Control Systems Project

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To: Dr. Hakam Shehadeh

*Note : **Discussion** of work is written as comments in code texts.*

ENEE3302 Control Project
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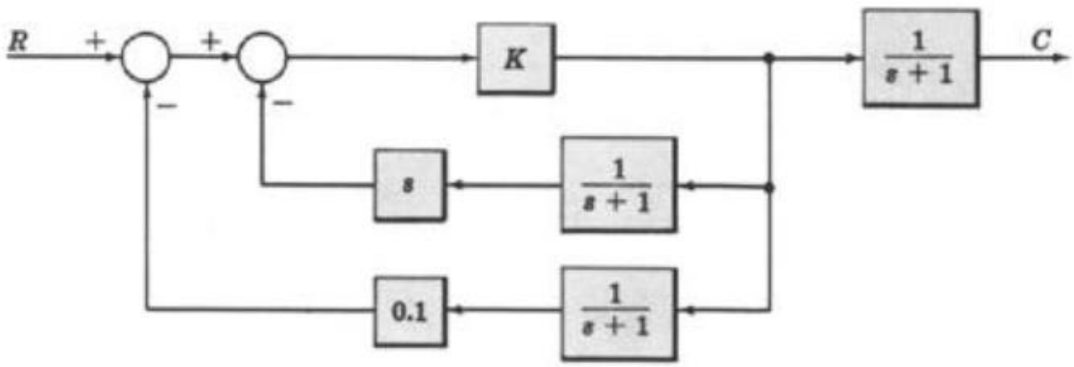
Part 1:

Part #1:

Using the following commands (series, parallel, feedback). (K = 10):

a) Write a MatLab program to build up the control system shown in Figure (1).

b) Plot the step response of the system.



Matlab Code: text

```
G1=tf(10,[1]);  %static gain k =10
H1=tf(1,[1,1]); % cont.time TF  =  1/(s+1)
H2=tf('s');      % cont.time TF  = s
H3=tf(0.1,[1]); % static gain0.1
H12=series(H1,H2); %H1 & H2 are in series (middle branch)
H22=series(H1,H3); %H1 & H3 are in series (lowest branch)
T1=feedback(G1,H12); %feedback relation of gain K and series combinantion
T=feedback(T1,H22);  %another feedabck of T1 generated and series combin.
system=series(T,H1)  % finally series relation between whole generated system T1 and H1
step(system)  % step response
xlabel("Time")
ylabel("Amp")
grid
```

Editor - C:\Users\ASUS\MatlabPro's\run.m

run.m

```matlab

G1=tf(10,[1]);  %static gain k =10
H1=tf(1,[1,1]); % cont.time TF  =  1/(s+1)
H2=tf('s');     % cont.time TF  = s
H3=tf(0.1,[1]); % static gain0.1
H12=series(H1,H2); %H1 & H2 are in series (middle branch)
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T1=feedback(G1,H12); %feedback relation of gain K and series combinantion
T=feedback(T1,H22);  %another feedabck of T1 generated and series combin.
system=series(T,H1)  % finally series relation between whole generated system T1 and H1
step(system)  % step response
xlabel("Time")
ylabel("Amp")
grid
```
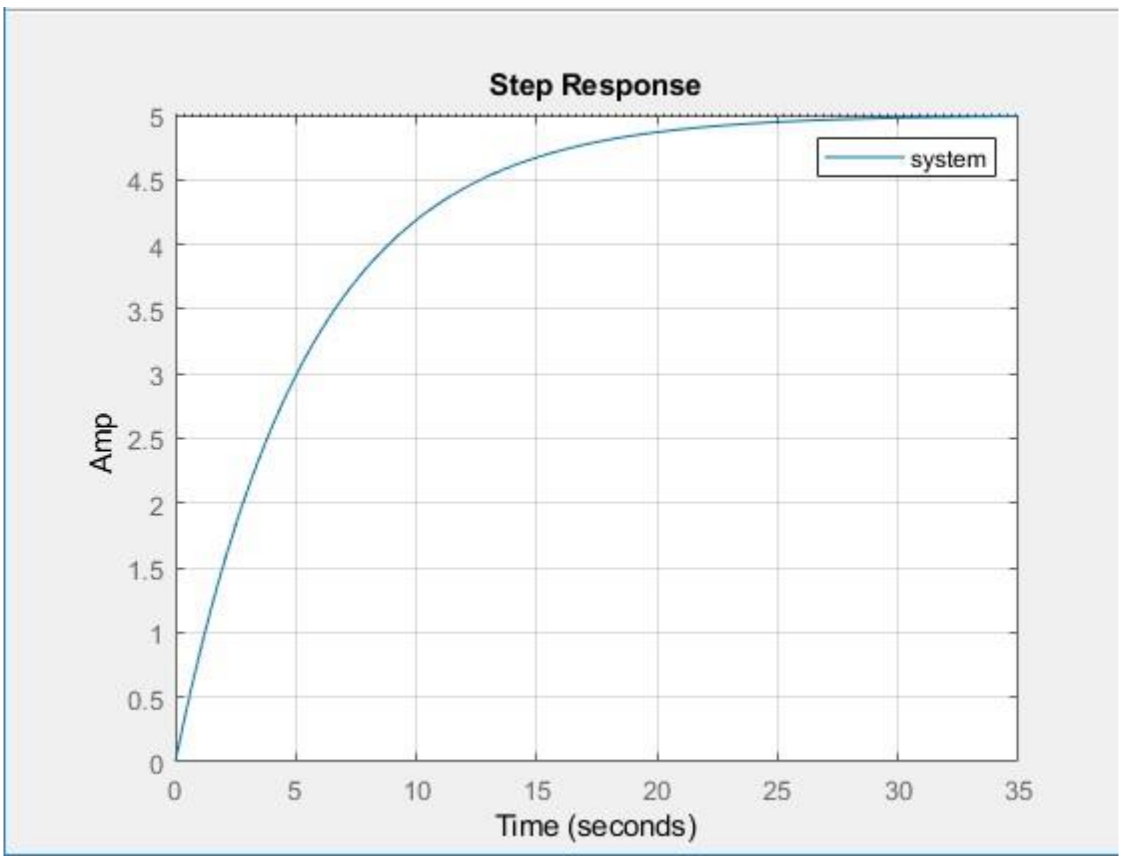

