Appendix

B

Control Theory Quiz

A set of questions with multiple answer choices is given here. These questions have been designed to capture important aspects of Control Theory covered in the book. For each of these questions, identify the best of the given answer choices. Compare your answers with the master key given at the end of the session. This quiz should serve the purpose of a self-appraisal test for the reader.

1. A linear time-invariant system initially at rest, when subjected to a unit-step input, gives a response $y(t) = te^{-t}$; $t > 0$. The transfer function of the system is

   (A) $\dfrac{1}{(s+1)^2}$ (B) $\dfrac{1}{s(s+1)^2}$ (C) $\dfrac{s}{(s+1)^2}$ (D) $\dfrac{1}{s(s+1)}$

2. The system shown in Fig. Q2 is of

   (A) zero order (B) first order
   (C) second order (D) third order

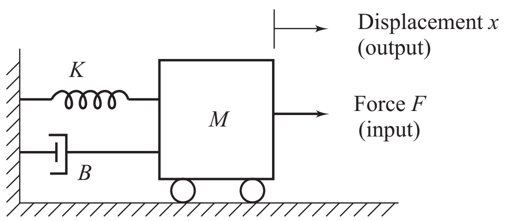


Fig. Q2

3. The impulse response of an initially relaxed linear system is $e^{-2t}\mu(t)$ where $\mu(t)$ is a unit step function. To produce a response of $te^{-2t}\mu(t)$, the input must be equal to

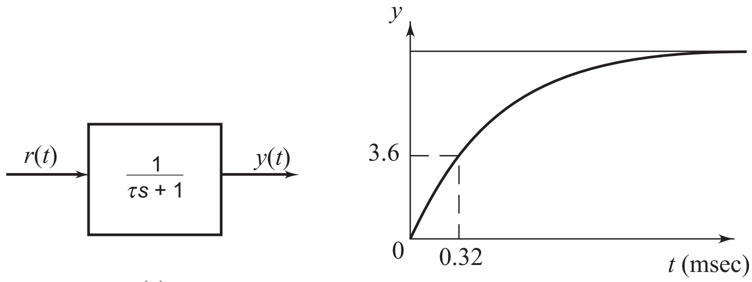
   (A) $2e^{-2t}\mu(t)$ (B) $\dfrac{1}{2}e^{-2t}\mu(t)$
   (c) $e^{-2t}\mu(t)$ (D) $e^{-t}\mu(t)$

4. The step response of a system with transfer function $G(s) = 1/(\tau s + 1)$ attains more than 98% of its final value in time t equal to

   (A) τ (B) 2τ (C) 3τ (D) 4τ

5. The response of the system of Fig. Q5a to an input $r(t) = 8\mu(t)$ is shown in Fig. Q5b. The time-constant τ is equal to

   (A) 0.535 msec (B) 0.32 msec (C) 0.09 msec (D) 11.25 msec



(a) (b)

Fig. Q5

6. Closed-loop transfer function of a unity-feedback system is given by $Y(s)/R(s) = 1/(\tau s + 1)$. Steady-state error to unit-ramp input is
   (A) ∞ (B) τ (C) 1 (D) $1/\tau$
7. The series RLC circuit shown in Fig. Q7 is underdamped if
   (A) $\left(\frac{R}{2L}\right)^2 < \frac{1}{LC}$
   (B) $\left(\frac{R}{2L}\right)^2 = \frac{1}{LC}$
   (C) $\left(\frac{R}{2L}\right)^2 > \frac{1}{LC}$
   (D) None of the answers in (A), (B), and (C) is correct

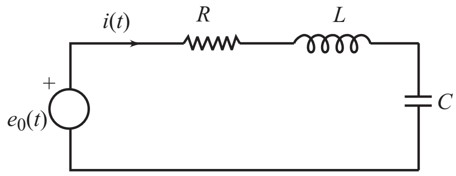


Fig. Q7

8. Closed-loop transfer function of a unity-feedback system is given by $\frac{Y(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$.
   Steady-state error to unit-ramp input is
   (A) ∞ (B) $2\zeta/\omega_n$
   (C) 1 (D) $4/\zeta\omega_n$
9. When two networks shown in Fig. Q9 are cascaded in tandem, the overall transfer function $E_4(s)/E_1(s)$ is
   (A) $H_1(s)\,H_2(s)$ (B) $H_1(s) + H_2(s)$
   (C) $H_1(s)/H_2(s)$ (D) None of the answers in (A), (B), and (C) is correct

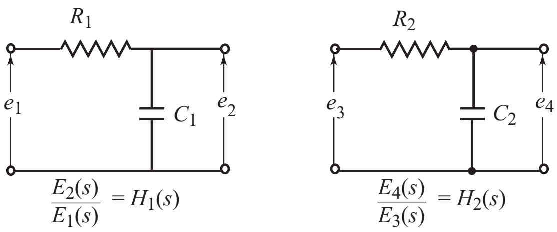


Fig. Q9

10. Dead-time model $e^{-s\tau_D}$ may be approximated by the transfer function
    (A) $\frac{1 - \frac{\tau_D}{2}s}{1 + \frac{\tau_D}{2}s}$ (B) $\frac{1 + \frac{\tau_D}{2}s}{1 - \frac{\tau_D}{2}s}$ (C) $\frac{1 - \tau_D s}{1 + \tau_D s}$ (D) $\frac{1 + \tau_D s}{1 - \tau_D s}$
11. If a system has two real and equal characteristic roots, it is described as
    (A) having no damping (B) being underdamped (C) being critically damped (D) being overdamped
12. If the roots of a characteristic equation are given by $s_{1,2} = -3 \pm j2$, the values of damping ζ and damped natural frequency ω_d are

(A) $\left(\frac{3}{\sqrt{13}}, \sqrt{13}\right)$ (B) $\left(\frac{1}{\sqrt{13}}, 2\right)$ (C) $\left(\frac{1}{\sqrt{13}}, \sqrt{13}\right)$ (D) $\left(\frac{3}{\sqrt{13}}, 2\right)$

13. A liquid-level system comprises two noninteracting tanks which can be represented by two first-order transfer functions in cascade having time constants τ_1 = 100 sec and τ_2 = 300 sec. The inflow $q(t)$ is the input and the level of the second tank is the output. The response of the output height to a step change in flow will be

(A) having no damping (B) underdamped (C) critically damped (D) overdamped

14. An open-loop control system requires an operator to set a motorized valve setting c where $0 < c < 1$, so that two fluids are mixed together. One stream has a constant flow of 10 m^3/hr and the outflowing stream should be 14 m^3/hr. The configuration is shown in Fig. Q14, where motorized valve dynamics are given. The value of valve setting to achieve the desired steady-state outflow is

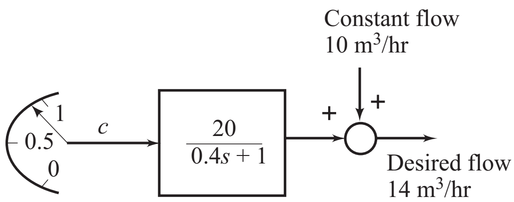


Fig. Q14

(A) 0.2 (B) 0.4

(C) 0.5 (D) 0.7

15. A linear approximation at the operating point (x^* = 0.5, u^* = 1.5) to $y(x, u) = 2x^2 + xu + u^2$, is

(A) $\delta y = 3.5\ \delta x + 3.5\ \delta u$ (B) $\delta y = 4\ \delta x + 2\ \delta u$

(C) $\delta y = 2\ \delta x + 3\ \delta u$ (D) $\delta y = 4.75\ \delta x + 3.75\ \delta u$

16. In a level control system, the fluid flow is related to the inflow rate by the following transfer function:

$$G(s) = \frac{\text{level } H(s)}{\text{inflow } Q(s)} = \frac{0.75}{2500s + 1}$$

Initially the tank is empty. The inflow control valve is suddenly opened to allow a flow rate of 0.5 m^3/sec into the tank. The level after 2500 sec is

(A) 0.474 m (B) 0.375 m (C) 0.75 m (D) 0.237 m

17. The system of Fig. Q17 is underdamped of

(A) $\frac{K}{M} > \left(\frac{B}{2M}\right)^2$

(B) $\frac{K}{M} = \left(\frac{B}{2M}\right)^2$

(C) $\frac{K}{M} < \left(\frac{B}{2M}\right)^2$

(D) None of the answers in (A), (B) and (C) is correct

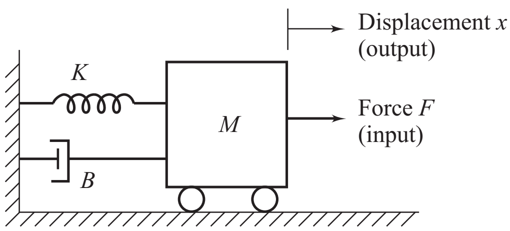


Fig. Q17

18. The damping ratio of the system of Fig. Q18 is

(A) $\frac{1}{2}\frac{1}{\sqrt{BM}}$

(B) $\frac{1}{2}\sqrt{\frac{M}{B}}$

(C) $\frac{1}{2}\sqrt{\frac{B}{M}}$

(D) None of the answers in (A), (B), and(C) is correct.

