Table of Contents

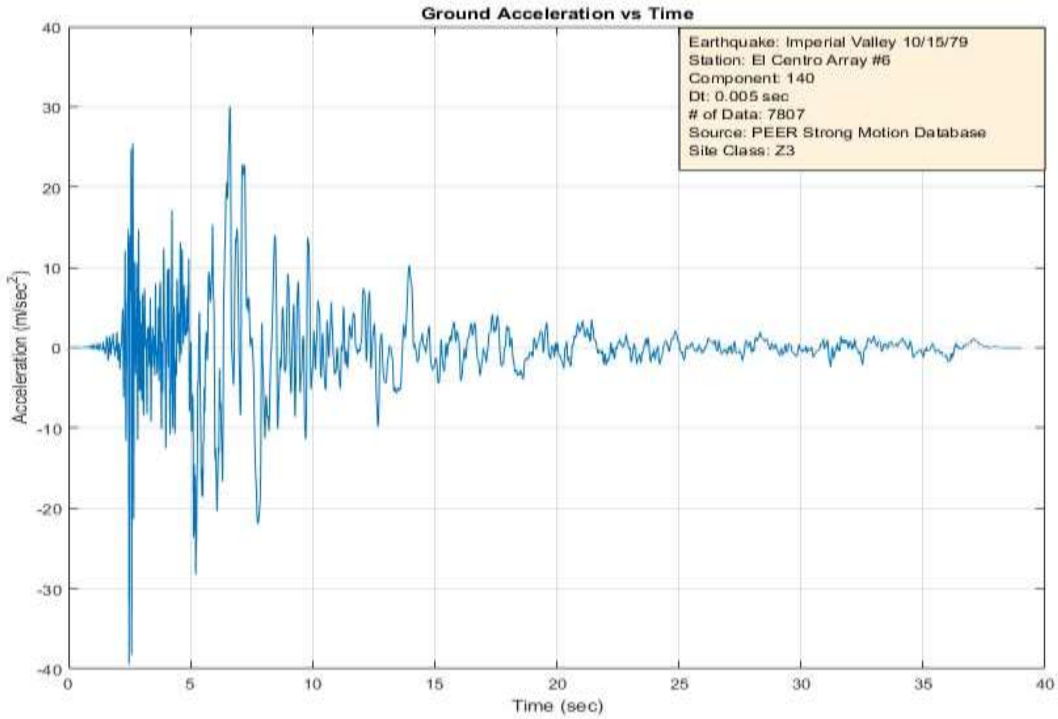
Introduction

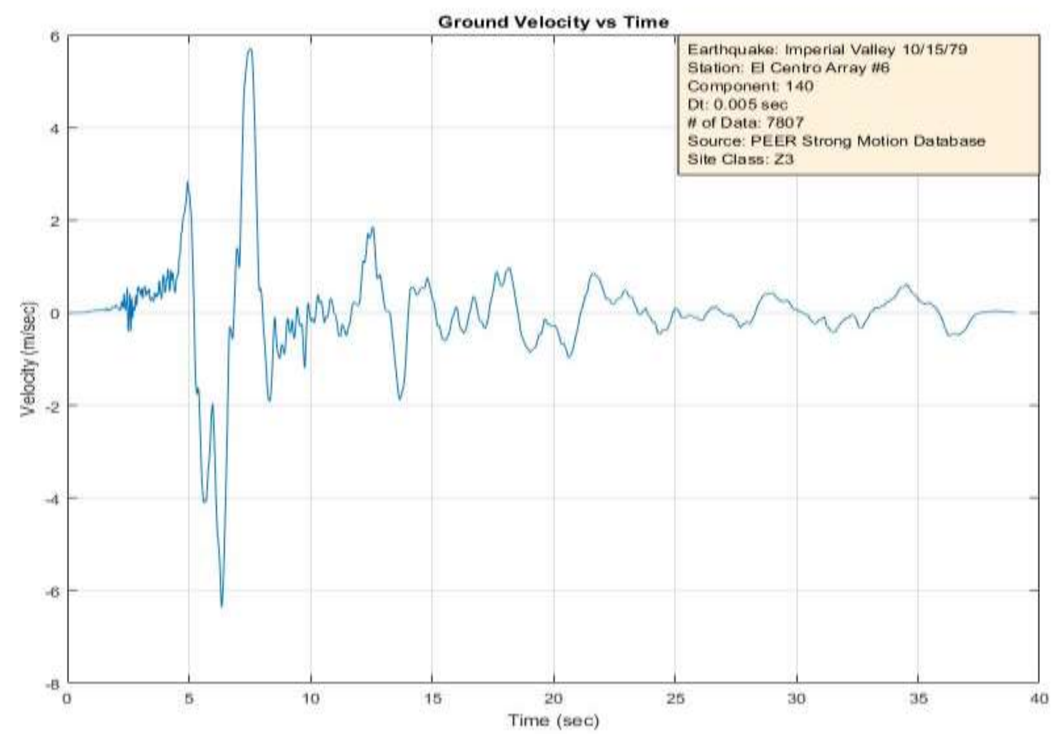
This report is prepared for the solutions of the assigned problems in the Homework 1. According to provided ground motion data E0140 earthquake has occurred on October 15th 1979, Imperial Valley. Earthquake site is underplayed with a Z3 type of soil. The station which acceleration data recorded is El Centro Array #6. Figure 1 shows extra information about the earthquake.

