Control Cheat-Sheet

1 Control Cheat-Sheet and MATLAB Design Practice

1.1 What Changes What: Time-Domain Response Summary

Consider the standard second-order transfer function:

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

1.2 Parameter Effects

- **Natural frequency** ω_n:
  - Increasing ω_n decreases rise time, settling time, and peak time.
- **Damping ratio** ζ:
  - Controls overshoot: higher $\zeta \rightarrow$ lower overshoot.
  - Affects settling time and stability.
- **Poles**:
  - Moving poles left $\rightarrow$ faster response.
  - Right-half plane poles $\rightarrow$ unstable.
- **Zeros**:
  - LHP zero: may reduce rise time but increase overshoot.
  - RHP zero: causes inverse response.
- **Gain** K: Increasing K speeds up response but increases overshoot and instability risk.

1.3 Useful Formulae

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

$$M_p = e^{\left(-\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\right)}$$

$$t_s(2\%) \approx \frac{4}{\zeta\omega_n}$$

$$t_r \approx \frac{1.8}{\omega_n}$$

$$e_{ss} = \frac{1}{1+K_p}$$

1.4 First-Order System

For

$$G(s) = \frac{1}{\tau s + 1},$$

$$t_r(10\% - 90\%) \approx 2.2\tau, \qquad t_s \approx 4\tau.$$