Control System Laboratory Report

Name and ID no. of the Student:

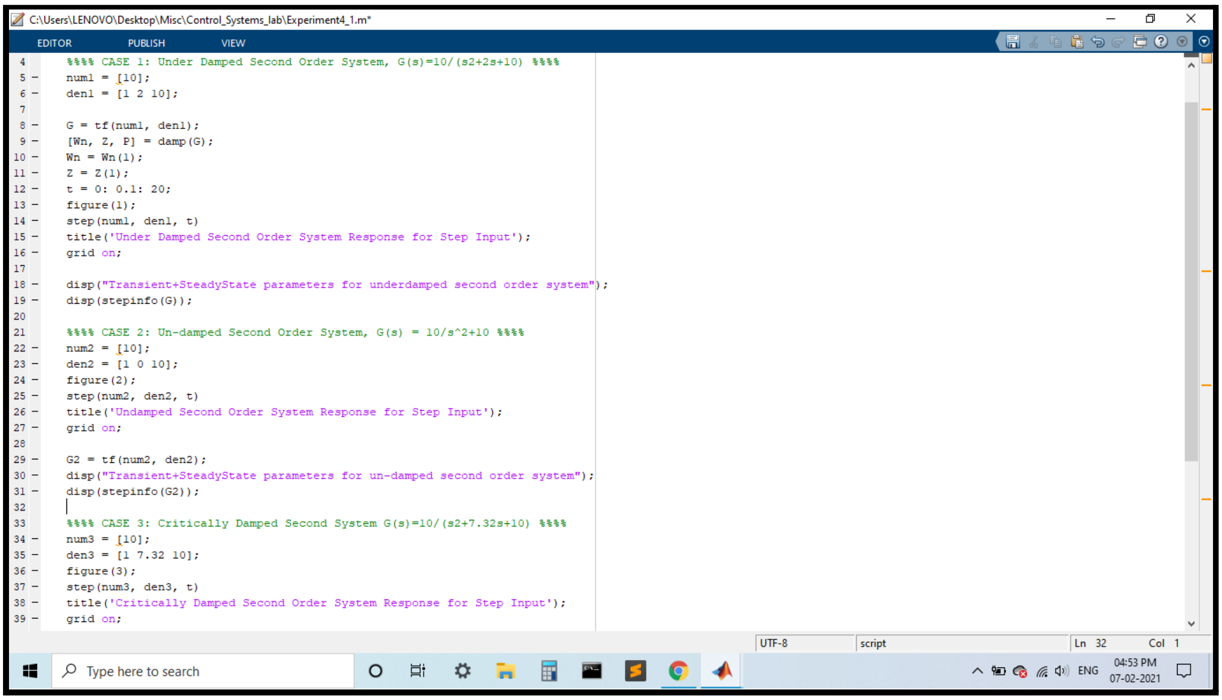
VISHWAS VASUKI GAUTAM, 2019A3PS0443H

Title of the Experiment:

Second Order Dynamic Systems

Model/Simulation:

a) The image below shows the MATLAB code for obtaining the step response of the second order system and getting the step response information from it.



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%%%% CASE 1: Under Damped Second Order System, G(s)=10/(s2+2s+10) %%%%
num1 = [10];
den1 = [1 2 10];

G = tf(num1, den1);
[Wn, Z, P] = damp(G);
Wn = Wn(1);
Z = Z(1);
t = 0: 0.1: 20;
figure(1);
step(num1, den1, t)
title('Under Damped Second Order System Response for Step Input');
grid on;

disp("Transient+SteadyState parameters for underdamped second order system");
disp(stepinfo(G));

%%%% CASE 2: Un-damped Second Order System, G(s) = 10/s^2+10 %%%%
num2 = [10];
den2 = [1 0 10];
figure(2);
step(num2, den2, t)
title('Undamped Second Order System Response for Step Input');
grid on;

G2 = tf(num2, den2);
disp("Transient+SteadyState parameters for un-damped second order system");
disp(stepinfo(G2));

