ECE1008 (Sensors & Control Systems) Experiment – 1 **04/12/2021**

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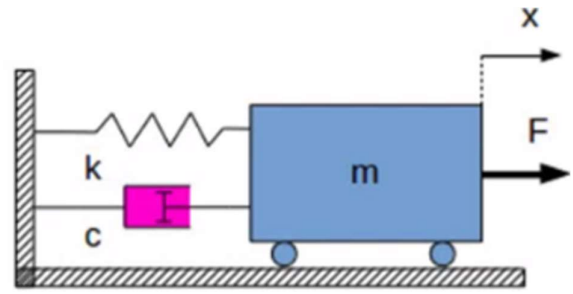
Aim :– Perform comprehensive analysis on the given translational mechanical system with different controller configuration

Specification :–

m = 1kg, c = 10 Ns/m, k = 1 N/m, F(s) = 1N



	P controller	PI Controller	PD Controller	PID Controller
Kp	300	300	300	300
Ki	--	0 – 500	--	0 – 500
Kd	--	--	0 – 500	0 – 500

Tasks :–

1) Derive open loop and closed loop transfer function
2) Develop block diagrams of P, PI, PD, PID controllers
3) Plot the step response in each of the above cases by varying Ki and Kd values and find optimum values to achieve desired response
4) Comment on observations made on system response in each configuration

The modelling equation is as follows :
$\mathbf{m\ddot{x} + b\dot{x} + kx = F}$ ---------- (1)

Taking Laplace transform :
$\mathbf{m*(s^2)*X(s) + b*s*X(s) + k*X(s) = F(s)}$ ---------- (2)

The transfer function between the displacement X(s) and the input F(s) then becomes :
$\mathbf{X(s) / F(s) = 1/[\ m*(s^2) + b*s + k]}$ ---------- (3)

We have m=1 kg, b=10 Ns/m, k=1N/m, F(s)=1,
So, the open loop transfer function,
$\mathbf{OLTF = 1/(\ s^2 + 10*s + 1)}$ ---------- (4)

Therefore, closed loop transfer function is as below:
$\mathbf{CLTF = 1/(\ s^2 + 10*s + 2)}$ ---------- (5)

Theory –

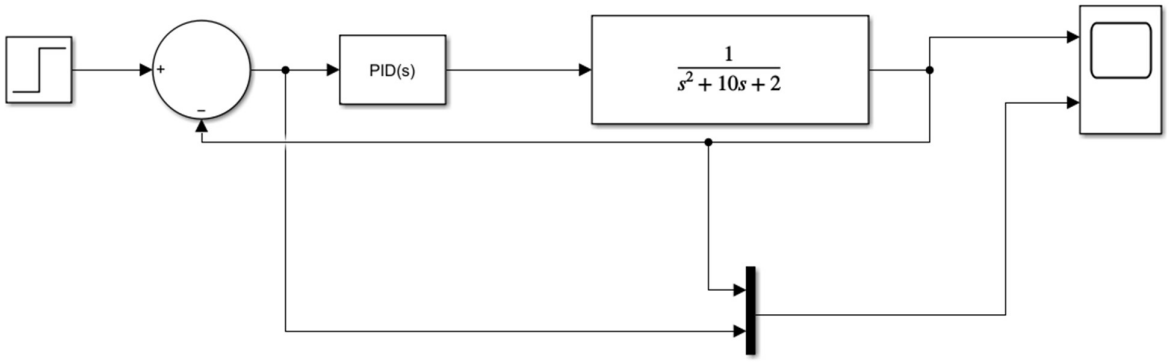
1. *Open-loop control system*:
A system in which the output is dependent on input but controlling action is totally independent of the output is called an Open-loop system.
It is also referred to as a non-feedback system, which is a type of continuous control system in which the output has no influence or effect on the control action of the input signal.
The manual system is also an open-loop control system.
The block diagram of the open-loop control system in which process output is totally independent of the controller action.

