Experiment No. 02

2.1 Experiment Name

Analyzing the dynamics of a Physical System (Mechanical system)

2.2 Objectives

- To become accustomed with the simulation of physical system in the MATLAB/Simulink environment.
- Learn how to use Simulink to create and simulate a physical (mechanical) system model.
- Learn how to use Simulink's test and measurement tools for plotting transfer functions and input, output graph for a physical system.

2.3 Theory

To analyze the dynamics of a Mechanical system, we considered a Mass spring damper system.

The mass-spring-damper model consists of discrete mass nodes distributed throughout an object and interconnected via a network of springs and dampers. This model is well-suited for modelling object with complex material properties such as nonlinearity and viscoelasticity.

In this system, a mess of 'M' is hanging along a spring of spring constant 'K'. There is a damper to limit the oscillation and the damping constant of 'B'. So, here Y(t) is the displacement of the system which is the required output.

Here,

f(t)= Force;
u(t)= Input;
Y(t)= Displacement;
M= Mass;
K= Spring constant;
B= Damping constant.

From analyzing the circuit,

$$M\left(\frac{d^2y(t)}{dt^2}\right) + B\left(\frac{dy(t)}{dt}\right) + K\,(y(t)) = u(t) \ldots\ldots\ldots (1)$$

This can be rewritten as,

$$\frac{d^2y(t)}{dt^2} = u(t)\left(\frac{1}{M}\right) - \frac{B}{M}\left(\frac{dy(t)}{dt}\right) - \frac{K}{M}\,(y(t))$$

Taking Laplace Transform of equation (1)

$$Ms^2Y(s) + BsY(s) + KY(s) = U(s) \ldots\ldots\ldots (2)$$

Thus, transfer function of the system,

$$\frac{Y(s)}{U(s)} = G(s) = \frac{1}{Ms^2+Bs+K}$$

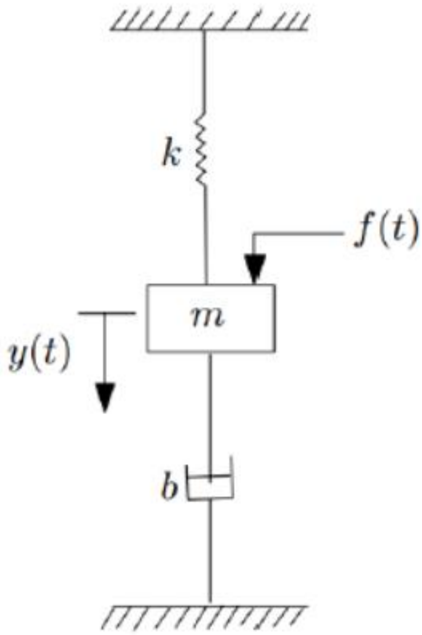

Fig 2.1: Mass spring damper system.