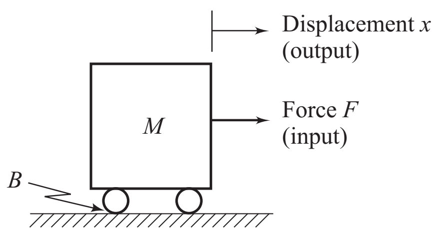


Fig. Q18

19. For a second-order system with damping $\zeta > 1$, the roots of the characteristic equation are
    (A) real but not equal (B) real and equal
    (C) complex conjugate (D) imaginary
20. The plot in Fig. Q20 shows the unit step response of a first-order system. Transfer function of the system is
    (A) $\frac{1}{5s+1}$ (B) $\frac{2}{15s+1}$
    (C) $\frac{2}{3s+1}$ (D) $\frac{1}{15s+1}$

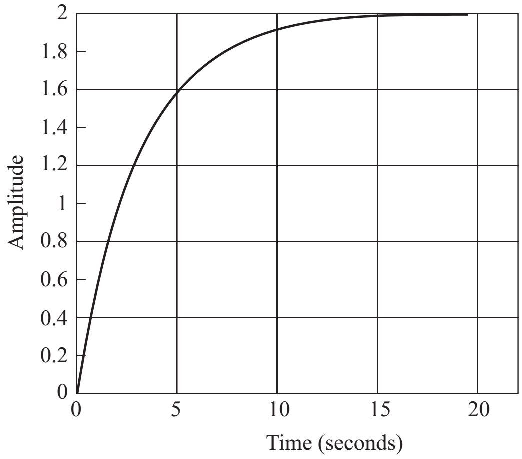


Fig. Q20

21. Three different systems have the following poles: $p_1 = -0.2$, $p_2 = -0.4$, $p_3 = -0.6$. What is the time-constant of the fastest step response?
    (A) 0.2 (B) 0.6
    (C) 1/0.2 (D) 1/0.6
22. Consider the following statements:
    (i) The test signals step, ramp and parabola are not useful for control-system analysis if actual inputs are not step, ramp, and parabola, respectively.
    (ii) Transient and steady-state performance of control systems is adequately given by the response to only one test signal, say step.
    (A) None of the above statements is true (B) Statement (i) is true but statement (ii) is false
    (C) Statement (i) is false but statement (ii) is true (D) Both the statements are true
23. Consider the op amp circuit shown in Fig. Q23. It can be used as
    (A) a lead compensator only (B) a lag compensator only
    (C) either a lead or a lag compensator (D) neither a lead nor a lag compensator

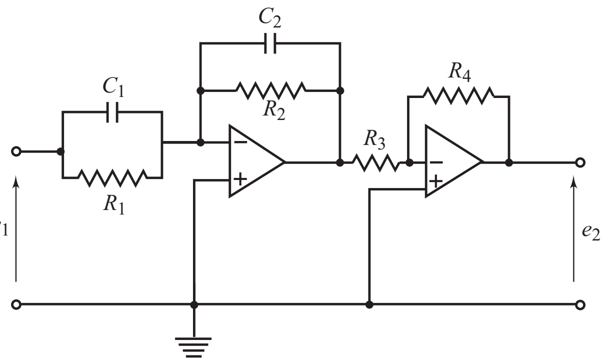


Fig. Q23

24. Consider the block diagram shown in Fig. Q24. The transfer function between $Y(s)$ and $W(s)$ is
    (A) $\frac{D(s)\,G(s)\,N(s)}{1+D(s)\,G(s)\,H(s)}$ (B) $\frac{N(s)}{1+D(s)\,G(s)\,H(s)}$
    (C) $\frac{N(s)}{1-D(s)\,G(s)\,H(s)}$ (D) None of the answers in (A), (B), and (C) is correct

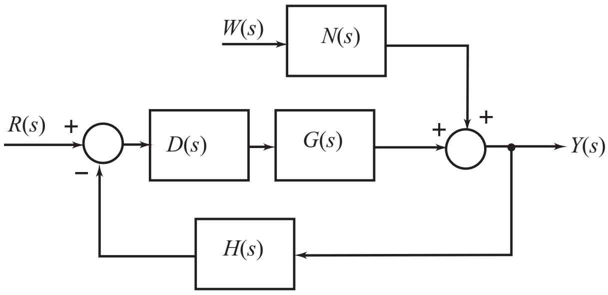


Fig. Q24

25. The gear train shown in Fig. Q25
    (A) reduces the speed and the torque
    (B) increases the speed and the torque
    (C) reduces the speed and increases the torque
    (D) increases the speed and reduces the torque

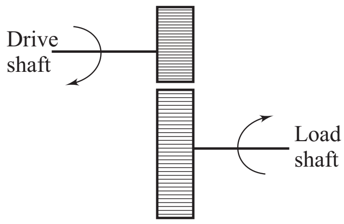


Fig. Q25

26. Effect of back emf in an armature-controlled dc servomotor is
    (A) to increase effective motor friction, thereby reducing motor time-constant
    (B) to increase effective motor friction, thereby increasing motor time-constant
    (C) to increase motor inertia, thereby increasing motor time-constant
    (D) to increase motor inertia, thereby reducing motor time-constant
27. Electrical time-constant of an armature-controlled dc servomotor is
    (A) equal to mechanical time-constant
    (B) smaller than mechanical time-constant
    (C) larger than mechanical time-constant
    (D) None of the answers in (A), (B), and (C) is correct
28. Ratio of the rotor reactance X to the rotor resistance R for a two-phase servomotor
    (A) is equal to that of a normal induction motor
    (B) is less than that of a normal induction motor
    (C) is greater than that of a normal induction motor
    (D) may be less or greater than that of a normal induction motor
29. A rotating load is connected to a field-controlled dc motor with negligible field inductance. A test results in output steady-state speed (ω) of 2 rad/sec when an input voltage (e_f) of 100 V is applied to the motor terminals. Also the test shows that output speed reaches 0.632×2 rad/sec within 0.75 sec. The transfer function $\omega(s)/E_f(s)$ of the motor is

    (A) $\dfrac{0.02}{(0.375s+1)}$ (B) $\dfrac{0.02}{0.75s+1}$ (C) $\dfrac{50}{0.75s+1}$ (D) $\dfrac{50}{(0.375s+1)}$

30. The transfer function from $R(s)$ to $Y(s)$ of the system of Fig. Q30 is

    (A) $\dfrac{s(\tau s+1)}{\tau s^2+(1+KK_2)s+KK_1}$ (B) $\dfrac{K_1 s(\tau s+1)}{\tau s^2+(1+KK_2)s+KK_1}$

    (C) $\dfrac{KK_1}{\tau s^2+(1+KK_2)s+KK_1}$ (D) $\dfrac{s(\tau s+1+KK_2)}{\tau s^2+(1+KK_2)s+KK_1}$

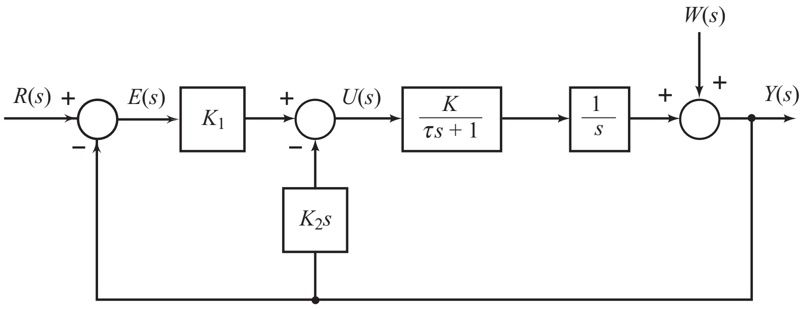


Fig. Q30

31. The transfer function from $W(s)$ to $Y(s)$ of the system of Fig. Q30 is

(A) 1

(B) $\dfrac{s(\tau s+1)}{\tau s^2+(1+KK_2)s+KK_1}$

(C) $\dfrac{KK_1}{\tau s^2+(1+KK_2)s+KK_1}$

(D) None of the answers in (A), (B), and (C) is correct

32. The transfer function between $R(s)$ and $E(s)$ of the system of Fig. Q30 is

(A) $\dfrac{s(\tau s+1+KK_2)}{\tau s^2+(1+KK_2)s+KK_1}$

(B) $\dfrac{s(\tau s+1)}{\tau s^2+(1+KK_2)s+KK_1}$

(C) $\dfrac{KK_1}{\tau s^2+(1+KK_2)s+KK_1}$

(D) $\dfrac{K_1 s(\tau s+1)}{\tau s^2+(1+KK_2)s+KK_1}$

33. The transfer function between $R(s)$ and $U(s)$ of the system of Fig. Q30 is

(A) $\dfrac{s(\tau s+1)}{\tau s^2+(1+KK_2)s+KK_1}$

(B) $\dfrac{s(\tau s+1+KK_2)}{\tau s^2+(1+KK_2)s+KK_1}$

(C) $\dfrac{KK_1}{\tau s^2+(1+KK_2)s+KK_1}$

(D) $\dfrac{K_1 s(\tau s+1)}{\tau s^2+(1+KK_2)s+KK_1}$

34. Consider the following statements:
   (i) Synchro is a three phase machine.
   (ii) Rotor of synchro transmiter is of dumb bell type while that of control transformer is cylindrical.
      (A) None of the above statements is true
      (B) Statement (i) is true but statement (ii) is false
      (C) Statement (i) is false but statement (ii) is true
      (D) Both the statements are true
35. Consider the following statements:
   (i) AC devices (servomotor, synchro) are normally operated at higher frequencies (400 Hz, for example) and not at 50 Hz.
   (ii) The output of a synchro is demodulated before feeding it to a dc motor for actuation of inertial load.
      (A) None of the above statements is true
      (B) Statement (i) is true but statement (ii) is false
      (C) Statement (i) is false but statement (ii) is true
      (D) Both the statements are true

36. A position control system has a two-loop configuration. The minor loop is a velocity-feedback loop realized through tachogenerator. Consider the following statements:
    (i) The tacho is usually mounted on motor shaft rather than the load shaft.
    (ii) The minor loop is a positive-feedback loop.
    (A) None of the above statements is true
    (B) Statement (i) is true but statement (ii) is false
    (C) Statment (i) is false but statement (ii) is true
    (D) Both the statements are true
37. Feedback control systems are
    (A) insensitive to both forward- and feedback-path parameter changes
    (B) less sensitive to feedback-path parameter changes than to forward-path parameter charges
    (C) less sensitive to forward-path parameter changes than to feedback-path parameter changes
    (D) equally sensitive to forward- and feedback-path parameter charges
38. In the system of Fig. Q38, sensitivity of $M(s) = Y(s)/R(s)$ with respect to parameter K_1 is
    (A) $\dfrac{1}{1+K_1K_2}$
    (B) $\dfrac{1}{1+K_1G(s)}$
    (C) 1
    (D) None of the answers in (A), (B), and (C) is correct

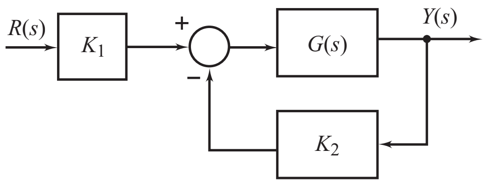


Fig. Q38

39. In the system of Fig. Q38, sensitivity of $M(s) = Y(s)/R(s)$ with respect to parameter K_2 is
    (A) $\dfrac{1}{1+K_2K_1}$
    (B) $\dfrac{1}{1+K_2G(s)}$
    (C) $\dfrac{-K_2G(s)}{1+K_2G(s)}$
    (D) None of the answers in (A), (B), and (C) is correct.
40. A speed control system is represented by the signal flow graph shown in Fig. Q40. The nominal value of the parameter K is 10. Sensitivity of $M(s) = \omega(s)/\omega_r(s)$ to changes in K is
    (A) $\dfrac{s+0.1}{s+11}$
    (B) $\dfrac{s+0.1}{s+0.2}$
    (C) $\dfrac{-0.1}{s+0.2}$
    (D) None of the answers in (A), (B), and (C) is correct.

