Second Order System Response

System Transfer Function

The transfer function H(s) for a second-order system is:

$$H(s) = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$$

where:

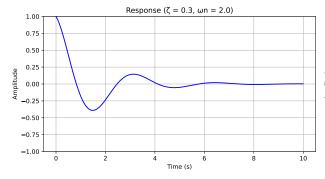
- ζ is the damping ratio
- ω_n is the natural frequency

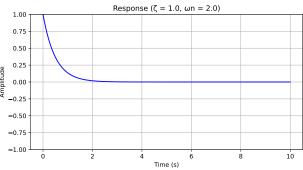
Response Types

The system exhibits three characteristic behaviors:

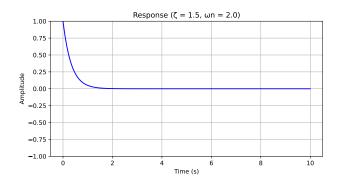
- 1. Underdamped $(\zeta < 1)$
 - System oscillates with decreasing amplitude
 - Common in systems with insufficient damping
- 2. Critically Damped ($\zeta = 1$)
 - Fastest return to steady state without oscillation
 - Optimal for many control applications
- 3. Overdamped $(\zeta > 1)$
 - Returns to steady state without oscillation
 - Slower response than critically damped

System Response Examples





- (a) Underdamped Response (= 0.3, n = 2.0)
- (a) Critically Damped Response ($\,=1.0,\,\,\mathrm{n}=2.0)$



(a) Overdamped Response ($\,=1.5,\,\,n=2.0)$