SNS COLLEGE OF TECHNOLOGY

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Department of Biomedical Engineering

Course Name: Control Systems

III Year : V Semester

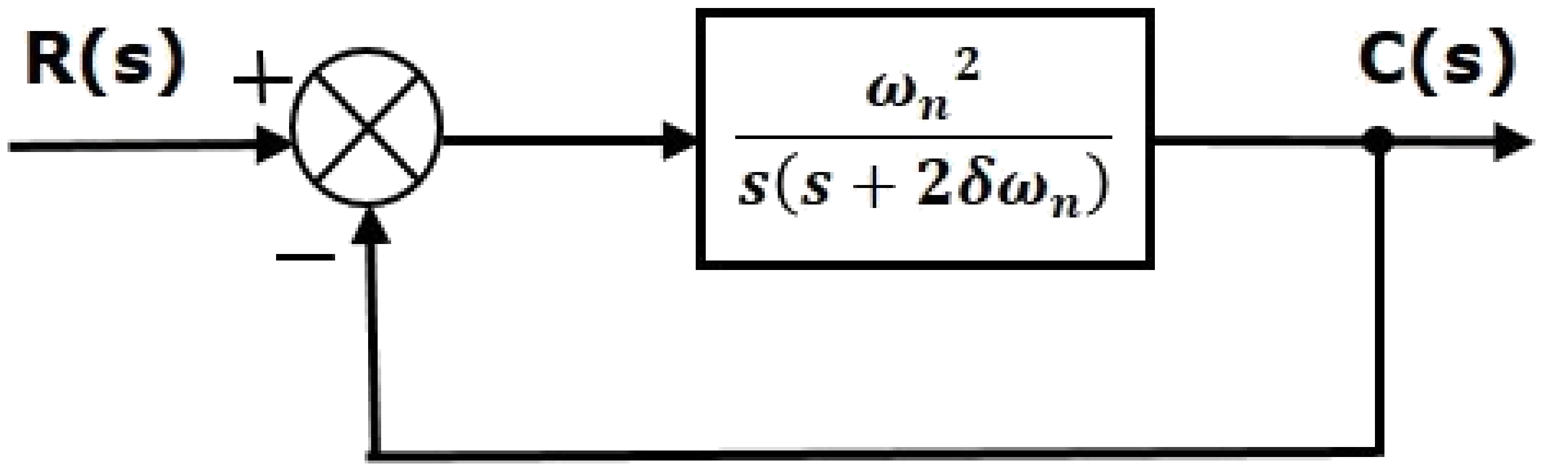
Unit II –Time Response

Topic : Time Domain Specifications

Introduction

Consider the following block diagram of the 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. The system is called as second order system