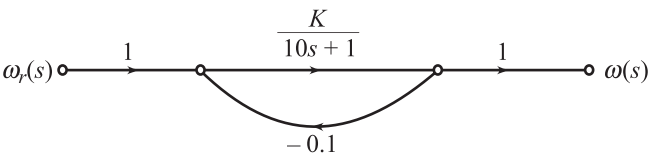


Fig. Q40

41. A speed control system is represented by the block diagram of Fig. Q41. The system is subjected to a step disturbance $W(s)$. $\omega_{ss}^{CL}/\omega_{ss}^{OL}$ (the steady-state speed under closed-loop operation/steady-state speed under open-loop operation) is equal to

(A) 1/2
(B) 1
(C) 2
(D) None of the answers in (A), (B), and (C) is correct

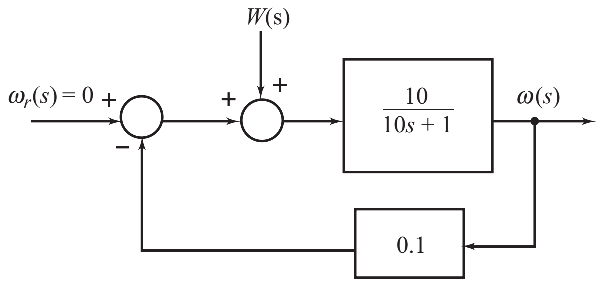


Fig. Q41

42. The time response of the system of Fig. Q42a to an input $r(t) = 10\,\mu(t)$ is shown in Fig. Q42b. The gain K is equal to
(A) 10
(B) 8
(C) 4
(D) None of the answers in (A), (B), and (C) is correct

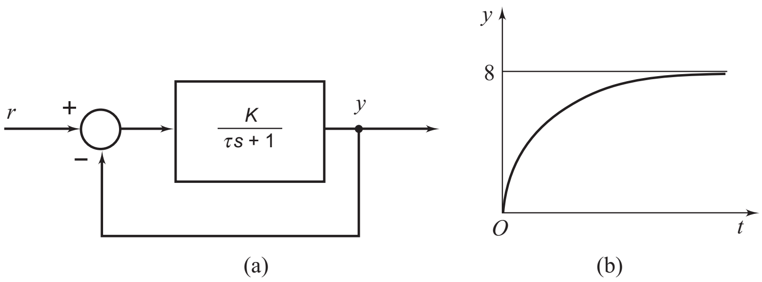


Fig. Q42

43. An inertial and a frictional load are driven by a dc motor with torque T_M. The dynamic model of the system is

$$T_M(t) = J\,\frac{d\omega(t)}{dt} + B\omega(t)$$

The steady-state speed of the motor for step input will be doubled when
(A) inertia J is doubled
(B) friction B is doubled
(C) both the inertia J and friction B are doubled
(D) None of the answers in (A), (B), and (C) is correct

44. Consider the following statements:
(i) If an open-loop system is unstable, applying feedback will always improve its stability.
(ii) If an open-loop system is subject to parameter variations, applying feedback will always improve robustness.
Which of the following is the correct answer?
(A) None of the above statements is true
(B) Statement (i) is true but statement (ii) is false
(C) Statement (i) is false but statement (ii) is true
(D) Both the statements are true

45. The characteristic equation of the closed-loop system of Fig. Q45 is
(A) $s^2 + 11s + 10 = 0$
(B) $s^2 + 11s + 130 = 0$
(C) $s^2 + 10s + 120 = 0$
(D) $s^2 + 10s + 12 = 0$

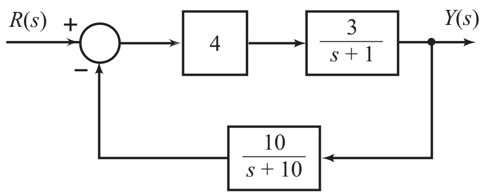


Fig. Q45

46. Which of the following describes the step response of the closed-loop system of Fig. Q46?
    (A) Underdamped
    (B) Critically damped
    (C) Overdamped
    (D) The output does not reach a steady-state value.

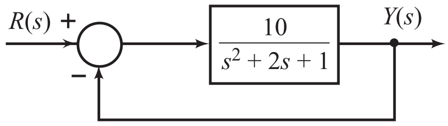


Fig. Q46

47. The system of Fig. Q47 has the steady-state error

    (A) $\frac{1}{1.125}$ (B) $\frac{0.1}{1.125}$

    (C) $\frac{1.1}{1.125}$ (D) None of the answers in (A), (B), and (C) is correct

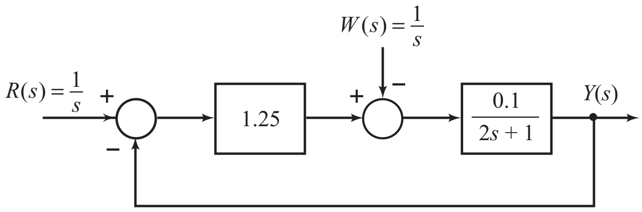


Fig. Q47

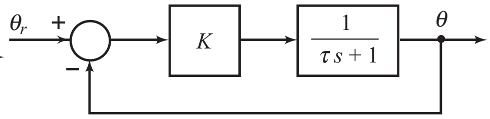


Fig. Q48

48. It is desired that the output θ changes by unit step with zero error at steady state (Fig. Q48). We can achieve it by injecting
    (A) θ_r = unit step (B) θ_r of step size $(1+K)/K$
    (C) θ_r of step size $K/(K+1)$ (D) None of the answers in (A), (B), and (C) is correct
49. Consider the system of Fig. Q49. The steady-state error is zero for

    (A) $K_f = 0$ (B) $K_f = \frac{1}{1.25}$

    (C) $K_f = 1.25$ (D) None of the answers in (A), (B), and (C) is correct

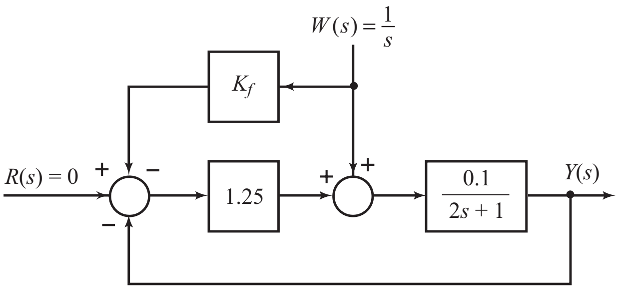


Fig. Q49

50. Sensitivity S_G^M of the closed-loop transfer function $M(s)$ with respect to open-loop transfer function $G(s)$ (Fig. Q50) is

    (A) $\frac{1}{2s^2 + (3K_P + 1)s + 3K_I}$ (B) $\frac{s(2s+1)}{2s^2 + (K_P + 1)s + 3K_I}$

    (C) $\frac{s(2s+1)}{2s^2 + (K_P + 1)s + K_I}$ (D) $\frac{s(2s+1)}{2s^2 + (3K_P + 1)s + 3K_I}$

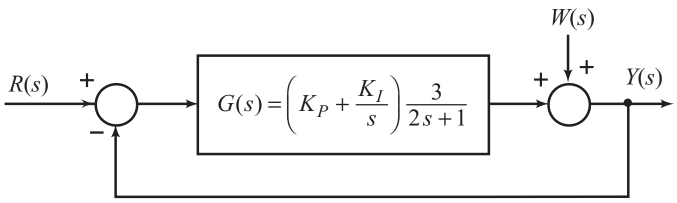


Fig. Q50

51. For what value of K is the time-constant of the system of Fig. Q51 equal to 0.2 seconds?
    (A) $K = 3$ (B) $K = 5$
    (C) $K = 7$ (D) $K = 9$
52. Consider the system of Fig. Q52. The K_P to move the time-constant to one sixth of its open-loop value is
    (A) $\frac{0.333}{2}$ (B) $\frac{0.333}{6}$
    (C) $\frac{6}{0.333}$ (D) $\frac{2}{0.333}$

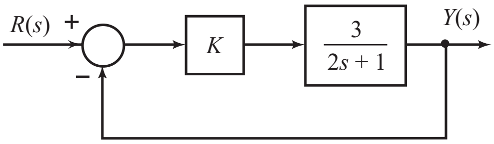


Fig. Q51

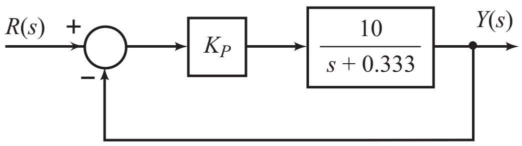


Fig. Q52

53. Consider the system of Fig. Q53. The steady-state offset is zero when K_P is
    (A) zero (B) infinity
    (C) any value of K_P (D) no value of K_P

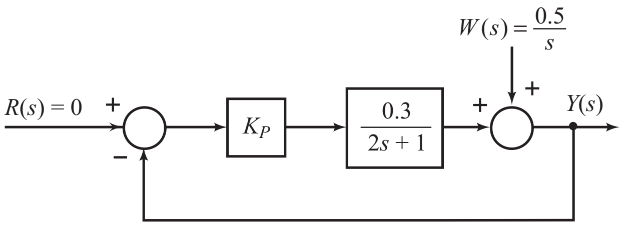


Fig. Q53

54. A proportional controller, K_P, is used with a first-order system $G(s) = K/(\tau s + 1)$ in unity-feedback structure. Increasing K_P will
    (A) increase the time-constant and decrease the steady-state error to step inputs
    (B) decrease the time-constant and decrease the steady-state error to step inputs
    (C) decrease the time-constant and increase the steady-state error to step inputs
    (D) increase the time-constant and increase the steady-state error to step inputs
55. Consider the system of Fig. Q55. K_I that gives critical damping is
    (A) 0.417
    (b) 0.257
    (C) 1
    (D) None of the answers in (A), (B), and (C) is correct

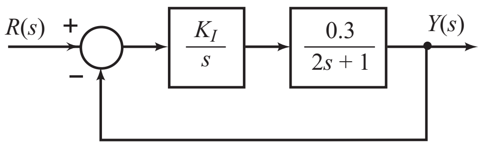


Fig. Q55

56. Consider the system of Fig. Q56. The steady-state offset is zero for

(A) $K_I = 0$ (B) $K_I = \infty$
(C) any value of K_I (D) no value of K_I

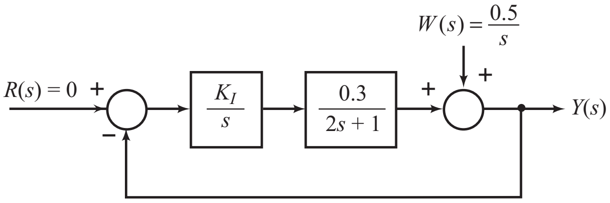


Fig. Q56

57. An integral controller K_I/s is used with a first-order system $G(s) = K/(\tau s + 1)$ in unity-feedback structure. Increasing K_I will

(A) decrease damping with no change in steady-state offset to step commands.
(B) decrease damping with decrease in steady-state offset to step commands.
(C) increase damping with no change in steady-state offset to step commands.
(D) increase damping with decrease in steady-state offset to step commands.