Step Response of the system:



System TF after reduction:

```
>> run

system =

      10 s^2 + 20 s + 10
  --------------------------
  11 s^3 + 24 s^2 + 15 s + 2

Continuous-time transfer function.
```

Part 2:

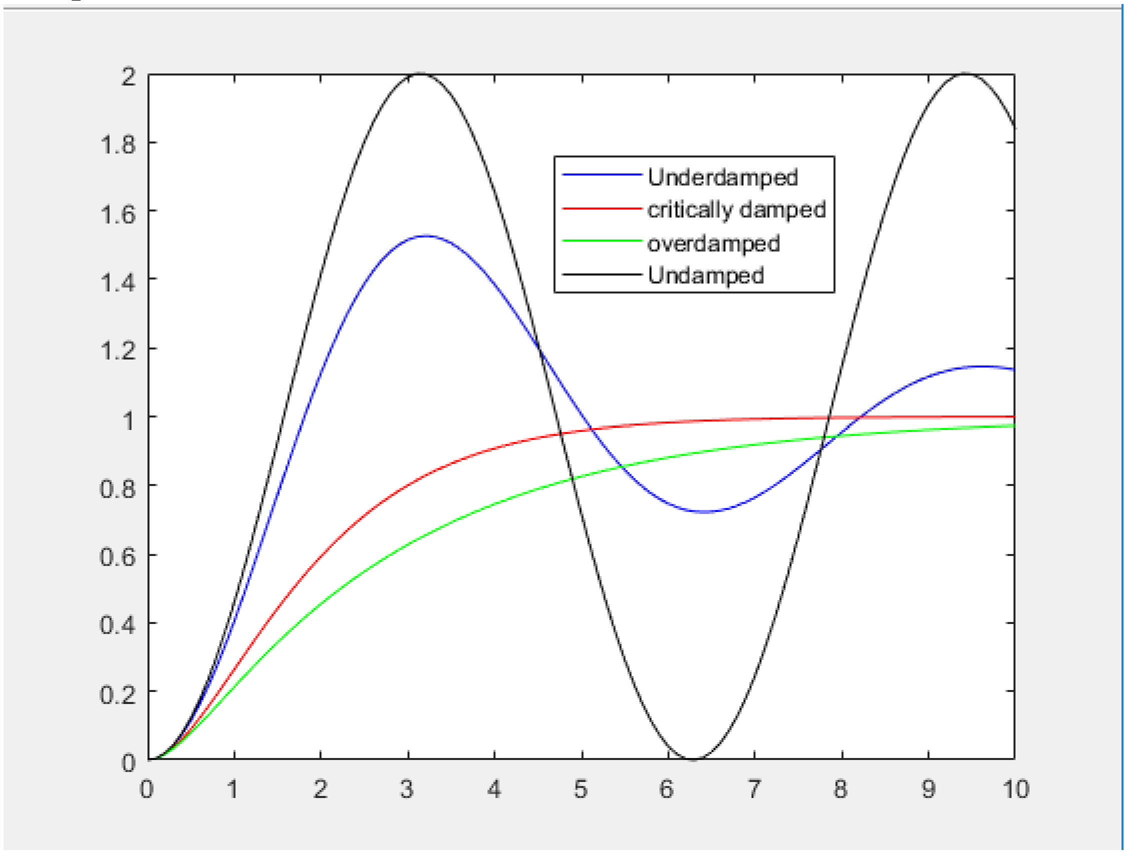
Part #2:

