Indian Institute of Information Technology, Allahabad
Department of Electronics and Communication Engineering

Course Name: Control System Lab

EXPERIMENT NO: 2

DETERMINATION OF STEP & IMPULSE RESPONSE OF A FIRST ORDER AND SECOND ORDER UNITY FEEDBACK SYSTEM.

Objective: Write a MATLAB code to obtain

I. Step and Impulse response of a first and second order unity feedback system.
II. Time domain specification (Rise time, Settling time, Overshoot, Delay time and Peak time) of the given system.
III. Plot graph of above responses.

Materials Required: MATLAB Software.

THEORY: The time response has utmost importance for the design and analysis of control systems because these are inherently time domain systems where time is independent variable. During the analysis of response, the variation of output with respect to time can be studied and it is known as time response. To obtain satisfactory performance of the system with respect to time must be within the specified limits. From time response analysis and corresponding results, the stability of system, accuracy of system and complete evaluation can be studied easily. Due to the application of an excitation to a system, the response of the system is known as time response and it is a function of time. The two parts of response of any system:

Transient response; Steady-state response.

Transient response: The part of the time response which goes to zero after large interval of time is known as transient response.

Steady state response: The part of response that means even after the transients have died out is said to be steady state response.

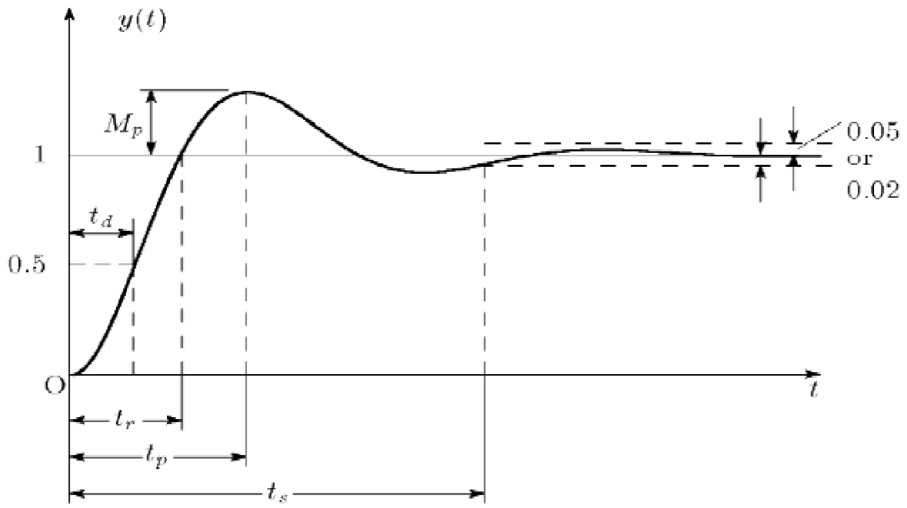
The total response of a system is sum of transient response and steady state response: C(t)=Ctr(t)+Css(t)

Time Response Specification Parameters: The transfer function of a 2-nd order system is generally represented by the following transfer function:

$$\frac{Y(S}{R(S)} = \frac{\omega_n^2}{s^2 + 2\varsigma\omega_n s + \omega_n^2}$$

The dynamic behavior of the second-order system can then be described in terms of two parameters: the damping ratio and the natural frequency.

If the dumping ratio is between 0 and 1, the system poles are complex conjugates and lie in the left-half *s* plane. The system is then called **underdamped**, and the transient response is **oscillatory**. If the damping ratio is equal to 1 the system is called **critically damped**, and when the damping ratio is larger than 1 we have **overdamped** system. The transient response of critically damped and overdamped systems do not oscillate. If the damping ratio is 0, the transient response does not die out.