58. The condition that all the roots of the polynomial

$$\Delta(s) = a_0s^3 + a_1s^2 + a_2s + a_3;\ a_i > 0$$

have negative real parts, is given by

(A) $a_1a_3 > a_0a_2$ (B) $a_1a_0 > a_2a_3$ (C) $a_1a_2 > a_0a_3$ (D) $a_2a_0 > a_1a_3$

59. Consider the following statements:

(i) All the roots of the polynomial

$$\Delta_1(s) = 3s^4 + 10s^3 + 5s^2 + 2$$

have negative real parts.

(ii) All the roots of the polynomial

$$\Delta_2(s) = s^4 + 4s^3 + 6s^2 + 4s - 5$$

have negative real parts.

Which of the following is the correct answer?

(A) None of the above statements is true
(B) Statement (i) is true but statement (ii) is false
(C) Statement (i) is false but statement (ii) is true
(D) Both the statements are true

60. The characteristic equation of a feedback control system is given by

$$2s^4 + s^3 + 2s^2 + 5s + 10 = 0$$

The number of roots in the right half of s-plane are

(A) zero (B) 1 (C) 2 (D) 3

61. The polynomial

$$\Delta(s) = s^3 + 3s^2 + 2s + 6$$

has

(A) two roots in left half s-plane and one root in right half
(B) two roots in right half s-plane and one root in left half
(C) two roots on $j\omega$-axis of s-plane and one root in right half
(D) two roots on $j\omega$-axis of s-plane and one root in left half.

62. The characteristic equation of a feedback control system is

$$s^3 + \alpha_1s^2 + \alpha_2s + K\alpha_2 = 0;\ \alpha_1,\ \alpha_2, > 0,$$

where K is a variable positive scalar parameter. The system is stable for all values of K given by

(A) $K > \alpha_2$ (B) $K < \alpha_2$ (C) $K > \alpha_1$ (D) $K < \alpha_1$

63. The open-loop transfer function of a unity feedback system is

$$G(s) = K/[s^2(s+5)];\ K > 0$$

The system is unstable for

(A) $K > 5$ (B) $K < 5$

(C) $K > 0$ (D) All the answers in (A), (B), and (C) are correct

64. A unity feedback system has open-loop transfer function

$$G(s) = K/[s(s+1)(s+2)];\ K > 0$$

The value of K that results in oscillatory response to step input, is

(A) 2 (B) 6 (C) 20 (D) 60

65. The first two rows of Routh tabulation of a third-order system are

s^3	2	2
s^2	4	4

(A) The characteristic equation has one root in right half s-plane

(B) The characteristic equation has two roots on the $j\omega$-axis at $s = \pm j$

(C) The characteristic equation has two roots on the $j\omega$-axis at $s = \pm 2j$

(D) None of the answers in (A), (B), and (C) is correct

66. Presence of transportion lag in the forward path of a closed-loop control system

(A) decreases margin of stability (B) increases margin of stability

(C) does not affect its margin of stability

67. Consider a unity-feedback system with plant $G(s) = \dfrac{1}{s^2+s+1}$ and cascade controller $D(s) = K_P + \dfrac{2}{s}$. The values of K_P for which the system is stable are

(A) $K_P > 0$ (B) unstable for all $K_P > 0$ (C) $K_P > 1$ (D) $K_P > 2$

68. The error function of a feedback system is

$$E(s) = \frac{(s+0.1)(s+0.5)}{s(s+0.1)(s+0.5)+0.5(s+1)}$$

The steady-state value of $e(t)$ is

(A) 0.001 (B) 0.1 (C) 0.01

(D) None of the answers in (A), (B), and (C) is correct

69. Consider the system of Fig. Q69. The steady-state error is less than 2% for step input for

(A) $K_c > 49$ (B) any value of K_c (C) no value of K_c (D) $K_c > 50$

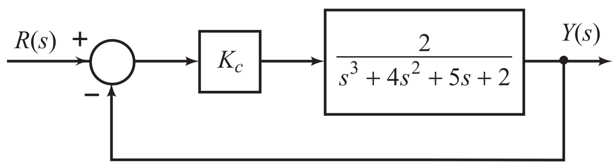


Fig. Q69

70. A unity feedback system has open-loop transfer function $G(s) = 9/[s(s+3)]$. The system has

(A) damping ratio = 1/2, and natural frequency = 9 (B) damping ratio = 1/6, and natural frequency = 3

(C) damping ratio = 1/6, and natural frequency = 9 (D) damping ratio = 1/2, and natural frequency = 3

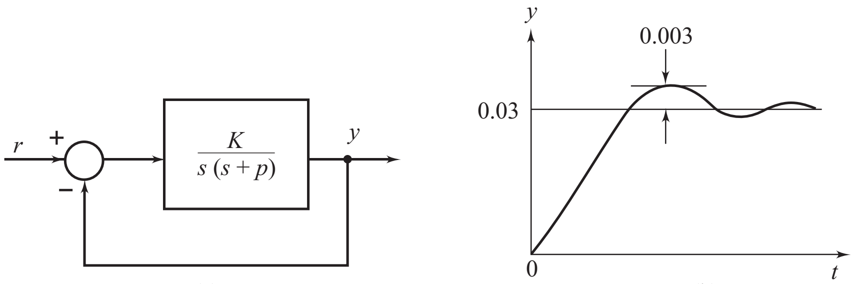
71. A unity feedback system has open-loop transfer function $G(s) = 25/[s(s+6)]$. The time t_p at which the peak of the step-input response occurs, is

(A) 11/7 sec (B) 11/4 sec (C) 11/14 sec (D) 11/28 sec

72. Peak overshoot of step-input response of an underdamped second-order system is explicitly indicative of
(A) settling time (B) rise time (C) natural frequency (D) damping ratio

73. A unity feedback system has open-loop transfer function $G(s) = 25/[s(s + 6)]$. The peak overshoot in the step-input response of the system is approximately equal to
(A) 5% (B) 10% (C) 15% (D) 20%

74. The step-input response of the system of Fig. Q74a is shown in Fig. Q74b. The value of damping ratio of the system is
(A) 0.39 (B) 0.49 (C) 0.59 (D) 0.69



(a) (b)

Fig. Q74

75. A unity feedback system with open-loop transfer function $G(s) = 4/[s(s + p)]$ is critically damped. The value of the parameter p is
(A) 4 (B) 3 (C) 2 (D) 1

76. A unity feedback system has open-loop transfer function $G(s)$. The steady-state error is zero for
(A) step input and type-1 $G(s)$ (B) ramp input and type-1 $G(s)$
(C) step input and type-0 $G(s)$ (D) ramp input and type-0 $G(s)$

77. A unity feedback system with forward path transfer function $G(s) = 1/[s^2(s + 1)]$ is subjected to an input $r(t) = K_1 + K_2 t + \frac{1}{2} t^2$. The steady-state error of the system is
(A) infinity (B) 1
(C) zero (D) None of the answers in (A), (B), and (C) is correct

78. Closed-loop transfer function of a unity feedback system is given by

$$\frac{Y(s)}{R(s)} = \frac{1}{\tau s + 1}$$

System K_v is
(A) τ (B) $1/\tau$ (C) 1 (D) ∞

79. Closed-loop transfer function of a unity feedback system is given by

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

System K_v is
(A) $\omega_n/2\zeta$ (B) 1 (C) ∞ (D) $2\zeta/\omega_n$

80. Consider the position control system of Fig. Q80. The value of K such that the steady-error is 10° for input $\theta_r = 400t\,\mu(t)$ rad/sec, is
(A) 104.5
(B) 114.5
(C) 124.5
(D) None of the answers in (A), (B), and (C) is correct

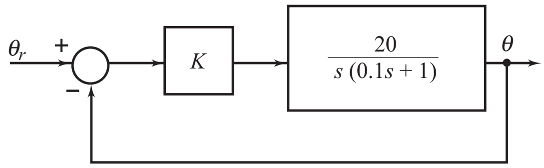


Fig. Q80

81. Consider the speed control system shown in Fig. Q81. Parameter variations occurring during operating conditions cause K_A to modify to $K'_A = 0.9K_A$. The value of K_A that limits the change in steady-state motor speed due to parameter variations to 0.1%, is
(A) 25 (B) 35 (C) 45 (D) 55

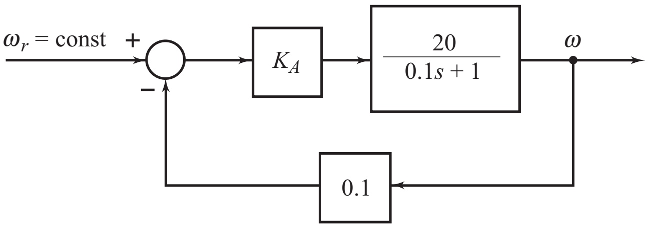


Fig. Q81

82. Derivative error compensation is employed in feedback control systems to
(A) increase the effective damping in the system
(B) decrease the effective damping in the system
(C) improve the steady-state response of the system

83. Tachogenerator feedback is sometimes used in position control systems to
(A) increase the effective damping in the system
(B) decrease the effective damping in the system
(C) improve the steady-state response of the system

84. Integral error compensation is employed in feedback control systems to
(A) improve damping
(B) improve speed of response
(C) reduce steady-state error

85. A temperature control system is found to have zero error to a constant tracking input, and an error of 0.5°C to a tracking input that is linear in time, rising at the rate of 40°C/sec. What is the type number of the system?
(A) 0 (B) 1
(C) 2 (D) Type number cannot be determined from the given information

86. Poles of second-order models with the same damping ratio lie
(A) on the real axis (B) on a radial line from the origin
(C) on the imaginary axis (D) None of the answers in (A), (B), and(C) is correct

87. The percentage overshoot of a second-order system $G(s) = \dfrac{K\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2}$ to a step input depends only on
(A) the value of the step input (B) the value of the damping ratio
(C) the value of the gain K (D) the parameter ω_n

88. Consider the system of Fig. Q88. Increasing proportional gain will
(A) increase the overshoot and decrease the steady-state error to ramp inputs
(B) decrease the overshoot and increase the steady-state error to ramp inputs
(C) increase the overshoot and increase the steady-state error to ramp inputs
(D) decrease the overshoot and decrease the steady-state error to ramp inputs

89. Consider the system of Fig. Q89. The steady-state offset is zero when
(A) $K_P = \infty$, $K_D = \infty$
(B) $K_P = 0$, K_D = any value
(C) $K_P = \infty$, K_D = any value
(D) no values of K_P and K_D

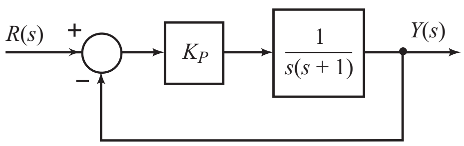


Fig. Q88

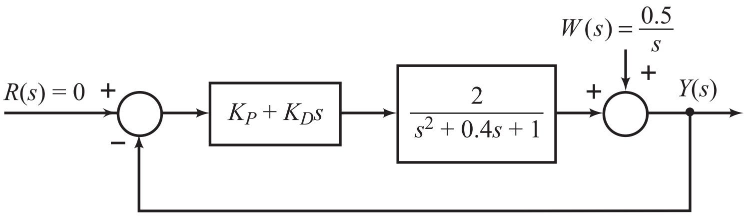


Fig. Q89

90. Consider the system of Fig. Q90. $R(s)$ and $W(s)$ are step signals
   (A) Steady-state error to $R(s)$ is zero and to $W(s)$ is non-zero
   (B) Steady-state error to $R(s)$ is non-zero and to $W(s)$ is zero
   (C) Steady-state error to both $R(s)$ and $W(s)$ is non-zero

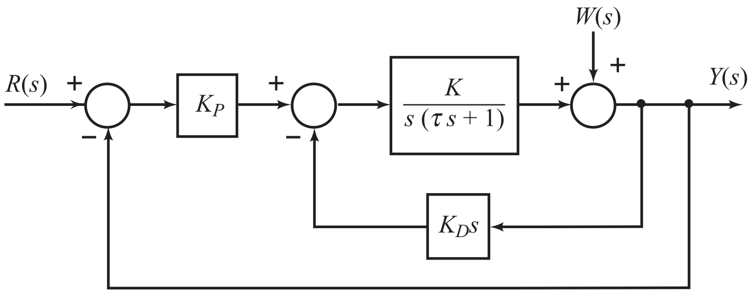


Fig. Q90

91. Consider the system of Fig. Q91. The steady-state error is less than 2% to step inputs for
   (A) any value of K_I
   (B) no values of K_I
   (C) $K_I > 50$
   (D) None of the answers is (A),(B), and (C) is correct

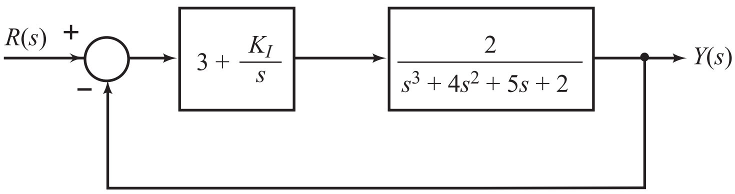


Fig. Q91

92. A unity feedback system has open-loop transfer function $G(s) = 1/s^2$. This uncompensated type-2 system possesses a satisfactory steady-state error for
   (A) step input signals
   (B) ramp input signals
   (C) both the step and ramp input signals
   (D) none of the step and ramp input signals
93. Consider the following statements:
   (i) Many systems are designed for peak overshoot in the range 5–25%.
   (ii) Desired dominant closed-loop poles are usually a complex-conjugate pair.
      (A) None of the above statements is true
      (B) Statement (i) is true but statement (ii) is false
      (C) Statement (i) is false but statement (ii) is true
      (D) Both the statements are true
94. The steady-state error due to step commands can be eliminated from proportional control systems with type-0 plants by

(i) intentionally 'misadjusting' reference input
(ii) introducing integral mode in the controller
(A) None of the above statements is true (B) Statement (i) is true but statement (ii) is false
(C) Statement (i) is false but statement (ii) is true (D) Both the statements are true

95. Consider the following statements:
(i) In a position control system, the integrating effect naturally appears in system plant.
(ii) We do not require integral control for position control systems to obtain zero steady-state error to step disturbances in load.
(A) None of the above statements is true (B) Statement (i) is true but statement (ii) is false
(C) Statement (i) is false but statement (ii) is true (D) Both the statements are true

96. A type-1 plant is changed to type-2 feedback system by the following cascade control action:
(A) PD (B) PI (C) Either PD or PI (D) Neither PD nor PI

97. A unity feedback system has open-loop poles at $s = -2 \pm j2$, $s = -1$, and $s = 0$; and a zero at $s = -3$. The angles made by the root-locus asymptotes with the real axis, and the point of intersection of the asymptotes are, respectively,
(A) (60°, –60°, 180°) and – 3/2 (B) (60°, – 60°, 180°) and – 2/3
(C) (45°, – 45°, 180°) and – 2/3 (D) (45°, – 45°, 180°) and – 4/3

98. Which of the root locus plots shown in Fig. Q98 is the correct plot for a unity feedback system with open-loop poles at $s = -1 \pm j1$, and a zero at $s = -2$?
(A) Fig. Q98a (B) Fig. Q98b (C) Fig. Q98c (D) Fig. Q98d

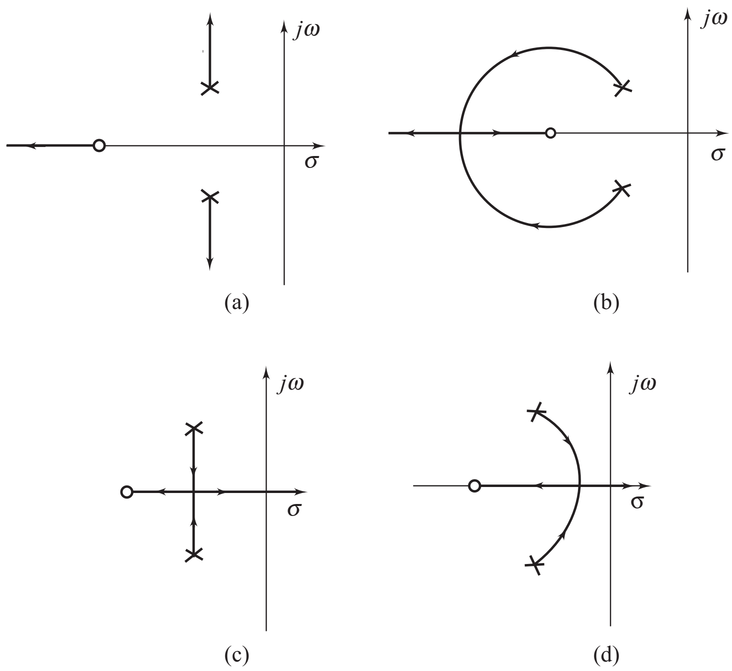


Fig. Q98

99. Which of the root locus plots shown in Fig. Q99 is the correct plot for a unity feedback system with open-loop transfer function $G(s) = K/[s^2(s + 5)]$?
(A) Fig. Q99a (B) Fig. Q99b (C) Fig. Q99c

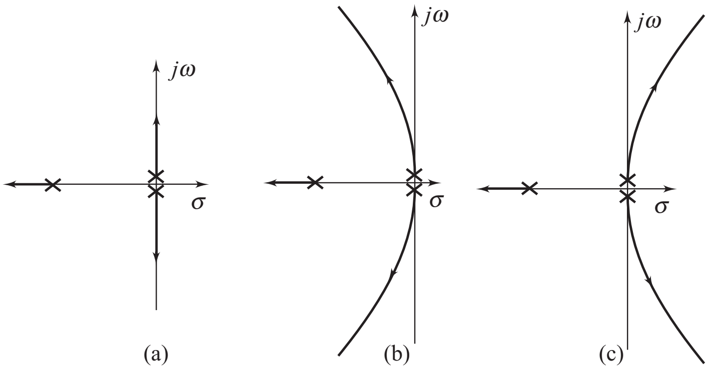


Fig. Q99

100. A unity feedback system has open-loop transfer function $G(s) = K(s+1)(s+2)/[s(s+3)(s+4)]$. For $K = 10$, the closed-loop poles are
(A) all real and distinct
(B) one real and two complex conjugate
(C) all real and repeated
(D) None of the answers in (A), (B), and (C) is correct

101. Root locus plot of a feedback system as gain K is varied, is shown in Fig. Q101. The system response to step input is non-oscillatory for
(A) $0 < K < 0.4$
(B) $0.4 < K < 6$
(C) $6 < K < \infty$
(D) None of the answers in (A), (B), and (C) is correct

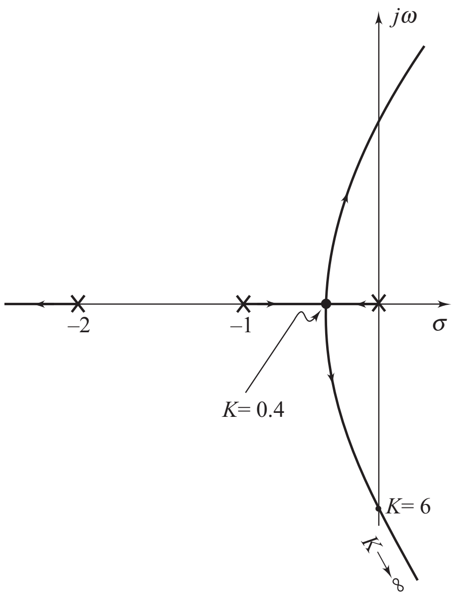


Fig. Q101

102. Consider the root locus plot shown in Fig. Q101.
(i) Adding a zero between $s = -1$ and $s = -2$ would move the root locus to the left.
(ii) Adding a pole at $s = 0$ would move the root locus to the right.
Which of the following is the correct answer?
(A) None of the above statements is true
(B) Statement (i) is true but statement (ii) is false
(C) Statement (i) is false but statement (ii) is true
(D) Both the statements are true

103. Consider the root locus plot of unity-feedback system with open-loop transfer function

$$G(s) = \frac{K(s+5)}{s(s+2)(s+4)(s^2+2s+2)}$$

The meeting point of the asymptotes on the real axis occurs at
(A) –1.2 (B) – 0.85 (C) – 1.05 (D) – .75

104. Consider the root locus plot of unity-feedback system with open-loop transfer function

$$G(s) = \frac{K(s+5)}{s(s+2)(s+4)(s^2+2s+2)}$$

The break away point of the root loci on the real axis occurs at

(A) – 3 (B) – 4.5

(C) – 5.5 (D) None of the answers is (A), (B), and (C) is correct

105. The transfer function of a lag compensator is

$$D(s) = \frac{1+\alpha\tau s}{1+\tau s}; \tau > 0$$

the value of α is given by

(A) $\alpha = 1$ (B) $\alpha > 1$

(C) $\alpha < 1$ (D) α is any constant

106. The root locus plot of the characteristic equation

$$1 + KF(s) = 0$$

is given in Fig. Q106. The value of K at $s = \pm j1$ is

(A) 4

(B) 1

(C) 10

(D) None of the answers in (A), (B), and (C) is correct

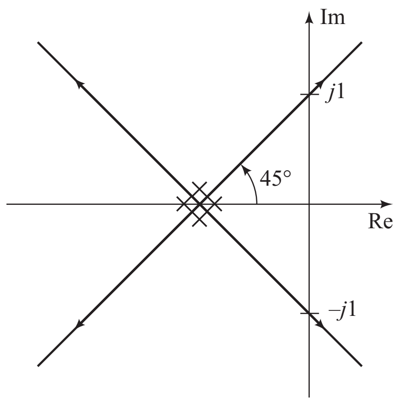


Fig. Q106

107. Consider the following statements:

(i) A lead compensator is nothing but a PD controller with a filter.

