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**Department of Computer Science and Engineering**  
**Dhulikhel, Kavrepalanchowk**



**A Lab Report**  
**on**  
**“Control System”**  
**Lab No: III**

**[Code No: COEG304]**

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CE 2022

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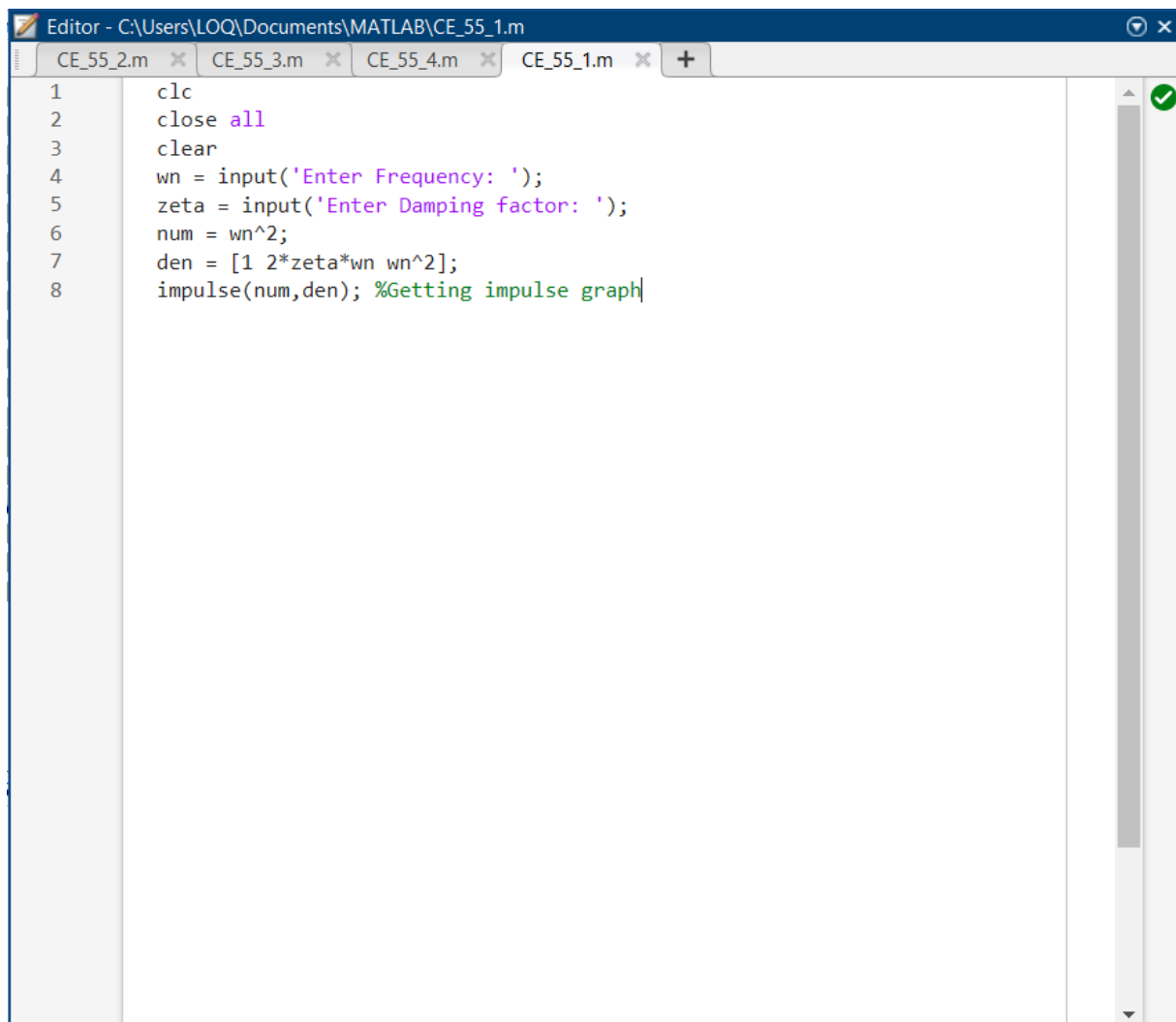
## Title: To visualize the response of a Second Order System

### Theory:

A second order system is given by the following transfer function:

$$T(s) = \frac{kw^2}{s^2 + 2\xi\omega s + \omega^2}$$

### Task 1: Impulse Response of System

The image shows a MATLAB Editor window with the title bar 'Editor - C:\Users\LOQ\Documents\MATLAB\CE\_55\_1.m'. There are four tabs open: 'CE\_55\_2.m', 'CE\_55\_3.m', 'CE\_55\_4.m', and 'CE\_55\_1.m'. The code in the editor is as follows:

```
1  clc
2  close all
3  clear
4  wn = input('Enter Frequency: ');
5  zeta = input('Enter Damping factor: ');
6  num = wn^2;
7  den = [1 2*zeta*wn wn^2];
8  impulse(num,den); %Getting impulse graph
```

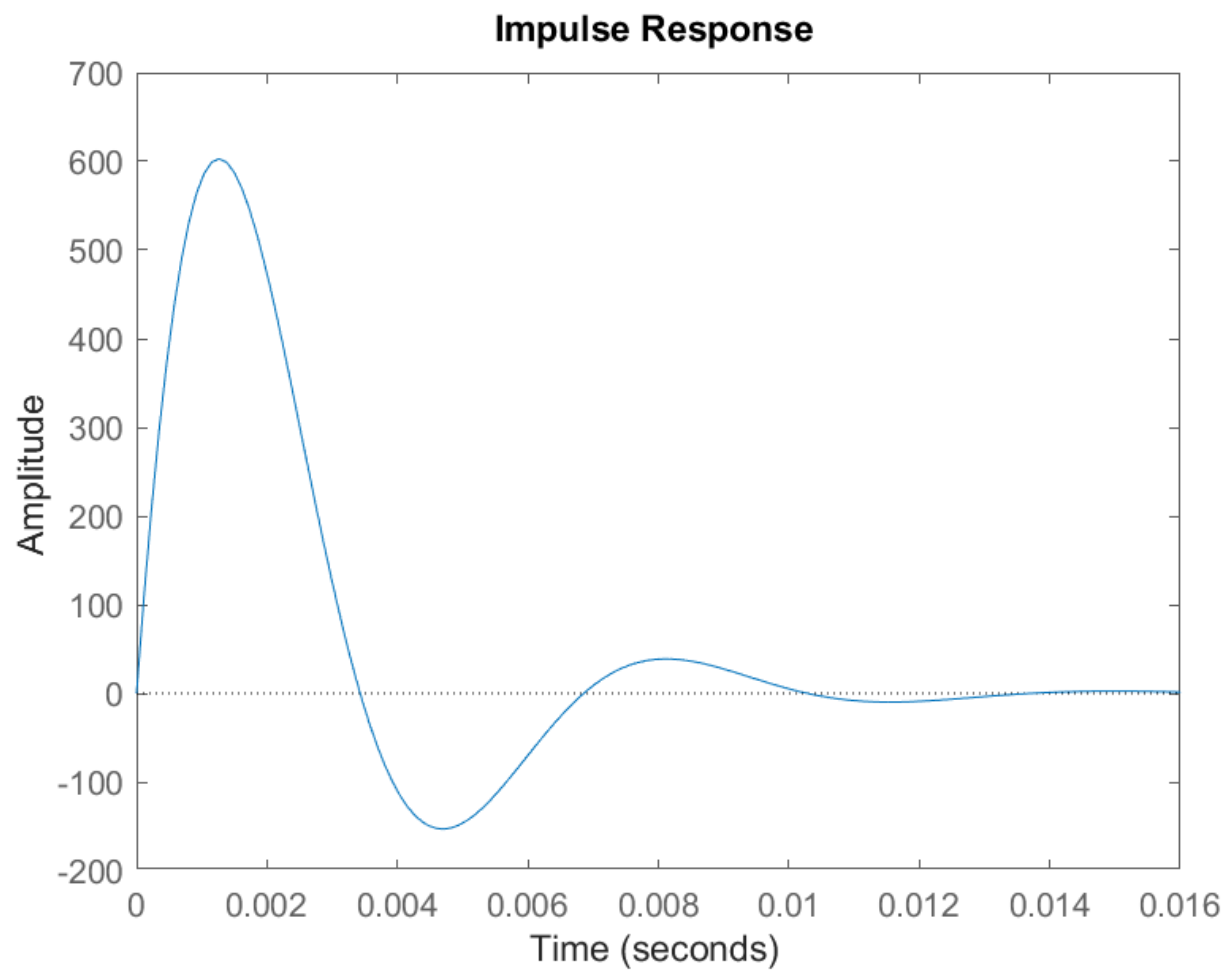
The code is line-numbered from 1 to 8. The window has a green checkmark icon in the top right corner.