Delay time (td)
The delay time is the time required for the response to reach half the final value the very first time.
Rise time (tr)
The rise time is the time required for the response to rise from 10% to 90%, 5% to 95%, or 0% to 100% of its final value. For underdamped second-order systems, the 0% to 100% rise time is normally used. For overdamped systems, the 10% to 90% rise time is commonly used.
Peak time (tp)
The peak time is the time required for the response to reach the first peak of the overshoot.
Maximum (percent) overshoot (Mp)
The maximum overshoot is the maximum peak value of the response curve measured from unity. If the final steady-state value of the response differs from unity, then it is common to use the maximum percent overshoot. It is defined by

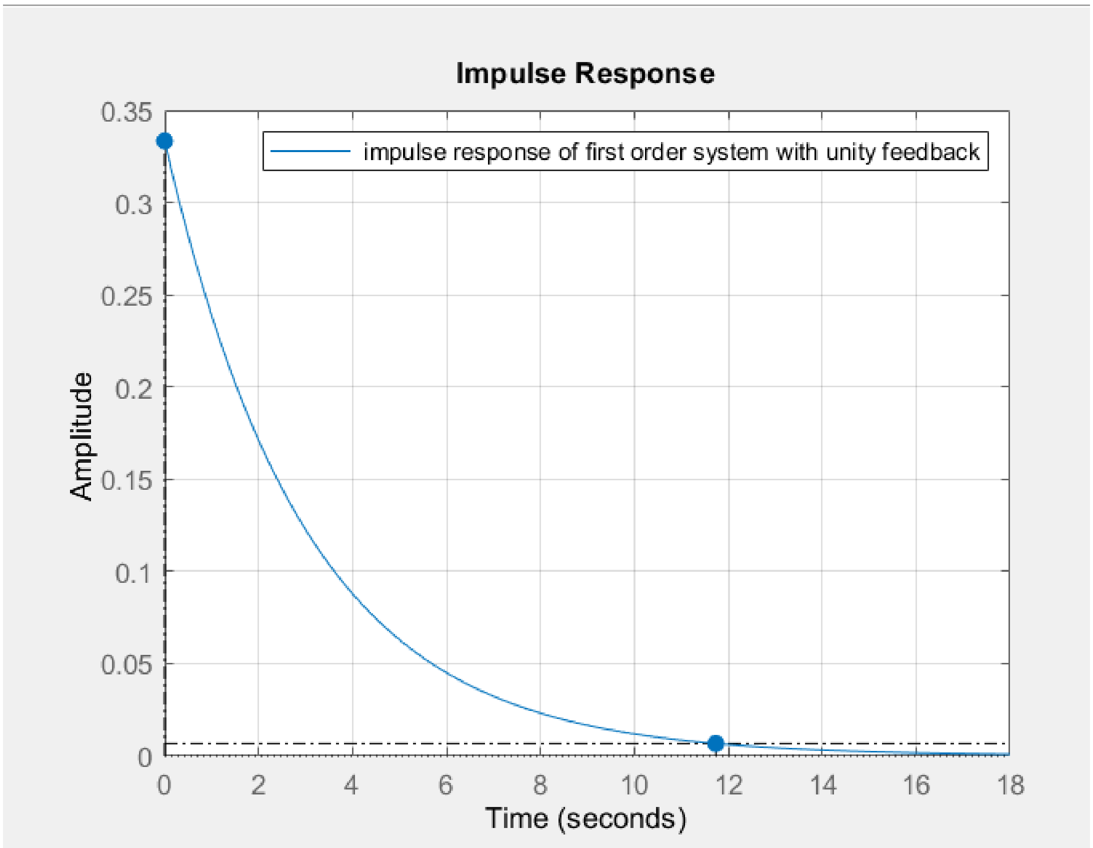
$$\frac{y(c_p) - c(\infty)}{\infty} \times 100\%$$

Settling time (ts)
The settling time is the time required for the response curve to reach and stay within a range about the final value of size specified by absolute percentage of the final value (usually 2% or 5%). The settling time is related to the largest time constant of the control system.