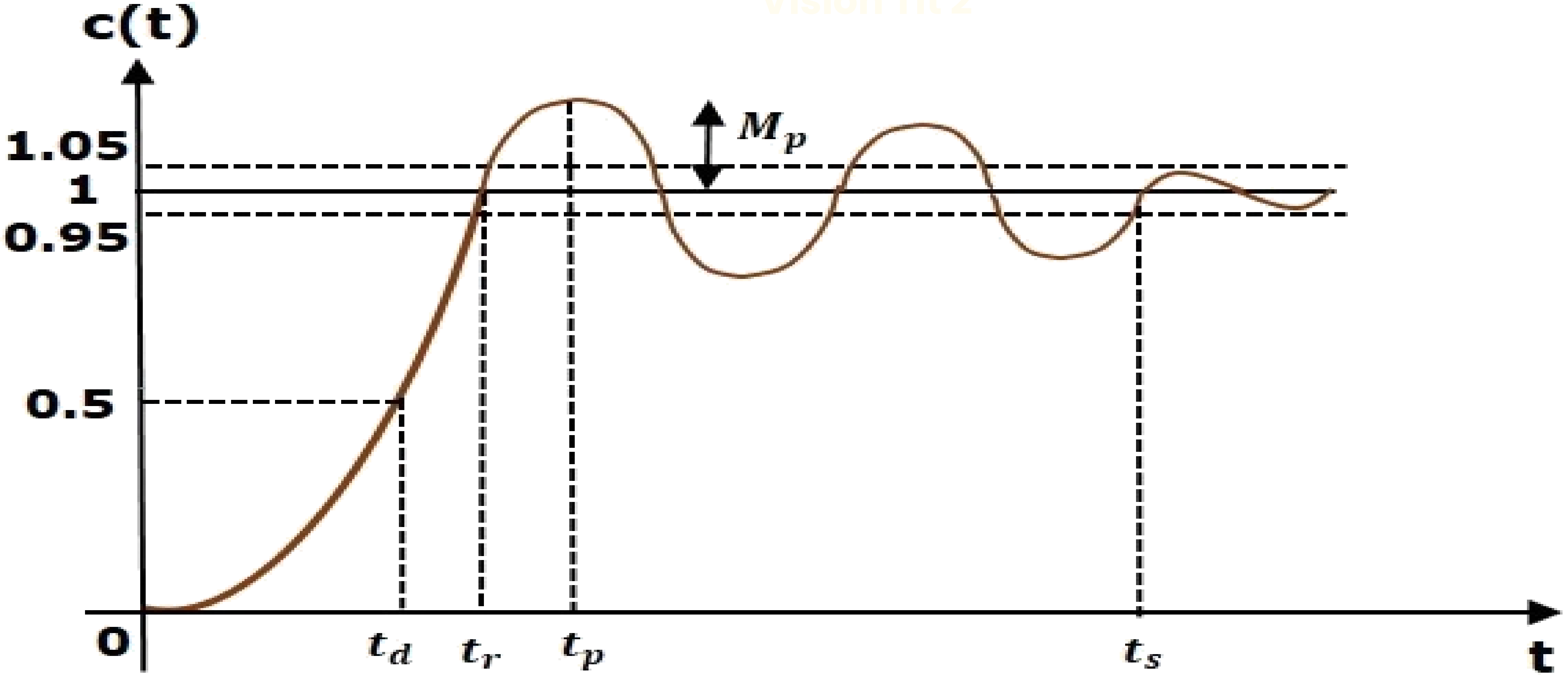


$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)} = \frac{\omega_n^2}{s^2+2\delta\omega_n s+\omega_n^2}$$

Underdamped System

