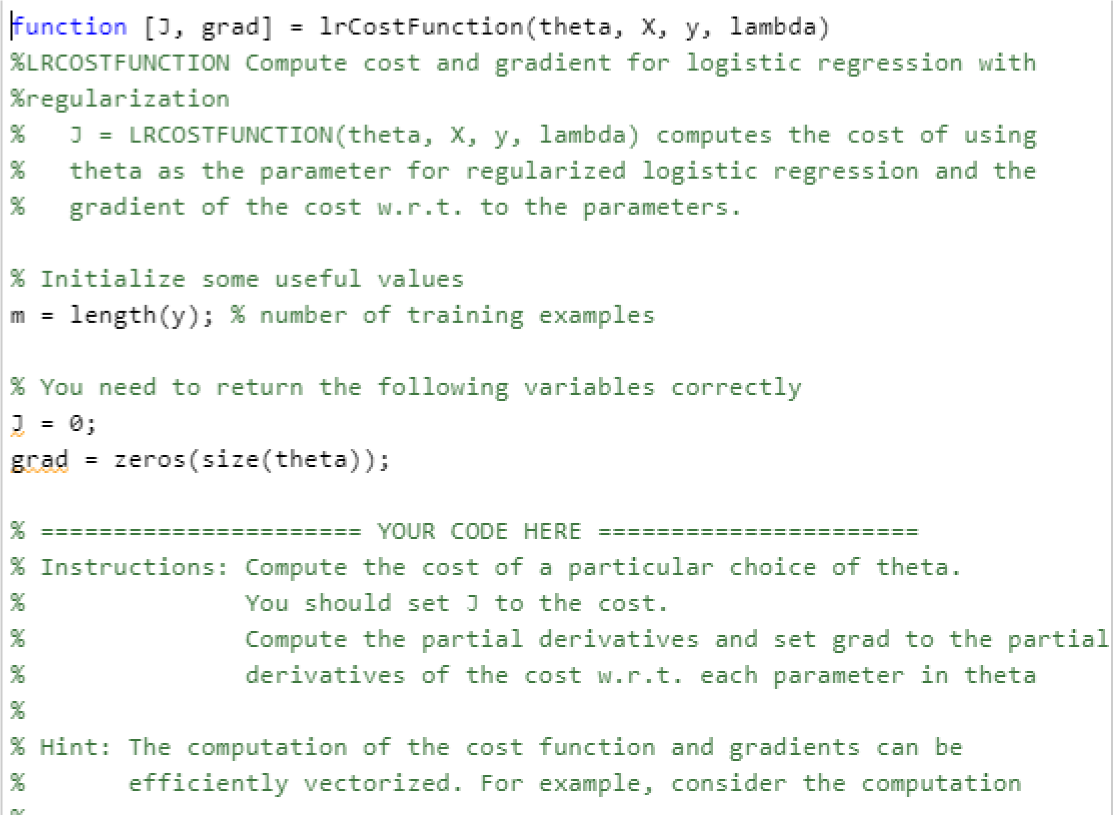
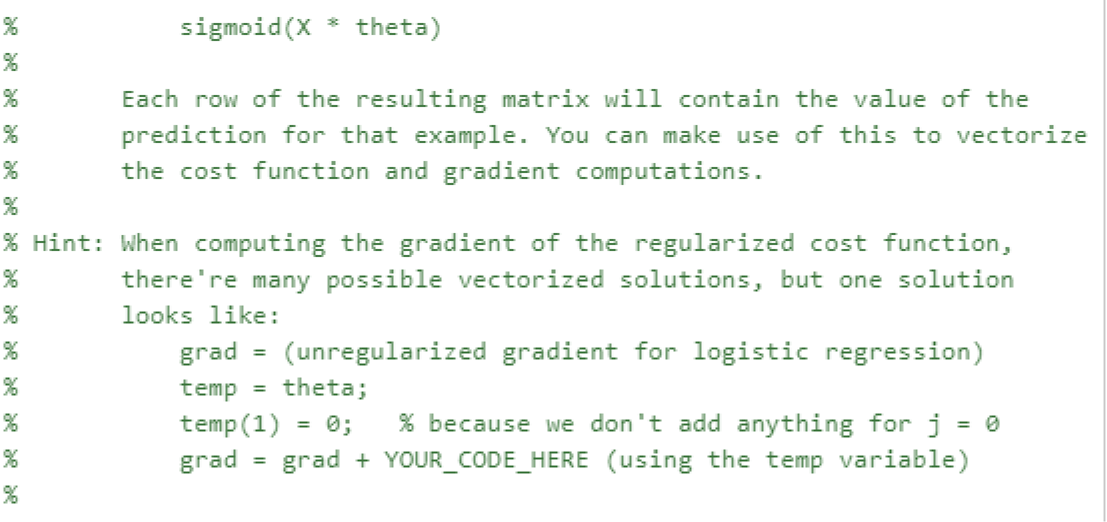
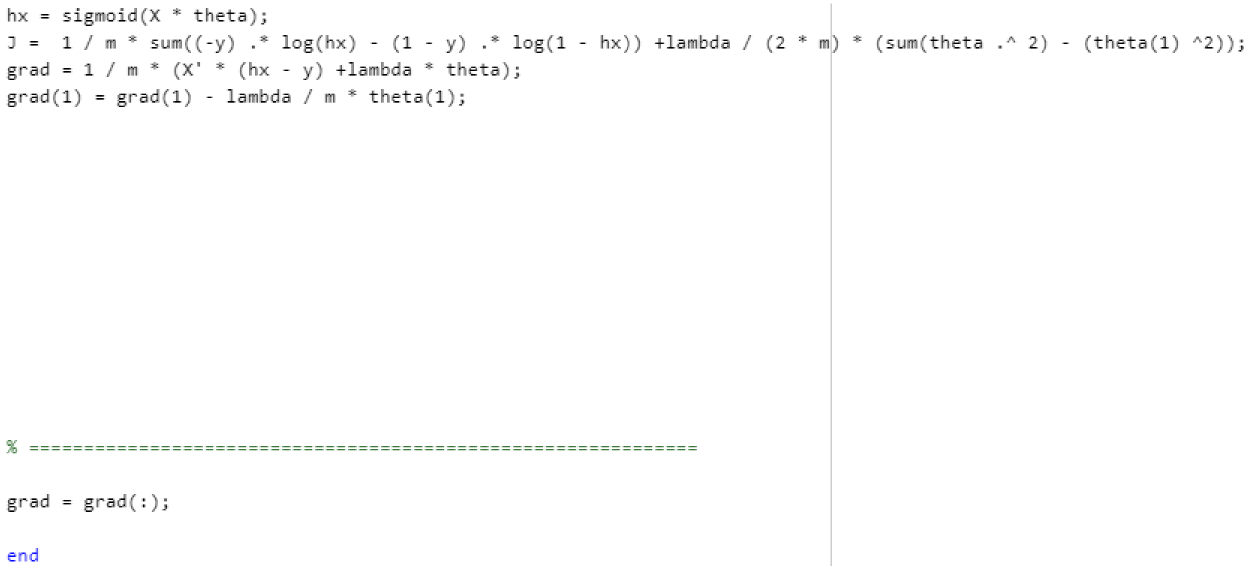


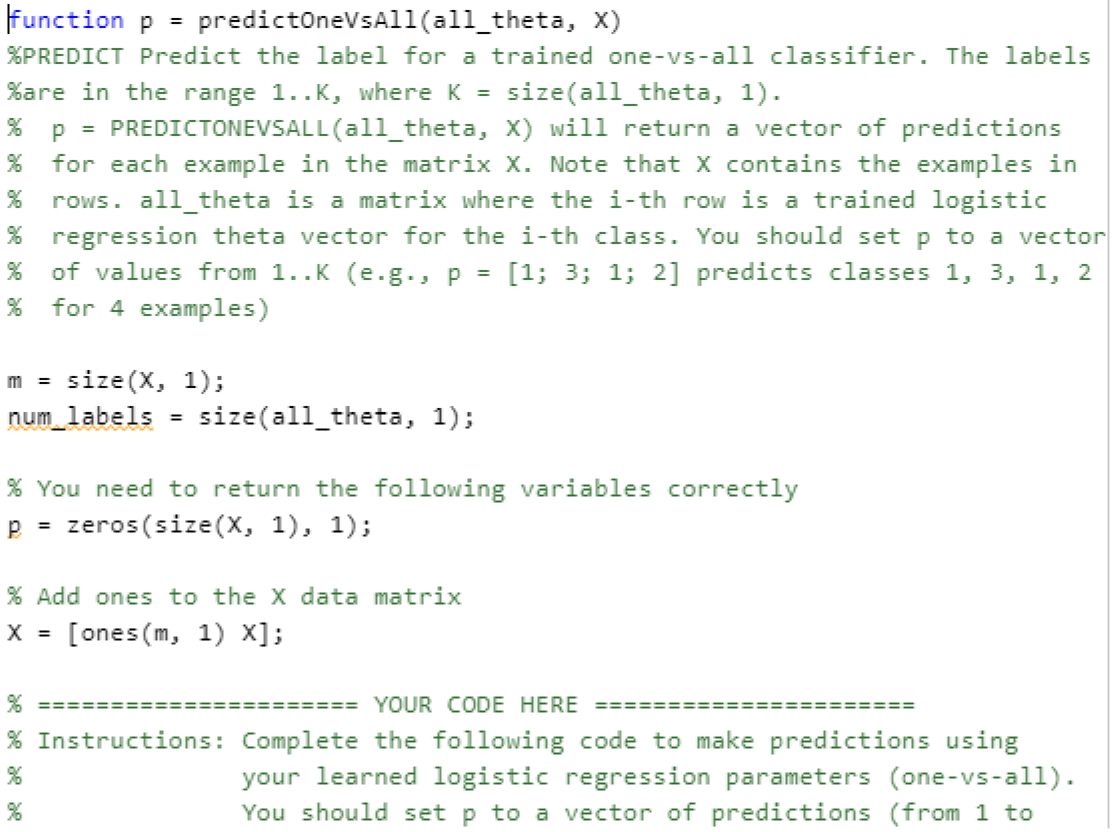
```
function [J, grad] = lrCostFunction(theta, X, y, lambda)
%LRCOSTFUNCTION Compute cost and gradient for logistic regression with
%regularization
%   J = LRCOSTFUNCTION(theta, X, y, lambda) computes the cost of using
%   theta as the parameter for regularized logistic regression and the
%   gradient of the cost w.r.t. to the parameters.

% Initialize some useful values
m = length(y); % number of training examples

% You need to return the following variables correctly
J = 0;
grad = zeros(size(theta));

% ====================== YOUR CODE HERE ======================
% Instructions: Compute the cost of a particular choice of theta.
%               You should set J to the cost.