MATLAB Code:

```
%impulse response of First order system G(s)= 1/(Ts)  and
unity feedback  where  T=3

    clc;
    clear all;
    close all;

        T=3;
        num=1;
        den=[T 0];
```

```
        G= tf(num,den);      % Transfer function
        t= feedback(G,1)
        impulse(t)          % for impulse response
        legend ( ' impulse response of first order system
with unity feedback')
Result
t =

     1
  -------
  3 s + 1

Continuous-time transfer function.
```

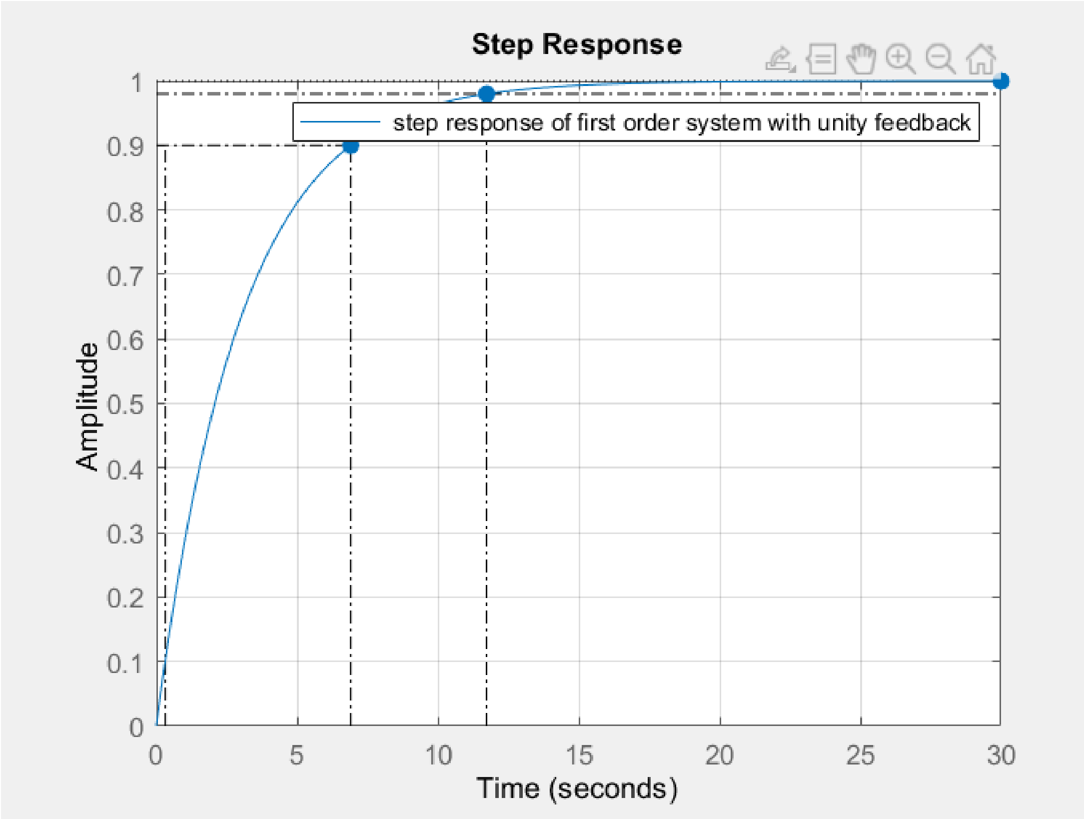



```
% Step response of first order system  G(s)= 1/(Ts)  and
unity feedback  where  T=3
        clc;
    clear all;
    close all;

        T=3;
        num=1;
        den=[T 0];
```

```
G= tf(num,den);        % Transfer function
t= feedback(G,1)

stepplot(t)          % for step response
data= stepinfo(t)    % for time domain specification of given system
legend ( ' step response of first order system with unity feedback')
```

Result:

```
t =

    1
  -------
  3 s + 1

Continuous-time transfer function.


data =

  struct with fields:

        RiseTime: 6.5910
    SettlingTime: 11.7362
     SettlingMin: 0.9045
     SettlingMax: 1.0000
       Overshoot: 0
      Undershoot: 0
            Peak: 1.0000
        PeakTime: 31.6375
```

