Problem 1

11 January 2022 09:59 AM

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```
%Problem#1(a) for Tn=0.02s & Damping=2%
clc
fid = fopen('El Centro Ground Motion data.txt') ; % open the text file
S = textscan(fid,'%s'); % text scan the data
fclose(fid) ; % close the file
S = S{1} ;
a_g = cellfun(@(x)str2double(x), S); % convert the cell array to double
% Remove NaN's which were strings earlier
a_g(isnan(a_g))=[];
col = 2;
count = 0;
temp_arr =[];
temp_row = [];
for i = 1:length(a_g)
    if count == col
        temp_arr = [temp_arr;
                    temp_row];
        count = 0;
        temp_row = [];
    end
    temp_row = [temp_row,a_g(i)];
    count = count +1;
end
temp_arr = [temp_arr;
            temp_row];
a_g = temp_arr(:,2:end);
a_g=a_g.*9.81;
clear temp_arr temp_row S;
% Creating Time axis
t=zeros(length(a_g),1);
for i=2:length(a_g)
    t(i)=t(i-1)+0.02;
end
del_t=t(2)-t(1);
%Producing ground velocity data
v_g=zeros(length(a_g),1);
for i=1:length(a_g)-1
    v_g(i+1)=v_g(i)+(del_t*(a_g(i+1)+a_g(i)))/2;
end
%Producing ground displacement data
u_g=zeros(length(a_g),1);
for i=1:length(a_g)-1
    u_g(i+1)=u_g(i)+del_t*v_g(i)+del_t^2*((a_g(i+1)/6)+(a_g(i)/3));
end
%Producing System response data
Tn=0.02; %Natural Period of the system
Z=0.02; %Damping ratio
Wn=(2*pi)/Tn; %Natural Frequency
Wd=Wn*sqrt(1-Z^2); %Damped Natural Frequency
%Defining Parameters required A,B,C,D & A1,B1,C1,D1
A=exp(-Z*Wn*del_t)*((Z/sqrt(1-Z^2))*sin(Wd*del_t)+cos(Wd*del_t));
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B=exp(-Z*Wn*del_t)*(sin(Wd*del_t)/Wd);
