```matlab
clear all;
close all;
clc;
load diabetes_scaled.mat;

% Creating test and train data sets
X_tr = X(1:500,:);
X_tt  = X(501:end,:);
Y_tr = y(1:500);
Y_tt  = y(501:end);

grid_sigma = 2.^(0:5);
grid_C = 2.^(6:11);
tol = 0.01;
[n, p] = size(X_tr);
% Cauchy kernel
cauchy_kernel = @(u,v,sigma) (1 + dist2(u, v)/(sigma^2)) .^-1;

num_sv = zeros(length(grid_sigma), length(grid_C));
CV_error_grid = zeros(length(grid_sigma), length(grid_C));

for i = 1:length(grid_sigma)
    grid_sigma_iter = grid_sigma(:,i);
    for j = 1:length(grid_C)
        grid_C_iter = grid_C(:,j);
            CV_error_iter = 0;
            for k = 1:5
                ind = (k-1)*100 + 1: k*100;

                X_tr_iter = X_tr;
                X_tr_iter( ind,:) = [];
                X_CV_iter = X_tr(ind,:);

                y_tr_iter = Y_tr;
                y_tr_iter(ind,:) = [];
                y_CV_iter = Y_tr(ind,:);

                kmat_tr = cauchy_kernel(X_tr_iter, X_tr_iter,
grid_sigma_iter);
                [alpha, bias] = smo(kmat_tr, y_tr_iter', grid_C_iter, tol);
                kmat_CV = cauchy_kernel(X_CV_iter, X_tr_iter,
grid_sigma_iter);
                y_pred = sign(kmat_CV * (y_tr_iter .* alpha') + bias);
                CV_error_iter = 1 - sum((y_pred == y_CV_iter))/100 +
CV_error_iter;
            end
            CV_error_grid(i, j) = CV_error_iter / 5;
    end
end

[min_error, ind] = min(CV_error_grid(:));
[m,n] = ind2sub(size(CV_error_grid),ind);

sigma_opt = grid_sigma(m); %4
C_opt = grid_C(n); %512

% Selected parameters: (sigma, C) :: (4, 512)
```

```matlab
% CV error: min_error :: 0.2480

% Final model
kmat_tr = cauchy_kernel(X_tr, X_tr, sigma_opt);
[alpha, bias] = smo(kmat_tr, Y_tr', C_opt, tol);
kmat_tt = cauchy_kernel(X_tt, X_tr, sigma_opt);
y_pred = sign(kmat_tt * (Y_tr .* alpha') + bias);
error_tt = 1 - sum((y_pred == Y_tt))/size(Y_tt, 1);
% test error :: 0.182
500 - sum(alpha == 0);
%number of support vectors :: 342
```

Question 4

```matlab
clear;
clc;

load yalefaces; % loads the 3-d array yalefaces
% for i=1:size(yalefaces,3)
%     x = double(yalefaces(:,:,i));
%     imagesc(x);
%     colormap(gray)
%     drawnow
%     %pause(.1)
% %    [U, S, V] = svd(x);
% end

yalefaces_mat = double(reshape(yalefaces, [], 2414)');
x_mean = mean(yalefaces_mat);
x_mean_mat = ones(size(yalefaces_mat))* diag(x_mean);
cov_base = yalefaces_mat - x_mean_mat;
cov_mat = (cov_base' * cov_base) ./ 2414;
[U, D] = eig(cov_mat);
eig_values = sum(D);
[sort_eig_values, index] = sort(eig_values,'descend');
semilogy(sort_eig_values)
for i = 1:length(sort_eig_values)
    var_cap = sum(sort_eig_values(:, 1:i)) / sum(sort_eig_values);
    if var_cap >= .95
        break
    end
end
% .95 variation captured: 43
% % dim reduction: .9787
for i = 1:length(sort_eig_values)
    var_cap = sum(sort_eig_values(:, 1:i)) / sum(sort_eig_values);
    if var_cap >= .99
        break
    end
end
% .99 variation captured: 167
% % dim reduction: .9172
subplot(5,4, 1)
```

```matlab
a = reshape(x_mean, 48, 42);
imagesc(a);
colormap(gray)
drawnow

for i = 1:19
    subplot(5, 4, i+1);
    x = reshape(U(:, index(i)), 48, 42);
    imagesc(x);
    colormap(gray)
    drawnow
end
```