The dynamic behaviour of the second-order system can be described in terms of two parameters ξ and ω_n. If $0 < \xi < 1$, the closed-loop poles are complex conjugate and lie in the left-half s plane. The system is then called under-damped, and the transient response is oscillatory. If $\xi = 1$, the system is called critically damped. Over-damped systems corresponds to $\xi > 1$. The transient responses of critically damped and Over-damped systems do not oscillate. If $\xi = 0$, the transient response does not die out. Plot a family of curves c(t) versus $\omega_n t$ with various values of ξ to represent these different cases.

Code: text

```
wn=1; %initializing Wn =1
damprat=0.2;  %first case is underpamped case
t=0:0.1:10; %taking first 10 sec's
[num,den]=ord2(wn,damprat); %displaying the 2nd order state space rep.
[y,x,t]=step(num,den,t);
plot(t,y,'b') %underdamped resp. in blue
grid
hold on
damprat=1; %critically damped case
[num1,den1]=ord2(wn,damprat);
[y1,x,t]=step(num1,den1,t);
plot(t,y1,'r') %in red
grid
hold on
damprat=1.5; %overdamped case
[num2,den2]=ord2(wn,damprat);
[y2,x,t]=step(num2,den2,t);
plot(t,y2,'g') %in green
grid
hold on
damprat=0; %undamped case
[num2,den2]=ord2(wn,damprat);
[y2,x,t]=step(num2,den2,t);
plot(t,y2,'k') %in black
grid
```

Responses of cases:



Part 3 :

Q1:

Part #3:

(a) Using MATLAB, obtain the unit-step response, unit-ramp response, and unit impulse response of the following system:

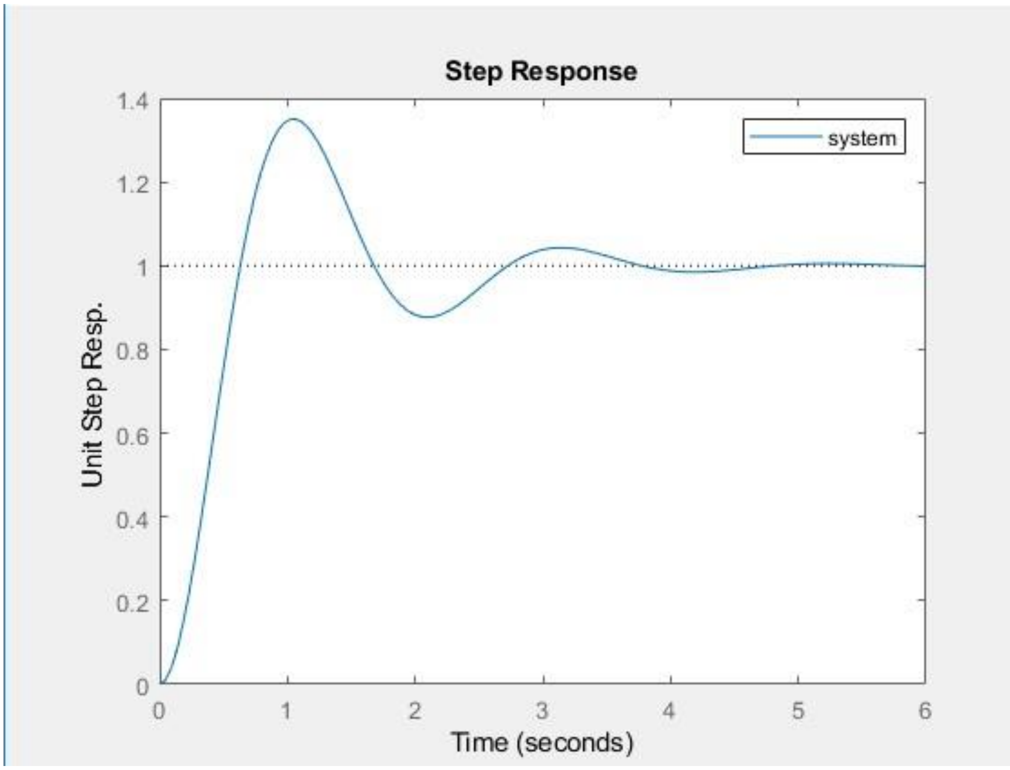
$$\frac{C(s)}{R(s)} = \frac{10}{s^2 + 2s + 10}$$