C=(((2*Z)/(Wn*del_t))+exp(-Z*Wn*del_t)*(((1-2*Z^2)/(Wd*del_t)-(Z/sqrt(1-Z^2)))*sin
(Wd*del_t)-(1+((2*Z)/(Wn*del_t)))*cos(Wd*del_t)))/Wn^2;
D=(1-((2*Z)/(Wn*del_t))+exp(-Z*Wn*del_t)*(((2*Z^2-1)/(Wd*del_t))*sin(Wd*del_t)+((2*Z)/
(Wn*del_t))*cos(Wd*del_t)))/Wn^2;
A1=-exp(-Z*Wn*del_t)*((Wn/sqrt(1-Z^2))*sin(Wd*del_t));
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B1=exp(-Z*Wn*del_t)*(cos(Wd*del_t)-(Z/sqrt(1-Z^2))*sin(Wd*del_t));
C1=((-1/del_t)+exp(-Z*Wn*del_t)*(((Wn/(sqrt(1-Z^2)))+(Z/(del_t*sqrt(1-Z^2))))*sin
(Wd*del_t)+(cos(Wd*del_t)/del_t)))/Wn^2;
D1=(1-exp(-Z*Wn*del_t)*((Z/sqrt(1-Z^2))*sin(Wd*del_t)+cos(Wd*del_t)))/(Wn^2*del_t);
u=zeros(length(a_g),1); %Initialising displacement response vector of the SDOF system
v=zeros(length(a_g),1); %Initialising velocity response vector of the SDOF system
a=zeros(length(a_g),1); %Initialising Acceleration response vector for the SDOF system
for i=1:length(a_g)-1
    u(i+1)=A*u(i)+B*v(i)-C*a_g(i)-D*a_g(i+1);
    v(i+1)=A1*u(i)+B1*v(i)-C1*a_g(i)-D1*a_g(i+1);
    a(i+1)=-a_g(i+1)-2*Z*Wn*v(i+1)-Wn^2*u(i+1);
end
u_t=u_g+u; %Absolute displacement response
a_t=a_g+a; %Absolute acceleration response
A_t=Wn^2*u; %Pseudo Spectral Acceleration(PSA)
figure(1)
plot(t(1:500),u(1:500),'r-','linewidth',2)
hold on
plot(t(1:500),u_g(1:500),'b-','linewidth',2)
hold on
plot(t(1:500),u_t(1:500),'g--','linewidth',2)
xlabel('Time(sec)');
ylabel('Displacement time histories(m)');
legend('u(t)','u_{g}(t)','u^{t}(t)');
grid on
figure(2)
plot(t(1:500),a_t(1:500),'r-','linewidth',2)
hold on
