design matrix
X(:,1)=N'; X(:,2)=ones(nTRs,1); X(:,3)=linspace(1,nTRs,nTRs)';
%3rd column models linear drift (a typical scan artifact)
figure(4)
X(:,3)=X(:,3)/max(X(:,3))
```

MICRO 513 Exercise Set 1 General Linear Model

Be able to draw a typical BOLD hemodynamic response function show approx. onset time (~2 s), peak time (~4-6 s), and return to baseline (~20 s).

Why does the BOLD response increase following neural activity?

After neural activity, oxygen levels are replenished by a local increase in blood flow. A higher ratio of oxygenated to deoxygenated hemoglobin yields a higher MRI signal. The response is “blood oxygenation level dependent”, i.e. BOLD.

Hence, BOLD is an indirect measure of neural activity. It is relatively slow because it is “hemodynamic”, i.e. related to blood flow.

X is the design matrix. What does each column in X correspond to?

Column 1 models the on/off stimulus, convolved with hrf Column 2 models baseline (constant term). Column 3 models linear drift (typical scan artifact)
here is the least squares estimate of the betas, assuming that the inverse of $X'X$ exists. Why might $X'X$ not be invertible?

For $X'X$ to be invertible, $X$ must be “full rank” meaning that all columns of $X$ are linearly independent, i.e. no column of $X$ is a linear combination of any other column.

Hence experiments must be designed so that all model predictors are linearly independent of each other. Otherwise there is not a unique solution for the betas.

In the example here, what does the contrast ‘$c$’ test for?

$c=[1 0 0]$ tests that the first beta is different from zero.

Notice the form of the $t$-stat: parameter/sqrt (variance of that parameter)

The estimate of the variance depends on assumption that the noise is normally distributed and uncorrelated. This is a critical assumption for the GLM solution.

$X*\beta\_\text{hat}$ is the projection of the model’s solution. What do we call the difference between the actual data and the projection ($Y\_\text{plot} - B\_\text{pred}\_\text{plot}$)?

The residual error
Matlab Figures:

Figure 1 - box car function

Figure 2 - HRF

Figure 3 - box car model function convolved with HRF
Figure 4 - design matrix

Figure 5 - hypothetical data

Figure 6 - the observed BOLD response (blue) and the BOLD response predicted by the GLM (black)