*Figure 1: Impulse Response of System Code*

The impulse response of a second order system shows how the system reacts to a very short input applied at time 0. It typically exhibits oscillations whose amplitude and decay depend on the damping factor and natural frequency. Underdamped condition means system gradually decays whereas overdamped means system returns to equilibrium without oscillations.

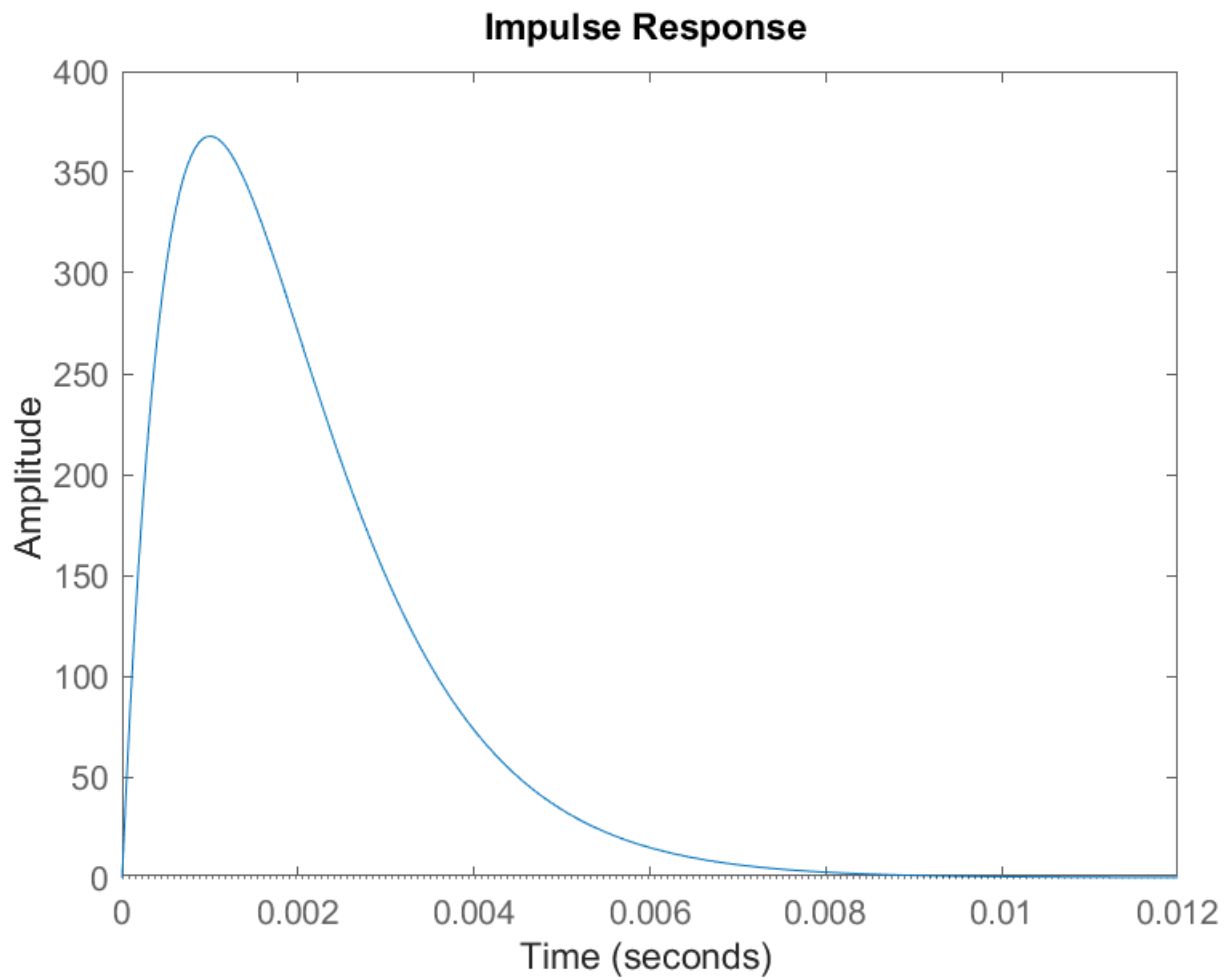
## Results:

For frequency = 1000 Hz, Damping Factor = 0.5



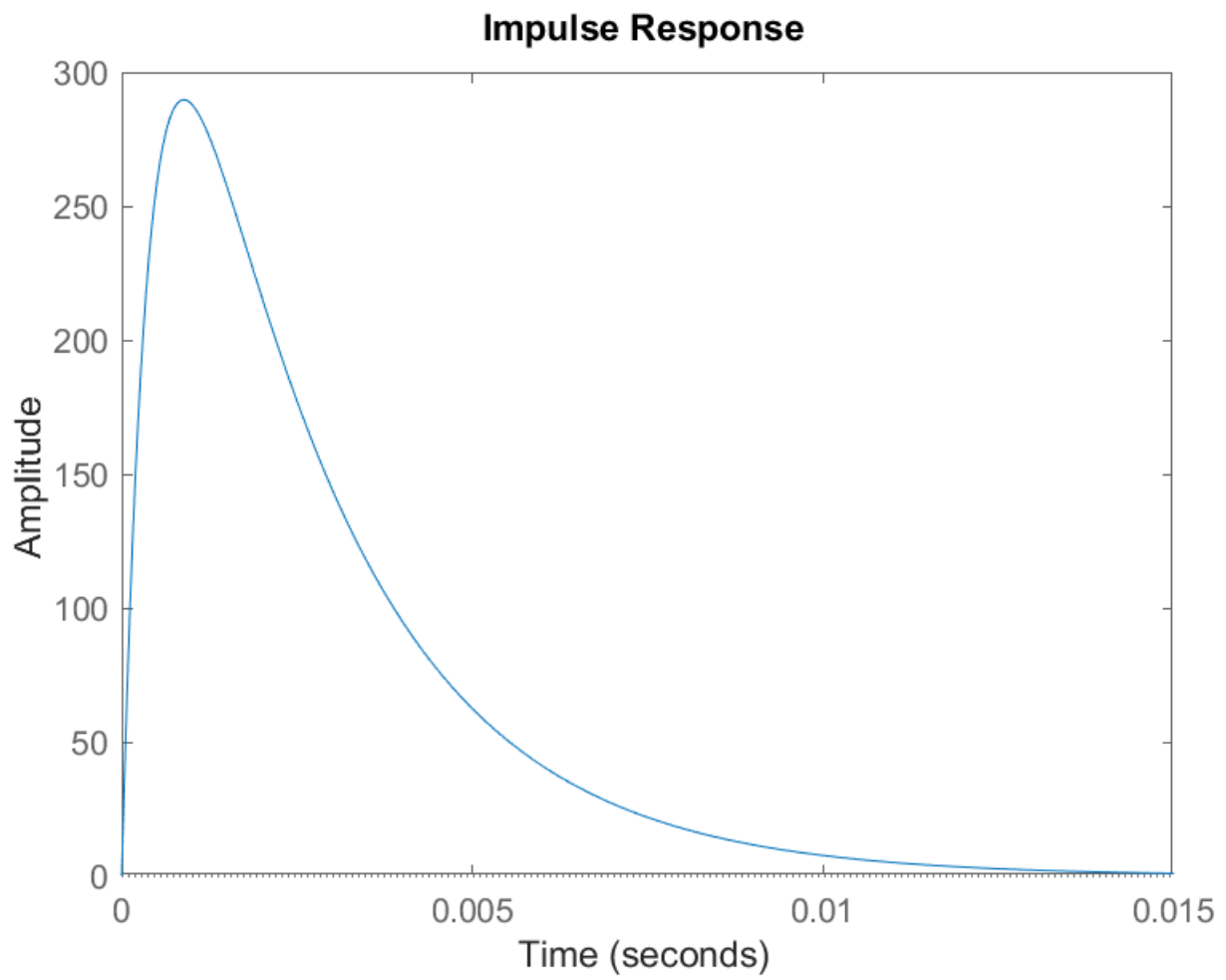
*Figure 2: Underdamped Impulse Response*