Where R(s) and C(s) are Laplace transforms of the input r(t) and the output c(t), respectively.

Step response of the systems code:txt

```
%G(s) = 1/(s2+2s+10)
num=10; %Numerator
den=[1 2 10]; %denominator
system=tf(num,den); %function of transfer
step(system) %plotting the step response
xlabel("Time")
ylabel("Unit Step Resp.")
```

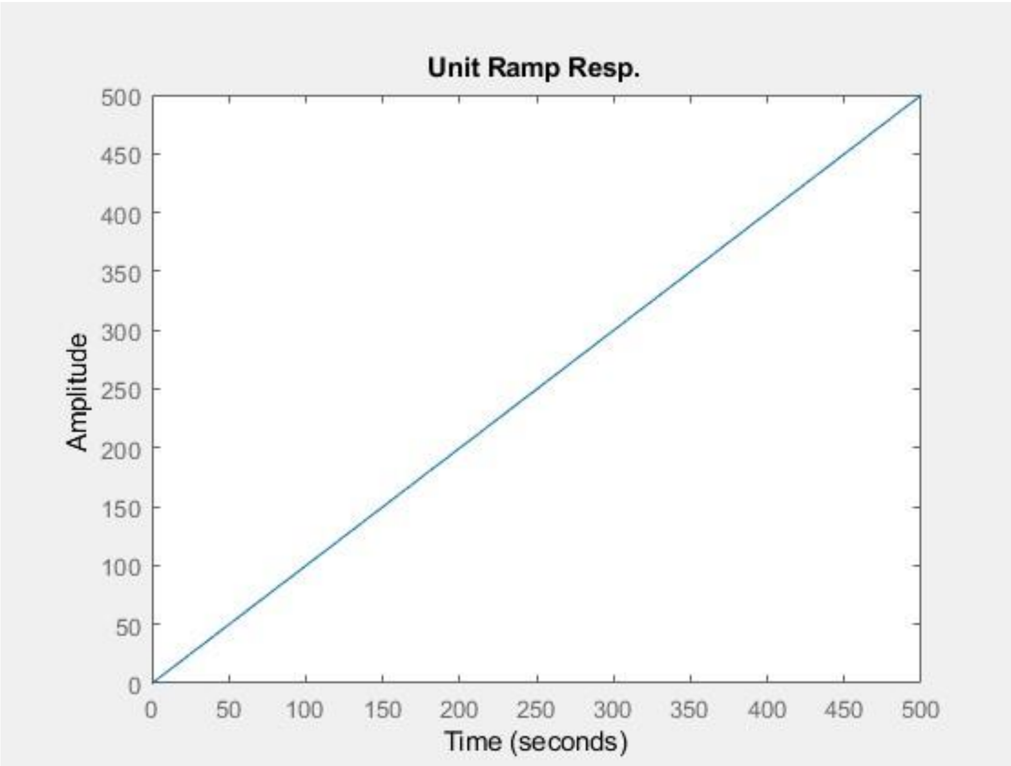
Step Response :



Ramp Response Code :text

```
%G(s) = 1/(s2+2s+10)
%in case we do not have a ramp function we multiply the
characterstic eq..
%by s --> G(s) = 10/(s3+2s2+10s+0)
num=10; %Numerator
den=[1 2 10 0]; %denominator
system=tf(num,den); %function of transfer
step(system) %plotting the step response
title("Unit Ramp Resp.")
xlabel("Time")
ylabel("Amplitude")
```