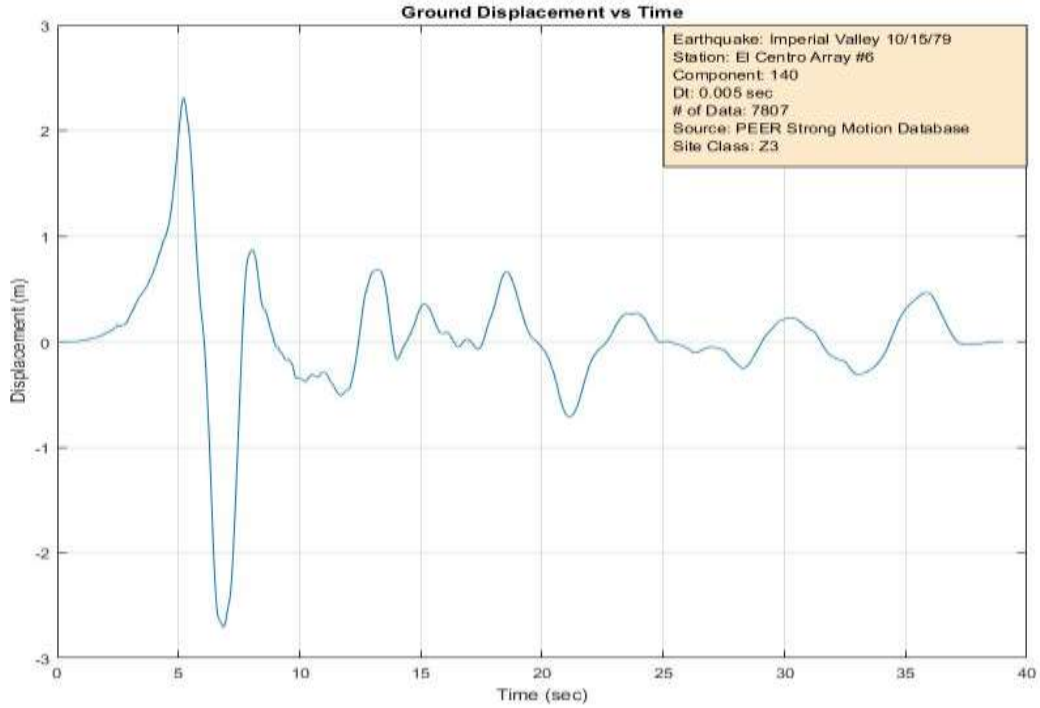
Figure 1: Earthquake Information

Question 1

```
% This script is written for CE490 Introduction to Earthquake Engineering

%%%%%%%%%%%%%%% PART-1 %%%%%%%%%%%%%%%
%%%%%%%%%%%%%%% Earthquake: Imperial Valley 10/15/79 %%%%%%%%%%%%%%
clear
close all
clc



time = 0:0.005:39.03;     % Dt: 0.005 sec (given in the .txt file), and 7807
data point exist (7807-1)*0.05=39.03

acceleration_recorded = dlmread('E06140.txt'); % importing the given
acceleration data file

u_double_dot = acceleration_recorded*9.80665; % determining the ground
acceleration by multiplying g=9.80665

u_dot = cumtrapz(time, u_double_dot); % velocity is obtained by taking
integral of the acceleration (cumulative trapezoidal integration method is
used)

u = cumtrapz(time,u_dot); % displacement is obtained by taking integral of
the velocity (cumulative trapezoidal integration method is used)

figure(1)

plot(time,u_double_dot);                % Acceleration vs Time graph is
plotted
 title('Ground Acceleration vs Time')
 xlabel('Time (sec)')
 ylabel('Acceleration (m/sec^2)')
 grid on

figure(2)
 plot(time, u_dot);                   % Velocity vs Time graph is plotted
 title('Ground Velocity vs Time')
 xlabel('Time (sec)')
 ylabel('Velocity (m/sec)')
 grid on

figure(3)
 plot(time, u);               % Displacement vs Time graph is plotted
 title('Ground Displacement vs Time')
 xlabel('Time (sec)')
 ylabel('Displacement (m)')
 grid on
```


Ground Acceleration vs Time
Earthquake: Imperial Valley 10/15/79
Station: El Centro Array #6
Component: 140
Dt: 0.005 sec
# of Data: 7807
Source: PEER Strong Motion Database
Site Class: Z3
Acceleration (m/sec^2)
Time (sec)


Ground Velocity vs Time
Earthquake: Imperial Valley 10/15/79
Station: El Centro Array #6
Component: 140
Dt: 0.005 sec
# of Data: 7807
Source: PEER Strong Motion Database
Site Class: Z3
Velocity (m/sec)
Time (sec)