(ii) A lag compensator has the characteristics of a PI controller

(A) None of the above statements is true

(B) Statement (i) is true but statement (ii) is false

(C) Statement (i) is false but statement (ii) is true

(D) Both the statements are true

108. Figure Q108 shows the Nyquist plot of a unity feedback system having open-loop transfer function $G(s)$ with one pole in right half of s-plane. The feedback system is

(A) stable

(B) unstable

(C) marginally stable

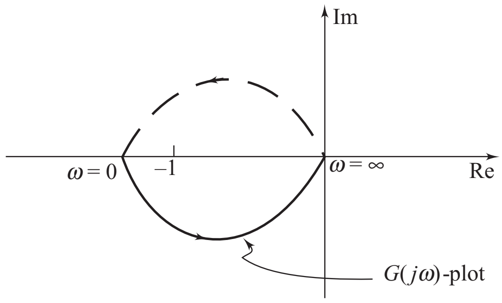


Fig. Q108

109. Figure Q109 shows the Nyquist plot of a unity feedback system having open-loop transfer function $G(s)$ with one pole in right half of s-plane. The feedback system is

(A) stable (B) unstable

(C) marginally stable

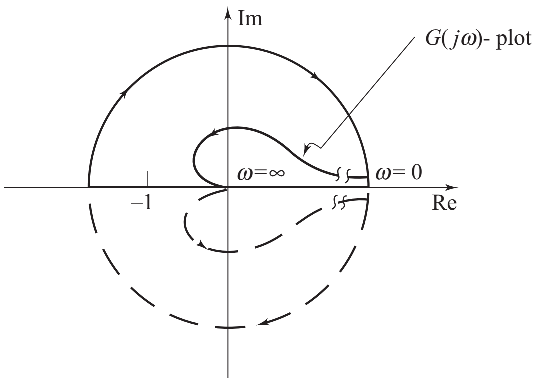


Fig. Q109

110. Polar plot of $G(j\omega) = 1/[j\omega(1 + j\omega\tau)]$

(A) crosses the negative real axis

(B) crosses the negative imaginary axis

(C) crosses the positive imaginary axis

(D) None of the answers in (A), (B), and (C) is correct

111. Which of the polar plots shown in Fig. Q111 is the correct plot for $G(j\omega) = 1/[(j\omega)^2(1 + j\omega\tau)]$?
(A) Fig. Q111a (B) Fig. Q111b (C) Fig. Q111c (D) Fig. Q111d

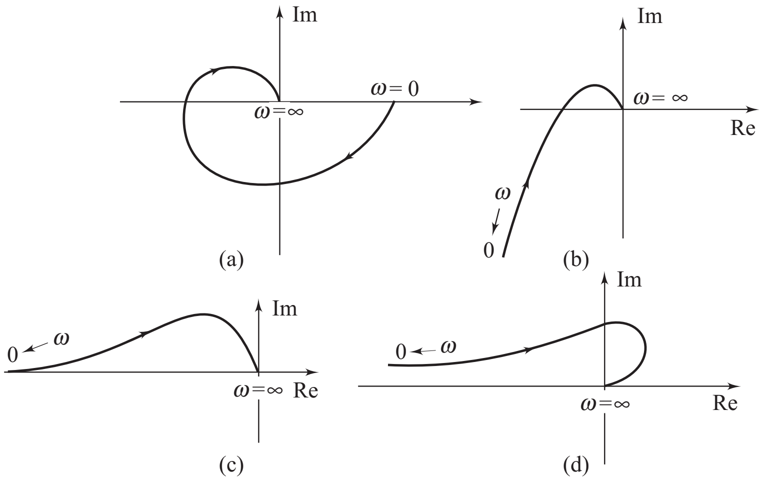


Fig. Q111

112. Which of the Bode asymptotic plots shown in Fig. Q112 is the correct plot for $G(s) = K/[s^2(s + 5)]$?
(A) Fig. Q112a (B) Fig. Q112b (C) Fig. Q112c (D) Fig. Q112d

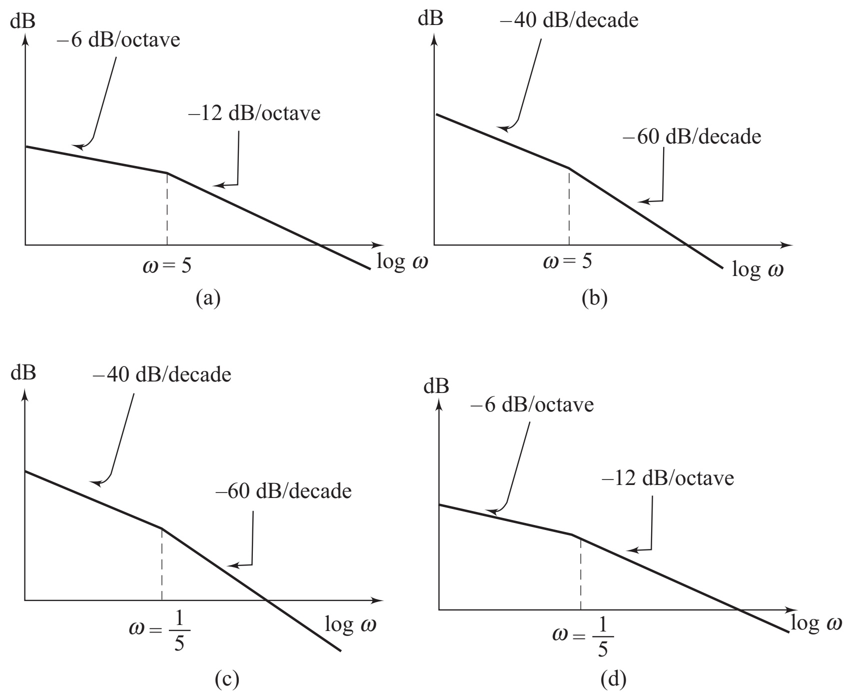


Fig. Q112

113. The Bode asymptotic plot of a transfer function is given in Fig. Q113. There
(A) are no poles at the origin (B) is one pole at the origin (C) are two poles at the origin

114. The Bode asymptotic plot of a transfer function is given in Fig. Q114. The transfer function has
(A) one pole and one zero (B) two poles and one zero (C) one pole and two zeros

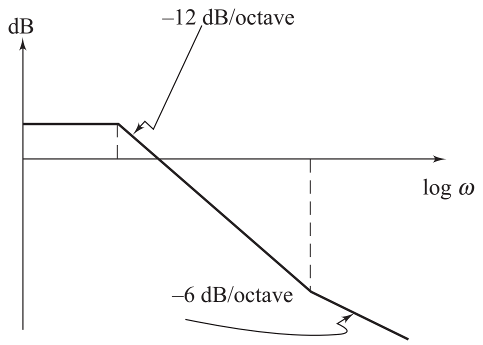


Fig. Q113

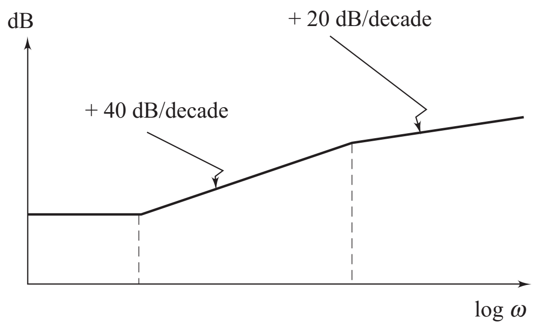


Fig. Q114

115. The minimum-phase transfer function that corresponds to the Bode asymptotic plot shown in Fig. Q115, is

(A) $\dfrac{1}{2s+1}$ (B) $2s + 1$

(C) $\dfrac{1}{\frac{1}{2}s+1}$ (D) $\frac{1}{2}s + 1$

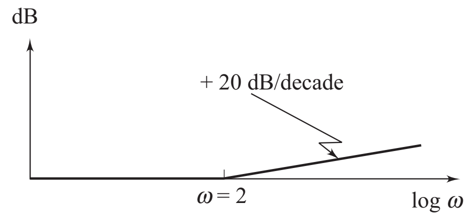


Fig. Q115

116. A unity feedback system has open-loop transfer function $G(s)$. Polar plot of $G(j\omega)$ is shown in Fig. Q116. The gain margin (GM) and the phase margin (ΦM) of the feedback system are

(A) $GM = -0.3$; $\Phi M = 112.33°$
(B) $GM = 0.3$; $\Phi M = 112.33°$
(C) $GM = 3.33$; $\Phi M = 67.67°$
(D) None of the answers in (A), (B), and (C) is correct

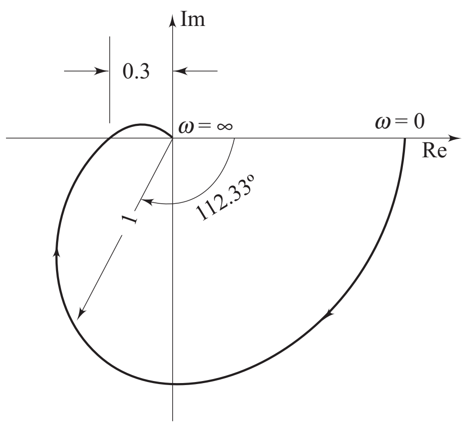


Fig. Q116

117. A unity feedback system has open-loop transfer function $G(s) = K/[s(1 + s\tau)]$. The gain margin of the feedback system is
(A) ∞
(B) 0
(C) 1
(D) None of the answers in (A), (B), and (C) is correct

118. A unity feedback system has open-loop transfer function $G(s)$. Bode plot of $G(j\omega)$ is shown in Fig. Q118. The feedback system has
(A) positive phase margin and negative gain margin
(B) positive phase margin and positive gain margin
(C) negative phase margin and negative gain margin
(D) negative phase margin and positive gain margin