For frequency = 1000 Hz, Damping Factor = 1



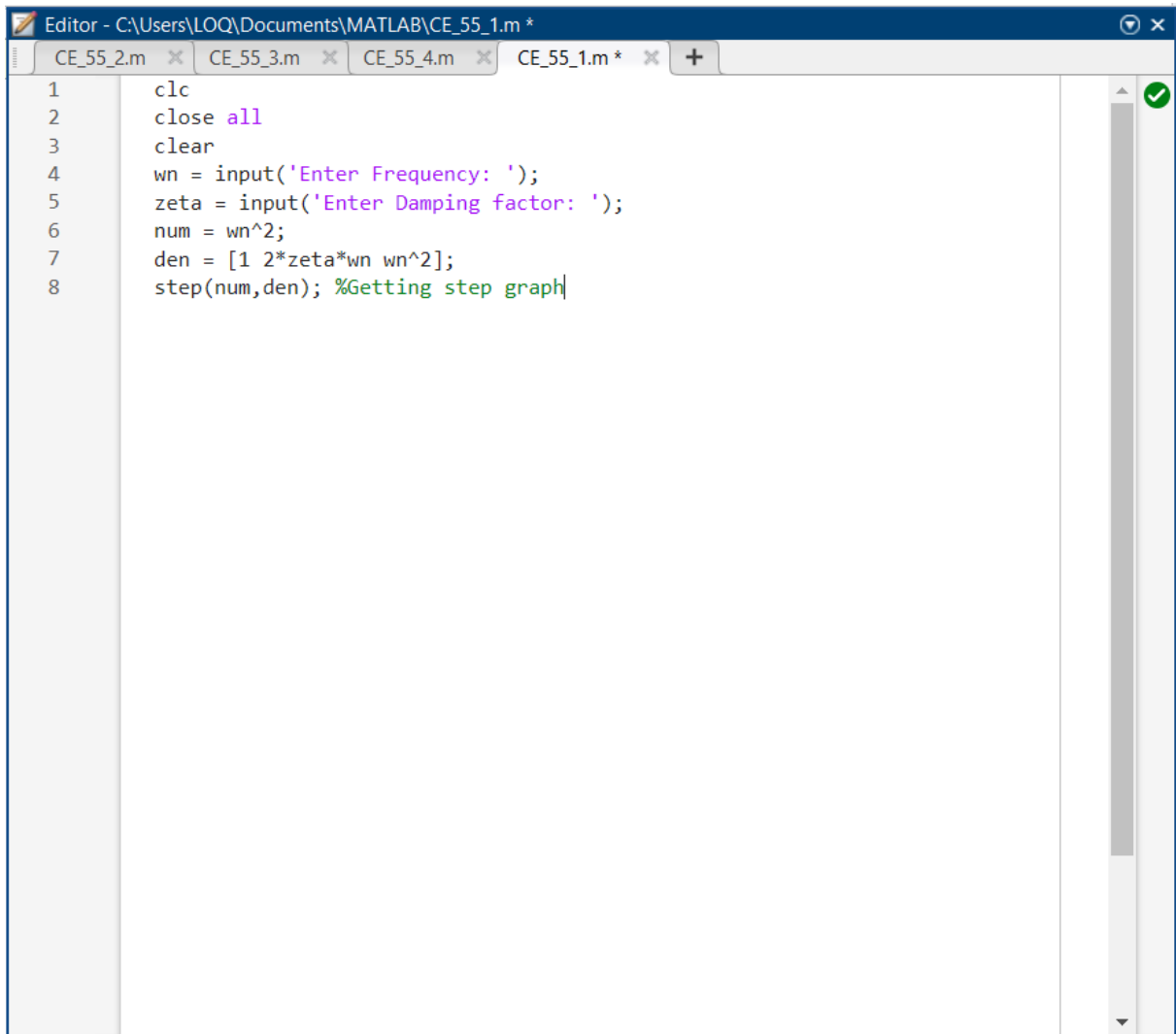
*Figure 3: Critically Damped Response*

For Frequency = 1000 Hz, Damping Factor = 1.4



*Figure 4: Overdamped Impulse Response*

## Task 2: Step Response of System

A screenshot of the MATLAB Editor window. The title bar reads "Editor - C:\Users\LOQ\Documents\MATLAB\CE\_55\_1.m \*". The window contains several tabs: "CE\_55\_2.m", "CE\_55\_3.m", "CE\_55\_4.m", and "CE\_55\_1.m \*". The active tab "CE\_55\_1.m" displays the following MATLAB code:

```
1  clc
2  close all
3  clear
4  wn = input('Enter Frequency: ');
5  zeta = input('Enter Damping factor: ');
6  num = wn^2;
7  den = [1 2*zeta*wn wn^2];
8  step(num,den); %Getting step graph
```

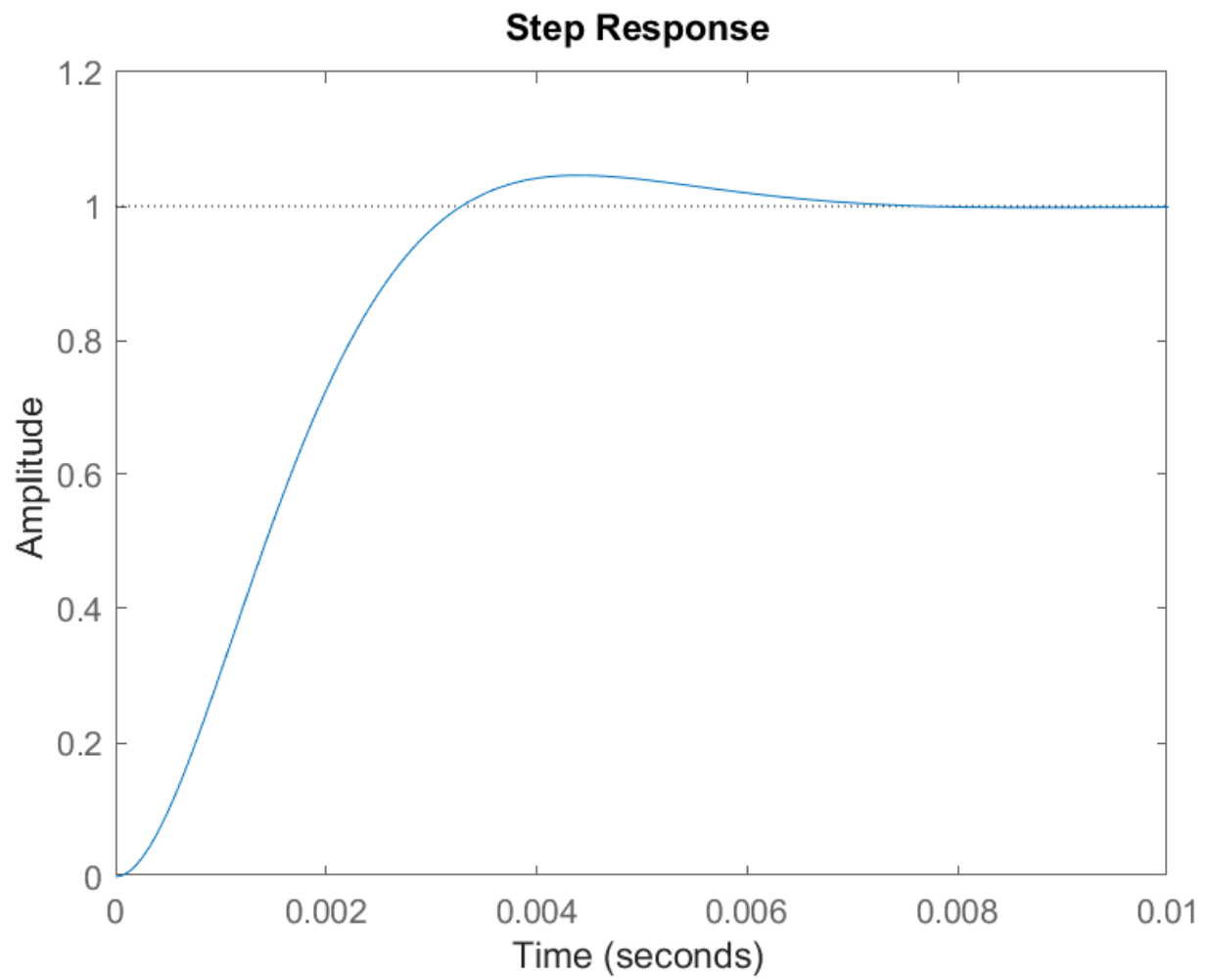
The code is line-numbered from 1 to 8. The window includes a vertical scrollbar on the right and a green checkmark icon in the top right corner.

*Figure 5: Step Response of System Code*

The step response of a second order system shows how the system reacts to a sudden, sustained input. Depending on the damping factor, the response may overshoot (underdamped), smoothly rise to final value (overdamped) or quickly reaches the final value without overshoot (critically damped)

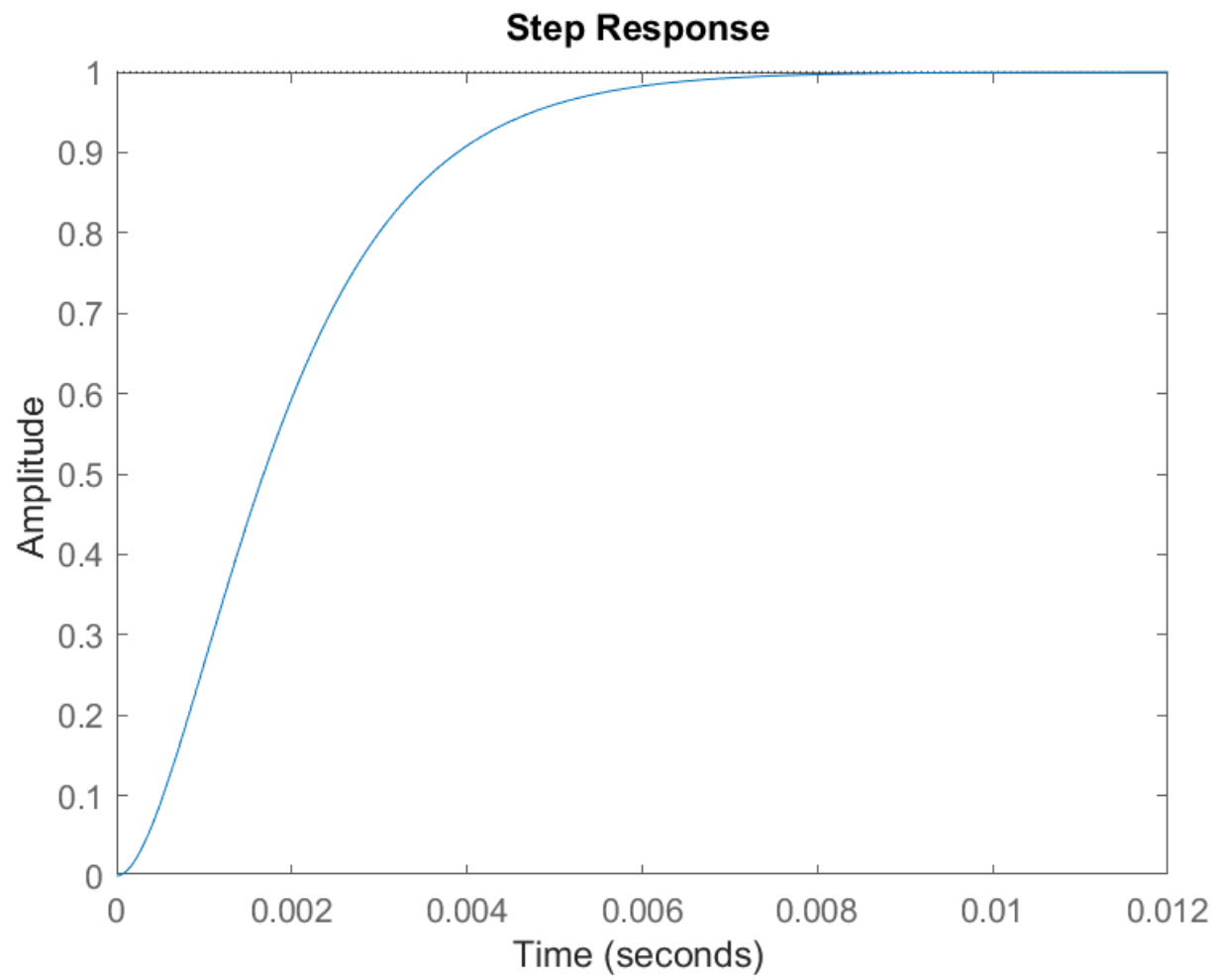
## Results:

For Frequency = 1000 Hz, Damping Factor = 0.7



*Figure 6: Underdamped Step Response*

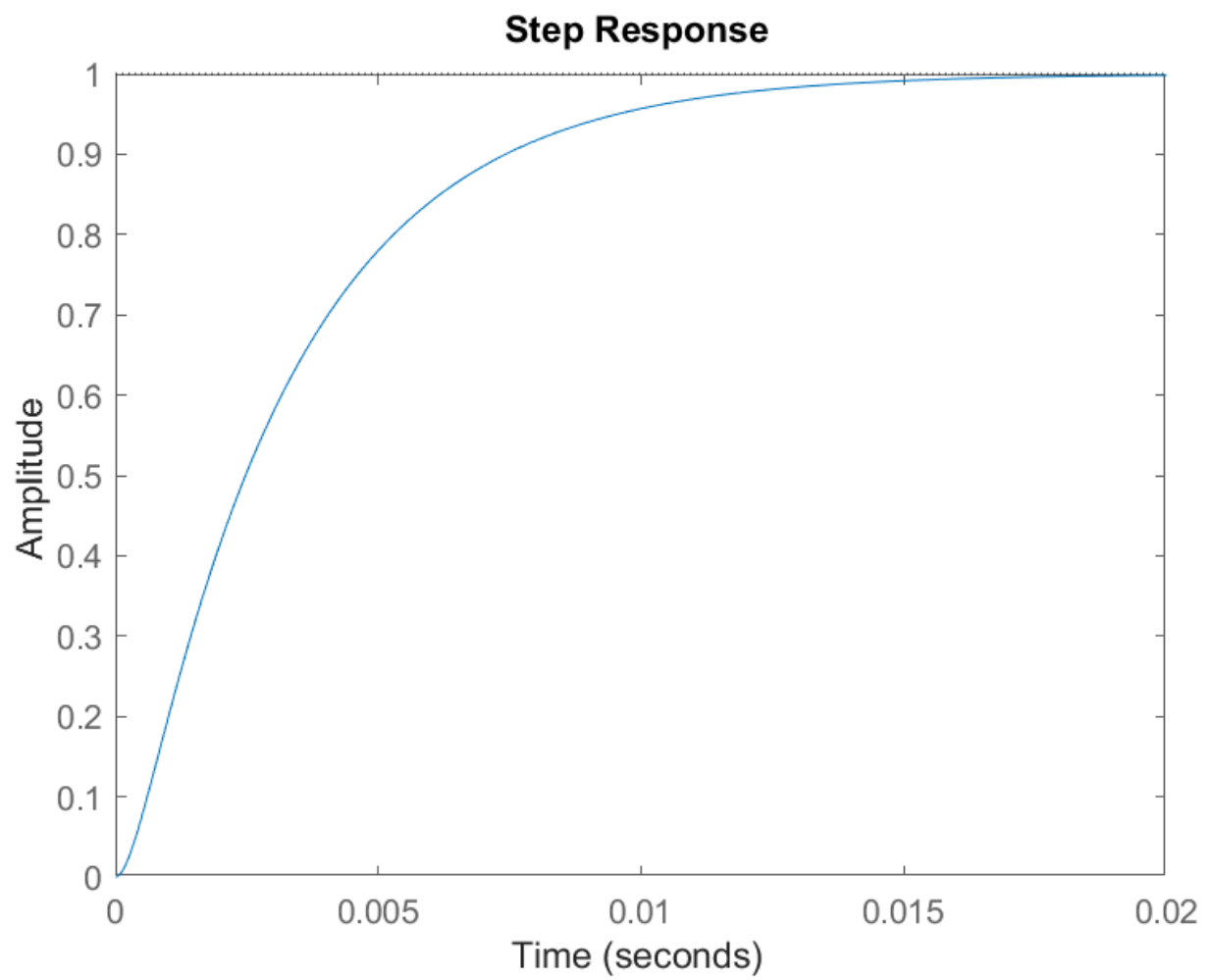
For Frequency = 1000 Hz, Damping Factor = 1



