

Solutions of Homework #1 (ASEN5022, Spring 2005)

Starting with the MATLAB code provided in the lecture notes and slides, extend the 1-DOF code to 2-DOF model problems discussed during January 13 and January 18. In doing so, choose your own model parameters, M_1 , m_2 , K_1 , k_2 , etc., with restriction $K_1/M_1 \neq k_2/m_2$.

- (1) Express equation(1) in the January 13 and 18 lecture notes in terms of the canonical form (or state space form), e.g., determine $[a]$, $[b]$, $[c]$, $[d]$.
- (2) with $f_2 = 0$ and a step load applied to mass M_1 , obtain the step response and plot your response results of x_1 and x_2 .
- (3) Vary the damping c_2 and plot, $x_1(\omega)/x_{st}(\omega)$, vs. the frequency ω by utilising (not the hard-wired code contained in the lecture note!) 'ss', 'tf' and 'freqresp' matlab functions as used in the 1-DOF example. This is called a FRF for the output x_1
- (4) Now choose the mass ratio $\mu = m_2/M_1 = 0.25$ and $(k_2/m_2)/(K_1/M_1) = 1/(1 + \mu)$. Plot the frequency response function of $x_1(\omega)/x_{st}(\omega)$.
- (5) Repeat Problem (2) for the model parameters given in Problem (4).
- (6) Summarize your findings (what have you learned from this homework?)

Note: my code employs $\sqrt{(k_2/m_2)/(K_1/M_1)} = 1/(1 + \mu)$ instead of $(k_2/m_2)/(K_1/M_1) = 1/(1 + \mu)$!

```
% A Matlab program to compute 2DOF computations.
% January 16, 2004 (KCP)
% copy the matlab part and drop into a Matlab file and run it!
clear all;
% Define some useful numbers:
Hz2rps=2*pi; rps2Hz=1/2/pi; % Conversions to/from Hz and rad/s

% Natural frequency of 1 Hz
omega_n=1*Hz2rps;
T_n = 2*pi/omega_n; % period of the response

for zeta=0:0.05:0.5,
% critical damping ratio
%zeta= 0.05; %5 percent
mu = 0.25;
% Natural frequency of 1 Hz
omega_1=1*Hz2rps; omega_2 = omega_1/(1+mu);
T_n = 2*pi/omega_1; % period of mass m_1 for uncoupled case

% state space model
a=[
0                1.0                0.0                0.0;
-(omega_1^2+mu*omega_2^2)  -2*zeta*mu*omega_2  mu*omega_2^2  2*zeta*mu*omega_2;
0                0                0.0                1.0;
```

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omega_2^2                2*zeta*omega_2            -omega_2^2            -2*zeta*omega_2
];

b=[0; omega_1^2; 0; 0]; % a force is applied, equivalent to unit static displacement
c=[1 0 0 0];           % both momentum and displacement are available

% specify state space model for this problem
sys = ss (a,b,c,0);

%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Time response computation
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% obtain the response, y1 =displ; y2=mementum
% step(sys); % simplest step response computation

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% for specified computations;
%
% the total time of simulation
    Tfinal = 6*T_n; % 6 periods
%specify the output time points:
    dt = (1/40)*(T_n); %40 samples per period
%time interval
    t = 0:dt:Tfinal;
%obtain response
    [y,t,x]=step(sys,t);
%plot the response
    figure(1);
    plot(t', y(:,1)', 'k');
    hold on;
    xlabel('Time(sec)');
    ylabel('Displacement');
    title('Step Response computed by specifying the time step');
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% end of response computation
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
% frequency response calculation
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Pick a range of frequencies to look at from 1 Hz to 10 Hz
wf= logspace(-0.5,0.5, 400)*Hz2rps;

```