plot(t(1:500),a_g(1:500),'b--','linewidth',2)
hold on
plot(t(1:500),A_t(1:500),'k-','linewidth',2)
xlabel('Time(sec)');
ylabel('Acceleration time histories(m/s^2)');
legend('a^{t}(t)','a_{g}(t)','A(t)');
grid on
ag_max=max(abs(a_g));
u_max=max(abs(u));
ug_max=max(abs(u_g));
ut_max=max(abs(u_t));
A_max=max(abs(A_t));
at_max=max(abs(a_t));
```

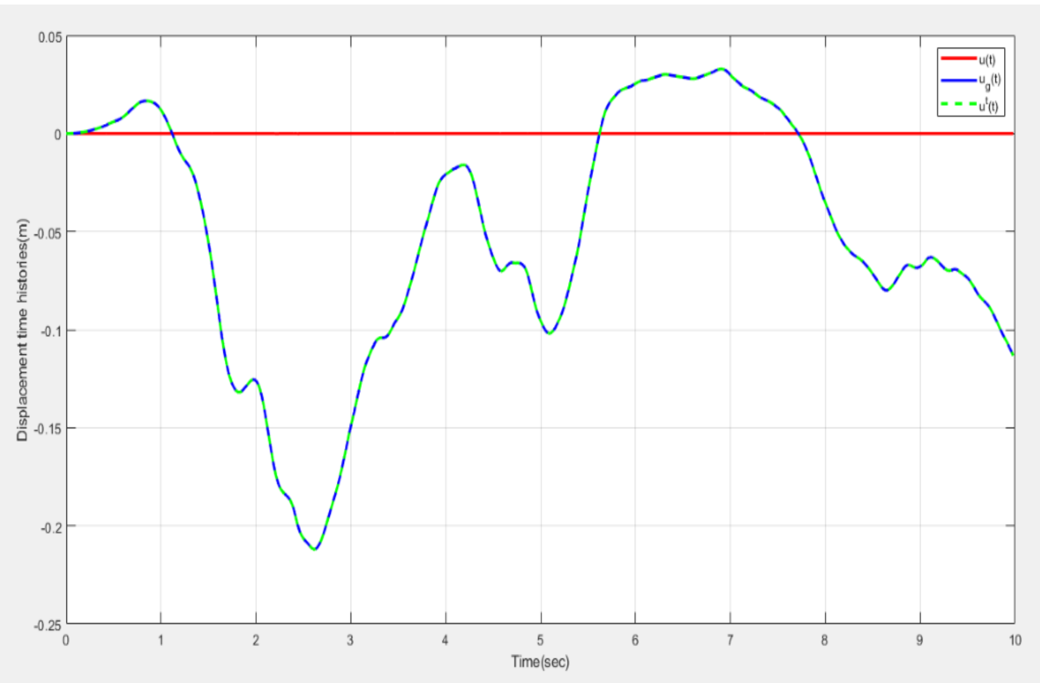

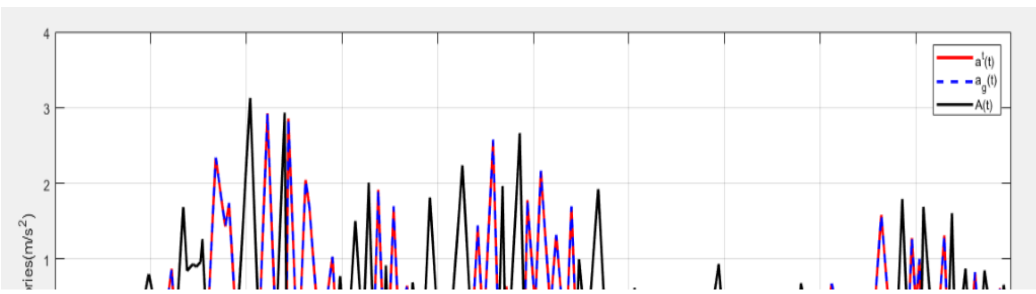

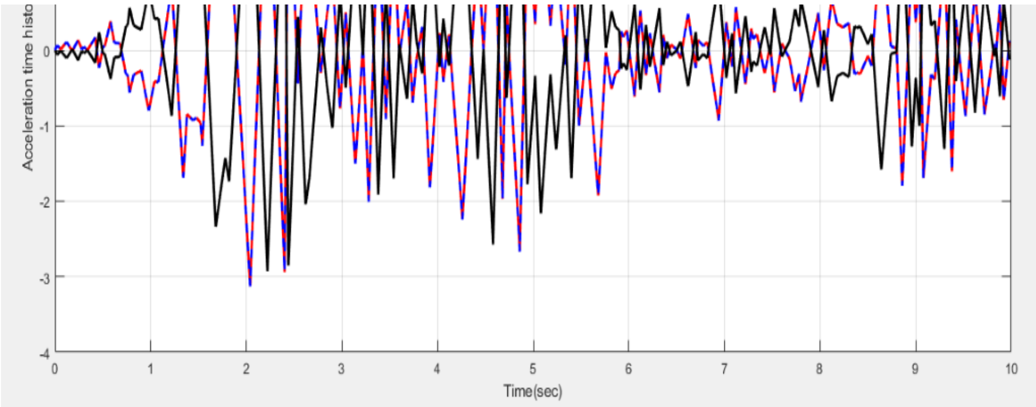

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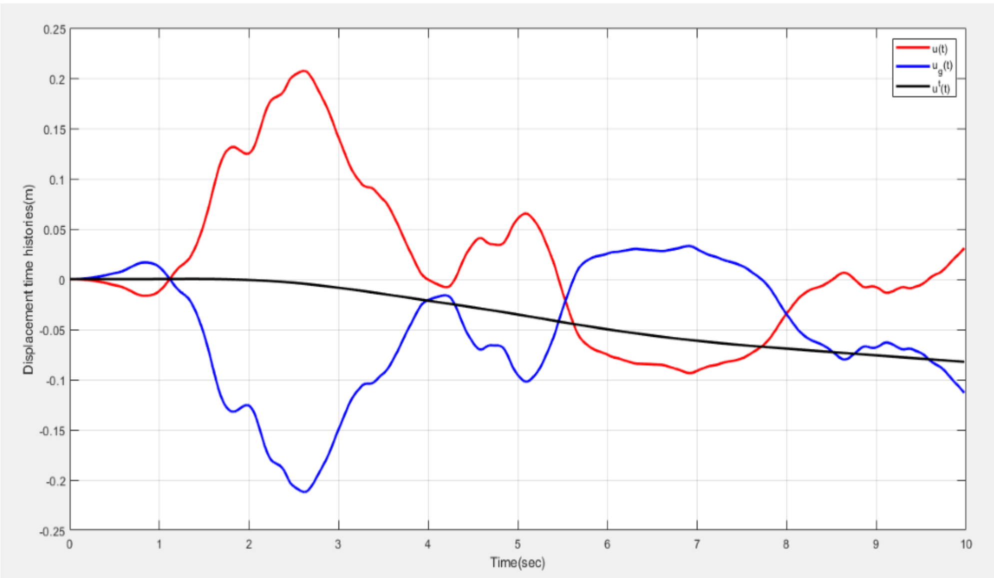
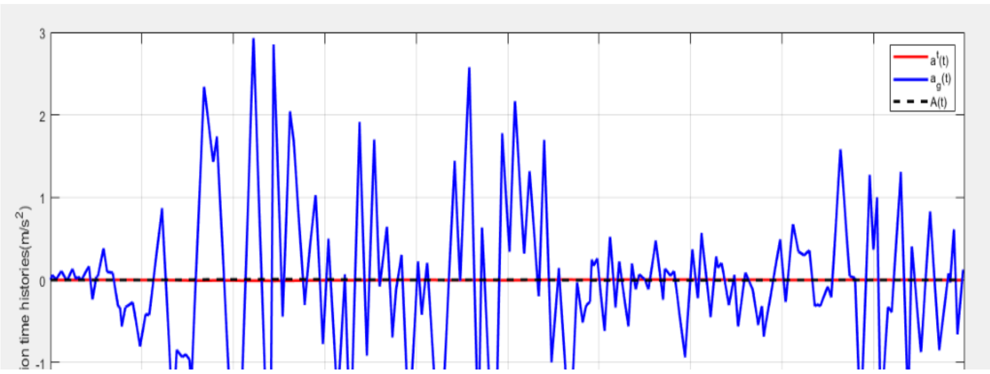
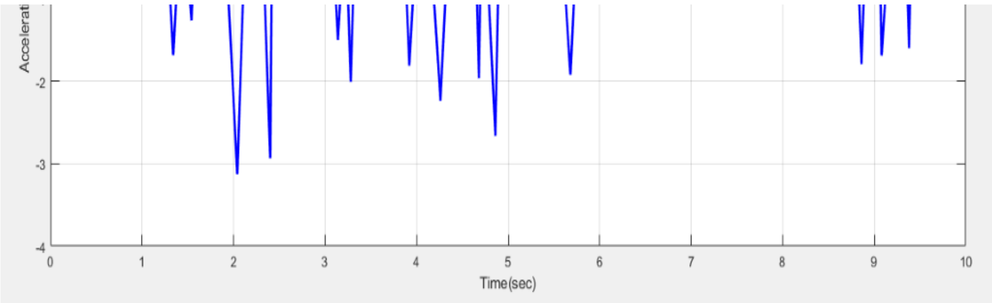
```
clc
fid = fopen('El Centro Ground Motion data.txt') ;  % open the text file
S = textscan(fid,'%s');   % text scan the data
fclose(fid) ;      % close the file
S = S{1} ;
a_g = cellfun(@(x)str2double(x), S);  % convert the cell array to double
% Remove NaN's which were strings earlier
a_g(isnan(a_g))=[];
col = 2;
count = 0;
temp_arr =[];
temp_row = [];
for i = 1:length(a_g)
    if count == col
        temp_arr = [temp_arr;
                    temp_row];
        count = 0;
        temp_row = [];
    end
    temp_row = [temp_row,a_g(i)];
    count = count +1;
end
temp_arr = [temp_arr;
            temp_row];
a_g = temp_arr(:,2:end);
a_g=a_g.*9.81;
clear temp_arr temp_row S;
% Creating Time axis
t=zeros(length(a_g),1);
for i=2:length(a_g)
    t(i)=t(i-1)+0.02;
end
del_t=t(2)-t(1);
%Producing ground velocity data
v_g=zeros(length(a_g),1);
for i=1:length(a_g)-1
    v_g(i+1)=v_g(i)+(del_t*(a_g(i+1)+a_g(i)))/2;
end