*Figure 7: Critically Damped Step Response*

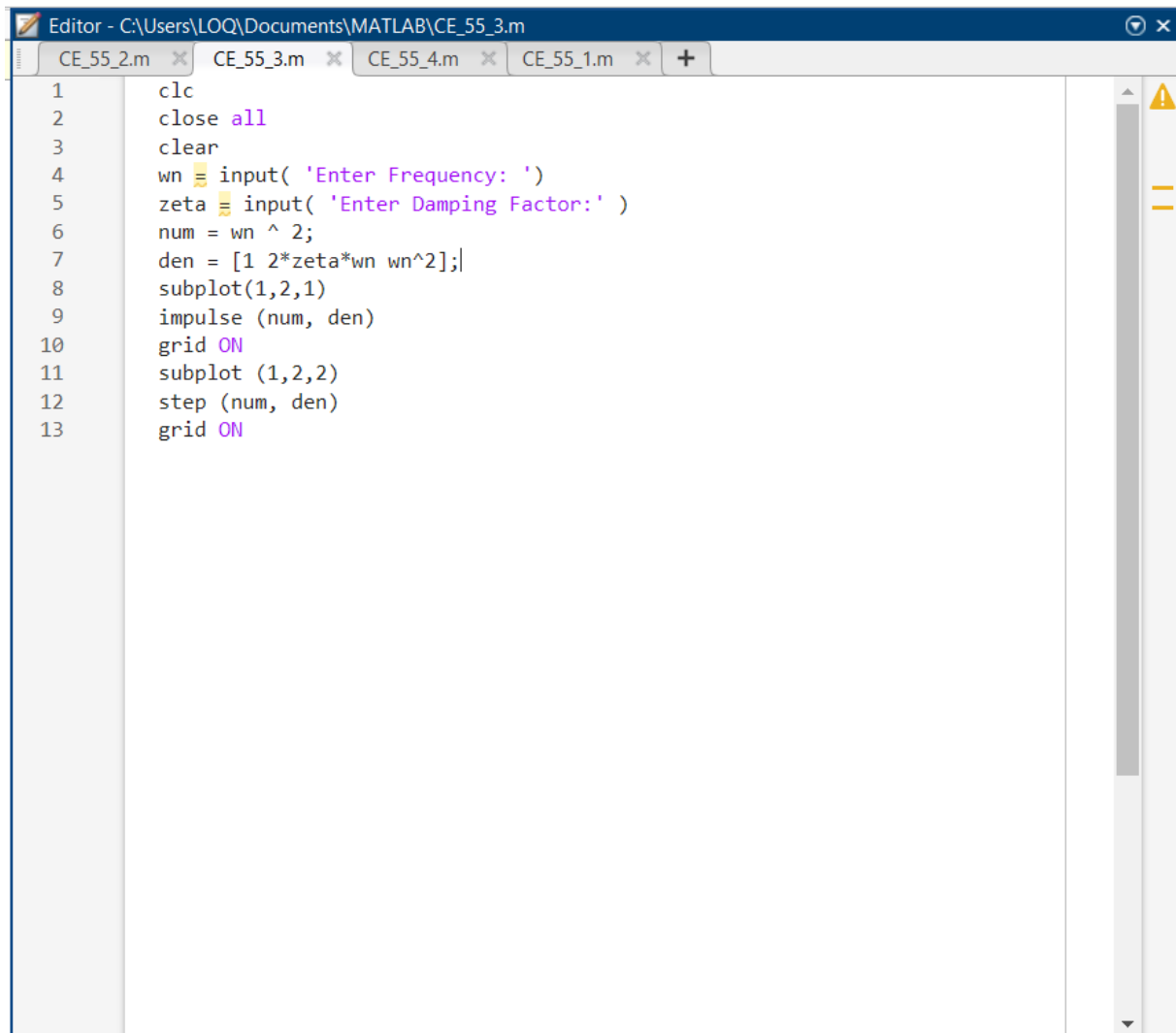


For Frequency = 1000 Hz, Damping Factor = 1.7



*Figure 8: Overdamped Step Response*

### Task 3: Impulse/Step Response of System

The image shows a MATLAB Editor window with the title bar "Editor - C:\Users\LOQ\Documents\MATLAB\CE\_55\_3.m". The window contains a script with 13 lines of code. The code defines a second-order system and plots its impulse and step responses. The code is as follows:

```
1  clc
2  close all
3  clear
4  wn = input( 'Enter Frequency: ' )
5  zeta = input( 'Enter Damping Factor:' )
6  num = wn ^ 2;
7  den = [1 2*zeta*wn wn^2];
8  subplot(1,2,1)
9  impulse (num, den)
10 grid ON
11 subplot (1,2,2)
12 step (num, den)
13 grid ON
```

The window has a tab bar at the top with four tabs: "CE\_55\_2.m", "CE\_55\_3.m", "CE\_55\_4.m", and "CE\_55\_1.m". The "CE\_55\_3.m" tab is active. On the right side of the editor, there is a vertical toolbar with a yellow warning icon at the top and a minus sign below it. The code is displayed in a light gray background with line numbers on the left.

