



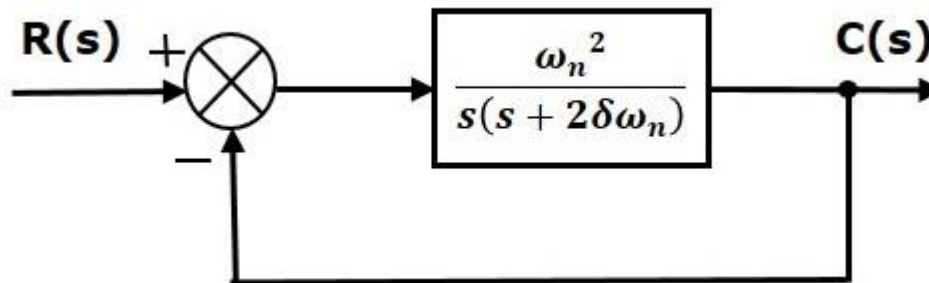
# UNIT II

# TIME DOMAIN SPECIFICATIONS



# INTRODUCTION

- Consider the following block diagram of closed loop control system. Here, an open loop transfer function,  $\frac{\omega_n^2}{s(s+2\zeta\omega_n)}$  is connected with a unity negative feedback.



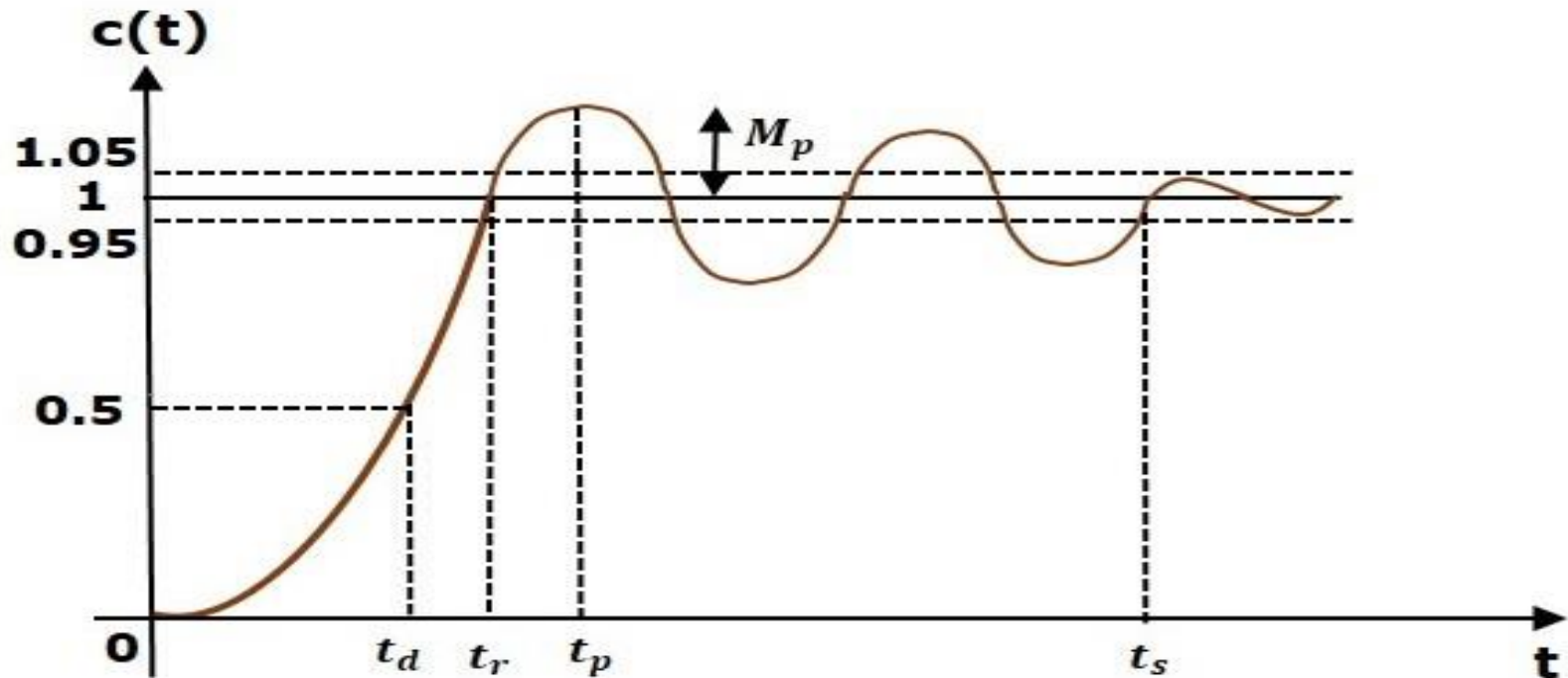
$$\frac{C(s)}{R(s)} = \frac{G(s)}{1 + G(s)} = \frac{\omega_n^2}{s^2 + 2\delta\omega_n s + \omega_n^2}$$



# INTRODUCTION

- The response of the system is given by,

$$c(t) = \left( 1 - \left( \frac{e^{-\delta\omega_n t}}{\sqrt{1 - \delta^2}} \right) \sin(\omega_d t + \theta) \right)$$





# INTRODUCTION

- The various time domain specifications are:
  1. Delay time
  2. Rise Time
  3. Peak Time
  4. Peak Overshoot
  5. Settling Time
  6. Steady State Errors



# INTRODUCTION

## 1. Delay time:

It is the time required for the response to reach half of its final value from the zero instant. It is denoted by  $t_d$ .

$$t_d = \frac{1 + 0.7\delta}{\omega_n}$$

## 2. Rise time ( $t_r$ ):

It is the time required for the response to rise from 0% to 100% of its final value.

$$t_r = \frac{\pi - \theta}{\omega_d}$$



# INTRODUCTION

## 3. Peak time ( $t_p$ ):

It is the time required for the response to reach the peak value for the first time. It is denoted by  $t_p$ . At  $t=t_p$ , the first derivative of the response is zero.

$$t_p = \frac{\pi}{\omega_d}$$

## 4. Peak Overshoot ( $M_p$ ):

Peak overshoot  $M_p$  is defined as the deviation of the response at peak time from the final value of response. It is also called the maximum overshoot.

$$\%M_p = \frac{c(t_p) - c(\infty)}{c(\infty)} \times 100 \qquad \%M_p = \left( e^{-\left(\frac{\delta\pi}{\sqrt{1-\delta^2}}\right)} \right) \times 100\%$$



# INTRODUCTION

## 5. Settling Time ( $t_s$ ):

It is the time required for the response to reach the steady state and stay within the specified tolerance bands around the final value. In general, the tolerance bands are 2% and 5%.

$$t_s = \frac{3}{\delta\omega_n} = 3\tau$$

$$t_s = \frac{4}{\delta\omega_n} = 4\tau$$