- Step Response of underdamped second order system:

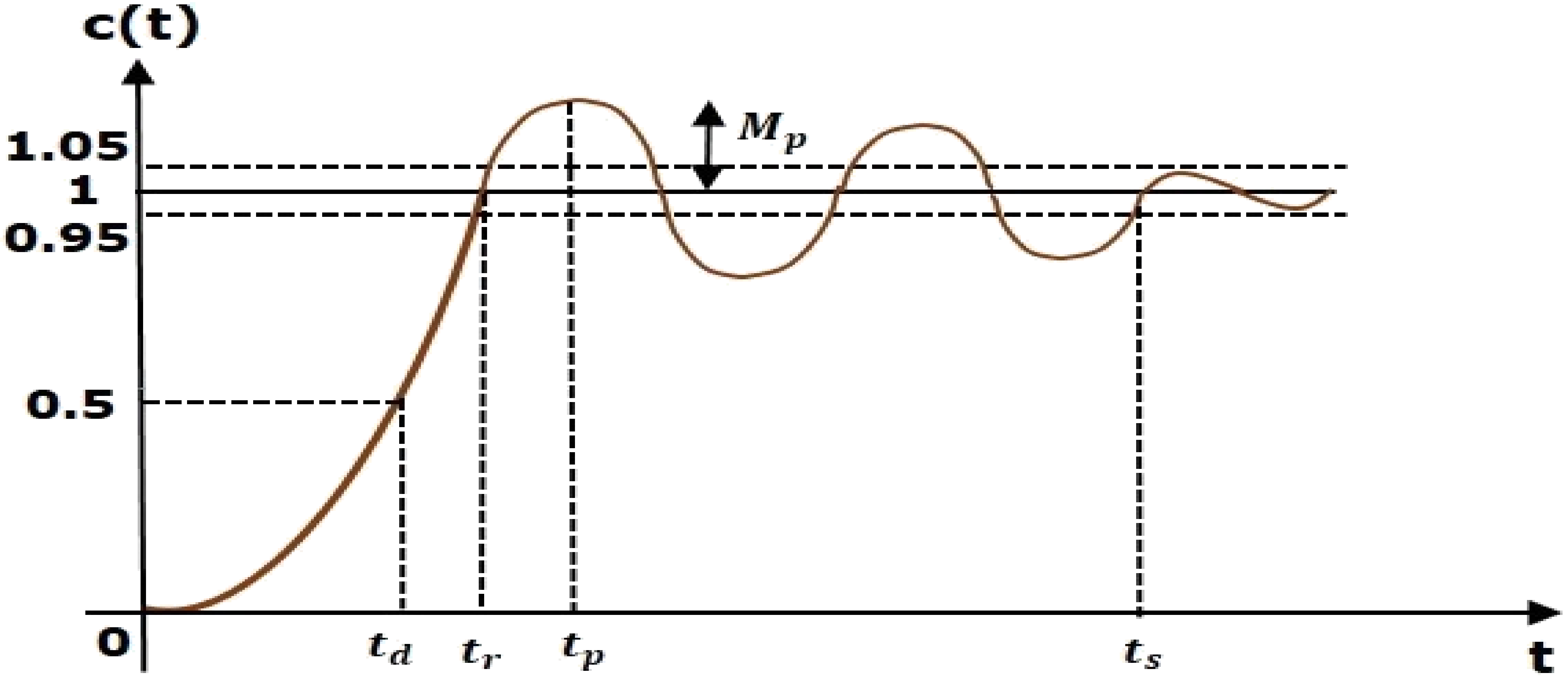
$$c(t) = \left(1 - \left(\frac{e^{-\delta\omega_n t}}{\sqrt{1-\delta^2}}\right)\sin(\omega_d t + \theta)\right)$$