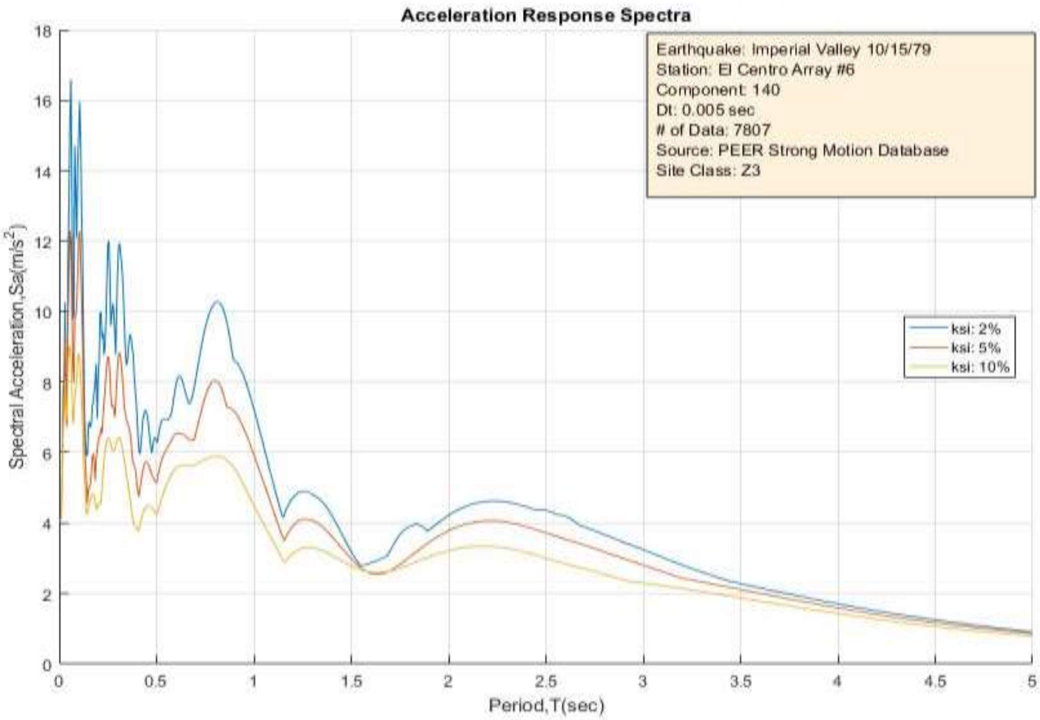


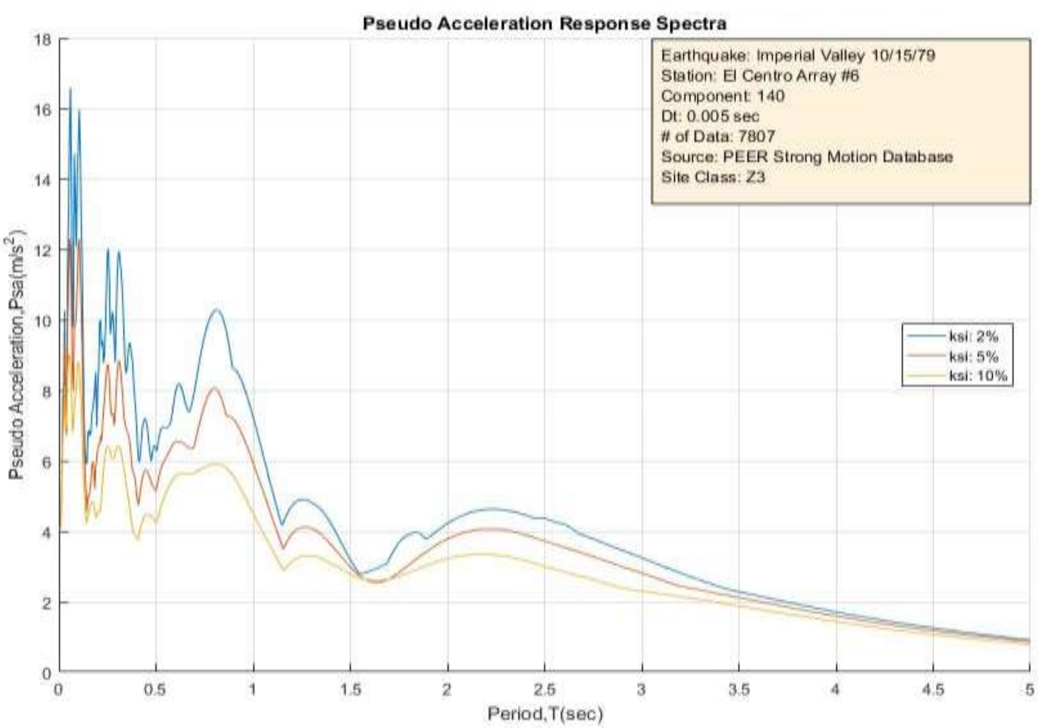
Question 2

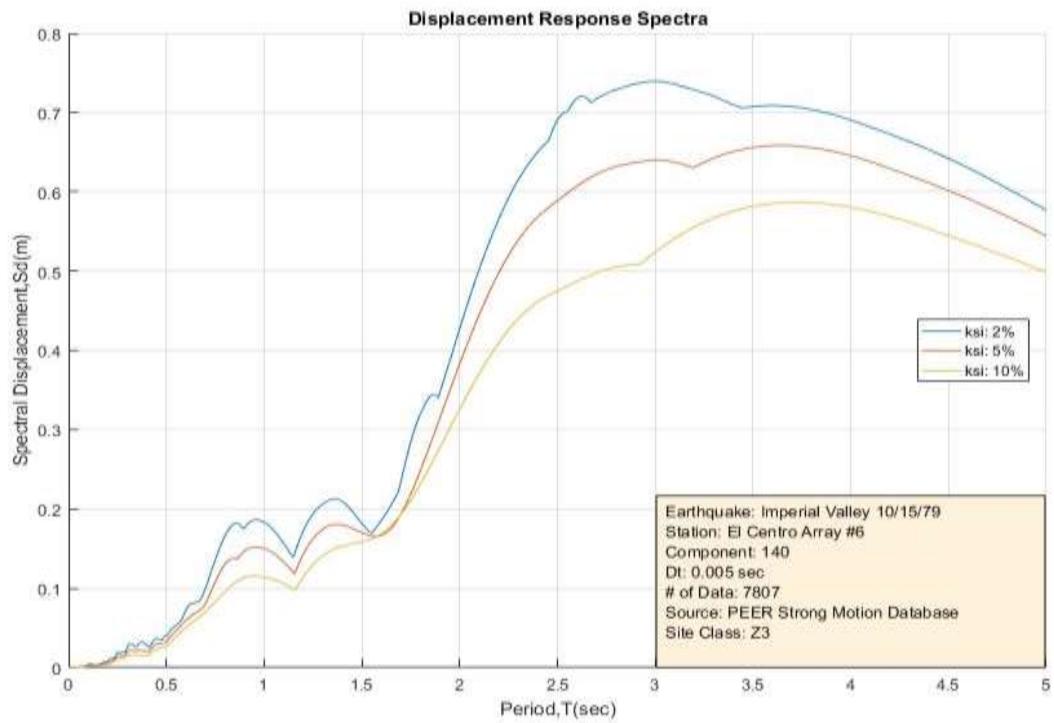
```
% This script is written for CE490 Introduction to Earthquake Engineering

%%%%%%%%%%%%%%% PART-2 %%%%%%%%%%%%%%%
%%%%%%%%%%%%%%% Earthquake: Imperial Valley 10/15/79 %%%%%%%%%%%%%%
clear
close all
clc


acceleration_recorded = dlmread('E06140.txt'); % importing the given
acceleration data file

size = size(acceleration_recorded);    % size of the imported data determined
by creating a matrix
n = size(1,1);                         % nomber of data included in .txt file
is determined

delta_t = 0.005;                       % Dt: 0.005 sec (given in the .txt
file)

time = (n-1)*delta_t;

ksi1 = [0.02;0.05;0.1];                  % a ksi1 matrix is created includes
asked ksi values

Sa = zeros(1000,1);                      % size is determined 5/0.005=1000
```

```
Sa1 = zeros(1000,1);                    % size is determined 5/0.005=1000

Sd = zeros(1000,1);                     % size is determined 5/0.005=1000