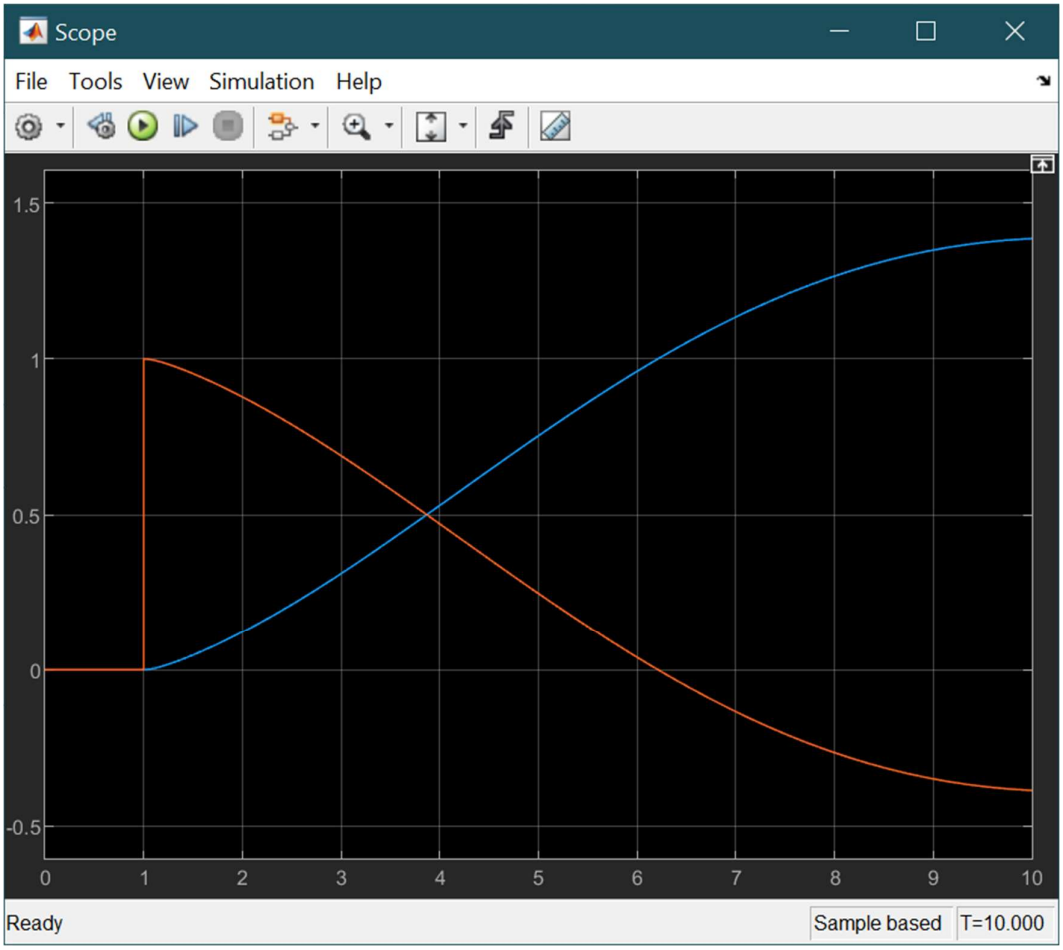
2. *Closed-Loop Control System*:
A system in which the controlling action is dependent on the output is called a Closed-loop system.
Output has an effect on input quantity in such a manner that the input quantity will adjust itself based on the output generated.
An open-loop control system can be converted to close loop control system by adding feedback.
This feedback automatically makes satisfactory changes in the output due to external disturbances.
In this way, the closed-loop control system is called an automatic control system or feedback control system.

