12.4 tf.exe Exercises for Chapter 12 tf

Exercise 12.1 scallywag

Use a computer to solve this problem. Consider the transfer function

$$H(s) = \frac{10(s+3)}{(s+2)(s^2+8s+41)}.$$

a. What are poles and zeros of H?
b. Comment on the stability of the system described by H (justify your comment).
c. Construct a pole-zero plot.
d. Use a function like the Python control package function `step_response` to simulate the unit step response of the system and plot it for $t \in [0, 3]$ seconds.

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25 p.

Exercise 12.2 swashbuckling

Consider a system with linear state-space model matrices

$$A = \begin{bmatrix} -1 & 4 \\ 0 & -3 \end{bmatrix} \qquad B = \begin{bmatrix} 1 \\ -1 \end{bmatrix} \tag{1a}$$

$$C = \begin{bmatrix} 1 & 0 \end{bmatrix} \qquad D = \begin{bmatrix} 0 \end{bmatrix}. \tag{1b}$$

1. Derive the transfer function $H(s)$ for the system. Express it as a single ratio in s.
2. What are the poles and zeros?
3. Compare the poles to the eigenvalues of A.
4. Draw or sketch a pole-zero plot.
5. With reference to the pole-zero plot, comment on the stability and transient free response characteristics of the system.
6. Use the inverse Laplace transform $\mathcal{L}^{-1}$ to find the system's forced response $y(t)$ to step input $u(t) = 9\,u_s(t)$.

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30 p.

Exercise 12.3 boris

Consider a mass-spring-damper system with mass m, spring constant k, and damping coefficient B with the I/O ODE

$$\ddot{y} + \frac{B}{m}\dot{y} + \frac{k}{m}y = \frac{1}{m}u$$

for input force $u(t) = F_S(t)$ and output position $y(t) = x_m(t)$.

a. Find the corresponding transfer function $H(s) = Y(s)/U(s)$.
b. Find the natural frequency and damping ratio in terms of system parameters m, k, and B.
c. What are poles and zeros of H in terms of system parameters m, k, and B?
d. For system parameters $m = 10$ kg, $k = 1 \cdot 10^5$ N/m, and $B = 500$ N·s/m, construct a pole-zero plot.
e. Comment on the stability of the system described by H. Are there any values of system parameters m, k, and B for which the system is marginally stable or unstable?
f. For system parameters $m = 10$ kg, $k = 1 \cdot 10^5$ N/m, and $B = 500$ N·s/m, use a function like the Python control package function `step_response()` to simulate the unit step response of the system and plot it for $t \in [0, 0.3]$ s.

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