%%%% CASE 3: Critically Damped Second System G(s)=10/(s2+7.32s+10) %%%%
num3 = [10];
den3 = [1 7.32 10];
figure(3);
step(num3, den3, t)
title('Critically Damped Second Order System Response for Step Input');
grid on;
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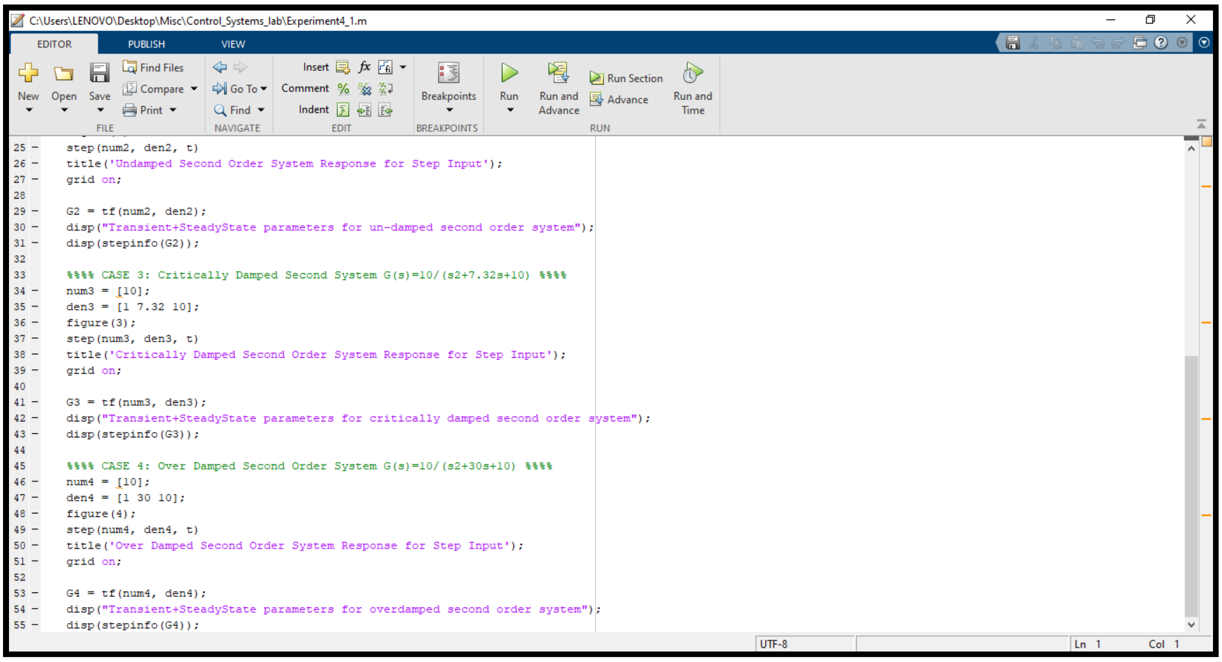
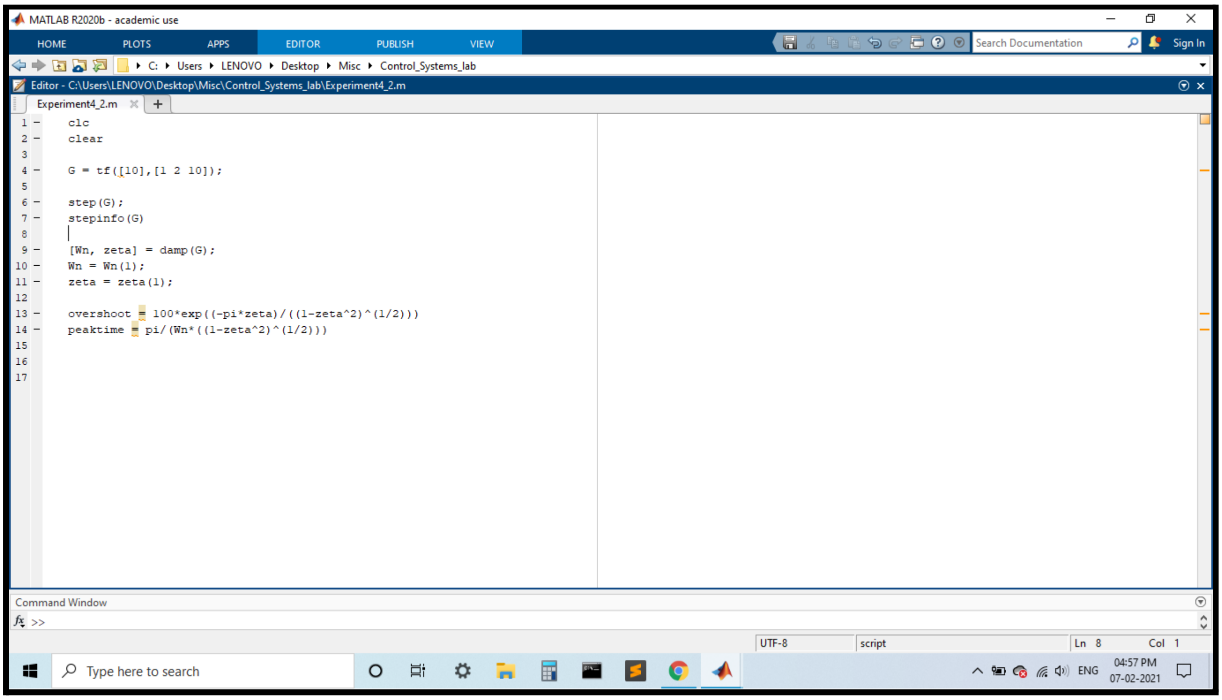
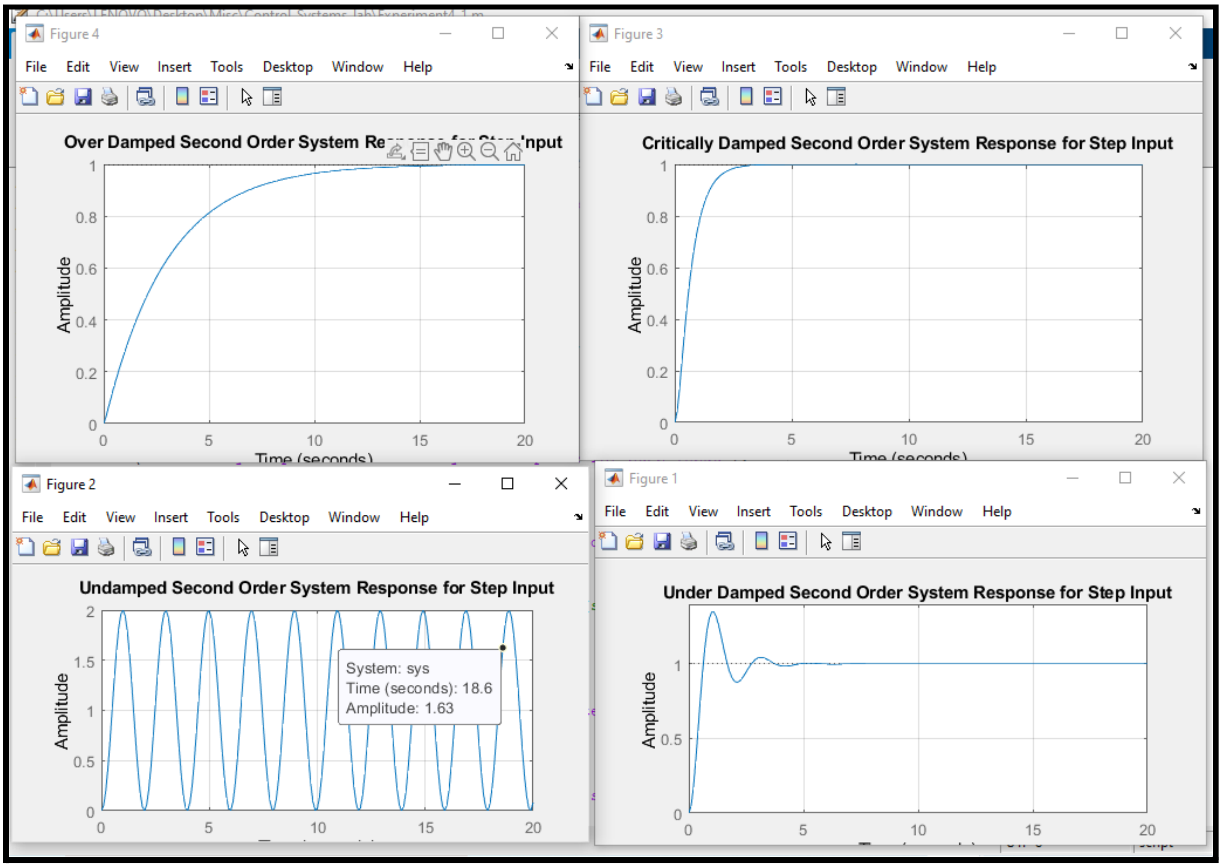