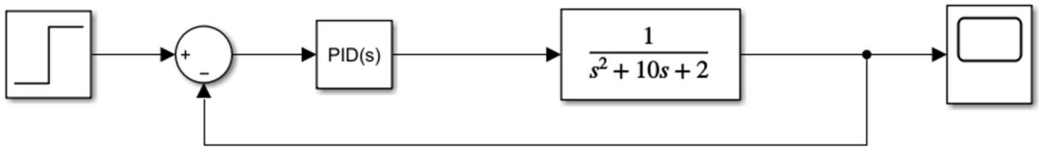
MATLAB Code to compute OLTF and CLTF –

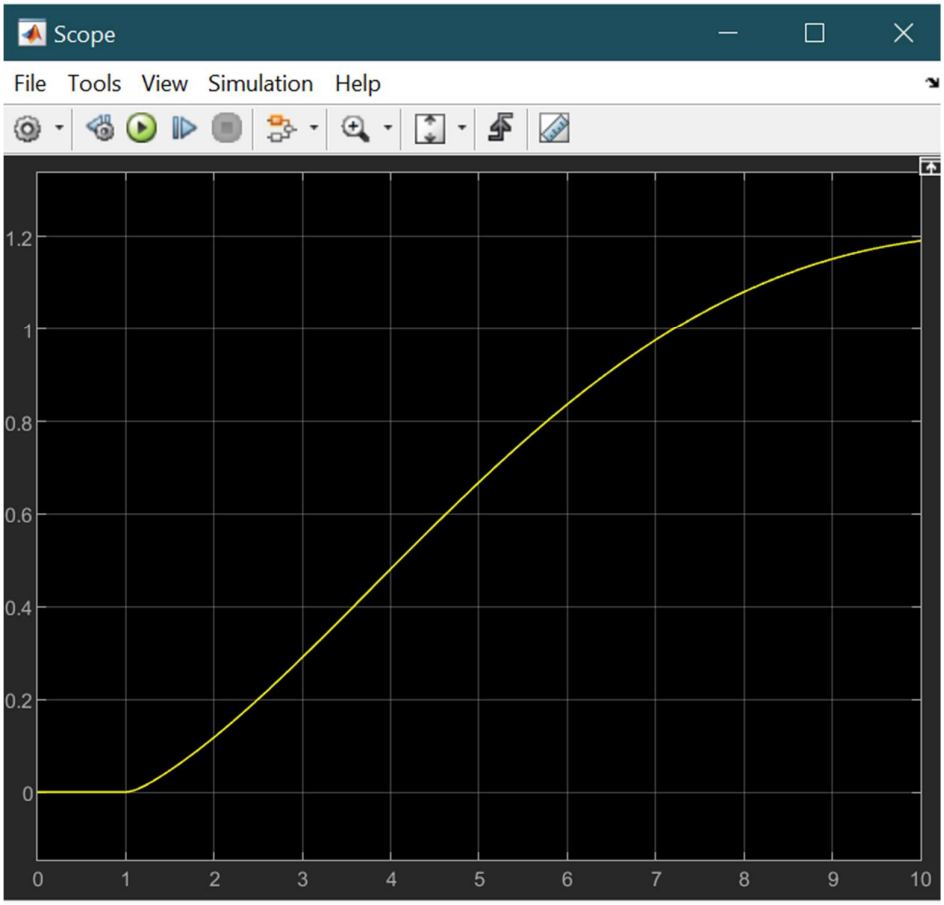
```
%% KHAN MOHD OWAIS RAZA (20BCD7138) %%
% ECE1008 (SENSORS & CONTROL SYSTEMS) %
% EXPERIMENT-1: MECHANICAL TRANSLATIONAL SYSTEM %
clc
clear all
close all
syms X F
% X(s) = dispalcement
% F(s) = input
% X(s)/F(s) = transfer function between displacement & input
% m = mass of block in the mechanical system (Kg)
% b = displacement-rate of change of impulse of system (Ns/m)
% k = spring constant of spring tied to block (N/m)
% s = complex number frequency parameter
m = input('Enter the value of mass of block :');
b = input('Enter the value of rate of change of impulse :');
k = input('Enter the value of spring constant : ')
% Specifications: m = 1Kg, b = 10Ns/m, k = 1 N/m
X/F == 1/[m*(s*s) + b*s + k]; % X/F = transfer function
% OLTF = Open Loop Transfer Function
% CLTF = Closed Loop Transfer Function
OLTF(s) = 1/(m*s*s + b*s + k);
CLTF(s) = [1/(m*s*s + b*s + k)]/[1 + 1/(m*s*s + b*s + k)];
```

