```
%=========================================================
% Penyelesaian persamaan diferensial dari sistem
% dua derajat kebebasan sebagai berikut:
%    ..          .
% m * x(t) + c * x(t) + k * x(t) = F(t)
%
% where
% m adalah matriks massa
% c adalah matriks redaman
% k adalah matriks kekakuan
% F(t) adalah fungsi gaya
% x(t) adalah respons
%=========================================================
%
clear all;
close all;
clc;
%
% Koefisien Tetap
%
m1 = 19044.75025; %massa di lantai 1 (kgs s^2/m)
m2 = 18890.62181; %massa di lantai 2 (kgs s^2/m)
k1 = 1775860.058; %kekakuan di lantai 1 (kg/m)
k2 = 1775860.058; %kekakuan di lantai 2 (kg/m)
vark1 = (0.05*k1)^2; % variansi variabel k1
vark2 = (0.05*k2)^2; % variansi variabel k2
%
% Matriks Massa
%
M(1,1) = m1;
M(1,2) = 0.0;
M(2,1) = 0.0;
M(2,2) = m2;
%
% Matriks Kekakuan
%
K(1,1) = k1 + k2;
K(1,2) = -k2;
K(2,1) = -k2;
K(2,2) = k2;
%
% Matriks Redaman
% C = matriks redaman (N det/m) yag didapat dengan
% menggunakan perluasan redaman Rayleigh
% dimana xi = redaman kritis 5%
%
xi = 0.05;
```

```
%
lam = eig(inv(M)*K);
%
for i = 1:2,
   w(i) = sqrt(lam(i));
end
%
for i = 1:2,
   for j = 1:2,
      W(i,j) = ((w(i))^(2*(j - 1)-1));
  end
end
%
for i = 1:2,
   XI(i) = 2.0*xi;
end
%
a = inv(W) * XI'
%
Ci = zeros(2,2);
%
for i = 1:2,
   Ci = Ci + a(i) * (inv(M)*K)^(i-1);
end
%
C = M*Ci;
%
% Bentuk matriks sistem persamaan diferensial linier orde pertama
%
A = [1 0 0 0;0 1 0 0;0 0 m1 0;0 0 0 m2];
B = [0 0 1 0;0 0 0 1;-K(1,1) -K(1,2) -C(1,1) -C(1,2);-K(2,1) -K(2,2) -C(2,1) -
C(2,2)];
%
% Data Gempa El Centro
%
g = 9.807;                % percepatan gravitasi m/det^2
load elcentro.dat;
Ug = g*elcentro(:,1);
%
mean_Ug     = mean(Ug)
std_Ug      = std(Ug)
var_Ug      = var(Ug)
%
% Pembentukan Waktu
%
t = 0:0.02:49.98;
tfinal = 49.98;
```

```
inc    = 0.01;
nstep    = tfinal / inc;
time=[0:1:nstep] * inc;
tspan = time;
U = interp1(t,Ug,time,'spline');
%
%=========================================================
% Perhitungan Orde Nol
%=========================================================
%
% Kondisi/Nilai Awal
%
y0 = [0; 0; 0; 0];
dy0 = zeros(2*2,1);
%
[T,Z]  = ode15s('zerode', tspan, y0,[],time,U,dy0,M,A,B);
[Z1] = interp1(T, Z(:,1), time, 'cubic');
[Z2] = interp1(T, Z(:,2), time, 'cubic');
[Z3] = interp1(T, Z(:,3), time, 'cubic');
[Z4] = interp1(T, Z(:,4), time, 'cubic');
%
figure;
plot(time,Z1,'-k');
%axis([0 0.0125 -2 2]);
xlabel('Waktu (det)');
ylabel('Perpindahan (m)');
title('Perpindahan di Lantai 1');
hold;
%
figure;
plot(time,Z2,'-k');
%axis([0 0.0125 -6 6]);
xlabel('Waktu (det)');
ylabel('Perpindahan (m)');
title('Perpindahan di Lantai 2');
hold;
%
%=========================================================
% Perhitungan Orde Pertama pada Tahap Pertama
%=========================================================
%
beta = a(2);
[FF1] = -beta*[Z3]-[Z1];
%
% Pembentukan Waktu
%
time=[0:1:length(FF1)-1]*inc;
```