%               Compute the partial derivatives and set grad to the partial
%               derivatives of the cost w.r.t. each parameter in theta
%
% Hint: The computation of the cost function and gradients can be
%       efficiently vectorized. For example, consider the computation
%
```



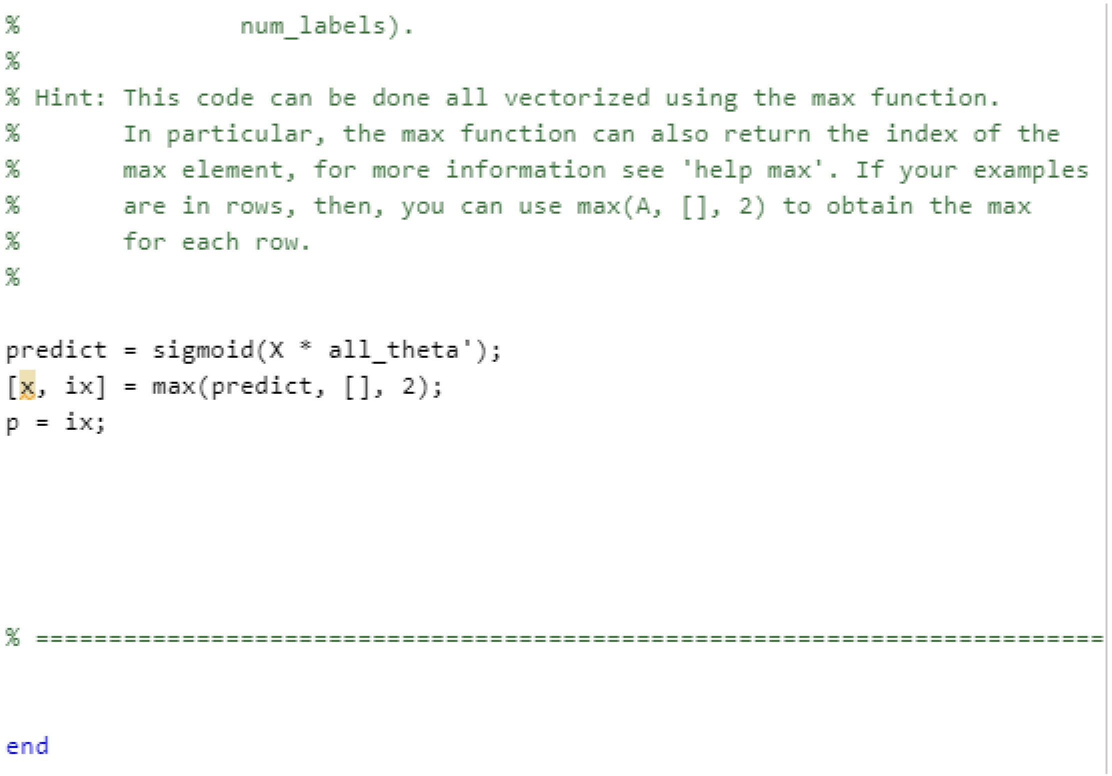
```
%           sigmoid(X * theta)
%
%       Each row of the resulting matrix will contain the value of the
%       prediction for that example. You can make use of this to vectorize
%       the cost function and gradient computations.
%
% Hint: When computing the gradient of the regularized cost function,
%       there're many possible vectorized solutions, but one solution
%       looks like:
%           grad = (unregularized gradient for logistic regression)
%           temp = theta;
%           temp(1) = 0;   % because we don't add anything for j = 0
%           grad = grad + YOUR_CODE_HERE (using the temp variable)
%
```



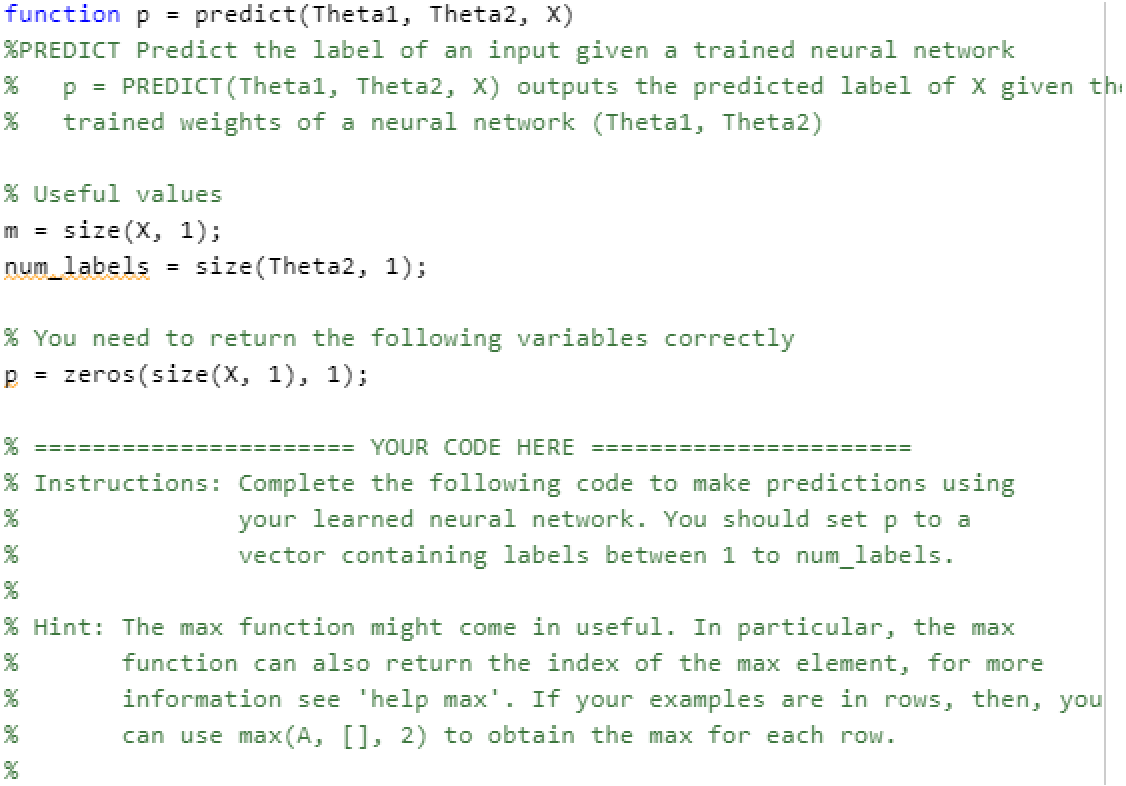
```
hx = sigmoid(X * theta);
J =  1 / m * sum((-y) .* log(hx) - (1 - y) .* log(1 - hx)) +lambda / (2 * m) * (sum(theta .^ 2) - (theta(1) ^2));