Sd1 = zeros(1000,1);                    % size is determined 5/0.005=1000

PSa = zeros(1000,1);                    % size is determined 5/0.005=1000

for i = 1:3
    ksi = ksi1(i,1);                    % asked ksi values are used from ksi1
matrix
    ii = 1;
    for T = 0:0.005:5

        mass = 1;

        omega_n = 2*pi/T;                    % natural frequency is
calculated

        k = omega_n*omega_n*mass;            % stiffness is determined

        c = 2*ksi*mass*omega_n;

        u = 0;

        u_dot = 0;

        for j = 1:n-1

            F_1 = -acceleration_recorded(j,1)*mass;

            F_2 = -acceleration_recorded(j+1,1)*mass;

            u_double_dot = (F_1-c*u_dot-k*u)/mass;

            k1 = k+(2*c)/delta_t+(4*mass)/(delta_t*delta_t);

            delta_F = F_2-F_1+(4*mass/delta_t+2*c)*u_dot+2*mass*u_double_dot;

            delta_u = delta_F/k1;

            delta_u_dot = 2*delta_u/delta_t-2*u_dot;

            delta_u_double_dot = 4*delta_u/(delta_t^2)-4*u_dot/delta_t-
2*u_double_dot;

            u = u+delta_u;

            u_dot = u_dot+delta_u_dot;

