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System Modeling & Control

Presented by

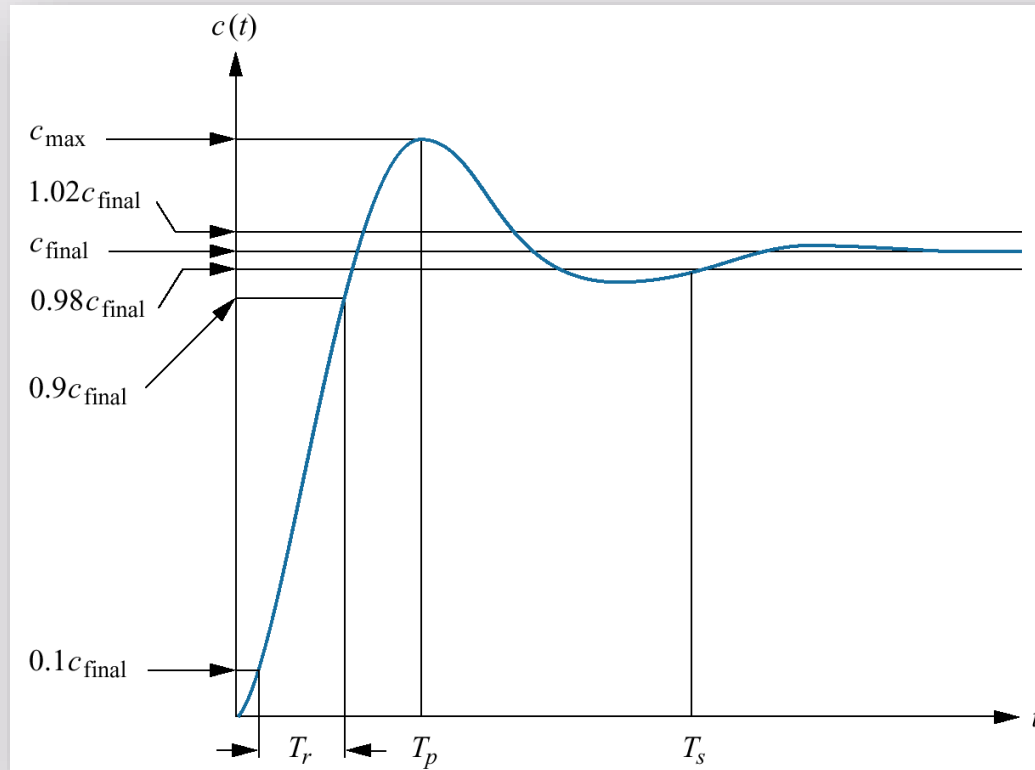
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TIME RESPONSE SPECIFICATIONS

Second-order underdamped response specifications



TIME RESPONSE SPECIFICATIONS

Rise time, T_r

The time for the waveform to go from 0.1 to 0.9 of its final value.

Peak time, T_p

The time required to reach the first or maximum peak.

$$T_p = \frac{\pi}{\omega_n \sqrt{1 - \zeta^2}}$$

Settling time, T_s

The time required for the transient's damped oscillation to reach and stay within $\pm 2\%$ of the steady-state value.

$$T_s = \frac{4}{\zeta \omega_n}$$

TIME RESPONSE SPECIFICATIONS

Percent overshoot, %OS

The amount that the waveform overshoots the steady-state, or final value at peak time, expressed as a percentage of the steady-state value.