%Producing ground displacement data
u_g=zeros(length(a_g),1);
for i=1:length(a_g)-1
    u_g(i+1)=u_g(i)+del_t*v_g(i)+del_t^2*((a_g(i+1)/6)+(a_g(i)/3));
end
%Producing System response data
Tn=30; %Natural Period of the system
Z=0.02; %Damping ratio
Wn=(2*pi)/Tn; %Natural Frequency
Wd=Wn*sqrt(1-Z^2); %Damped Natural Frequency
%Defining Parameters required A,B,C,D & A1,B1,C1,D1
A=exp(-Z*Wn*del_t)*((Z/sqrt(1-Z^2))*sin(Wd*del_t)+cos(Wd*del_t));
B=exp(-Z*Wn*del_t)*(sin(Wd*del_t)/Wd);
```

```
C=(((2*Z)/(Wn*del_t))+exp(-Z*Wn*del_t)*(((1-2*Z^2)/(Wd*del_t)-(Z/sqrt(1-Z^2)))*sin↙
(Wd*del_t)-(1+((2*Z)/(Wn*del_t)))*cos(Wd*del_t)))/Wn^2;
D=(1-((2*Z)/(Wn*del_t))+exp(-Z*Wn*del_t)*(((2*Z^2-1)/(Wd*del_t))*sin(Wd*del_t)+((2*Z)/↙
(Wn*del_t))*cos(Wd*del_t)))/Wn^2;
A1=-exp(-Z*Wn*del_t)*((Wn/sqrt(1-Z^2))*sin(Wd*del_t));
B1=exp(-Z*Wn*del_t)*(cos(Wd*del_t)-(Z/sqrt(1-Z^2))*sin(Wd*del_t));
C1=((-1/del_t)+exp(-Z*Wn*del_t)*(((Wn/(sqrt(1-Z^2)))+(Z/(del_t*sqrt(1-Z^2))))*sin↙
(Wd*del_t)+(cos(Wd*del_t)/del_t)))/Wn^2;
D1=(1-exp(-Z*Wn*del_t)*((Z/sqrt(1-Z^2))*sin(Wd*del_t)+cos(Wd*del_t)))/(Wn^2*del_t);
u=zeros(length(a_g),1); %Initialising displacement response vector of the SDOF system
v=zeros(length(a_g),1); %Initialising velocity response vector of the SDOF system
a=zeros(length(a_g),1); %Initialising Acceleration response vector for the SDOF system
for i=1:length(a_g)-1
    u(i+1)=A*u(i)+B*v(i)-C*a_g(i)-D*a_g(i+1);
    v(i+1)=A1*u(i)+B1*v(i)-C1*a_g(i)-D1*a_g(i+1);
    a(i+1)=-a_g(i+1)-2*Z*Wn*v(i+1)-Wn^2*u(i+1);
end
u_t=u_g+u; %Absolute displacement response
a_t=a_g+a; %Absolute acceleration response