grad = 1 / m * (X' * (hx - y) +lambda * theta);
grad(1) = grad(1) - lambda / m * theta(1);









% =============================================================

grad = grad(:);

end
```



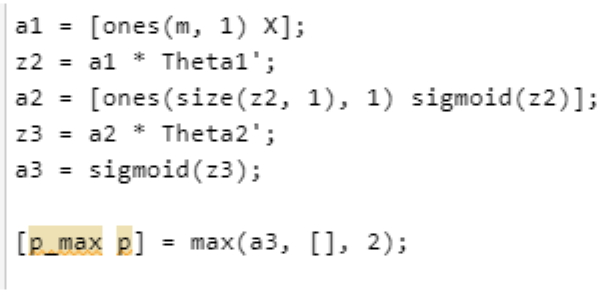
```
function p = predictOneVsAll(all_theta, X)
%PREDICT Predict the label for a trained one-vs-all classifier. The labels
%are in the range 1..K, where K = size(all_theta, 1).
%  p = PREDICTONEVSALL(all_theta, X) will return a vector of predictions
%  for each example in the matrix X. Note that X contains the examples in
%  rows. all_theta is a matrix where the i-th row is a trained logistic
%  regression theta vector for the i-th class. You should set p to a vector
%  of values from 1..K (e.g., p = [1; 3; 1; 2] predicts classes 1, 3, 1, 2
%  for 4 examples)

m = size(X, 1);
num_labels = size(all_theta, 1);

% You need to return the following variables correctly
p = zeros(size(X, 1), 1);

% Add ones to the X data matrix
X = [ones(m, 1) X];

% ====================== YOUR CODE HERE ======================
% Instructions: Complete the following code to make predictions using
%               your learned logistic regression parameters (one-vs-all).
