KATHMANDU UNIVERSITY

DHULIKHEL KAVRE

COEG-304: Instrumentation and Control

Lab Sheet No. 2

SUBMITTED BY

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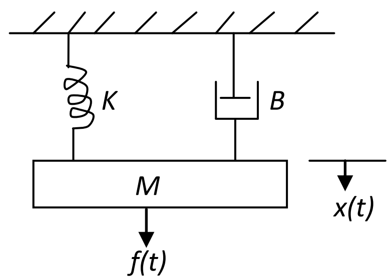
Mathematical Modeling
2.1 Modeling a system

Example-1
Consider the simple mechanical system as shown in the figure below. Three forces influence the motion of the mass, namely, the applied force, the frictional force, and the spring force.



Ans:

Applying Newton's law of motion, the force equation of the system is

$$M\frac{d^2x}{dt^2} + B\frac{dx}{dt} + Kx = f(t)$$

Let $x_1 = x$ and $x_2 = \frac{dx}{dt}$, then

$$\frac{dx_1}{dt} = x_2$$

$$\frac{dx_2}{dt} = \frac{1}{M}[f(t) - Bx_2 - Kx_1]$$

With the system initially at rest, a force of 25 Newton is applied at time t = 0. Assume that the mass M = 1 Kg, frictional coefficient B = 5 N/m/sec., and the spring constant K = 25 N/m. The above equations are defined in an M-file **Mechsys.m** as follows:

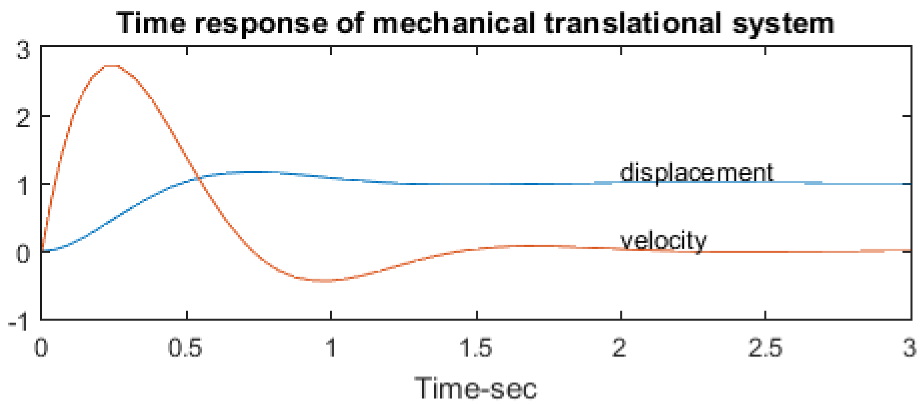
```
function [ xdot ] = Mechsys( t,x )
%   Detailed explanation goes here
   F=25;
   M=1;
   B=5;
   k=25;
   xdot=[x(2);1/M*(F-B*x(2)-k*x(1))];

end
```

Save the above instructions as **Mechsys.m** and execute the following instructions:

```
tspan=[0,3];
```

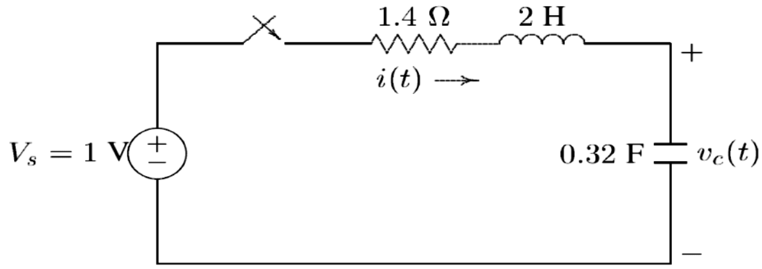
```
x0=[0,0];
[t,x]=ode23('Mechsys',tspan,x0);
subplot(2,1,1),plot(t,x);
title('Time response of mechanical translational system');
xlabel('Time-sec');
text(2,1.2,'displacement');
text(2,.2,'velocity');
```

The result of the simulation is as shown below:



Example-2

The circuit elements in the figure below are R = 1.4Ω, L = 2H, and C = 0.32F, the initial inductor current is zero, and the initial capacitor voltage is 0.5 volts. A step voltage of 1 volt is applied at time t = 0. Determine i(t) and v(t) over the range 0 < t < 15 sec. Also, obtain a plot of current versus capacitor voltage.



Ans:

Applying KVL

$$Ri + L\frac{di}{dt} + v_c = V_s$$

and

$$i = C\frac{dv_c}{dt}$$

Let

$$x_1 = v_c$$

and

$$x_2 = i$$

then

$$\dot{x}_1 = \frac{1}{C}x_2$$

and

$$\dot{x}_2 = \frac{1}{L}(V_s - x_1 - Rx_2)$$

The above equations are defined in an M-file Elecsys.m as follows:

```
function [ xdot ] = Elecsys( t,x )
%Summary of this function goes here
%   Detailed explanation goes here
R=1.4;
c=0.32;
L=2;
Vs=1;
xdot=[x(2)/c;1/L*(Vs-R*x(2)-x(1))];
end
```

Save the above instructions as **Elecsys.m** and execute the following instructions:

```
tspan=[0,10];
x0=[0.5,0];
[t,x]=ode23('Elecsys',tspan,x0);
subplot(2,1,1),plot(t,x);
title('Time response of electrical system');
xlabel('Time-sec');
text(9,1.2,'voltage');
text(9,0.2,'current');
```

Result of simulation is as shown below: