Do the selected problems listed next from the following two attached pages.

Probs. 2a,   4,   a, b, d and f of problems 8, 17 and 18,   20a ,   23a and c,   24

State Space

SS

20. What three pieces of information must be given in order to solve for the output response of a system using state-space techniques?

State Space

SS

21. How can the poles of a system be found from the state equations?

Problems

1. Derive the output responses for all parts of Figure 4.7. [Section: 4.4]

2. Find the output response, $c(t)$, for each of the systems shown in Figure P4.1. Also find the time constant, rise time, and settling time for each case. [Sections: 4.2, 4.3]
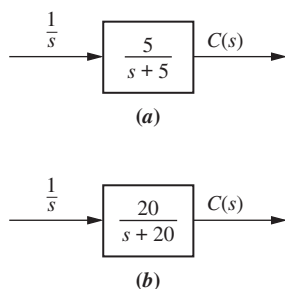
$$\frac{1}{s} \rightarrow \boxed{\frac{5}{s+5}} \rightarrow C(s)$$

(a)

$$\frac{1}{s} \rightarrow \boxed{\frac{20}{s+20}} \rightarrow C(s)$$

(b)

FIGURE P4.1

3. Plot the step responses for Problem 2 using MATLAB.

MATLAB

ML

4. Find the capacitor voltage in the network shown in Figure P4.2 if the switch closes at $t = 0$. Assume zero initial conditions. Also find the time constant, rise time, and settling time for the capacitor voltage. [Sections: 4.2, 4.3]
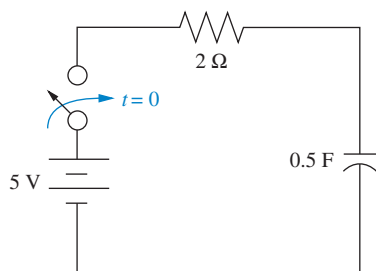
FIGURE P4.2

5. Plot the step response for Problem 4 using MATLAB. From your plots, find the time constant, rise time, and settling time.

MATLAB

ML

6. For the system shown in Figure P4.3, (a) find an equation that relates settling time of the velocity of the mass to M; (b) find an equation that relates rise time of the velocity of the mass to M. [Sections: 4.2, 4.3]
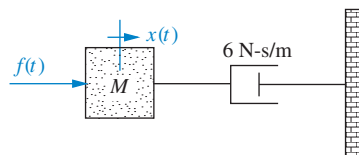
FIGURE P4.3

7. Plot the step response for Problem 6 using MATLAB. From your plots, find the time constant, rise time, and settling time. Use $M = 1$ and $M = 2$.

MATLAB

ML

8. For each of the transfer functions shown below, find the locations of the poles and zeros, plot them on the s-plane, and then write an expression for the general form of the step response without solving for the inverse Laplace transform. State the nature of each response (overdamped, underdamped, and so on). [Sections: 4.3, 4.4]

a. $T(s) = \dfrac{2}{s+2}$

b. $T(s) = \dfrac{5}{(s+3)(s+6)}$

c. $T(s) = \dfrac{10(s+7)}{(s+10)(s+20)}$

d. $T(s) = \dfrac{20}{s^2 + 6s + 144}$

e. $T(s) = \dfrac{s+2}{s^2 + 9}$

f. $T(s) = \dfrac{(s+5)}{(s+10)^2}$

9. Use MATLAB to find the poles of [Section: 4.2]

MATLAB

ML

$$T(s) = \frac{s^2 + 2s + 2}{s^4 + 6s^3 + 4s^2 + 7s + 2}$$

10. Find the transfer function and poles of the system represented in state space here. [Section: 4.10]

$$\dot{\mathbf{x}} = \begin{bmatrix} 3 & -4 & 2 \\ -2 & 0 & 1 \\ 4 & 7 & -5 \end{bmatrix} \mathbf{x} + \begin{bmatrix} -1 \\ -2 \\ 3 \end{bmatrix} u(t)$$

$$y = \begin{bmatrix} 1 & 7 & 1 \end{bmatrix} \mathbf{x}; \mathbf{x}(0) = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