b) The image below shows the MATLAB code for obtaining the peak time and overshoot values analytically and graphically.



Results:

a) The below is the plot and the step response information obtained when the MATLAB code was run.



And the transient response and steady state response for each system is given in the text below:

Transient+SteadyState parameters for underdamped second order system

RiseTime: 0.4259

SettlingTime: 3.5359

SettlingMin: 0.8772

SettlingMax: 1.3507

Overshoot: 35.0670

Undershoot: 0

Peak: 1.3507

PeakTime: 1.0592

Transient+SteadyState parameters for un-damped second order system

RiseTime: NaN

SettlingTime: NaN

SettlingMin: NaN

SettlingMax: NaN

Overshoot: NaN

Undershoot: NaN

Peak: Inf

PeakTime: Inf

Transient+SteadyState parameters for critically damped second order system

RiseTime: 1.3140

SettlingTime: 2.3733

SettlingMin: 0.9005

SettlingMax: 0.9994

Overshoot: 0

Undershoot: 0

Peak: 0.9994

PeakTime: 4.3351

Transient+SteadyState parameters for overdamped second order system

RiseTime: 6.5174

SettlingTime: 11.6386

SettlingMin: 0.9034

SettlingMax: 1.0000

Overshoot: 0

Undershoot: 0

Peak: 1.0000

PeakTime: 31.2820

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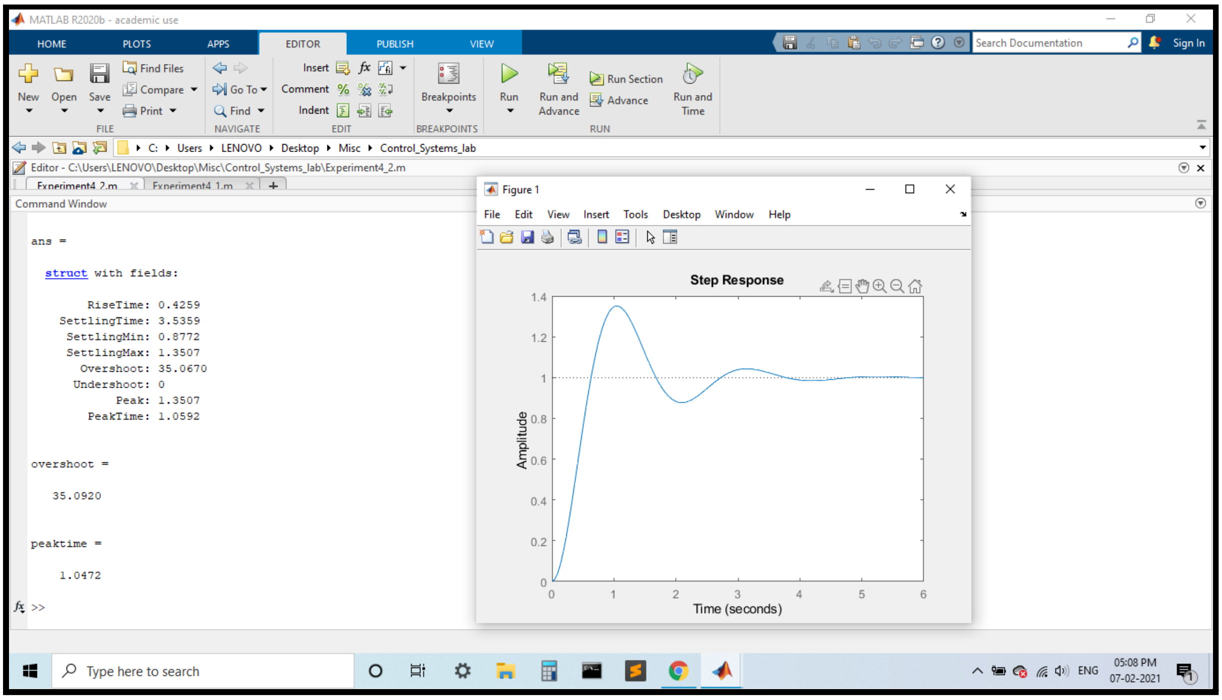
b)

The below plot is the step response from the MATLAB code along with the step information calculated analytically and graphically.



Conclusive remarks:

In order to obtain the time response of the system, we initially need to obtain the model of the system in terms of its input and output (transfer function) in laplace domain. Using this transfer function we can get the output of any system by specifying the input. Once the input is specified we take the Inverse laplace transform of the equation to convert it back to time domain, this will result in response of the system for the given input. If the input given in u(t) then the response is called step response.

The step response of a standard second order system can be classified into 4 types, they are Underdamped, Overdamped, Critically damped and Undamped which depend on the value of the damping. This classification allows the user to choose the type of system depending on their application. For example, a robot arm designer would want his system to be overdamped or critically damped to avoid overshoot in the arm beyond the steady state position, or any other form of oscillations around the steady state position. Hence, the robot arm designer can choose the type of second order system suitable for their application (a critically damped/overdamped system here).

The step response of a second order system is divided into 2 stages, the transient response and the steady state response. There are several other parameters associated with these responses such as peak time, max overshoot, steady state error, settling time, etc. These parameters allow the user/designer to further fine tune the system depending on their application. For example a musical instrument designer will model the strings of their instrument in such a way that the system is underdamped with high overshoot and long settling time or else the music from the instrument will be just a dull thud.

From this we can conclude that the second order system has a variety of applications and depending on the application a suitable second order system can be chosen.