Figure 9: Impulse/Step System Code

For Frequency = 60 Hz, Damping Factor = 0.3

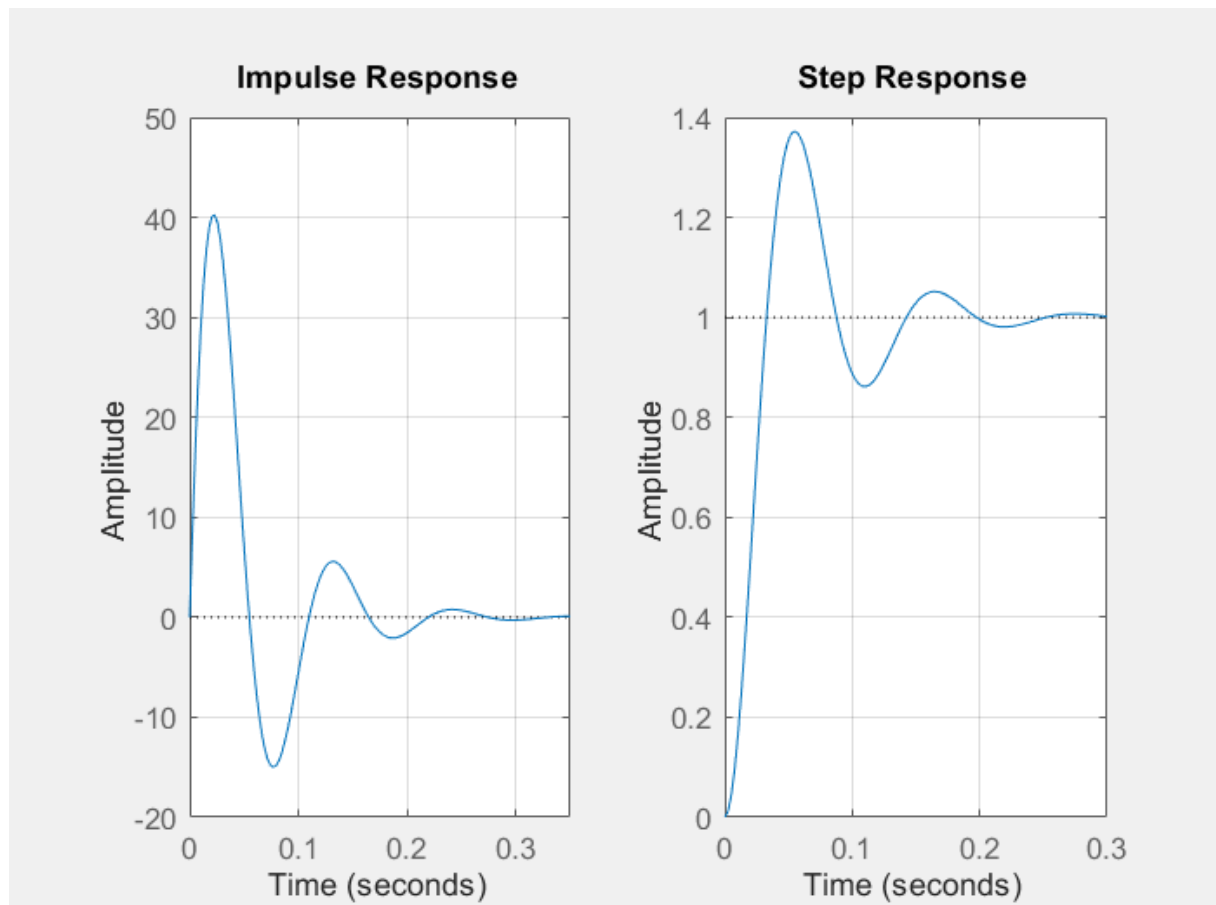


Figure 10: Underdamped Response

For Frequency = 60 Hz, Damping Factor = 1

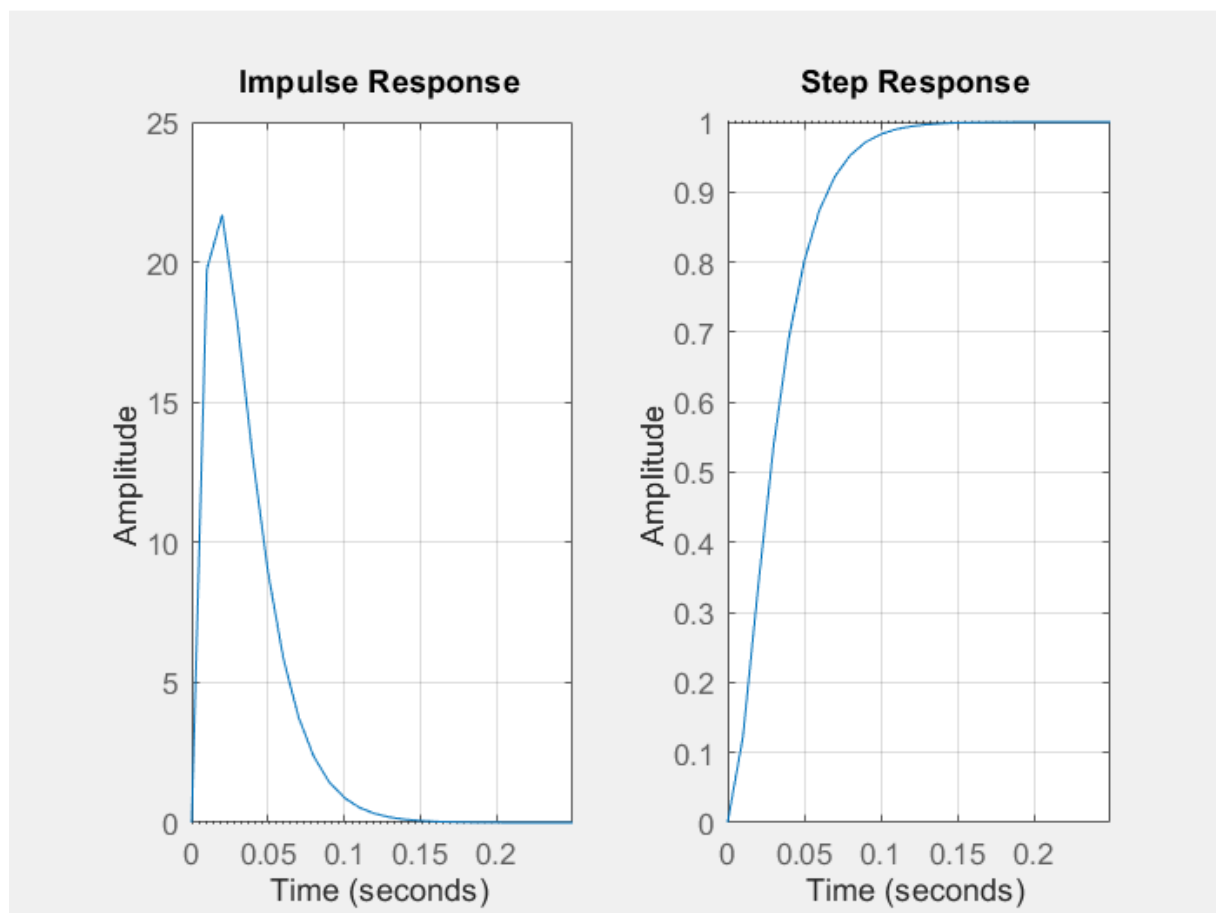
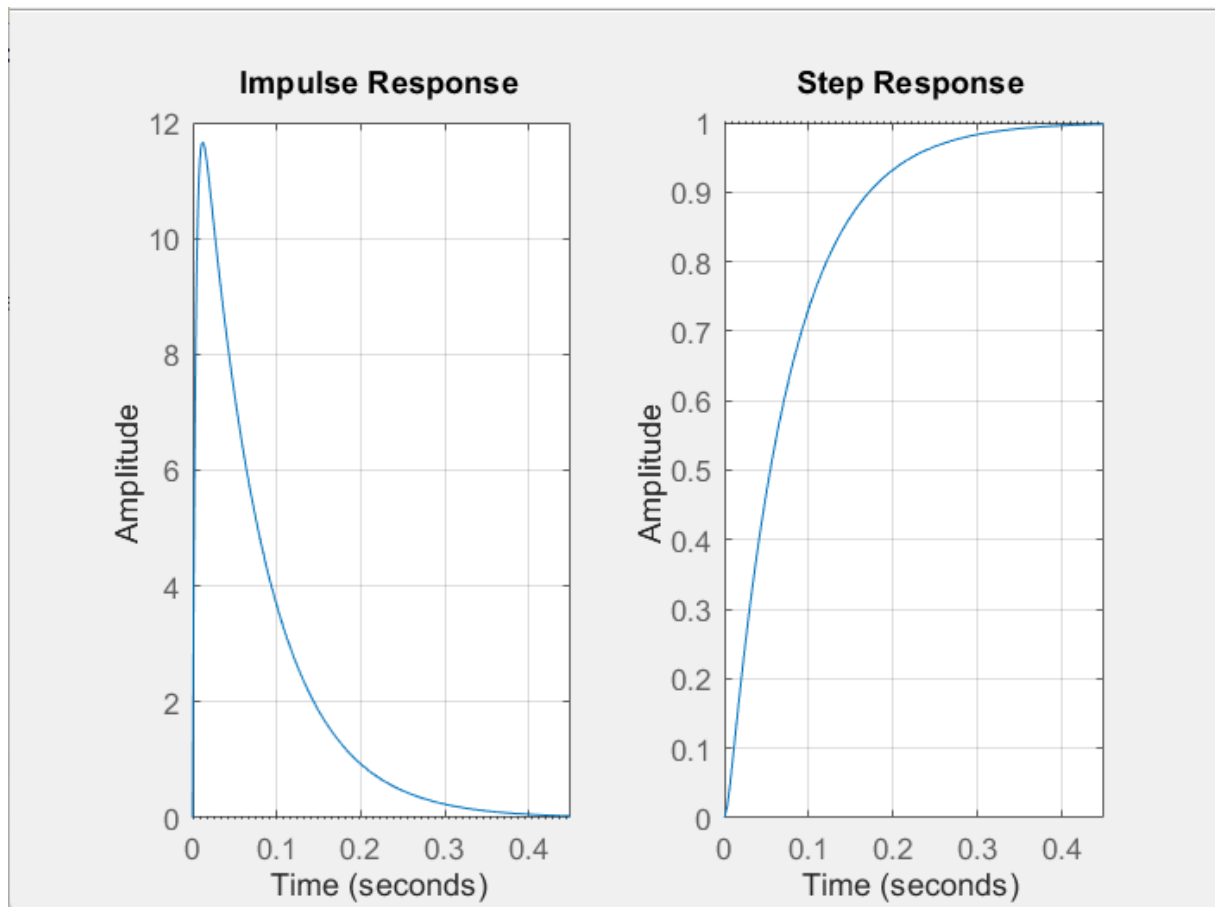


Figure 11: Critically Damped Response

For Frequency = 60 Hz, Damping Factor = 2.3



*Figure 12: Overdamped Response*

Here, with constant frequency, increasing the damping reduces oscillations and overshoot, leading to a slower but smoother response. Lower damping results in more pronounced oscillations and overshoot before settling.