            u_double_dot = u_double_dot+delta_u_double_dot;

            Sa1(j,1) = u*omega_n^2;

            Sd1(j,1) = u;
        end
```

```
        Sa(ii,1) = max(abs(Sa1));

        Sd(ii,1) = max(abs(Sd1));

        PSa(ii,1) = (omega_n^2)*Sd(ii,1);

            ii = ii+1;

    end


    figure(1)
    hold on

      plot(0:0.005:5,Sa)

      title('Acceleration Response Spectra')

      xlabel('Period,T(sec)')

      ylabel('Spectral Acceleration,Sa(m/s^2)')

      legend('ksi: 2%','ksi: 5%','ksi: 10%','Location','east')
      grid on


    figure(2)

     hold on
        plot(0.00:0.005:5,Sd)

        title('Displacement Response Spectra')

        xlabel('Period,T(sec)')

        ylabel('Spectral Displacement,Sd(m)')

        legend('ksi: 2%','ksi: 5%','ksi: 10%','Location','east')

        grid on


    figure(3)
     hold on
        plot(0.00:0.005:5,PSa)

        title('Pseudo Acceleration Response Spectra')

        xlabel('Period,T(sec)')

        ylabel('Pseudo Acceleration,Psa(m/s^2)')

        legend('ksi: 2%','ksi: 5%','ksi: 10%','Location','east')
       grid on
end
```


Acceleration Response Spectra
Earthquake: Imperial Valley 10/15/79
Station: El Centro Array #6
Component: 140
Dt: 0.005 sec
# of Data: 7807
Source: PEER Strong Motion Database
Site Class: Z3
ksi: 2%
ksi: 5%
ksi: 10%
Spectral Acceleration,Sa(m/s^2)
Period,T(sec)
0
2
4
6
8
10
12
14
16
18
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5


Pseudo Acceleration Response Spectra
Earthquake: Imperial Valley 10/15/79
Station: El Centro Array #6
Component: 140
Dt: 0.005 sec
# of Data: 7807
Source: PEER Strong Motion Database
Site Class: Z3
ksi: 2%
ksi: 5%
ksi: 10%
Pseudo Acceleration,Psa(m/s^2)
Period,T(sec)
0
2
4
6
8
10
12
14
16
18
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5

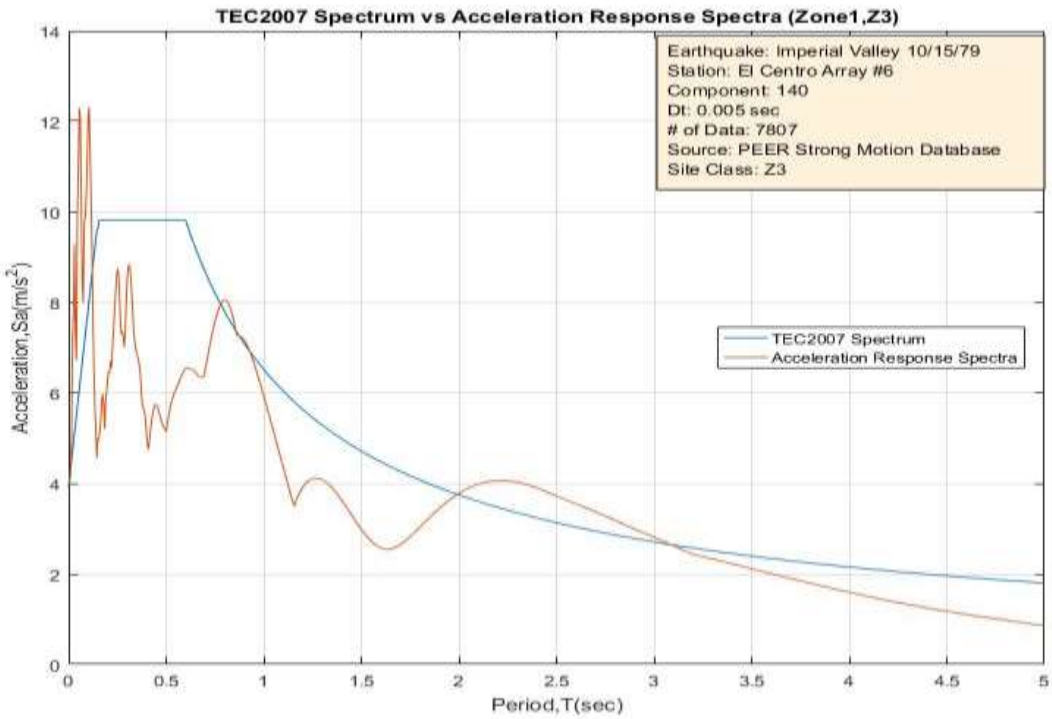


Question 3

```
% This script is written for CE490 Introduction to Earthquake Engineering

%%%%%%%%%%%%%%% PART-3 %%%%%%%%%%%%%%
%%%%%%%%%%%%%%% Earthquake: Imperial Valley 10/15/79 %%%%%%%%%%%%%%
clear
close all
clc


acceleration_recorded = dlmread('E06140.txt'); % importing the given
acceleration data file

size = size(acceleration_recorded);    % size of the imported data determined
by creating a matrix
n = size(1,1);                         % nomber of data included in .txt file
is determined

delta_t = 0.005;                       % Dt: 0.005 sec (given in the .txt
file)

time = (n-1)*delta_t;
```

```
ksi1 = [0.02;0.05;0.1];                      % a ksi1 matrix is created includes
asked ksi values

Sa = zeros(1000,1);                          % size is determined 5/0.005=1000

Sa1 = zeros(1000,1);                         % size is determined 5/0.005=1000

Sd = zeros(1000,1);                          % size is determined 5/0.005=1000

Sd1 = zeros(1000,1);                         % size is determined 5/0.005=1000

PSa = zeros(1000,1);                         % size is determined 5/0.005=1000

Ta = 0.15;                                     % for Z3 soil type Ta
Tb = 0.60;                                     % for Z3 soil type Tb

A0 = 0.40;                                     % for zone 1
I = 1;                                         % building importance factor
g = 9.80656;                                   % gravity

tec_data = zeros(1000,1);
i = 1;
for T = 0:0.005:5
    if T < Ta
        S = 1+1.5*(T/Ta);                                    % spectrum
coefficient
    elseif Ta < T && T < Tb
        S = 2.5;
    elseif Tb < T
        S = 2.5*(Tb/T)^0.8;
    end
    tec_data(i,1)=S;
    i = i+1;
end

A = (A0*I)*tec_data;

Sae = A*g;

plot(0:0.005:5,Sae)

ii=1;
    for T = 0:0.005:5

        ksi = 0.05;                                 % specified in the question