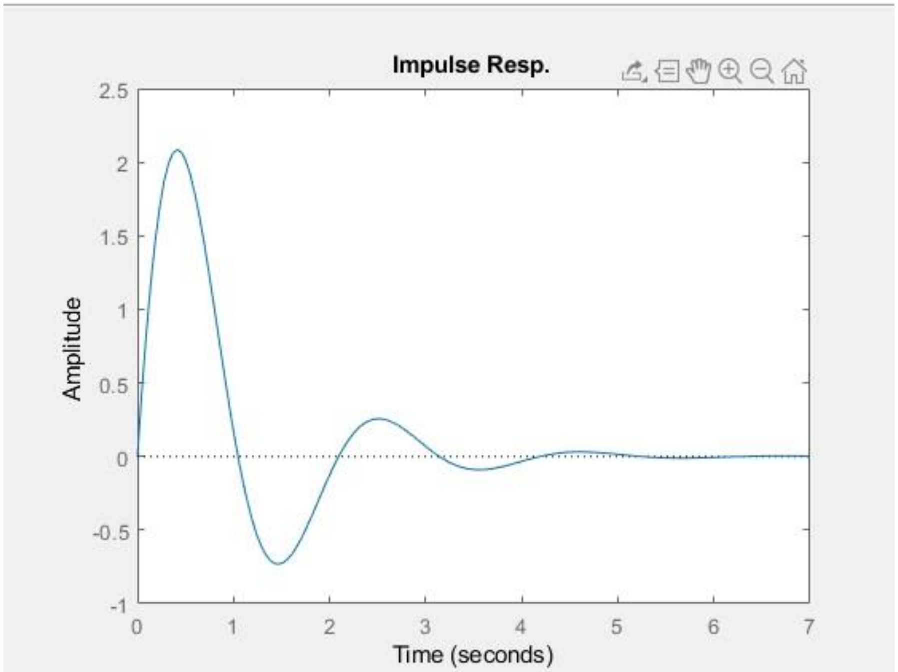
Ramp response:



Impulse response code:text

```
%G(s) = 1/(s2+2s+10)

num=10; %Numerator
den=[1 2 10]; %denominator
system=tf(num,den); %function of transfer
impulse(system) %plotting the impulse response
title("Impulse Resp.")
xlabel("Time")
ylabel("Amplitude")
```

Impulse response:



Q2:

(b) Using MATLAB, obtain the unit-step response, unit-ramp response, and unit impulse response of the following system:

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & -0.5 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0.5 \\ 0 \end{bmatrix} u$$

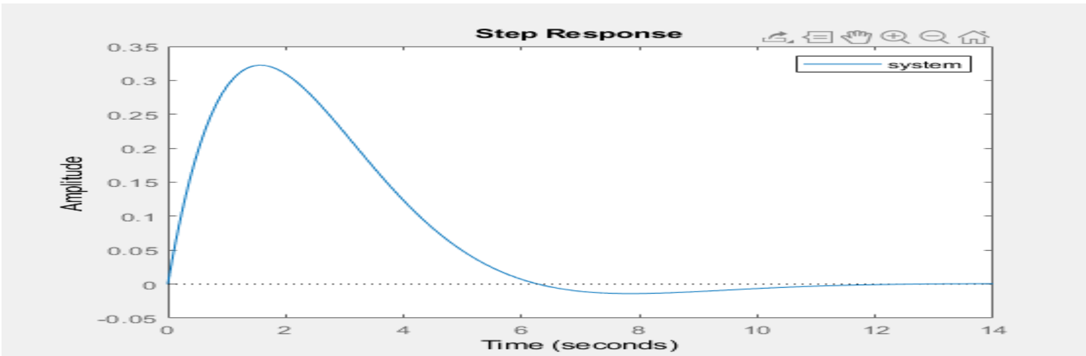
$$y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Where u is the input and y is the output.

Step Response code: text

```
%for a state space model
A = [-1,-0.5;1,0]
B = [0.5;0]
C = [1,0]
system = ss(A,B,C,0) %D=0 , ss is the function of generating cont. time ss
model
step(system)
```

Step Resp.