For Frequency = 30 Hz, Damping Factor = 0.3

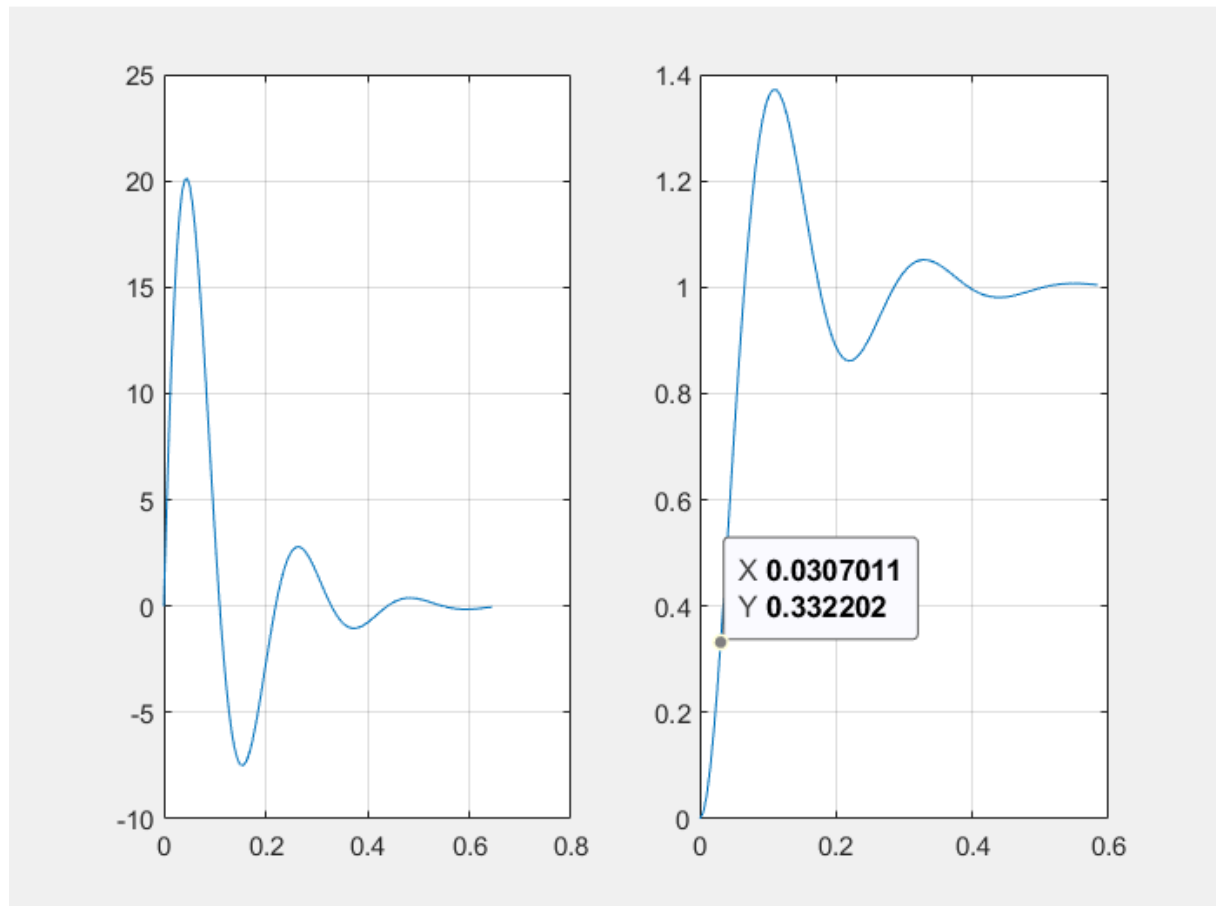


Figure 13: Underdamped Response at 30Hz

For Frequency = 60 Hz, Damping Factor = 0.3

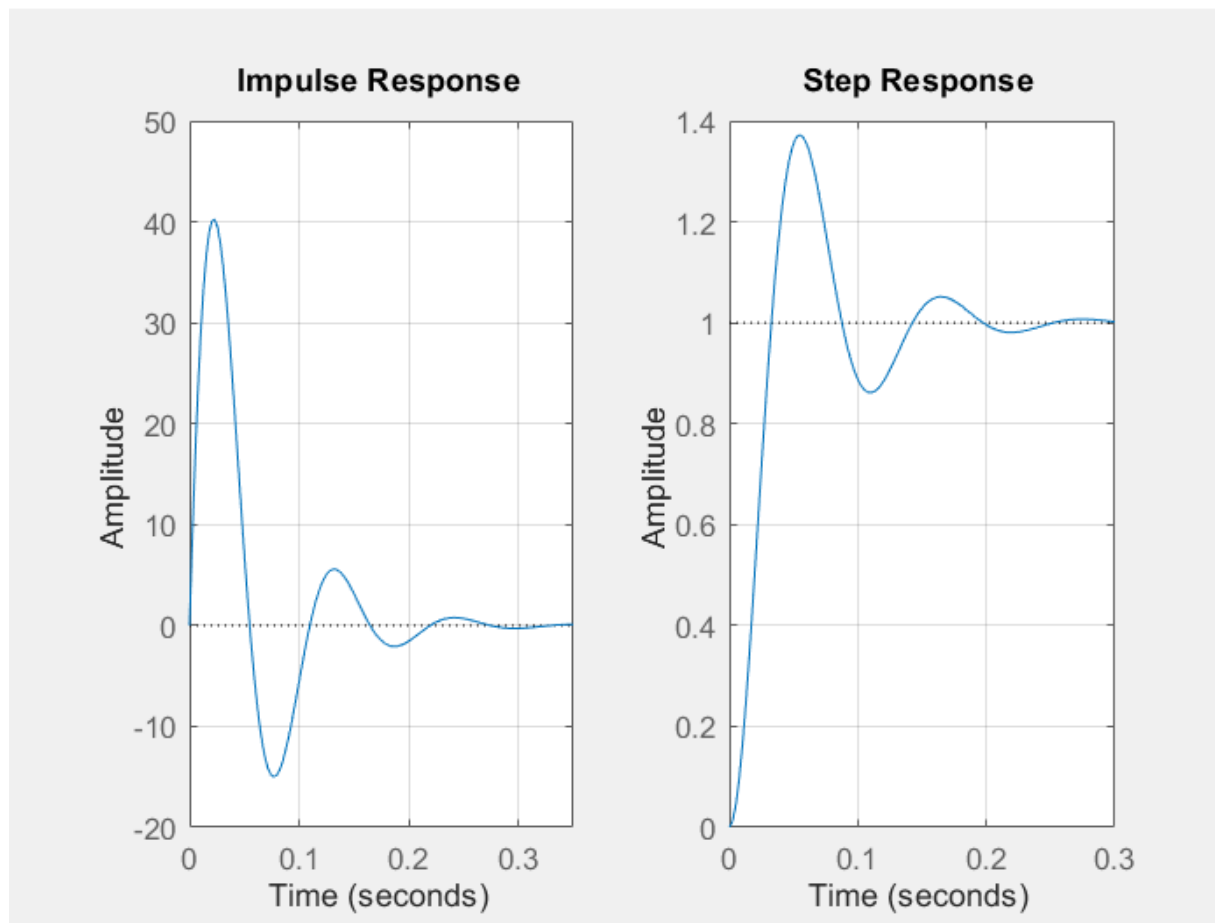
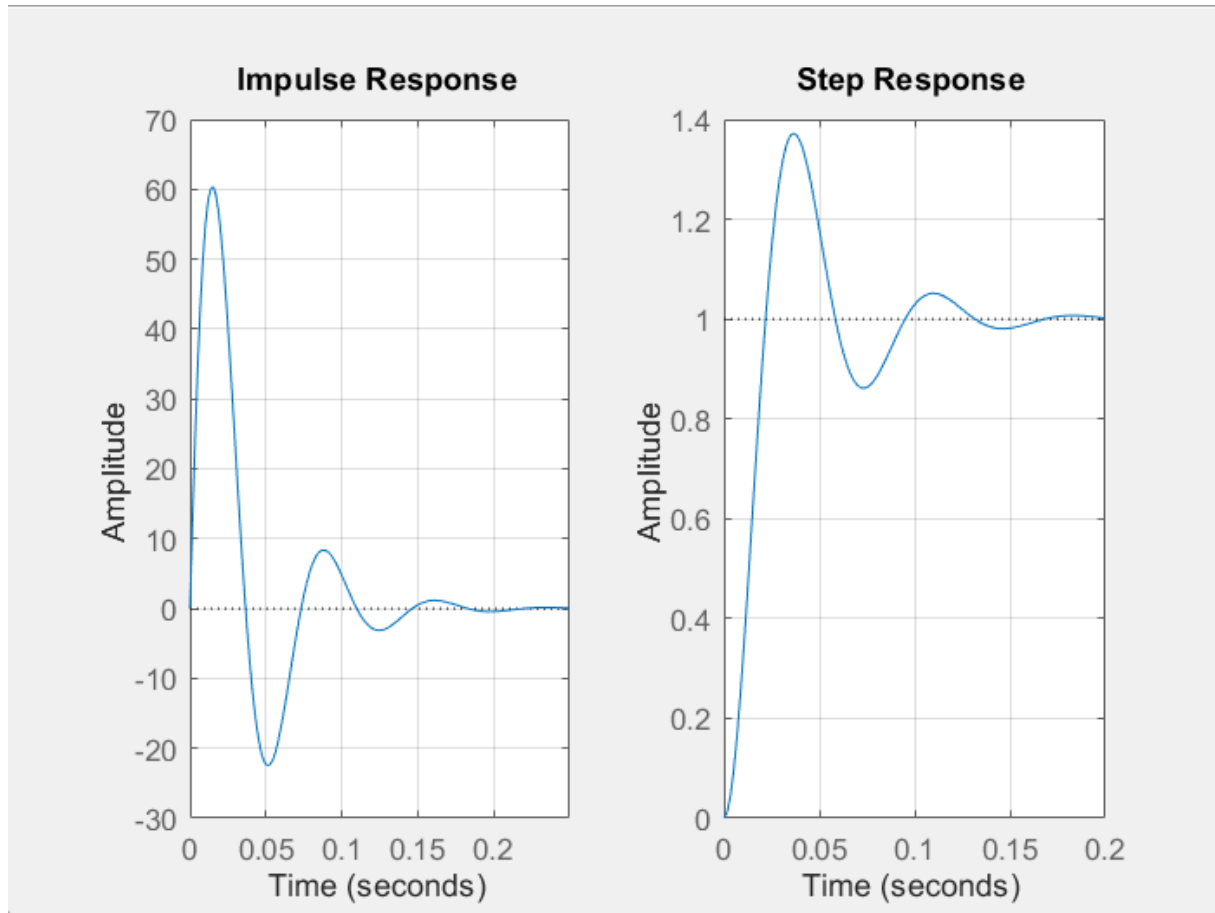