A_t=Wn^2*u; %Pseudo Spectral Acceleration(PSA)
figure(1)
plot(t(1:500),u(1:500),'r-','linewidth',2)
hold on
plot(t(1:500),u_g(1:500),'b-','linewidth',2)
hold on
plot(t(1:500),u_t(1:500),'k-','linewidth',2)
xlabel('Time(sec)');
ylabel('Displacement time histories(m)');
legend('u(t)','u_{g}(t)','u^{t}(t)');
grid on
figure(2)
plot(t(1:500),a_t(1:500),'r-','linewidth',2)
hold on
plot(t(1:500),a_g(1:500),'b-','linewidth',2)
hold on
plot(t(1:500),A_t(1:500),'k-','linewidth',2)
xlabel('Time(sec)');
ylabel('Acceleration time histories(m/s^2)');
legend('a^{t}(t)','a_{g}(t)','A(t)');
grid on
ag_max=max(abs(a_g));
u_max=max(abs(u));
ug_max=max(abs(u_g));
ut_max=max(abs(u_t));
A_max=max(abs(A_t));
at_max=max(abs(a_t));
```







Comments:

In the 1st case, we see that as the natural Period is very less(=0.02s), the structure is very rigid and hence the relative displacement(u(t)) of the body is almost zero and thus the total (=u(t)+ug(t)) is almost equal as that of the ground, the total acceleration (a_t(t)) is same as the ground acceleration and the pseudo Spectral acceleration (A(t)) is the negative of a_t(t).

In the 2nd case, Tn=30s and thus the system is very flexible. In such cases, the total displacement remains zero as the body does not displacement from its original position but the relative displacement u(t) is negative of the ground displacement as evident from the plot itself. The system being at its original position, u_t(t)=0, the total acceleration a_t(t) also remains zero along with the pseudo spectral acceleration A(t)=0.