$$\%OS = e^{-(\zeta\pi/\sqrt{1-\zeta^2})} \times 100\%$$

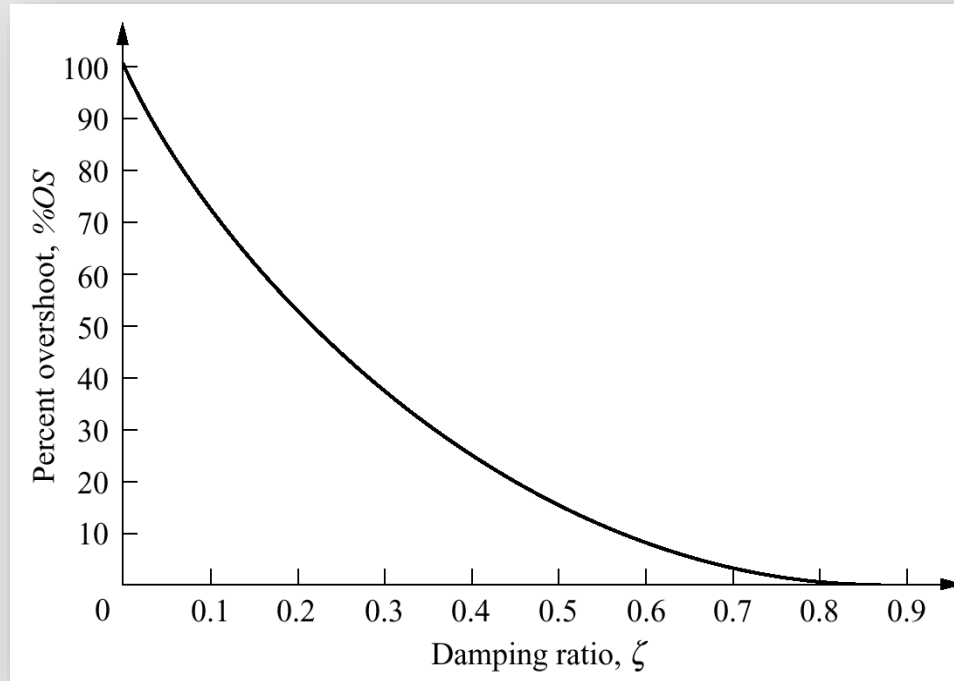
$$\zeta = \frac{-\ln(\%OS/100)}{\sqrt{\pi^2 + \ln^2(\%OS/100)}}$$



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SYSTEM PERFORMANCE

Percent overshoot versus damping ratio



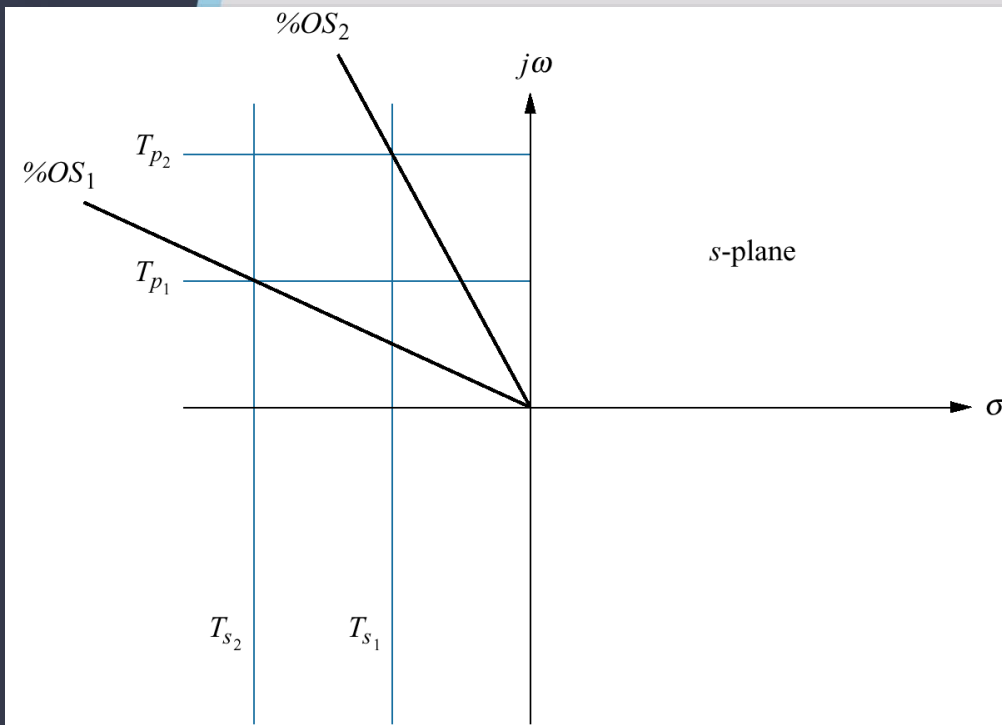


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SYSTEM PERFORMANCE

Lines of constant peak time T_p , settling time T_s and percent overshoot %OS



$$\begin{aligned} T_{s2} &< T_{s1} \\ T_{p2} &< T_{p1} \\ \%OS_1 &< \%OS_2 \end{aligned}$$