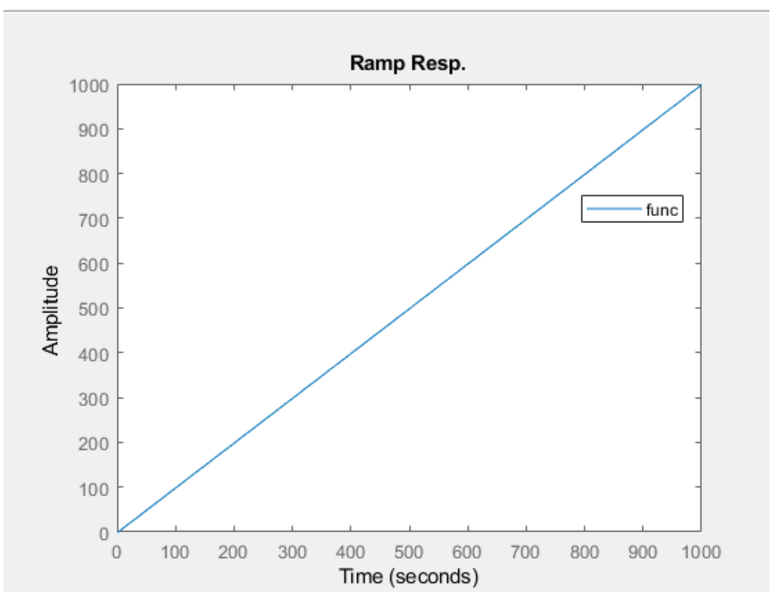
Unit Ramp Response code: text

```
%for a state space model
%in case there is no ramp function in syntax
%I converted the ss model into TF using ss2tf function
A = [-1,-0.5;1,0]
B = [0.5;0]
C = [1,0]
system = ss(A,B,C,0) %D=0 , ss is the function of generating cont.
time ss model
[num,den] = ss2tf(A,B,C,0)
sssss=tf(system) %line 9
newnum=[0.5] %after getting the TF run in line 9
newden=[1,1,0.5,0] % here I mltiplied the charact. eq by s to get the
tu(t) which is ramp
func=tf(newnum,newden)
step(func)
title("Ramp Resp.")
```

Line 9 Output:

```
num =

         0    0.5000         0


den =

    1.0000    1.0000    0.5000


sssss =

      0.5 s
  -------------
  s^2 + s + 0.5

Continuous-time transfer function.
```

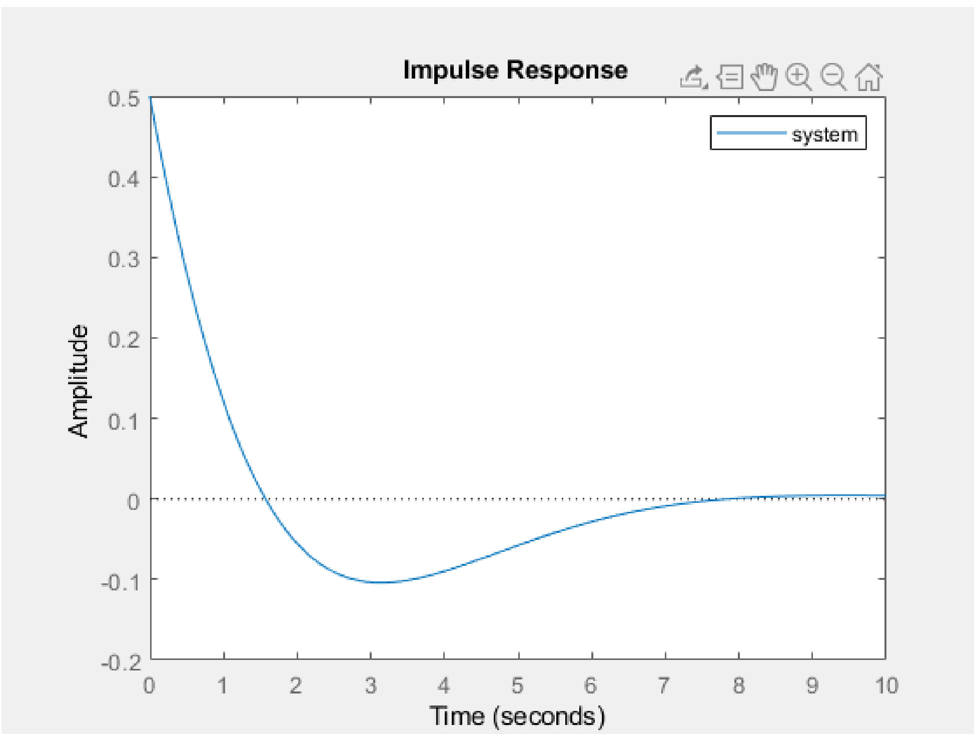
Ramp Resp.



Unit Impulse code: text

```
%for a state space model
A = [-1,-0.5;1,0]
B = [0.5;0]
C = [1,0]
system = ss(A,B,C,0) %D=0 , ss is the function of generating cont. time ss
model
impulse(system)
```

Unit Impulse Resp.



Done by :
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