        mass = 1;                                   % unit mass

        omega_n = 2*pi/T;                           % natural frequency

        k = omega_n*omega_n*mass;

        c = 2*ksi*mass*omega_n;

        u = 0;                                       % displacement

        u_dot = 0;                                   % velocity
```

```
        for j = 1:n-1

            F_1 = -acceleration_recorded(j,1)*mass;

            F_2 = -acceleration_recorded(j+1,1)*mass;

            u_double_dot = (F_1-c*u_dot-k*u)/mass;

            k1 = k+(2*c)/delta_t+(4*mass)/(delta_t*delta_t);

            delta_F = F_2-F_1+(4*mass/delta_t+2*c)*u_dot+2*mass*u_double_dot;

            delta_u = delta_F/k1;

            delta_u_dot = 2*delta_u/delta_t-2*u_dot;

            delta_u_double_dot = 4*delta_u/(delta_t^2)-4*u_dot/delta_t-
2*u_double_dot;

            u = u+delta_u;

            u_dot = u_dot+delta_u_dot;

            u_double_dot = u_double_dot+delta_u_double_dot;

            Sa1(j,1) = u*omega_n^2;

            Sd1(j,1) = u;

        end

        Sa(ii,1) = max(abs(Sa1));

        Sd(ii,1) = max(abs(Sd1));

        PSa(ii,1) = omega_n*omega_n*Sd(ii,1);

            ii = ii+1;
    end


  hold on

      plot(0:0.005:5,Sa)

      title('TEC2007 Spectrum vs Acceleration Response Spectra (Zone1,Z3)')

      xlabel('Period,T(sec)')

      ylabel('Acceleration,Sa(m/s^2)')

      legend('TEC2007 Spectrum','Acceleration Response
Spectra','Location','east')

      grid on
```



Question 4

In the second part of the homework, Acceleration Response, Pseudo Acceleration Response and Displacement Response Spectra with respect to Period curves are obtained for three different damping ratios. By looking those curves, it can be said that effect of the damping ratio is significantly high for smaller periods as compared to the higher periods. Moreover, spectral parameters decrease as the damping ratio increases. In the case of smaller periods, small changes in the damping ratio result in significant changes at the behavior of the structural system. Having different damping ratios does not affect the spectral parameters seriously for the situation of relatively higher periods.

In the third part of the homework, TEC design response spectrum and Acceleration Response Spectra are compared. Since design response spectrum is mean and smoother version of a larger spectra, there are differences between TEC Spectrum and Acceleration Response Spectra. However, when all the data is considered and checked for the input values Acceleration Response Spectra is similar to the TEC Spectrum and gives reasonable results.