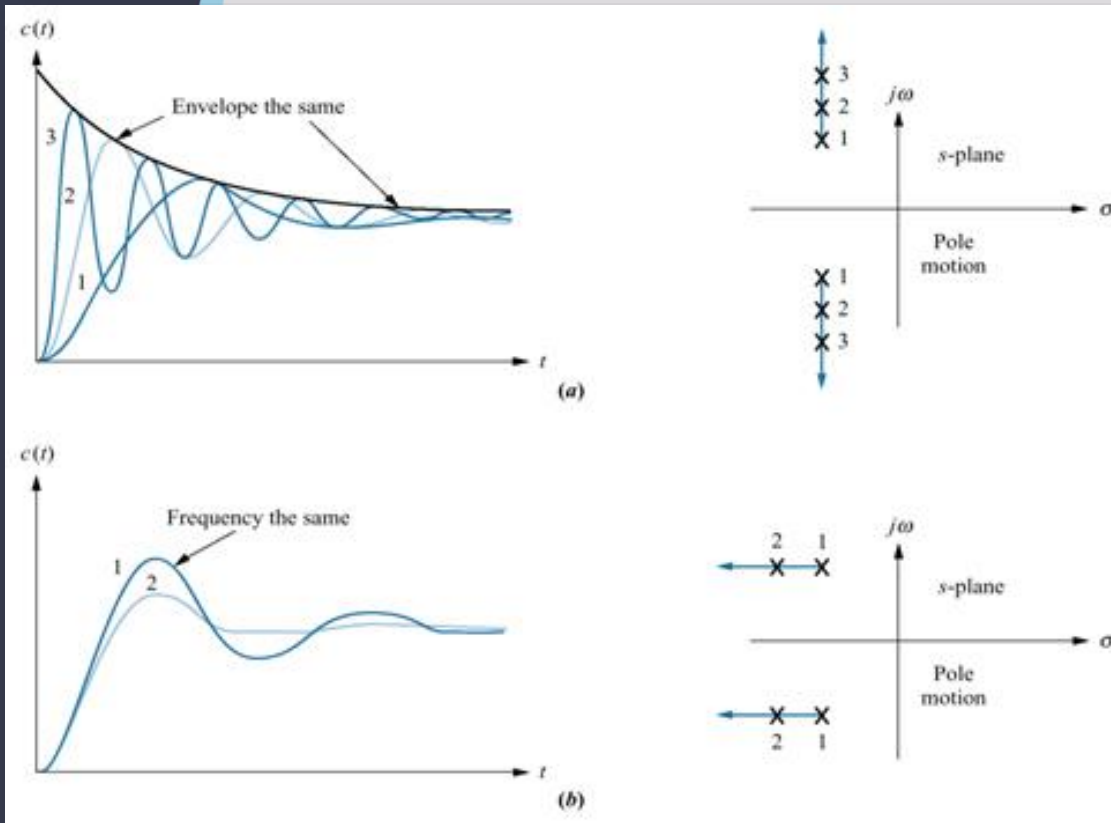


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SYSTEM PERFORMANCE

Step responses of second-order underdamped systems as poles move



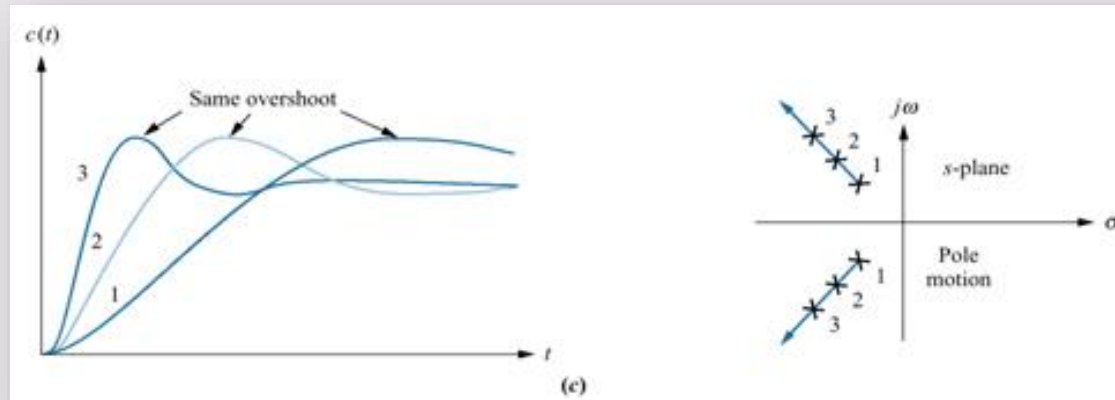
- a) With constant real part
- b) With constant imaginary part



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SYSTEM PERFORMANCE

Step responses of second-order underdamped systems as poles move



c) With constant damping ratio