Closed loop control system using Simulink –

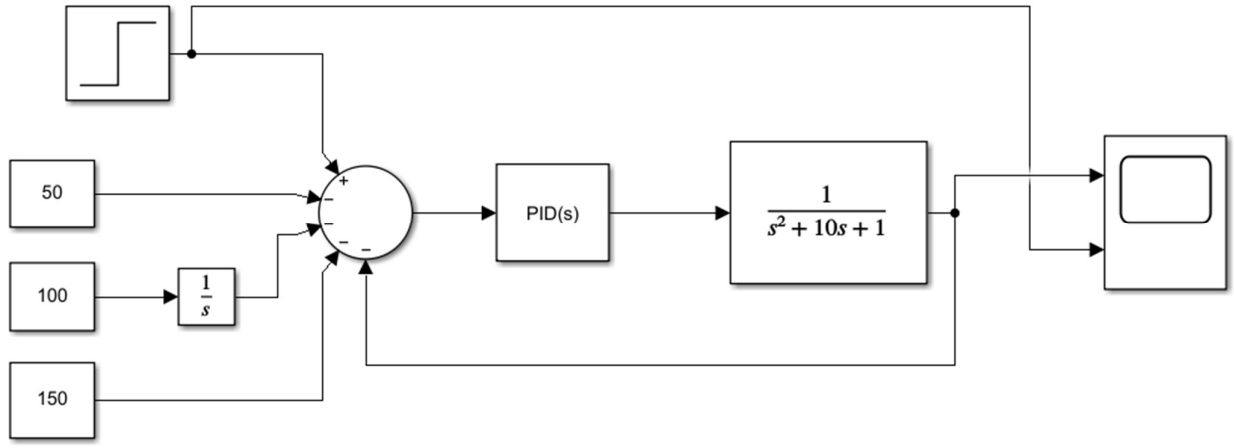


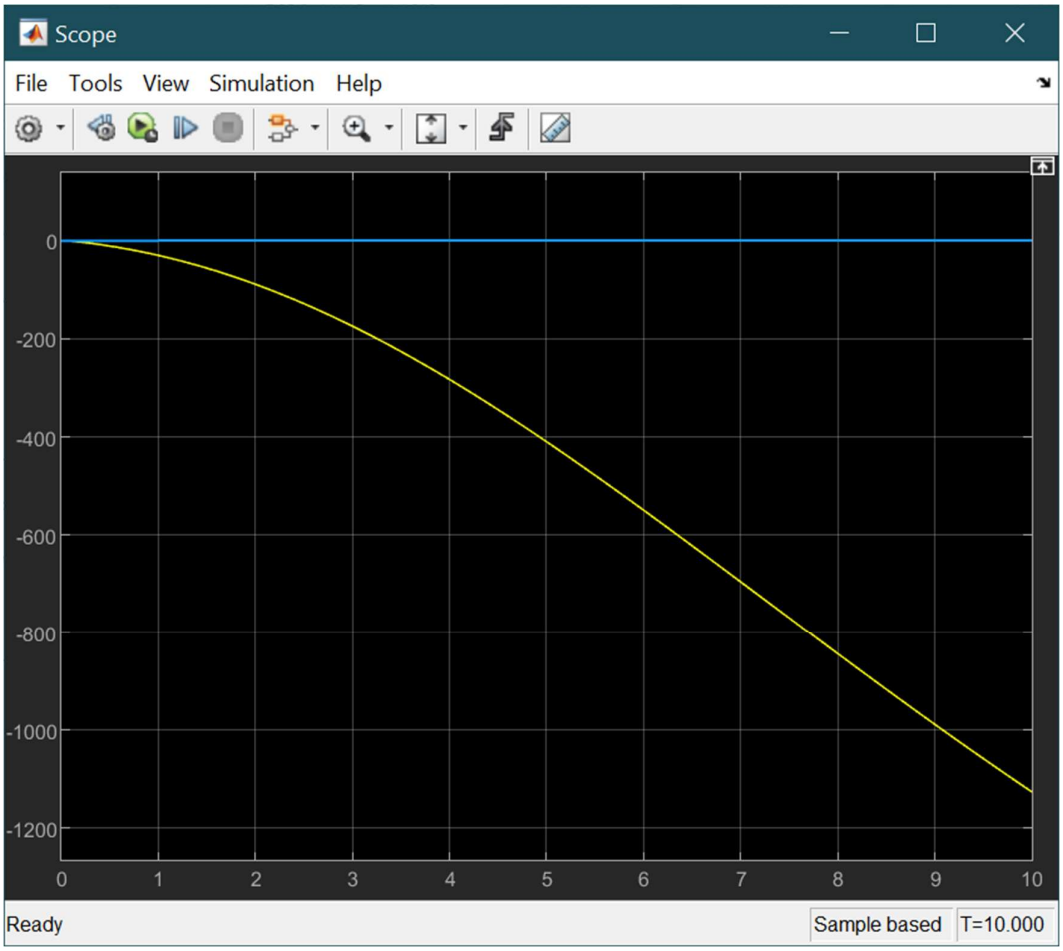


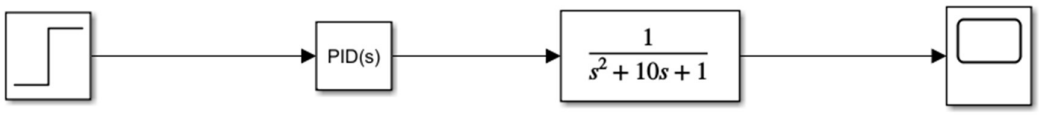

+
−