%               You should set p to a vector of predictions (from 1 to
```



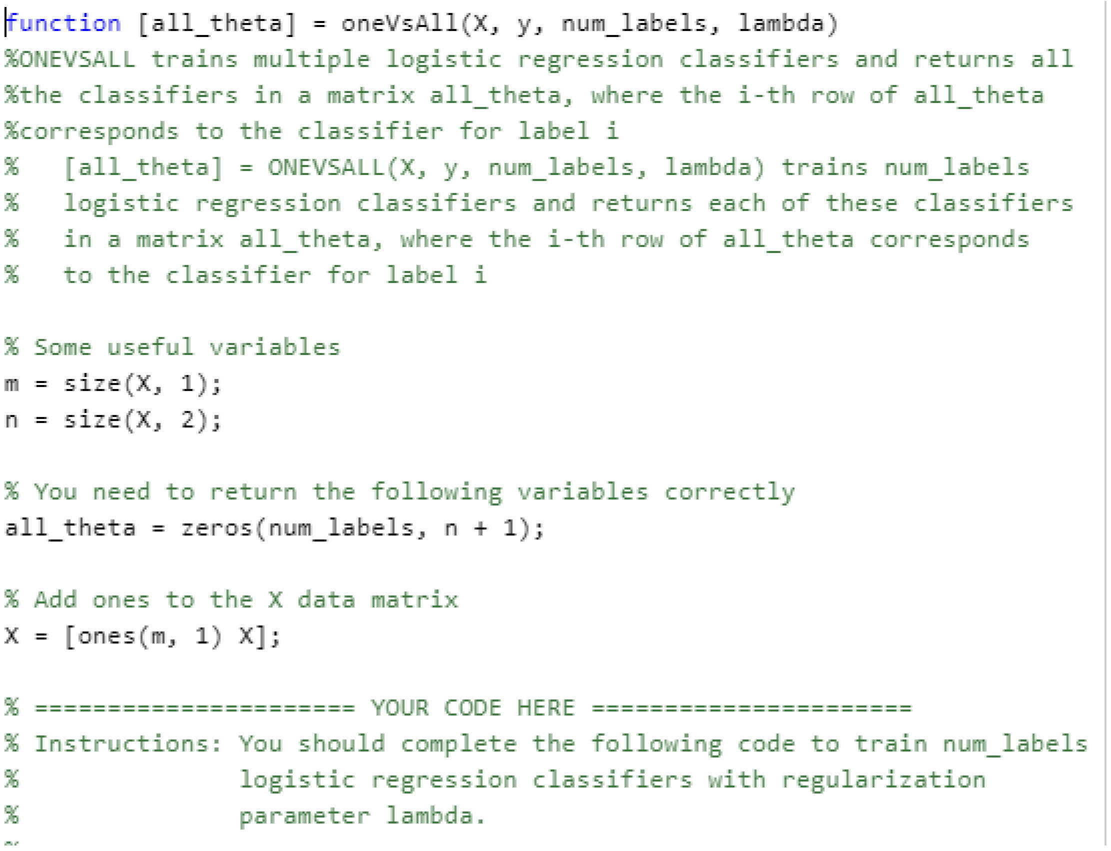
```
%                num_labels).
%
% Hint: This code can be done all vectorized using the max function.
%       In particular, the max function can also return the index of the
%       max element, for more information see 'help max'. If your examples
%       are in rows, then, you can use max(A, [], 2) to obtain the max
%       for each row.
