EECE7244: MICROELECTROMECHANICAL SYSTEMS
HOMEWORK ASSIGNMENT 1

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TASK

To find the step response to the linear second order dynamical system described below using MATLAB.

$$\dot{x_1} = x_2$$

$$\dot{x_2} = -\frac{k}{m}x_1 - \frac{b}{m}x_2 + \frac{1}{m}F$$

This system is identical to a second order damper with the parameters considered as described below -

- $k = 3$ (Spring Constant)
- $m = 2$ (Mass of the object)
- $b = 0.5$ (Damping Coefficient)
- $F = 1$ (Unit Step Response)

The state variables $\dot{x_1}$ and $\dot{x_2}$ are equivalent to position and velocity here.

HYPOTHESIS

Since this system corresponds to a second order damper, the assumption for the plots of the position and velocity state variables with respect to time are that they should be oscillations which damp with time and settle at an equilibrium.

ASSUMPTIONS

- Time Span : 0 to 50
- Initial Conditions : $x_1(0) = x_2(0) = 0$

RESULTS AND PLOTS

The plots that depict the state variables versus time is given below.

- **x_1 versus t**

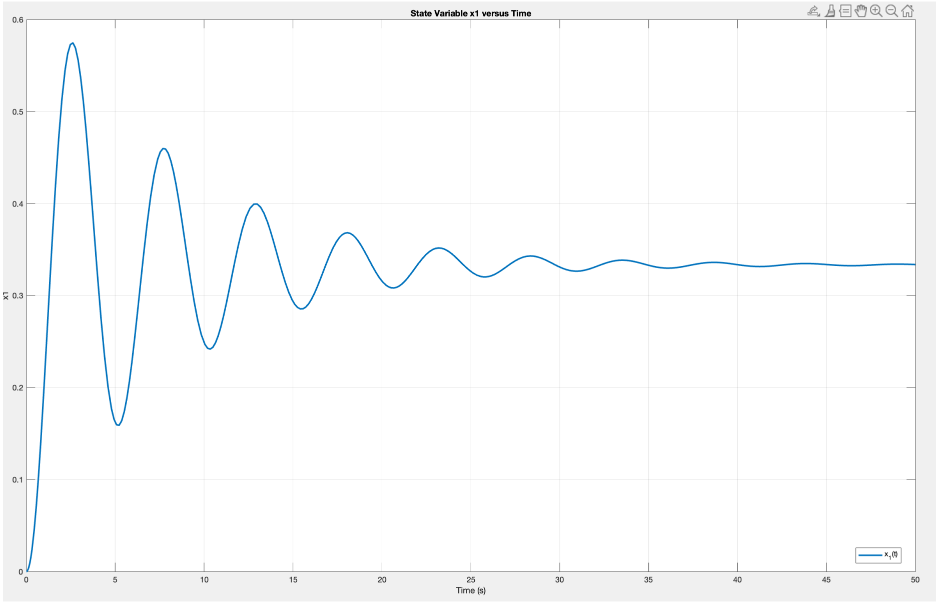

Figure 1: x_1 versus t

- **x_2 versus t**

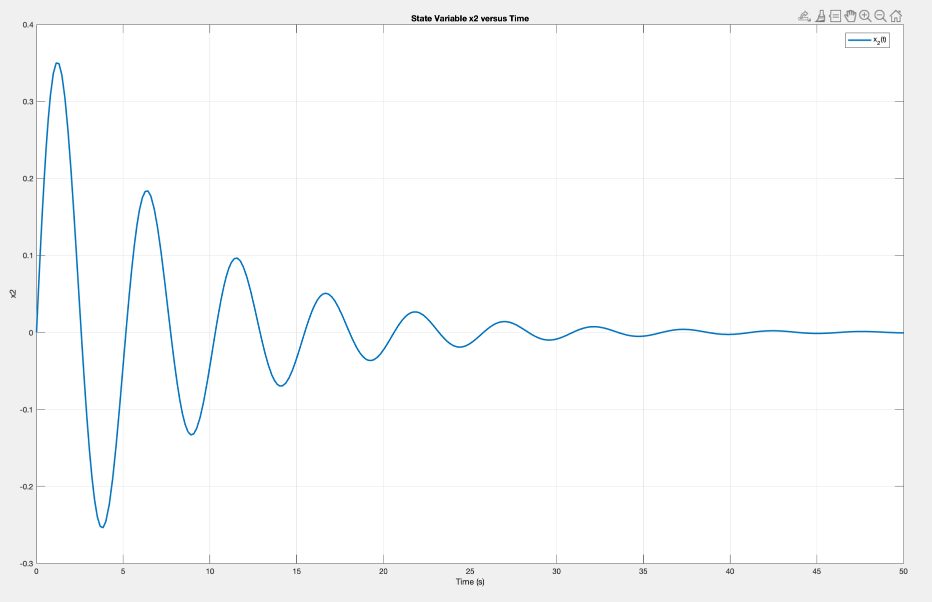

Figure 2: Caption

INFERENCES

Based on the results seen a few inferences can be made as follows.

- The second order damper system is an underdamped system as seen by the oscillations of the state variables with respect to time before settling. Analytically this can be seen as given below.

$$\zeta = \frac{b}{\sqrt{km}} = \frac{0.5}{\sqrt{3 \times 2}} = 0.204$$

$$\zeta = 0.204 < 1 \implies \text{underdamped system}$$

- The system takes about 32 seconds to settle within 2% of the final settling value, which dictates a slow settling.

MATLAB CODE

```
%% MEMS - Homework 1
% © Avaneeth Anil 2025
clc;
clear all;
close all;

% System Parameters
k = 3;
m = 2;
b = 0.5;
time_span = [0 50];
initial_conditions = [0 0];

% ODE
[t,y] = ode45(@(t,x) msd(t,x,[],m,k,b), time_span, initial_conditions);
x1 = y(:,1);
x2 = y(:,2);

% Defining the ODE Function
function dx = msd(t,x,flag,m,k,b)
    dx = zeros(2,1);
    dx(1) = x(2);
    equation = -(k/m)*x(1) - (b/m)*x(2) + 1/m;
    dx(2) = equation;
end

% Plots of the state variables vs time

figure;
```

```
plot(t,x1,'LineWidth',2);
grid on;
xlabel('Time (s)');
ylabel('x1')
title('State Variable x1 versus Time')
legend('x_1(t)','Location','best')

figure;
plot(t,x2,'LineWidth',2);
grid on;
xlabel('Time (s)');
ylabel('x2')
title('State Variable x2 versus Time')
legend('x_2(t)','Location','best');
```

GITHUB LINK WITH THE CODE FOR EASY ACCESS

https://github.com/avaneethanil/MEMS-HW1