Time Domain Specifications

- 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

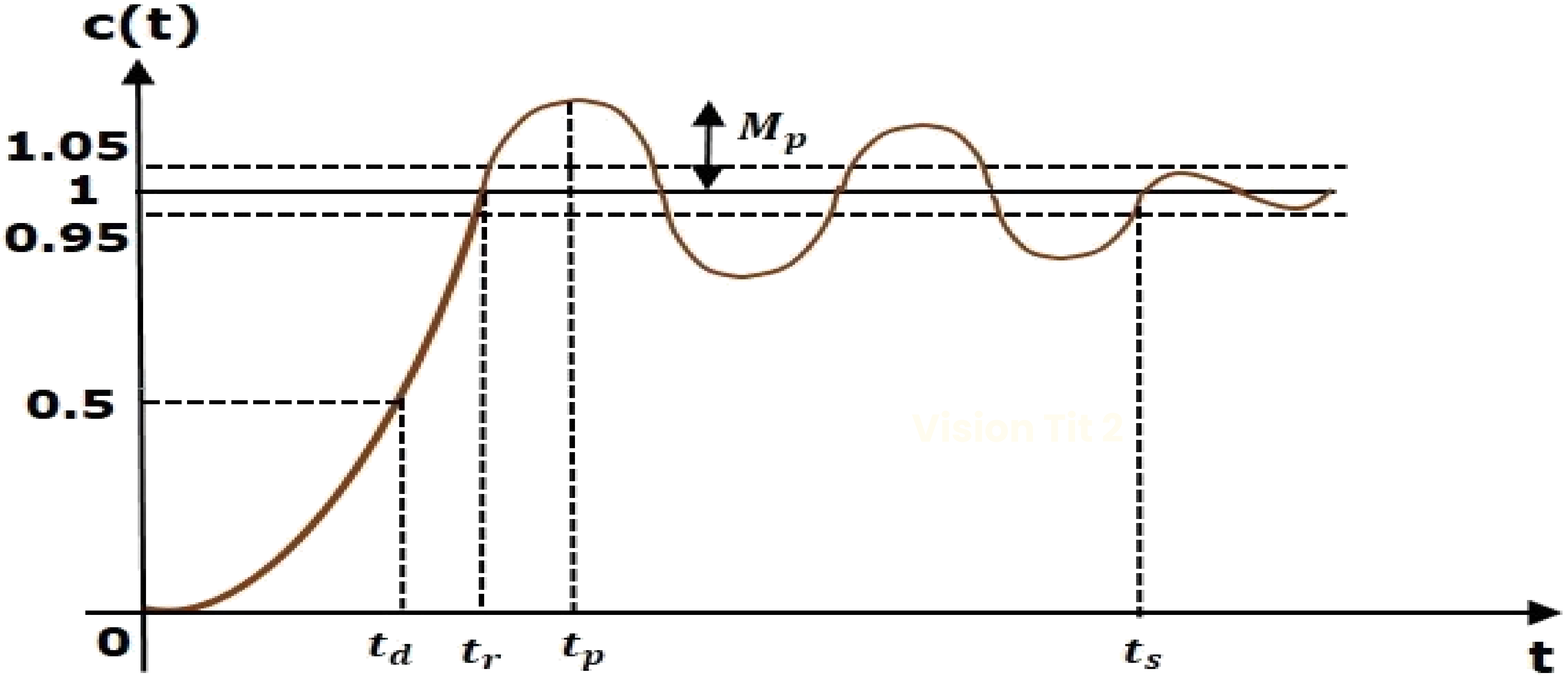
Delay Time



- 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 (sec)

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

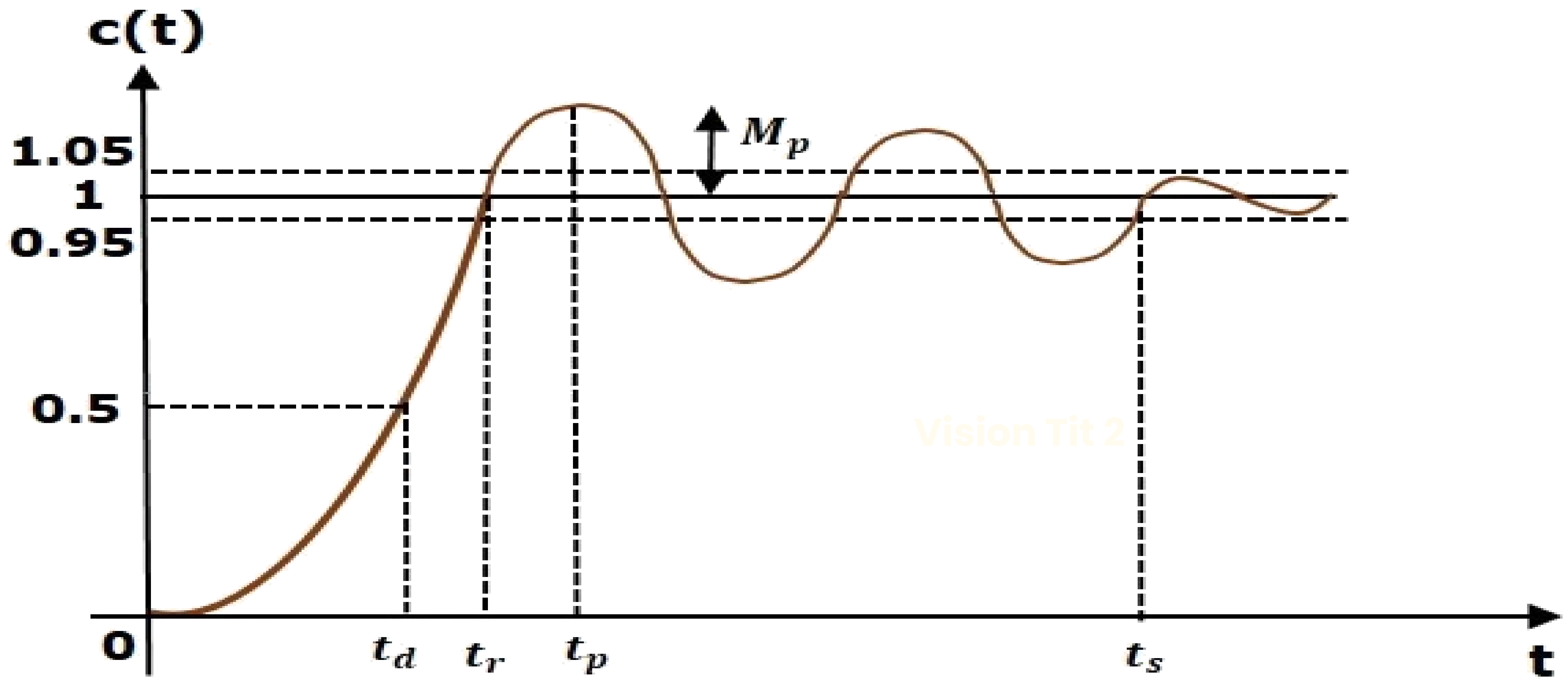
Rise Time



- It is the time required for the response to rise from 0% to 100% of its final value and represented by t_r (sec)

