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%           Advanced vibration
% Free response of a 3 DOF nonproportional damped system
% using a set of 6 state space equations.
m1=2;m2=1;m3=1.5;           % Define masses
k1=150;k2=100;k3=80;k4=25;  % Stiffnesses
c1=.15;c2=.15;c3=.15;c4=.15; % Dampers
%c1=.0;c2=.0;c3=.0;c4=.0; % Dampers
m=[m1 0 0; 0 m2 0; 0 0 m3]; % Mass matrix
c=[c1+c2+c4 -c2 -c4; -c2 c2+c3 -c3; -c4 -c3 c3+c4]; % Damping matrix
k=[k1+k2+k4 -k2 -k4; -k2 k2+k3 -k3; -k4 -k3 k3+k4]; % Stiffness matrix

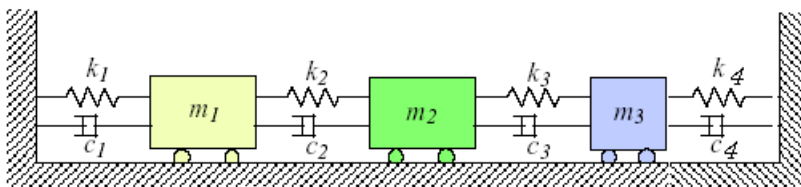
zero=[0 0 0; 0 0 0; 0 0 0]; %zero matrix
A=[zero m; m c];
B=[-m zero; zero k];
[v d]=eig(-inv(A)*B)       % eigenvalues & eigenvectors

amp(:,1)=abs(v(:,1))       % amplitudes of each mode
amp(:,2)=abs(v(:,3))
amp(:,3)=abs(v(:,5))
phase(:,1)=atan2(imag(v(:,1)), real(v(:,1)))*180/pi % phase of each mode
phase(:,2)=atan2(imag(v(:,3)), real(v(:,3)))*180/pi
phase(:,3)=atan2(imag(v(:,5)), real(v(:,5)))*180/pi

for ii=1:6
v(1:6,ii)=v(1:6,ii)./v(6,ii);
end

%response of system
x0=[0 0 0]'; % initial conditions
dx0=[.1 0 0]';
y0=[dx0
    x0];
t0=0;tf=10.;dt=.05;nn=round((tf-t0)/dt)+1;
ivy0=inv(v)*y0;
ti=t0;           % compute responses
for i=1:nn
    for j=1:6
        ewniv0(j)=exp(d(j,j)*ti)*ivy0(j);
    end
    y(:,i)=v*ewniv0';
    t(i)=ti;
    ti=ti+dt;
end
plot(t,y(4,:),t,y(5,:), '--',t,y(6,:), ':')
title('Free response of 3 DOF system,solid-x1, dash-x2, dot-x3');
xlabel('time (sec)');
ylabel('displacement (m)');

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d =

-0.1960+15.6409i	0	0	0	0	0
0	-0.1960-15.6409i	0	0	0	0
0	0	-0.0201+4.5784i	0	0	0
0	0	0	-0.0201-4.5784i	0	0
0	0	0	0	-0.1465+11.0380i	0
0	0	0	0	0	-0.1465-11.0380i

v =

-0.3875+0.0024i	-0.3875-0.0024i	0.3216+0.0022i	0.3216-0.0022i	0.6991	0.6991
0.8893	0.8893	0.5679+0.0017i	0.5679-0.0017i	0.3699-0.0052i	0.3699+0.0052i
-0.2345-0.0007i	-0.2345+0.0007i	0.7270	0.7270	-0.6052-0.0054i	-0.6052+0.0054i
0.0005+0.0248i	0.0005-0.0248i	0.0002-0.0703i	0.0002+0.0703i	-0.0008-0.0633i	-0.0008+0.0633i
-0.0007-0.0568i	-0.0007+0.0568i	-0.0002-0.1240i	-0.0002+0.1240i	-0.0009-0.0335i	-0.0009+0.0335i
0.0001+0.0150i	0.0001-0.0150i	-0.0007-0.1588i	-0.0007+0.1588i	0.0002+0.0548i	0.0002-0.0548i

amp =

phase =

0.3875	0.3217	0.6991	179.6518	0.3901	0
0.8893	0.5679	0.3699	0	0.1671	-0.8120
0.2345	0.7270	0.6052	-179.8322	0	-179.4892
0.0248	0.0703	0.0633	88.9339	-89.8610	-90.7602
0.0569	0.1240	0.0335	-90.7178	-90.0840	-91.5722
0.0150	0.1588	0.0548	89.4499	-90.2511	89.7506