2.4 Apparatus

- Simulink

2.5 Simulink

2.5.1 Block Diagram

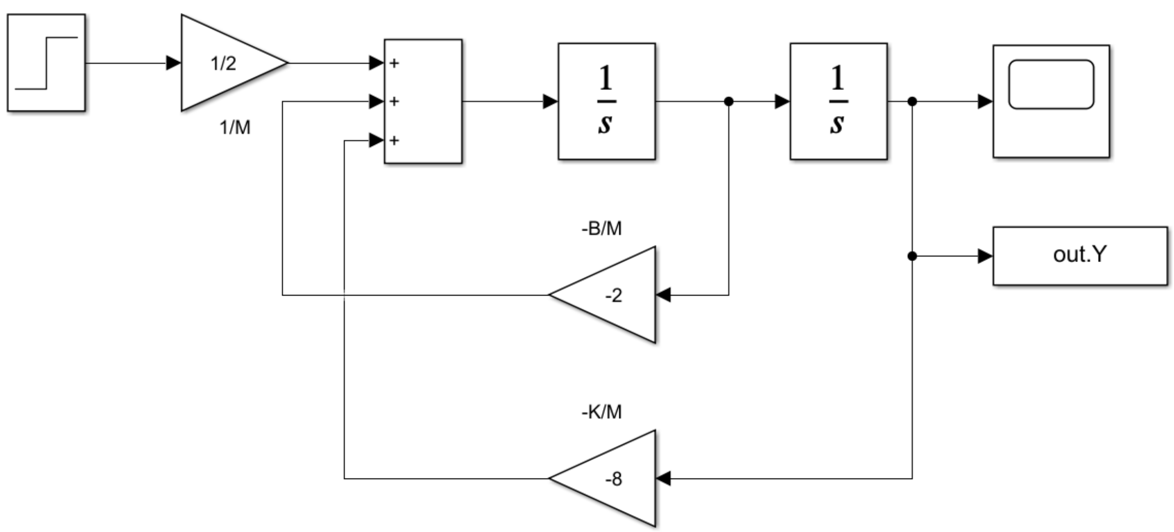

Fig 2.2: Block Diagram of a mass-spring-damper system in Simulink.

2.5.2 MATLAB Code

```
clc
x = plot(out.Y);
disp(out.Y)
```

2.5.3 Displacement response

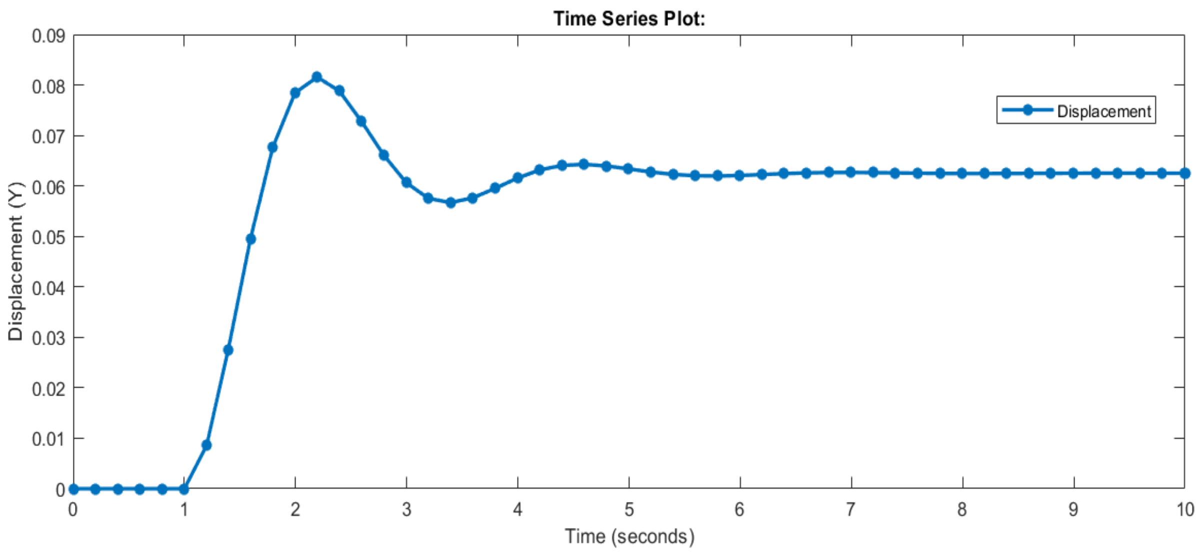

Fig 2.3: Input & Output plot of a mass-spring-damper system in Simulink.

2.6 Discussion & Conclusion

In this experiment we investigated the dynamics of a physical system, also known as mechanical system. For this experiment, we adapted to mass spring damper system, represented the dynamics using a block diagram, and generated an output for various constants or gains by using a unit step function as triggering.

We gave M=2kg, B=4Ns/m, and k=16Nm-1 as input for a sample simulation on Simulink. For a unit step function as input, the output was transient for 6 seconds before reaching steady state. This output was also plotted using MATLAB code. For this, we used ‘to work space’, defined it as ‘out.Y’ and later defined it as a variable in code and plotted out the graph.

As a result, the dynamics of a mass spring damper system were investigated by creating a block diagram in Simulink and commanding it with a MATLAB.m file.