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

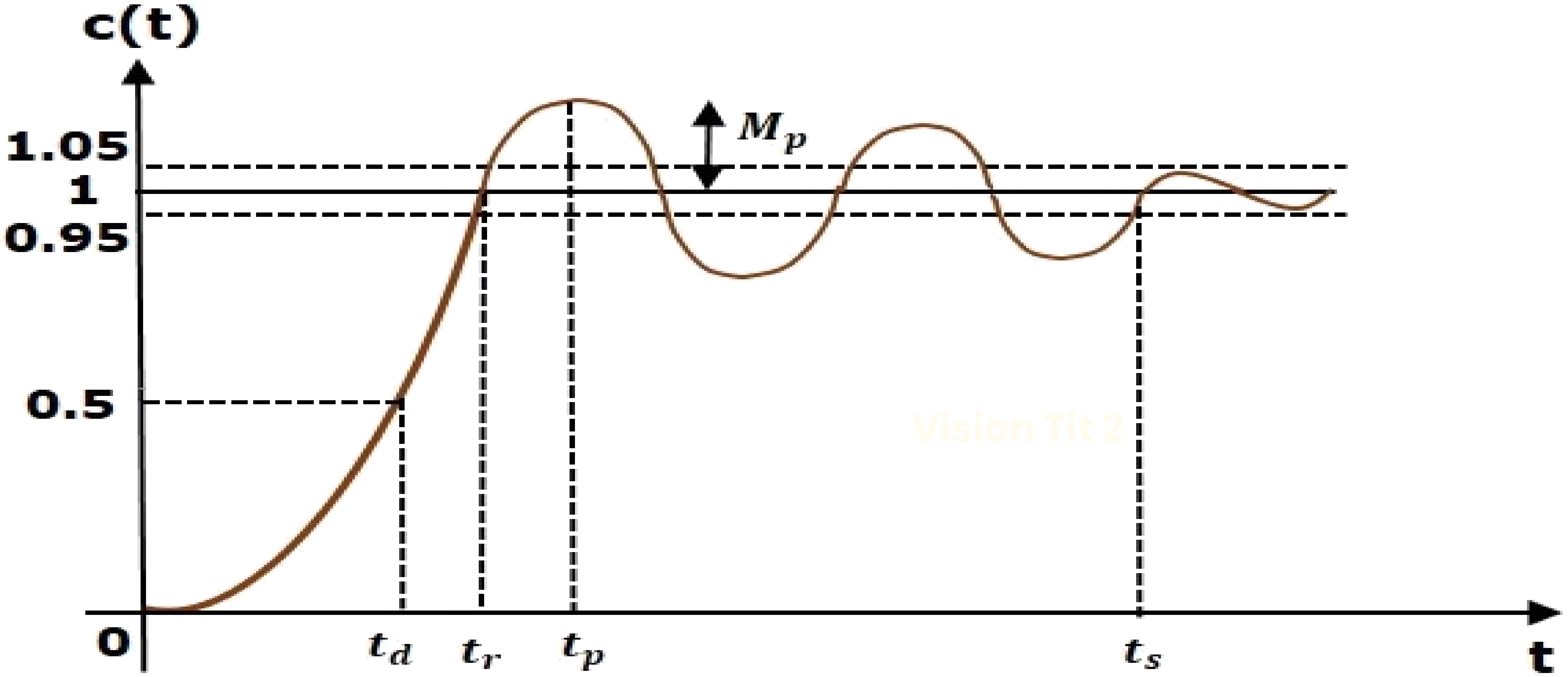
Peak Time



- It is the time required for the response to reach the peak value for the first time. It is denoted by t_p (sec). At $t=t_p$, the first derivate of the response is zero.