PID(s)
$\frac{1}{s^2+10s+2}$

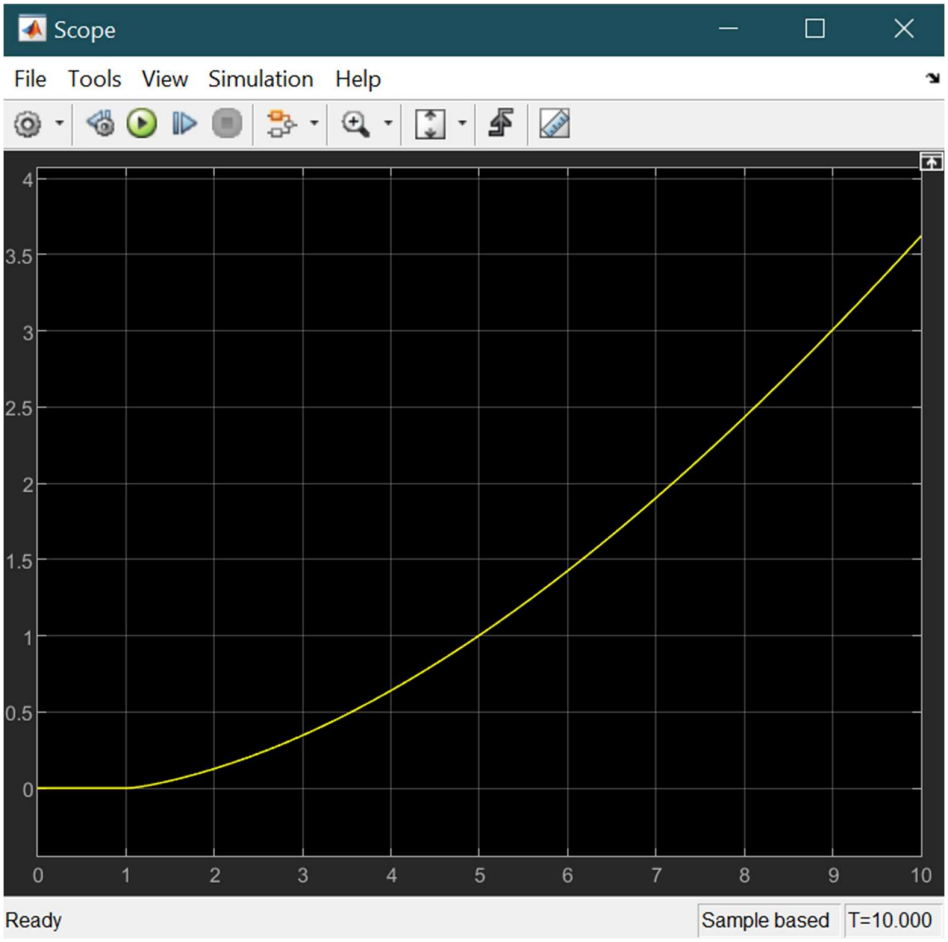

Scope
File Tools View Simulation Help
1.2
1
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7 8 9 10