Figure 14: Underdamped Response at 60Hz

For Frequency = 90 Hz, Damping Factor = 0.3



*Figure 15: Underdamped Response at 90 Hz*

At constant damping, increasing frequency results in faster oscillations and a quicker system response. Lower frequencies produce slower system movements and longer settling times.



## Task 4: MATLAB SIMULINK

Q: Find the step and impulse response of second order system with natural frequency being last two digits of your roll number(55) and damping factor 0.5.

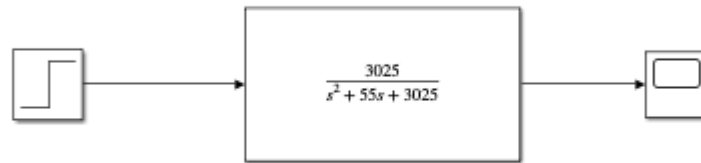


Figure 16: Step Response SIMULINK Block

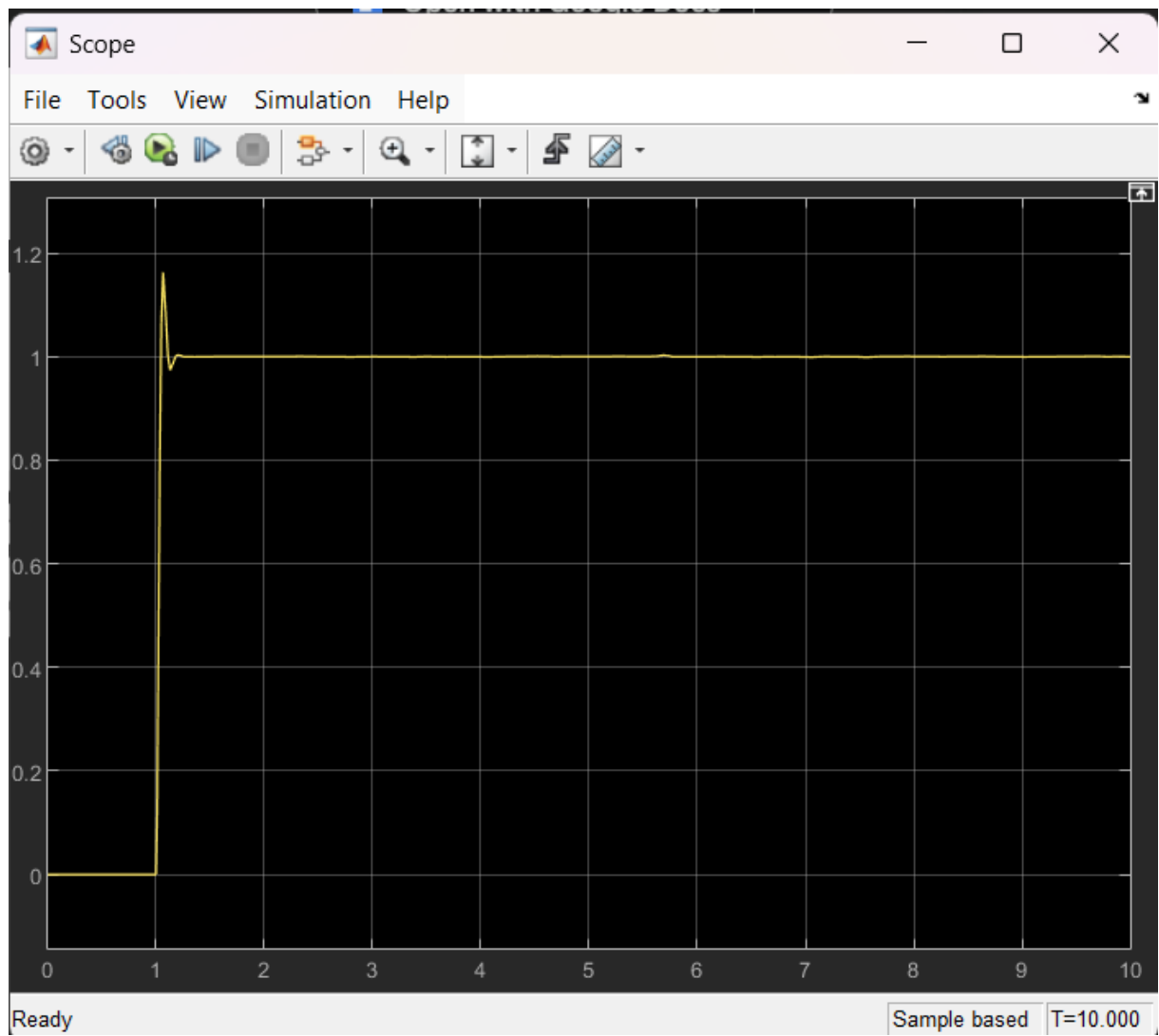


Figure 17: Step Response SIMULINK

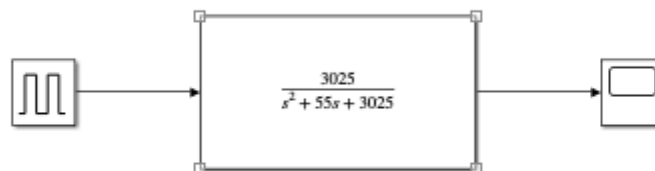


Figure 18: Impulse Response SIMULINK Block



*Figure 19: Impulse Response SIMULINK Block*

## Conclusion

The lab successfully demonstrated the behavior of a second-order system to both step and impulse inputs using MATLAB and Simulink. System parameters like damping and frequency heavily influence time-domain responses like overshoot, rise time, and settling time.