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

Peak Overshoot (Mp)

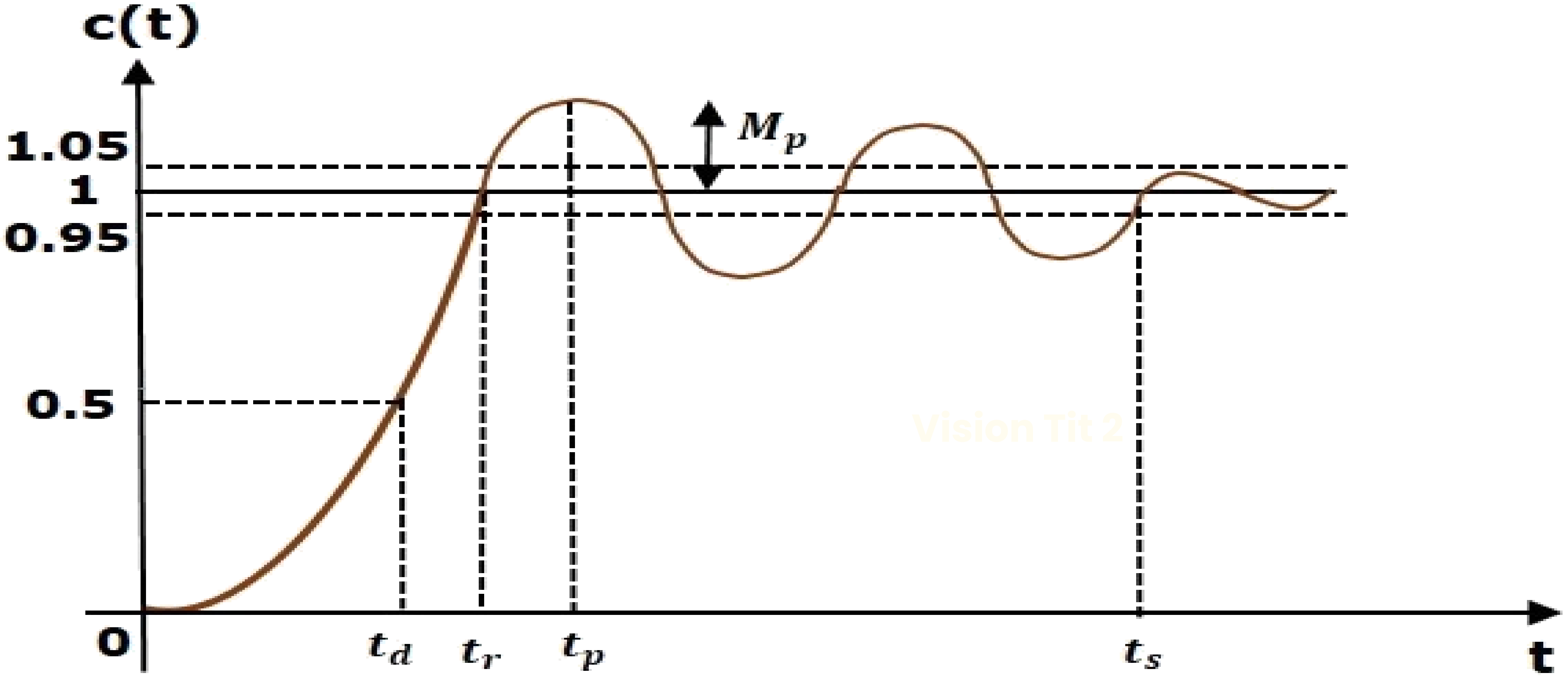


- Peak overshoot M_p is defined as the deviation of the response at peak time from the final value of response. It is also called the maximum overshoot.

$$\%M_p = \frac{c(t_p) - c(\infty)}{c(\infty)} \; x \; 100$$

$$\%M_p = (e^{-(\frac{\xi\pi}{\sqrt{1-\xi^2}})}) x \; 100\%$$

Settling Time (ts)



- 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%.

$$t_s = \frac{3}{\xi\omega_n} = 3\tau \qquad t_s = \frac{4}{\xi\omega_n} = 4\tau$$