Open loop control system using Simulink –

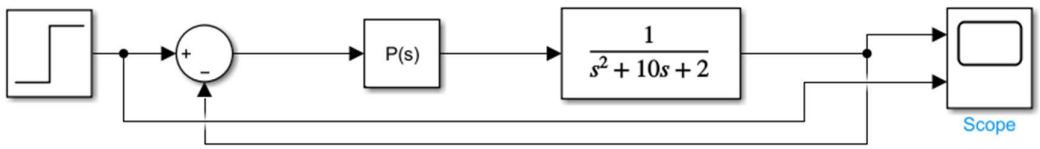


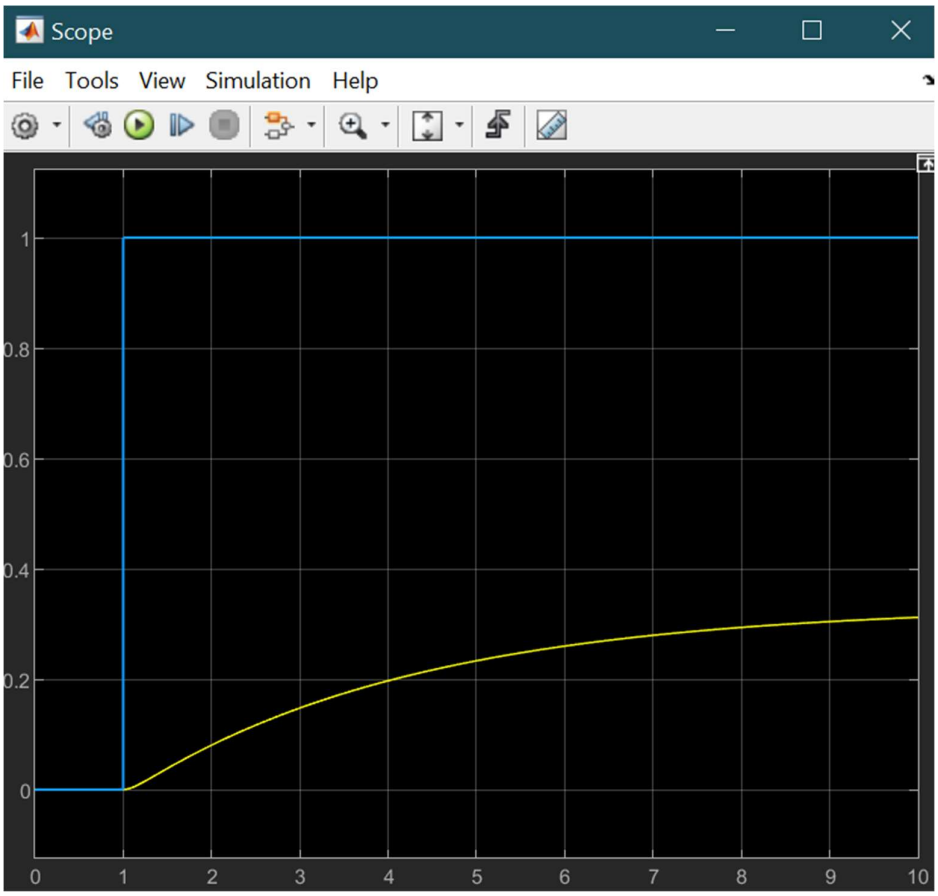



PID(s)
$\frac{1}{s^2+10s+1}$

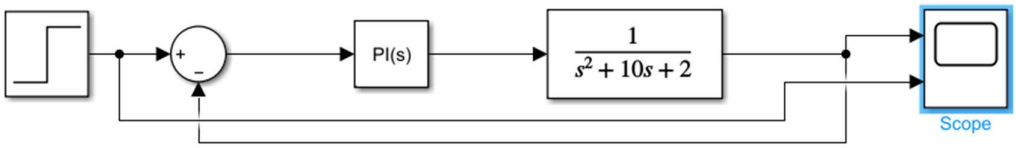

Scope
