Automatic control system (seventh edition)

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Examination range: Chapters 2, 3, 4, 5, 6, 7

1. Find the poles and zeros of the following functions (including the ones at infinity, if any). Mark the finite poles with X and the finite zeros with O in the s-plane.
   $G(s)=\frac{10(s+2)}{S(s^2+2s+2)}$

2. Find the Laplace transforms of the following functions. Use the theorems on Laplace transforms if applicable.
   $g(t)=5te^{-5t}u_s(t)$

3. Find the poles and zeros of the following functions (including the ones at infinity, if any). Mark the finite poles with X and the finite zeros with O in the s-plane.
   $G(s)=\frac{10s(s+1)}{(S+2)(s^2+3s+2)}$

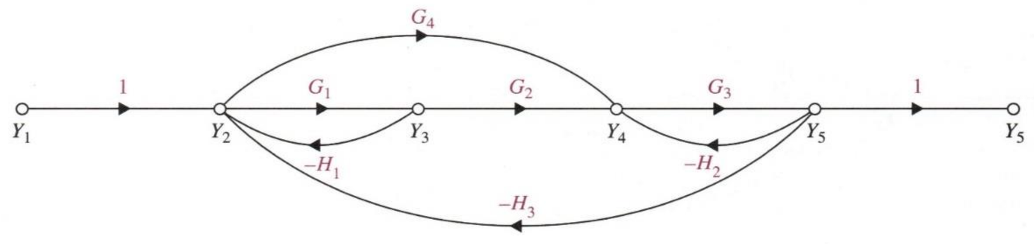
4. Solve the following differential equations by means of the Laplace transform. Assume zero initial conditions.
   $$\frac{d^2f(t)}{dt^2}+5\frac{df(t)}{dt}+4f(t)=e^{-2t}u_s(t)$$

5. Solve the following differential equations by means of the Laplace transform.
   $$\frac{dx_1(t)}{dt}=x_2(t)$$
   $$\frac{dx_2(t)}{dt}=-2x_1(t)-3x_2(t)+u_s(t) \quad x_1(0)=1\ ,x_2(0)=0$$

6. Find the inverse Laplace transforms of the following functions.
   $G(s)=\frac{1}{s(s+2)(s+3)}$

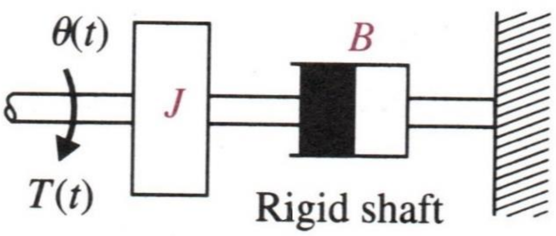
7. Apply the gain formula to the SFGs shown in Fig. (a) to find the following transfer functions:

$$\frac{Y_5}{Y_1}$$



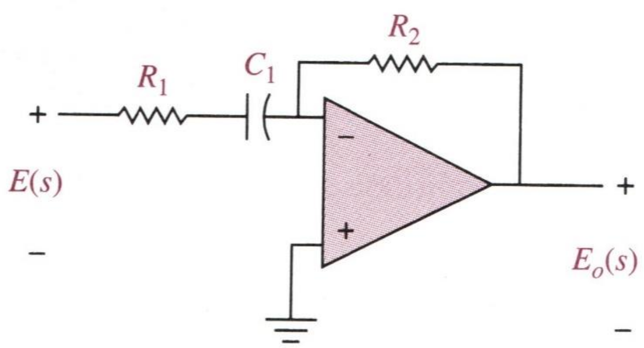
(a)

8. Write the torque equations of the rotational systems shown in Fig. (a) Draw state diagrams using a minimum number of integrators. Write the state equations from the state diagrams. Find the transfer function $\Theta(s)/T(s)$ for the system in Fig. (a).



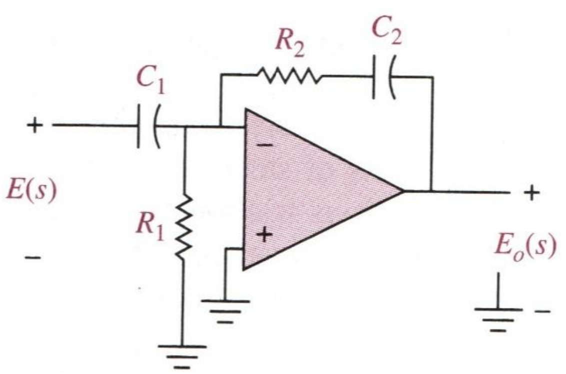
(a)

9. Find the transfer functions $E_o(S)/E(s)$ for the circuits shown in Fig.(a)



(a)

10. Find the transfer functions $E_0(s)/E(s)$ for the circuits shown in Fig.(b)



(b)

11. The following differential equations represent linear time-invariant systems. Write the dynamic equations (state equations and output equations) in vector-matrix form.

$$\frac{d^2y(t)}{dt^2} + 4\frac{dy(t)}{dt} + y(t) = 5r(t)$$

12. The following differential equations represent linear time-invariant systems. Write the dynamic equations (state equations and output equations) in vector-matrix form.

$$2\frac{d^3y(t)}{dt^3} + 3\frac{d^2y(t)}{dt^2} + 5\frac{dy(t)}{dt} + 2y(t) = r(t)$$

13. The state equations of a linear time-invariant system are represented by

$$\frac{dx(t)}{dt} = \boldsymbol{A}\boldsymbol{x}(t) + \boldsymbol{B}\boldsymbol{u}(t)$$

Find the state transition matrix $\phi(t)$, the characteristic equation, and the eigenvalues of A for the following cases.

$$A = \begin{bmatrix} -3 & 0 \\ 0 & -3 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

14. The state equations of a linear time-invariant system are represented by

$$\frac{dx(t)}{dt} = \boldsymbol{A}\boldsymbol{x}(t) + \boldsymbol{B}\boldsymbol{u}(t)$$

Find the state transition matrix $\phi(t)$, the characteristic equation, and the eigenvalues of A for the following cases.

$$A = \begin{bmatrix} 0 & 2 \\ -2 & 0 \end{bmatrix} \quad B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

15. For each of the characteristic equations of feedback control systems given, determine the range of K so that the system is asymptotically stable. Determine the value of K so that the system is marginally stable and the frequency of sustained oscillation if applicable.

$$s^4 + 25s^3 + 15s^2 + 20s + K = 0$$

16. For each of the characteristic equations of feedback control systems given, determine the range of K so that the system is asymptotically stable. Determine the value of K so that the system is marginally stable and the frequency of sustained oscillation if applicable.

$$s^3 + 20s^2 + 5s + 10K = 0$$

17. The block diagram of a motor-control system with tachometer feedback is shown in Fig.20. Find the range of the tachometer constant K_t, so that the system is asymptotically stable.

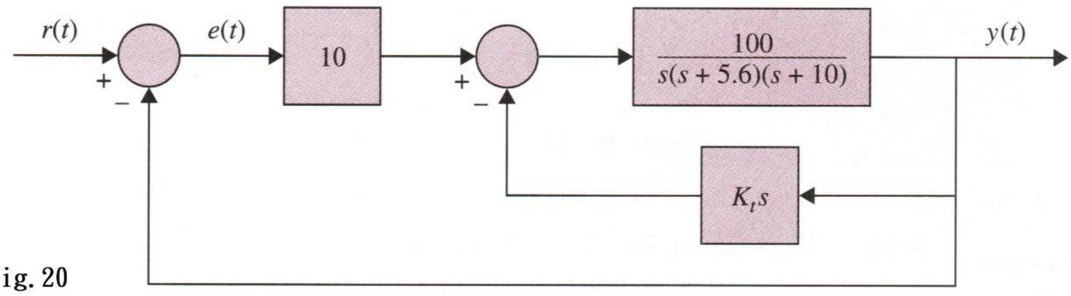


Fig. 20

18. Determine the step, ramp, and parabolic error constants of the following unity-feedback control systems. The forward-path transfer functions are given.

$$G(s) = \frac{1000}{(1 + 0.1s)(1 + 10s)}$$

19. Determine the step, ramp, and parabolic error constants of the following unity-feedback control systems. The forward-path transfer functions are given.

$$G(s) = \frac{1000}{S(S + 10)(S + 100)}$$

20. The unit-step response of a linear control system is shown in Fig. 21 Find the transfer function of a second-order prototype system to model the system.

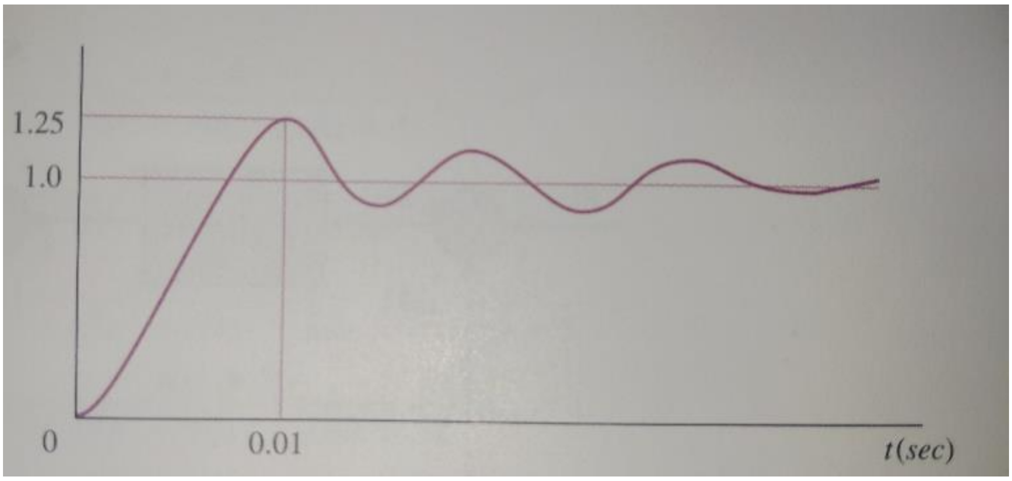


Fig. 21