

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:

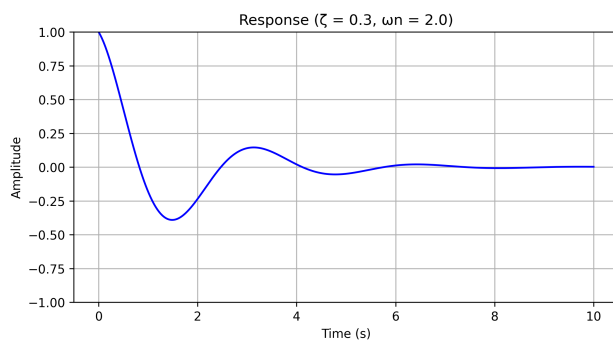
- ζ is the damping ratio
- ω_n is the natural frequency

Response Types

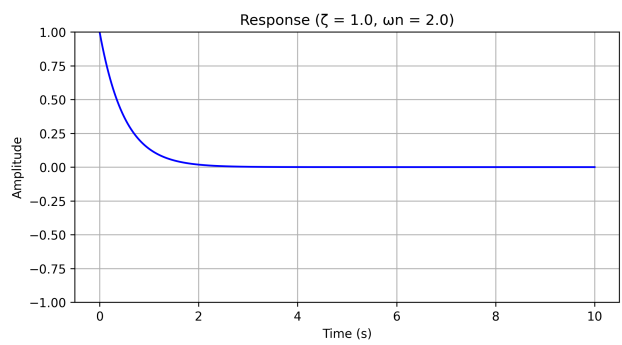
The system exhibits three characteristic behaviors:

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

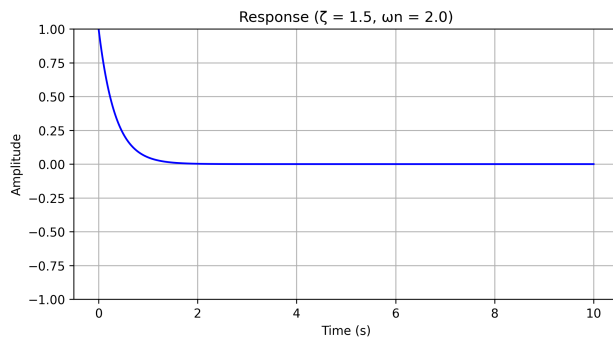
System Response Examples



(a) Underdamped Response ($\zeta = 0.3, n = 2.0$)



(a) Critically Damped Response ($\zeta = 1.0, n = 2.0$)



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