Experiment No. 2

Modeling of Mass-Spring-Damper System (SISO Open Loop)

Objectives

- Understand system modeling.
- Understand system transfer function, governing equation and block diagram.
- Observe response of system.
- Observe behavior of system.

Circuit Diagram

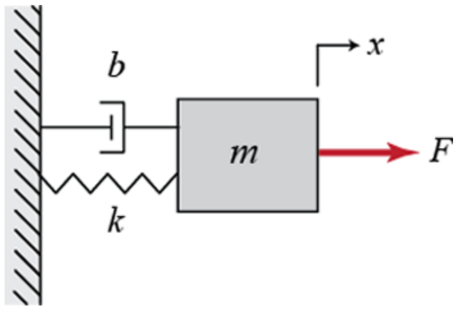

FIGURE 2.1: Mass-Spring-Damper System

The free body diagram for this system is shown below. The spring force is proportional to the displacement of the mass, x, and the viscous damping force is proportional to the velocity of the mass, $v = \dot{x}$. Both forces oppose the motion of the mass and are therefore shown in the negative x-direction. Note also, that $x = 0$ corresponds to the position of the mass when the spring is unstretched.

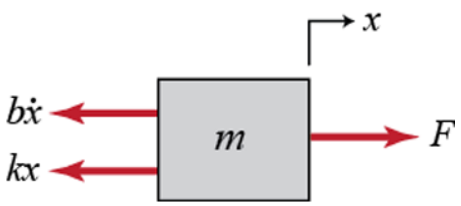

FIGURE 2.2: Forces on Mass-Spring-Damper System

System properties:

No.	Parameter	Value
1	F	1.0 N
2	k	1.0 N/m
3	b	0.9 Ns/m
4	m	2.0 Kg

Section 2.1: Theoretical Calculations

- Find governing equation of system shown in Figure 2.1
- Find block diagram of system.
- Find transfer function of system.
- Find zero, pole and gain from transfer function.
- Find transfer function of system in time domain.
- Find unit step response of system.
- Fill table below.

Observation Set:

No.	Time	Distance
1	5s	
2	10s	
3	15s	
4	20s	
5	25s	
6	30s	
7	35s	
8	40s	

Section 2.2: Simulation

2.2.1 Matlab Command Window

- Define Transfer function of system in Matlab using ”tf”.
- Find poles of transfer function using ”pole”.
- Find zero, pole and gain from transfer function using ”tf2zp”.

- Find pole zero plot of system using ”pzmap”.
- Find bode plot of system using ”bode”.
- Find unit step response of system using ”stepplot”.
- Fill table below.

Observation Set:

No.	Time	Distance
1	5s	
2	10s	
3	15s	
4	20s	
5	25s	
6	30s	
7	35s	
8	40s	

Matlab Functions:

No.	Code
1	tf
2	pole
3	zero
4	zpkdata
5	tf2zp
6	pzmap
7	bode
8	stepplot
9	ilaplace
10	vpa

2.2.2 Matlab Simulink

- Define Transfer function of system..
- Find pole zero plot of system.
- Find bode plot of system.
- Find unit step response of system.

- Fill table below.

Observation Set:

No.	Time	Distance
1	5s	
2	10s	
3	15s	
4	20s	
5	25s	
6	30s	
7	35s	
8	40s	

Point to ponder:

- Product of system transfer function H(s) and unit step (1/s) IS EQUAL to convolution of system time domain h(t) and unit step u(t) and it IS EQUAL to solution of governing equation.
- System have multiple state space representations but single unique transfer function.
- Number of poles is equal to number of zeros.
- Poles in left plane of pole-zero plot make system stable while poles in right plane makes system unstable.
- System becomes marginally stable if there is at least one pole on imaginary axis in pole-zero plot.
- Two poles on origin make system unstable.
- Transfer Function us Unique while state space representation is infinitely many.