```
tspan = time;
%
% Nilai Awal
%
y0 = [0; 0; 0; 0];
dy0 = zeros(2*2,1);
%
[T,F1] = ode15s('first1', tspan, y0, [], time, FF1,A,B);
[F11] = interp1(T, F1(:,1), time, 'cubic');
[F12] = interp1(T, F1(:,2), time, 'cubic');
[F13] = interp1(T, F1(:,3), time, 'cubic');
[F14] = interp1(T, F1(:,4), time, 'cubic');
%
[FF21] = -beta*([Z3]-[Z4])-([Z1]-[Z2]);
[FF22] = -[F12];
%
% Pembentukan Waktu
%
time=[0:1:length(FF21)-1]*inc;
tspan = time;
%
% Nilai Awal
%
y0 = [0; 0; 0; 0];
%
[T,F2] = ode15s('first2', tspan, y0, [], time, FF21, FF22,A,B);
[F21] = interp1(T, F2(:,1), time, 'cubic');
[F22] = interp1(T, F2(:,2), time, 'cubic');
[F23] = interp1(T, F2(:,3), time, 'cubic');
[F24] = interp1(T, F2(:,4), time, 'cubic');
%
%=========================================================
% Variansi
%=========================================================
%
for i=1:1:length(F12),
   var1(i) = sqrt(F1(i,1) * F1(i,1) * vark1 + F2(i,1) * F2(i,1) * vark2);
   var2(i) = sqrt(F1(i,2) * F1(i,2) * vark1 + F2(i,2) * F2(i,2) * vark2);
end
%
figure;
plot(time,var1,'-k');
xlabel('Waktu (det)');
ylabel('Simpangan Baku Perpindahan (m)');
title('Simpangan Baku Perpindahan pada Lantai 1');
hold;
%
```

```
figure;
plot(time,var2,'-k');
xlabel('Waktu (det)');
ylabel('Simpangan Baku Perpindahan (m)');
title('Simpangan Baku Perpindahan pada Lantai 2');
hold;
%
%=========================================================
% Second Order Computation
%=========================================================
%
[FS1] = (-beta*[F13]-[F11])*vark1+(-beta*([F23]-[F24])-[F21]+[F22])*vark2;
[FS2] = (beta*([F23]-[F24])+[F21]-[F22])*vark2;
% Time
time=[0:1:length(FS1)-1]*inc;
tspan = time;
% Initial conditions
y0 = [0; 0; 0; 0];
%
[T,S] = ode15s('second', tspan, y0, [], time, FS1, FS2,A,B);
[S1] = interp1(T, S(:,1), time, 'cubic');
[S2] = interp1(T, S(:,2), time, 'cubic');
[S3] = interp1(T, S(:,3), time, 'cubic');
[S4] = interp1(T, S(:,4), time, 'cubic');
%
figure;
plot(time,S1,'-k');
xlabel('Waktu (det)');
ylabel('Perpindahan (m)');
title('Kontribusi Orde Kedua Perpindahan pada Lanatai 1');
hold;
%
figure;
plot(time,S2,'-k');
xlabel('Waktu (det)');
ylabel('Perpindahan (m)');
title('Kontribusi Orde Kedua Perpindahan pada Lanatai 1');
%
%
%=========================================================
% Perpindahan Total = (Orde Nol + Orde Kedua) Perpindahan Rata-rata
%=========================================================
%
[TD1] = [Z1] + [S1];
[TD2] = [Z2] + [S2];
%
figure;
```

```
plot(time,TD1,'-');
xlabel('Waktu (det)');
ylabel('Perpindahan (m)');
title('Perpindahan pada Lantai 1');
hold;
%
plot(time,Z1,':r');
h = legend('Tidak Ada Variabel Acak', 'Kekakuan sebagai Variabel Acak');
hold;
%
figure;
plot(time,TD2,'-');
xlabel('Waktu (det)');
ylabel('Perpindahan (m)');
title('Perpindahan pada Lantai 2');
hold;
%
plot(time,Z2,':r');
h = legend('Tidak Ada Variabel Acak', 'Kekakuan sebagai Variabel Acak');
hold;
```