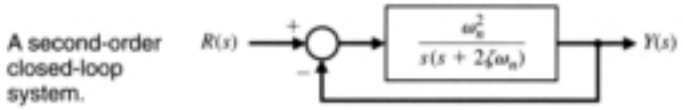
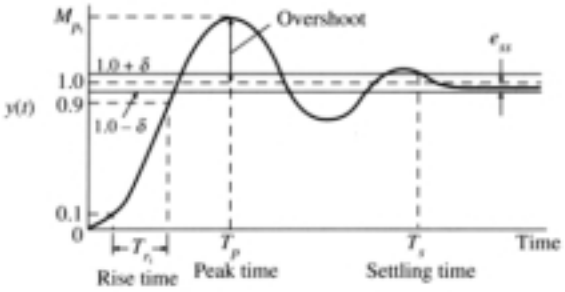
Selected Tables and Formulas for Design

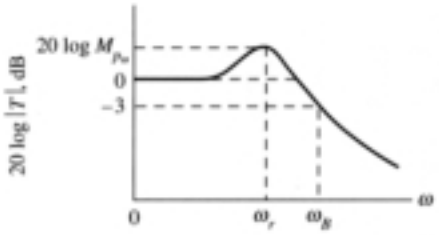
A second-order closed-loop system.



UNIT STEP RESPONSE



CLOSED-LOOP MAGNITUDE PLOT



- Settling time (to within 2% of the final value)

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

- Maximum magnitude ($\zeta \leq 0.7$)

$$M_{p_w} = \frac{1}{2\zeta\sqrt{1 - \zeta^2}}$$

- Percent overshoot

$$M_{p_t} = 1 + e^{-\zeta\pi/\sqrt{1-\zeta^2}} \quad \text{and} \quad P.O. = 100e^{-\pi\zeta/\sqrt{1-\zeta^2}}$$

- Time-to-peak

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

- Resonant frequency ($\zeta \leq 0.7$)

$$\omega_r = \omega_n\sqrt{1 - 2\zeta^2}$$

- Rise time (time to rise from 10% to 90% of final value)

$$T_{r_1} = \frac{2.16\zeta + 0.60}{\omega_n} \qquad (0.3 \leq \zeta \leq 0.8)$$

- Bandwidth ($0.3 \leq \zeta \leq 0.8$)

$$\omega_B = (-1.196\zeta + 1.85)\omega_n$$

PID Controller:

$$G_c(s) = K_P + K_D s + \frac{K_1}{s} = \frac{(s + z_1)(s + z_2)}{s}$$