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.

```matlab
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)
%plot design matrix (rescaled for plotting)
figure(4)
X(:,3)=X(:,3)/max(X(:,3))
colormap(gray);image(X*64);
```

Be able to draw a typical BOLD hemodynamic response function show approx. onset time, peak time, and return to baseline.

Why does the BOLD response increase following neural activity?

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

Is the GLM method univariate or multivariate? Explain.

What assumptions do we make about the noise to satisfy the Gauss-Markov conditions?

If we meet these assumptions, what does it tells us about using Ordinary Least Squares to estimate the betas?
%create and plot hypothetical BOLD data by convolving boxcar with an hrf, then adding baseline activation, scanner drift, and noise.
theta=2.9; B0=40; delta=.01; beta=[theta; B0; delta];
Y=X*beta+normrnd(0,4,[nTRs,1]);
Y_plot=zeros(1,12001);
for i=1:480
    Y_plot(i*25)=Y(i);
end;
figure(5); plot(t,Y_plot); axis([0 1200 30 60]);

%Estimate the beta vector and error variance i.e. Solve the GLM for beta values.
beta_hat=inv(X'*X)*X'*Y
Var_e=(Y-X*beta_hat)'*(Y-X*beta_hat)/(nTRs-1-length(beta))

%Hypothesis testing; Compute the t statistic
c=[1;0;0];
t_stat=c'*beta_hat/sqrt(Var_e*c'*inv(X'*X)*c)

%plot predicted BOLD signal (projection)
B_pred=X*beta_hat;
Bpred_plot=zeros(1,12001);
for i=1:480
    Bpred_plot((i-1)*25+1:i*25)=B_pred(i);
end;
figure(6); plot(t,Y_plot); axis([0 1200 30 60]);
hold on; plot(t, Bpred_plot, 'k-', 'Linewidth', 3)

Here is the least squares estimate of the betas, assuming that the inverse of X'X exists. Why might X'X not be invertible?

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

Notice the form of the t_stat: parameter/sqrt(variance of that parameter)

X*beta_hat is the projection of the model’s solution. What do we call the difference between the actual data and the projection (Y_plot - Bpred_plot)?

MICRO 513 Exercise Set 1 General Linear Model

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Matlab Figures:

Figure 1 - box car function

Figure 2 - HRF

Figure 3- box car model function convolved with HRF