%

predict = sigmoid(X * all_theta');
[x, ix] = max(predict, [], 2);
p = ix;






% =========================================================================


end
```



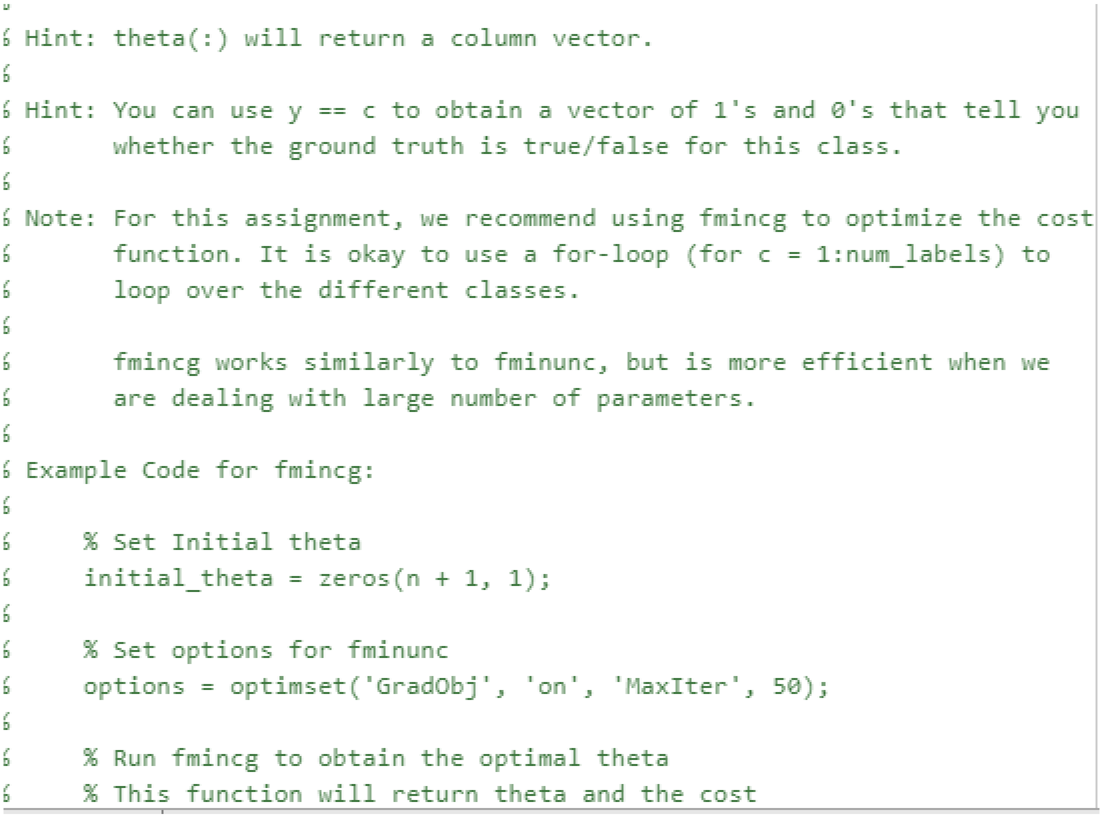
```
function p = predict(Theta1, Theta2, X)
%PREDICT Predict the label of an input given a trained neural network
%   p = PREDICT(Theta1, Theta2, X) outputs the predicted label of X given th
%   trained weights of a neural network (Theta1, Theta2)

% Useful values
m = size(X, 1);
num_labels = size(Theta2, 1);

% You need to return the following variables correctly
p = zeros(size(X, 1), 1);

% ====================== YOUR CODE HERE ======================
% Instructions: Complete the following code to make predictions using
%               your learned neural network. You should set p to a
%               vector containing labels between 1 to num_labels.
%
% Hint: The max function might come in useful. In particular, the max
%       function can also return the index of the max element, for more
%       information see 'help max'. If your examples are in rows, then, you
%       can use max(A, [], 2) to obtain the max for each row.