11. Repeat Problem 10 using MATLAB. [Section: 4.10] *MATLAB ML*

12. Write the general form of the capacitor voltage for the electrical network shown in Figure P4.4. [Section: 4.4]
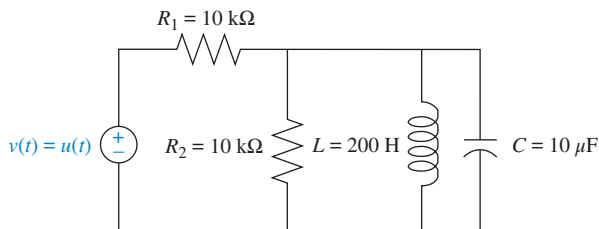

FIGURE P4.4

13. Use MATLAB to plot the capacitor voltage in Problem 12. [Section: 4.4] *MATLAB ML*

14. Solve for $x(t)$ in the system shown in Figure P4.5 if $f(t)$ is a unit step. [Section: 4.4]
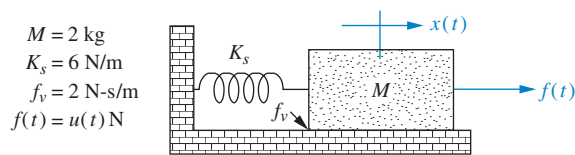

FIGURE P4.5

15. The system shown in Figure P4.6 has a unit step input. Find the output response as a function of time. Assume the system is underdamped. Notice that the result will be Eq. (4.28). [Section: 4.6]
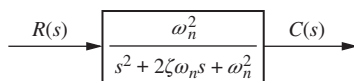

FIGURE P4.6

16. Derive the relationship for damping ratio as a function of percent overshoot, Eq. (4.39). [Section: 4.6]

17. Calculate the exact response of each system of Problem 8 using Laplace transform techniques, and compare the results to those obtained in that problem. [Sections: 4.3, 4.4]

18. Find the damping ratio and natural frequency for each second-order system of Problem 8 and show that the value of the damping ratio conforms to the type of response (underdamped, overdamped, and so on) predicted in that problem. [Section: 4.5]

19. A system has a damping ratio of 0.15, a natural frequency of 20 rad/s, and a dc gain of 1. Use inverse Laplace transforms to find an analytic expression of the response of the system to a unit-step input. [Section: 4.6]

20. For each of the second-order systems that follow, find ζ, ω_n, T_s, T_p, T_r, and %OS. [Section: 4.6]

a. $T(s) = \dfrac{16}{s^2 + 3s + 16}$

b. $T(s) = \dfrac{0.04}{s^2 + 0.02s + 0.04}$

c. $T(s) = \dfrac{1.05 \times 10^7}{s^2 + 1.6 \times 10^3 s + 1.05 \times 10^7}$

21. Repeat Problem 20 using MATLAB. Have the computer program estimate the given specifications and plot the step responses. Estimate the rise time from the plots. [Section: 4.6] *MATLAB ML*

22. Use MATLAB's LTI Viewer and obtain settling time, peak time, rise time, and percent overshoot for each of the systems in Problem 20. [Section: 4.6] *GUI Tool GUIT*

23. For each pair of second-order system specifications that follow, find the location of the second-order pair of poles. [Section: 4.6]

a. %OS = 12%; T_s = 0.6 second

b. %OS = 10%; T_p = 5 seconds

c. T_s = 7 seconds; T_p = 3 seconds

24. Find the transfer function of a second-order system that yields a 15% overshoot and a settling time of 0.7 second. [Section: 4.6]

25. For the system shown in Figure P4.7, do the following: [Section: 4.6]

a. Find the transfer function $G(s) = X(s)/F(s)$.

b. Find ζ, ω_n, %OS, T_s, T_p, T_r, and C_{final} for a unit-step input.