File Tools View Simulation Help
4
3.5
3
2.5
2
1.5
1
0.5
0
0 1 2 3 4 5 6 7 8 9 10
Ready
Sample based
T=10.000

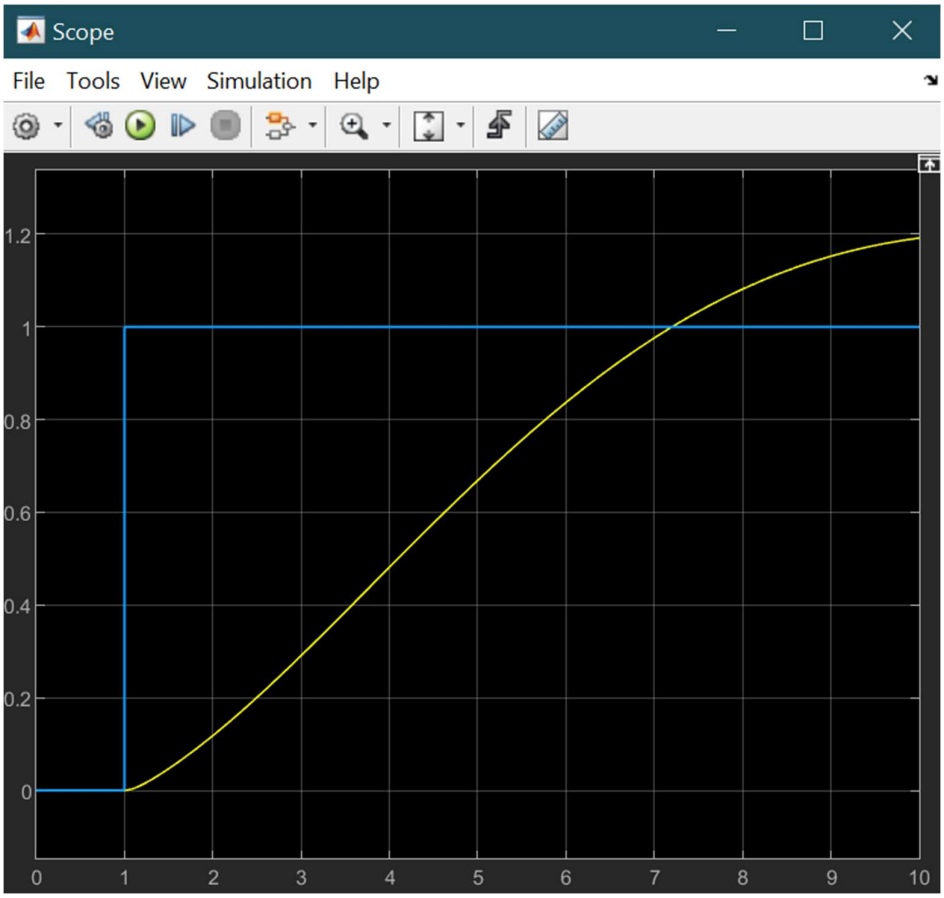
P controller –





PI controller –





PD controller –