%
```



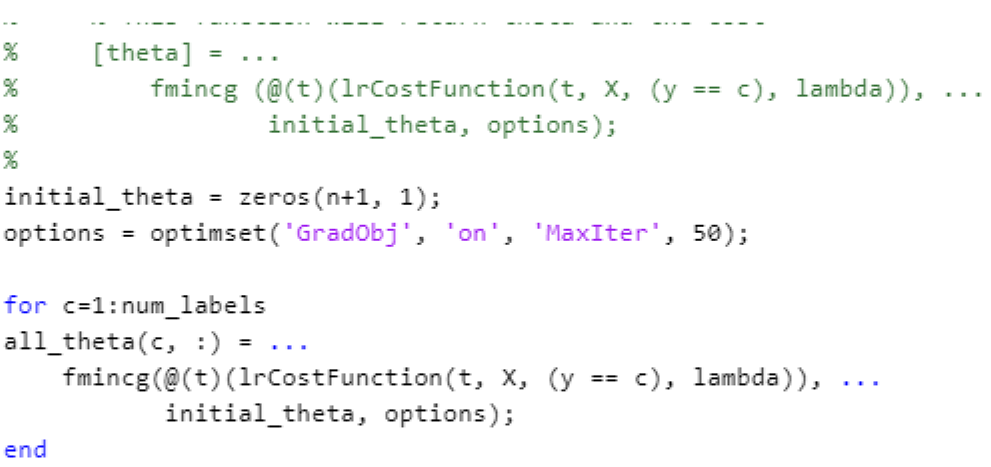
```
a1 = [ones(m, 1) X];
z2 = a1 * Theta1';
a2 = [ones(size(z2, 1), 1) sigmoid(z2)];
z3 = a2 * Theta2';
a3 = sigmoid(z3);

[p_max p] = max(a3, [], 2);
```



```
function [all_theta] = oneVsAll(X, y, num_labels, lambda)
%ONEVSALL trains multiple logistic regression classifiers and returns all
%the classifiers in a matrix all_theta, where the i-th row of all_theta
%corresponds to the classifier for label i
%   [all_theta] = ONEVSALL(X, y, num_labels, lambda) trains num_labels
%   logistic regression classifiers and returns each of these classifiers
%   in a matrix all_theta, where the i-th row of all_theta corresponds
%   to the classifier for label i

% Some useful variables
m = size(X, 1);
n = size(X, 2);

% You need to return the following variables correctly
all_theta = zeros(num_labels, n + 1);

% Add ones to the X data matrix
X = [ones(m, 1) X];

% ====================== YOUR CODE HERE ======================
% Instructions: You should complete the following code to train num_labels
%               logistic regression classifiers with regularization
%               parameter lambda.
```



```
%
% Hint: theta(:) will return a column vector.
%
% Hint: You can use y == c to obtain a vector of 1's and 0's that tell you
%       whether the ground truth is true/false for this class.
%
% Note: For this assignment, we recommend using fmincg to optimize the cost
%       function. It is okay to use a for-loop (for c = 1:num_labels) to
%       loop over the different classes.
%
%       fmincg works similarly to fminunc, but is more efficient when we
%       are dealing with large number of parameters.
%
% Example Code for fmincg:
%
%     % Set Initial theta
%     initial_theta = zeros(n + 1, 1);
%
%     % Set options for fminunc
%     options = optimset('GradObj', 'on', 'MaxIter', 50);
%
%     % Run fmincg to obtain the optimal theta
%     % This function will return theta and the cost
```



```
%     [theta] = ...
%         fmincg (@(t)(lrCostFunction(t, X, (y == c), lambda)), ...
%                 initial_theta, options);
%
initial_theta = zeros(n+1, 1);
options = optimset('GradObj', 'on', 'MaxIter', 50);

for c=1:num_labels
all_theta(c, :) = ...
    fmincg(@(t)(lrCostFunction(t, X, (y == c), lambda)), ...
           initial_theta, options);
end
```