119. The corner frequencies in Bode plot of the transfer function

$$G(s) = \frac{6(s^2+10s+100)}{s^2(50s^2+15s+1)}$$

are
(A) 1,50
(B) 100,1
(C) 10,1
(D) None of the answers in (A), (B), and (C) is correct

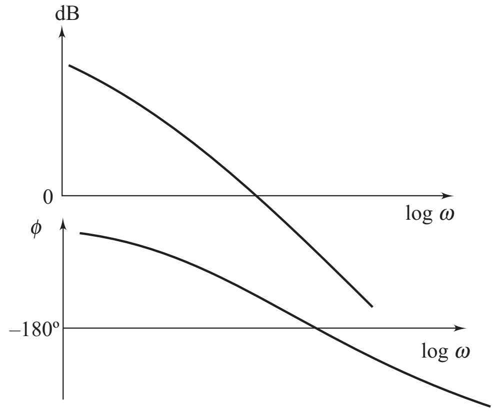


Fig. Q118

120. The low-frequency asymptote in Bode plot of

$$G(s) = \frac{6(s^2+10s+100)}{s^2(50s^2+15s+1)}$$

has a slope of
(A) 0 dB/decade (B) – 20 dB/decade
(C) – 40 dB/decade (D) None of the answers in (A), (B), and (C) is correct

121. The high-frequency asymptote in Bode plot of

$$G(s) = \frac{6(s^2+10s+100)}{s^2(50s^2+15s+1)}$$

has a slope of
(A) 0 dB /decade (B) – 20 dB/decade
(C) – 40 dB/decade (D) None of the answers in (A), (B), and(C) is correct

122. If a system's gain is given as $|G(j\omega_0)| = 0$ dB, what will happen to an input signal at the frequency ω_0?
(A) It will be amplified (B) It will be attenuated
(C) There will be no output signal (D) None of the answers in (A), (B), and (C) is correct

123. An engineer applies the input $r(t) = 2\sin t$ to a chemical process and measures the output as $y(t) = 0.4\sin(t - 1.55)$. What are the gain and phase of the system?
(A) (– 14dB, – 89°) (B) (– 8dB, – 1.55°) (C) (–14 dB, – 1.55°) (D) (– 8dB, – 89°)

124. A current to pressure transducer has a gain of – 10 dB and a phase of – 60° at $\omega = 10$ rad/sec. An input signal of $r(t) = 5\cos(10t - \pi/2)$ is injected. What is the output signal?
(A) $1.58\cos(20t - 5\pi/6)$ (B) $1.58\cos(10t - \pi/6)$
(C) $1.58\cos(10t + \pi/6)$ (D) None of the answers in (A), (B), and (C) is correct

125. Bode magnitude plot of a system has – 20 dB gain at low frequencies. The system is
(A) type-0 (B) type-1
(C) type-2 (D) Nothing can be deduced about type number from the given information

126. A PI controller $K_P + K_I/s = 100 + 0.01/s$ has a high-frequency gain of 40dB. The values of K_P and K_I that reduce high-frequency gain to 20dB are (calculations based on asymptote plot in Bode coordinates)
(i) (10,0.01) (ii) (10,0.001)
(A) Both the statements are true (B) Statement (i) is true but (ii) is false
(C) Statement (i) is false but (ii) is true (D) Both the statements are false

127. The frequency response of the system $G(s) = e^{-\tau_D s}/s$ at frequency $\omega = \pi/(2\tau_D)$ gives magnitude and phase of
(A) $2\tau_D/\pi$, – 90° (B) $2\tau_D/\pi$, –180°
(C) $2\tau_D/\pi$,0° (D) None of the answers in (A), (B) and (C) is correct

128. A PD controller has transfer function $(0.1 + 0.01s)$. The frequency at which the magnitude is 20dB is (calculations based on asymptotic plot is Bode coordinates)
(A) 10 (B) 1000 (C) 1 (D) 100

129. Frequency response of a system is given in the following table.

Frequency (rad/sec)	*Gain*	*Phase (deg)*
0.1	5	0
1	1.5	– 90
10	0.25	– 180
100	0.1	– 235

Gain margin is
(A) 4 (B) 0.25 (C) 5 (D) 1.5

130. Frequency response of a system is given in the following table.

Frequency (rad/sec)	*Gain*	*Phase (deg)*
1	10	– 50
10	2	– 100
100	1	– 155
1000	0.1	– 235

Phase margin is
(A) – 25° (B) +25° (C) – 55° (D) +55°

131. Nyquist plot and Bode magnitude plot of two systems are given in Fig. Q131.
(A) Both the systems are type-0
(B) Both the systems are type-1
(C) System I is type-0 and system II is type-1
(D) System II is type-0 and system I is type-1

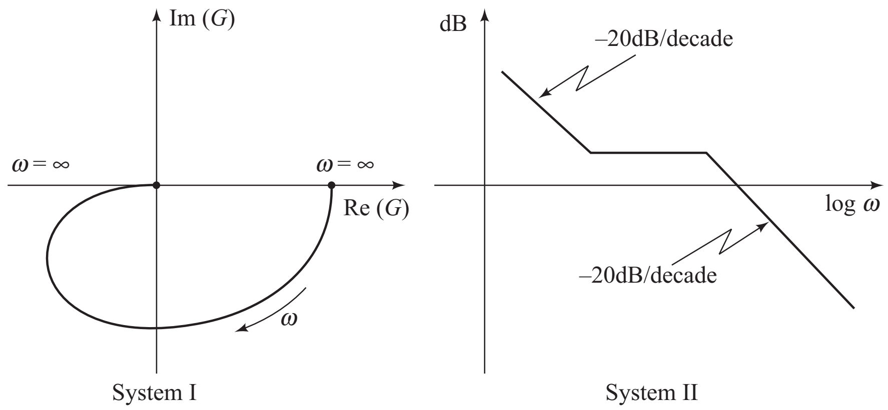


Fig. Q131

132. Consider the following statements for an underdamped second-order system:
(i) Peak overshoot in step-input response reduces as damping is increased from 0.2 to 0.6.
(ii) Resonance peak in frequency response reduces as damping is increased from 0.2 to 0.6.
Which of the following is the correct answer?
(A) None of the above statements is true (B) Statement (i) is true but statement (ii) is false
(C) Statement (i) is false but statement (ii) is true (D) Both the statements are true

133. Undamped natural frequency ω_n and resonance frequency ω_r of a unity feedback system with open-loop transfer function

$$G(s) = \frac{\omega_n^2}{s\left(s+2\zeta\omega_n\right)}\ ;\ \zeta < 1/\sqrt{2}\ ,$$

are related as

(A) $\omega_n = \omega_r$ (B) $\omega_n > \omega_r$

(C) $\omega_n < \omega_r$ (D) None of the answers in (A), (B), and (C) is correct

134. For a unity feedback system with open-loop transfer function $G(s) = \dfrac{\omega_n^2}{s\left(s+2\zeta\omega_n\right)}$, $\zeta < 0.7$;
   (i) phase margin is explicitly indicative of damping ratio;
   (ii) resonance peak is explicitly indicative of damping ratio.
   Which of the following answers is correct?
   (A) None of the above statements is true (B) Statement (i) is true but statement (ii) is false
   (C) Statement (i) is false but statement (ii) is true (D) Both the statements are true
135. Open-loop transfer function of a unity feedback system is $G(s) = K/[s(s+5)]$. The gain K that results in a phase margin of 50° is approximately
   (A) 15 (B) 20 (C) 25 (D) 30
136. Consider a unity-feedback system with open-loop transfer function $G(s) = \dfrac{K}{s(s+1)}$. Increase in gain K will cause:
   (A) the gain crossover frequency to reduce (B) the gain crossover frequency to increase
   (C) the system to respond more slowly (D) None of the statement in (A), (B), and (C) is correct
137. The closed-loop dynamics of a system is of second-order. To improve the damping, we should
   (A) decrease the phase margin (B) increase the phase margin
   (C) decrease the gain margin (D) increase the gain margin
138. The vertical axis of the Nichols chart represents
   (A) open-loop gain (B) open-loop phase (C) closed-loop gain (D) closed-loop phase
139. *M*-Contours on the Nichols chart represent
   (A) open-loop gain (B) open-loop phase (C) closed-loop gain (D) closed-loop phase
140. Consider the following statements
   (i) The resonance peak of the frequency response of $G/(1+G)$ is given by the *M*-contour on the Nichols chart which is tangent to the Nichols plot of G.
   (ii) The resonance peak of the frequency response of $G/(1+G)$ is the peak value of the frequency response of $G/(1+G)$ on Bode magnitude plot.
   (A) Both the statements are true (B) Statement (i) is true but (ii) is false
   (C) Statement (i) is false but (ii) is true (D) Both the statements are false
141. The closed-loop dynamics of a system is of second-order. The resonance peak of the closed-loop frequency response is related to
   (i) overshoot of time response
   (ii) damping ratio
   (A) Both the statements are true (B) Statement (i) is true but (ii) is false
   (C) Statement (i) is false but (ii) is true (D) Both the statements are false
142. The bandwidth of $G/(1+G)$
   (i) is the frequency at which the – 3 dB *M*-contour on Nichols chart intersects the Nichols plot of G.
   (ii) is the frequency at which the Bode magnitude plot of $G/(1+G)$ has a gain of – 3 dB.
   (A) Both the statements are true (B) Statement (i) is true but (ii) is false
   (C) Statement (i) is false but (ii) is true (D) Both the statements are false

143. A unity-feedback system has open-loop transfer function

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

(i) The peak overshoot of step-input response of $G/(1+G)$ is indicative of damping
(ii) The resonance peak of frequency response of $G/(1+G)$ is indicative of damping.
(A) Both the statements are true (B) Statement (i) is true but (ii) is false
(C) Statement (i) is false but (ii) is true (D) Both the statements are false

144. For the system $1/(s^2 + 0.1s + 1)$, the resonance frequency ω_r and natural frequency ω_n are related as
(A) $\omega_r = \omega_n$ (B) $\omega_r > \omega_n$
(C) $\omega_r < \omega_n$ (D) None of the answers in (A), (B), and (C) is correct

145. Maximum phase-lead of the compensator $D(s) = (0.5s + 1)/(0.05s + 1)$, is
(A) 52° at 4 rad/sec (B) 52° at 10 rad/sec
(C) 55° at 12 rad/sec (D) None of the answers in (A), (B), and (C) is correct

146. In control systems
(i) reduction in bandwidth results in sluggish response;
(ii) reduction in bandwidth results in better signal/noise ratio.
Which of the following is the correct answer?
(A) None of the above statements is true
(B) Statement (i) is true but statement (ii) is false
(C) Statement (i) is false but statement (ii) is true
(D) Both the statements are true