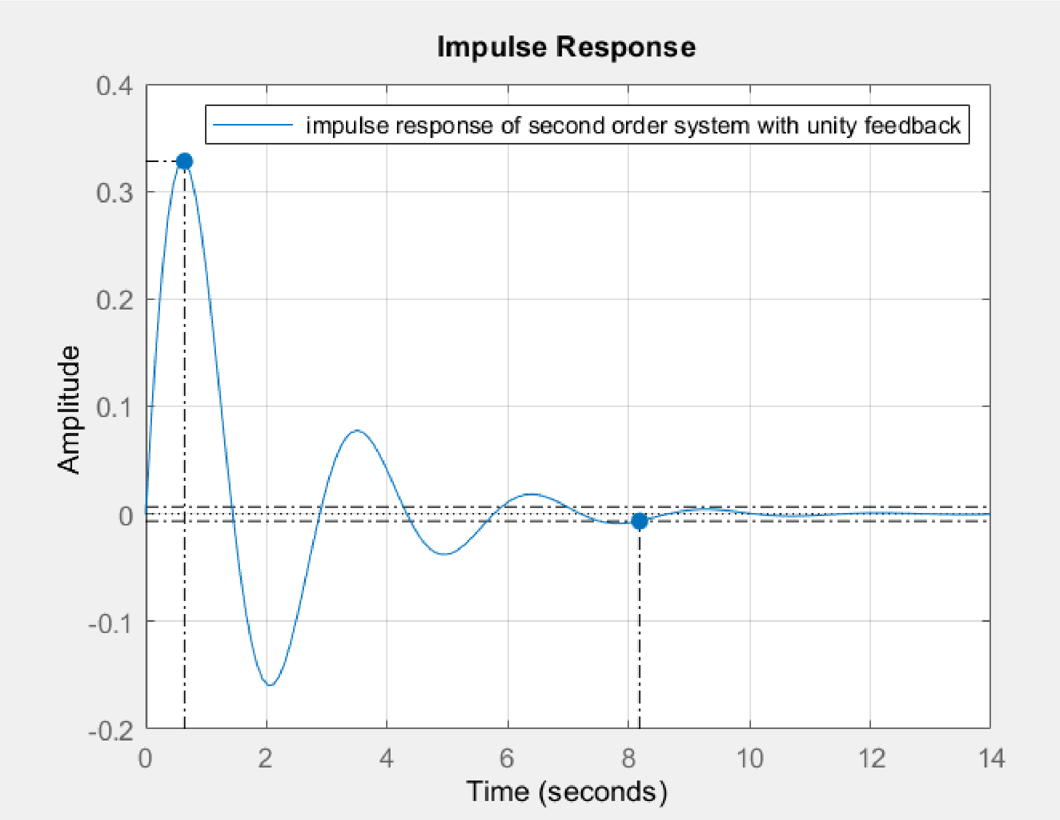



```
%impulse response of second order system G(s)=
1/(s^2+s+4)  and unity feedback
clc;
     clear all;
     close all;
     num = [1];
den = [1 1 4];
g = tf (num,den)
t = feedback(g,1)
impulse(t)
legend ( ' impulse response of second order system with
unity feedback')
```

Result:-

```
g =

       1
  -----------
```

```
  s^2 + s + 4

Continuous-time transfer function.


t =

       1
  -----------
  s^2 + s + 5

Continuous-time transfer function.
```




```
%step response of second order system G(s)= 1/(s^2+s+4)
and unity feedback
       clc;
       clear all;
       close all;
       num = [1];
den = [1 1 4];
g = tf (num,den)
t = feedback(g,1)
step(t,'r')
data= stepinfo(t)
legend ( ' step response of second order system with
unity feedback')
```

```
g =

       1
  -----------
  s^2 + s + 4

Continuous-time transfer function.


t =

       1
  -----------
  s^2 + s + 5

Continuous-time transfer function.


data =

  struct with fields:

        RiseTime: 0.5533
    SettlingTime: 7.5607
     SettlingMin: 0.1528
     SettlingMax: 0.2970
       Overshoot: 48.5150
      Undershoot: 0
            Peak: 0.2970
        PeakTime: 1.4737
```