147. Consider the following statements:
(i) Lead compensation is suitable for systems having unsatisfactory transient response. It also provides a limited improvement in steady-state response.
(ii) Lag compensation is suitable for systems with satisfactory transient response but unsatisfactory steady-state response.
Which of the following is the correct answer?
(A) None of the statements is true
(B) Statement (i) is true but statement (ii) is false
(C) Statement (i) is false but statement (ii) is true
(D) Both the statements are true

148. Consider the following statements:
(i) The natural frequency ω_n must be large for good performance; however, bandwidth considerations impose a limit on increasing ω_n.
(ii) When design considerations impose a limit on ω_b, a PD compensator with a filter is suitable.
(A) None of the above statments is true (B) Statement (i) is true but statement (ii) is false
(C) Statement (i) is false but statement (ii) is true (D) Both the statements are true

149. Consider the sampled-data system shown in Fig. Q149. Steady-state error for unit-ramp input is
(A) $\frac{1}{KT}$ (B) $\frac{T}{K}$
(C) $\frac{1}{K}$ (D) None of the answers in (A), (B), and (C) is correct

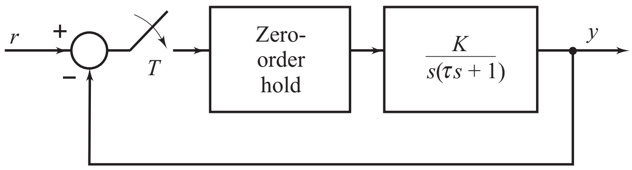


Fig. Q149

150. In a digital control system, selection of a large sampling period
(A) increases the stability margin
(B) decreases the stability margin
(C) has no effect on stability
(D) has an effect on stability that depends on plant parameters

151. In a digital control scheme, selection of a large sampling interval
(A) improves the steady-state performance
(B) deteriorates the steady-state performance
(C) has no effect on steady-state performance
(D) has an effect on steady-state performance that depends on plant parameters

152. In a sampled-data control system, delay introduced by sampling and reconstruction process is approximately equal to
(A) sampling interval
(B) twice the sampling interval
(C) half the sampling interval
(D) None of the answers in (A), (B), and (C) is correct

153. Given a state variable model

$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{b}u$$
$$y = \mathbf{c}\mathbf{x} + du$$

Under the transformation $\mathbf{x} = \mathbf{P}\,\bar{\mathbf{x}}$; $\mathbf{P}$ a constant nonsingular matrix, the model becomes

$$\dot{\bar{\mathbf{x}}} = \bar{\mathbf{A}}\,\bar{\mathbf{x}} + \bar{\mathbf{b}}\,u$$
$$y = \bar{\mathbf{c}}\,\bar{\mathbf{x}} + du$$

(A) $\bar{\mathbf{A}} = \mathbf{PAP}^{-1}$; $\bar{\mathbf{b}} = \mathbf{P}^{-1}\mathbf{b}$; $\bar{\mathbf{c}} = \mathbf{cP}$
(B) $\bar{\mathbf{A}} = \mathbf{P}^{-1}\mathbf{AP}$; $\bar{\mathbf{b}} = \mathbf{P}^{-1}\mathbf{b}$; $\bar{\mathbf{c}} = \mathbf{cP}$
(C) $\bar{\mathbf{A}} = \mathbf{P}^{-1}\mathbf{AP}$; $\bar{\mathbf{b}} = \mathbf{Pb}$; $\bar{\mathbf{c}} = \mathbf{cP}$
(D) $\bar{\mathbf{A}} = \mathbf{P}^{-1}\mathbf{AP}$; $\bar{\mathbf{b}} = \mathbf{Pb}$; $\bar{\mathbf{c}} = \mathbf{cP}^{-1}$

154. A state variable formulation of a system is given by the equations

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u$$
$$y = [1 \quad 0]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

The transfer function of the system is
(A) $\dfrac{1}{(s+1)\,(s+3)}$
(B) $\dfrac{1}{s+1}$
(C) $\dfrac{1}{s+3}$
(D) None of the answers in (A), (B), and (C) is correct

155. A state variable formulation of a system is given by the equations

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & 0 \\ 0 & -3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u;\ x_1(0) = x_2(0) = 0$$
$$y = [1 \quad 0]\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

The response $y(t)$ to unit-step input is
(A) $1 + e^{-t}$
(B) $\dfrac{1}{3}\,(1 - e^{-3t})$
(C) $1 - e^{-t}$
(D) None of the answers in (A), (B), and (C) is correct

156. The eigenvalues of the matrix

$$\mathbf{A} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -3 & -4 \end{bmatrix}$$

are

(A) 0, – 1, – 3 (B) 0, – 3, – 4
(C) 0, 0, – 4 (D) None of the answers in (A), (B), and (C) is correct

157. Given the system

$$\dot{\mathbf{x}} = \begin{bmatrix} 0 & 0 & -20 \\ 1 & 0 & -24 \\ 0 & 1 & -9 \end{bmatrix} \mathbf{x} + \begin{bmatrix} 3 \\ 1 \\ 0 \end{bmatrix} u$$

$$y = [0 \quad 0 \quad 1]\mathbf{x}$$

The characteristic equation of the system is

(A) $s^3 + 20s^2 + 24s + 9 = 0$
(B) $s^3 + 9s^2 + 24s + 20 = 0$
(C) $s^3 + 24s^2 + 9s + 20 = 0$
(D) None of the answers in (A), (B), and (C) is correct

158. A state variable model of a system is given by

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ -2 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = [1 \quad 0] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

The system is

(A) controllable and observable (B) controllable but unobservable
(C) observable but uncontrollable (D) uncontrollable and unobservable

159. The transfer function

$$G(s) = \mathbf{c}(s\mathbf{I} - \mathbf{A})^{-1}\mathbf{b}$$

of the system

$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{b}u$$
$$y = \mathbf{c}\mathbf{x} + du$$

has pole-zero cancellation. The system

(A) is uncontrollable and unobservable (B) is observable but uncontrollable
(C) is controllable but unobservable (D) may be any one of (A), (B), and (C)

160. The transfer function

$$G(s) = \mathbf{c}(s\mathbf{I} - \mathbf{A})^{-1}\mathbf{b}$$

of the system

$$\dot{\mathbf{x}} = \mathbf{A}\mathbf{x} + \mathbf{b}u$$
$$y = \mathbf{c}\mathbf{x} + du$$

has no pole-zero cancellation. The system

(A) is controllable and observable (B) is observable but uncontrollable
(C) is controllable but unobservable (D) may be any one of (A), (B), and (C)

161. Consider the system

$$\mathbf{A} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}; \mathbf{b} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}; \mathbf{c} = [4 \quad 5 \quad 1]$$

The transfer function of the system has pole-zero cancellation. The system is

(A) controllable and observable
(B) uncontrollable and unobservable
(C) controllable but unobservable
(D) observable but uncontrollable

162. Consider the system

$$\mathbf{A} = \begin{bmatrix} 0 & -2 \\ 1 & -3 \end{bmatrix}; \mathbf{b} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}; \mathbf{c} = [0 \quad 1]$$

The transfer function of the system has pole-zero cancellation. The system is

(A) controllable and observable
(B) uncontrollable and unobservable
(C) controllable but unobservable
(D) observable but uncontrollable

163. In a control system design exercise for a marine engine, an engineer is using the state-space framework. The system model is given by

$$\dot{\mathbf{x}} = \begin{bmatrix} 13/6 & 4/3 \\ -4/3 & -7/6 \end{bmatrix}\mathbf{x} + \mathbf{b}u; \mathbf{b} = \begin{bmatrix} 0 \\ 0.5 \end{bmatrix}$$

The engineer decides to experiment with a different method of actuation for the system and this leads to the different input matrix

$$\mathbf{b}_1 = \begin{bmatrix} -1/6 \\ 1/3 \end{bmatrix}$$

(A) Both the systems are controllable
(B) System with input matrix **b** is controllable, and it becomes uncontrollable when **b** is changed to $\mathbf{b}_1$
(C) System with input matrix **b** is uncontrollable and it becomes controllable when **b** is changed to $\mathbf{b}_1$
(D) Both the systems are uncontrollable

164. Given the state variable model {**A**,**b**,**c**} of a single-input, single-output system. The asymptotic stability is determined from

(A) **A**,**b** and **c** matrices
(B) **A** and **b** matrices
(C) **A** and **c** matrices
(D) **A** matrix

Master Key

1. (C)	2. (C)	3. (C)	4. (D)
5. (A)	6. (B)	7. (A)	8. (B)
9. (D)	10. (A)	11. (C)	12. (D)
13. (D)	14. (A)	15. (A)	16. (D)
17. (A)	18. (D)	19. (A)	20. (C)
21. (D)	22. (A)	23. (C)	24. (B)
25. (C)	26. (A)	27. (B)	28. (B)
29. (B)	30. (C)	31. (B)	32. (A)
33. (D)	34. (C)	35. (D)	36. (B)
37. (C)	38. (C)	39. (C)	40. (B)
41. (A)	42. (C)	43. (D)	44. (C)
45. (B)	46. (A)	47. (C)	48. (B)
49. (B)	50. (D)	51. (A)	52. (A)

53. (B)	54. (B)	55. (A)	56. (C)
57. (A)	58. (C)	59. (A)	60. (C)
61. (D)	62. (D)	63. (D)	64. (B)
65. (B)	66. (A)	67. (C)	68. (D)
69. (C)	70. (D)	71. (C)	72. (D)
73. (B)	74. (C)	75. (A)	76. (A)
77. (B)	78. (B)	79. (A)	80. (B)
81. (D)	82. (A)	83. (A)	84. (C)
85. (B)	86. (B)	87. (B)	88. (A)
89. (C)	90. (B)	91. (D)	92. (D)
93. (D)	94. (D)	95. (B)	96. (B)
97. (B)	98. (B)	99. (C)	100. (A)
101. (A)	102. (D)	103. (D)	104. (D)
105. (C)	106. (A)	107. (D)	108. (A)
109. (B)	110. (D)	111. (C)	112. (B)
113. (A)	114. (C)	115. (D)	116. (C)
117. (A)	118. (B)	119. (D)	120. (C)
121. (C)	122. (D)	123. (A)	124. (D)
125. (A)	126. (A)	127. (B)	128. (B)
129. (A)	130. (B)	131. (C)	132. (D)
133. (B)	134. (D)	135. (C)	136. (B)
137. (B)	138. (A)	139. (C)	140. (A)
141. (A)	142. (A)	143. (A)	144. (C)
145. (D)	146. (D)	147. (D)	148. (D)
149. (C)	150. (B)	151. (C)	152. (C)
153. (B)	154. (B)	155. (C)	156. (A)
157. (B)	158. (A)	159. (D)	160. (A)
161. (C)	162. (D)	163. (B)	164. (D)