Control Systems Questions

MCQ Question 1

View this Question Online >

Consider a linear time-invariant system whose input r(t) and output y(t) are related by the following differential equation:

$$\frac{d^2y(t)}{dt^2} + 4y\left(t\right) = 6r\left(t\right)$$

The poles of this system are at

1. +2j, -2j
2. +2, -2
3. +4, -4
4. +4j, -4j

Answer (Detailed Solution Below)

Option 1 : +2j, -2j

Control Systems MCQ Question 1 Detailed Solution

Concept:

A transfer function is defined as the ratio of Laplace transform of the output to the Laplace transform of the input by assuming initial conditions are zero.

TF = L[output]/L[input]

$$TF = \frac{C(s)}{R(s)}$$

For unit impulse input i.e. r(t) = δ(t)

⇒ R(s) = δ(s) = 1

Now transfer function = C(s)

Therefore, the transfer function is also known as the impulse response of the system.

Transfer function = L[IR]

IR = L^{-1} [TF]

Calculation:

Given the differential equation is,

$$\frac{d^2y(t)}{dt^2} + 4y\left(t\right) = 6r\left(t\right)$$

By applying the Laplace transform,

s^2 Y(s) + 4 Y(s) = 6 R(s)

$$\Rightarrow \frac{Y(s)}{R(s)} = \frac{6}{s^2+4}$$

Poles are the roots of the denominator in the transfer function.

⇒ $s^2 + 4 = 0$

⇒ s = ±2j

MCQ Question 2

View this Question Online >

Which of the following methods is the strongest tool to determine the stability and the transient response of the system?

1. Routh- Hurwitz criterion
2. Bode plot
3. Nyquist plot

4. Root locus

Answer (Detailed Solution Below)

Option 4 : Root locus

Control Systems MCQ Question 2 Detailed Solution

- **The root locus is the strongest tool for determining stability and the transient response of the system as it gives the exact pole-zero location and also their effect on the response**
- A Bode plot is a useful tool that shows the gain and phase response of a given LTI system for different frequencies
- The Nyquist plot in addition to providing absolute stability also gives information on the relative stability of stable systems and degree of instability of the unstable system
- Routh-Hurwitz criterion is used to find the range of the gain for stability and gives information regarding the location of poles

MCQ Question 3

View this Question Online >

Let Y(s) be the unit-step response of a causal system having a transfer function $G(s) = \frac{3-s}{(s+1)(s+3)}$

that is, $Y(s) = \frac{G(s)}{s}$**. The forced response of the system is**

1. u(t) – 2e $^{-t}$ + e $^{-3t}$ u(t)
2. 2 u(t) – 2e $^{-t}$ + e $^{-3t}$ u(t)
3. 2u(t)
4. u(t)

Answer (Detailed Solution Below)

Option 4 : u(t)

Control Systems MCQ Question 3 Detailed Solution

Concept:

The output response of a system is equal to the sum of natural response and forced response.

Forced response: The response generated due to the pole of the input function is called the forced response.

Natural response: The response generated due to the pole of system function is called the natural response.

Calculation:

The output y(s) is given as

$$y(s) = \frac{G(s)}{s} = \frac{3-s}{s(s+1)(s+3)}$$

Converting into partial fractions

$$y(s) = \frac{3-s}{s(s+1)(s+3)} = \frac{A}{s} + \frac{B}{(s+1)} + \frac{C}{(s+3)}$$

Multiply whole equation LHS and RHS by s and put s = 0

A = 1

Multiply whole equation by (s + 1) and put s = -1

B = -2

Multiply whose equation by (s + 3) and put s = -3

C = 1

$$y(s) = \frac{1}{s} - \frac{2}{s+1} + \frac{1}{s+3}$$

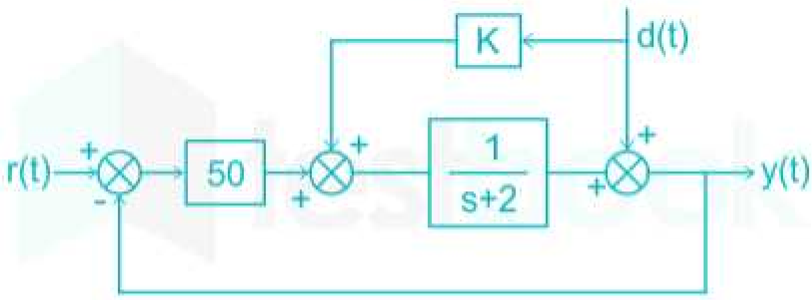
Taking the ILT, we get:

$$y(t) = \underbrace{u(t)}_{\substack{\downarrow \\ \textit{Forced response}}} \underbrace{- 2e^{-t}u(t) + e^{-3t}u(t)}_{\substack{\downarrow \\ \textit{Transient response}}}$$

MCQ Question 4

View this Question Online >

Consider the control system shown in figure with feed forward action for rejection of a measurable disturbance d(t). The value of k, for which the disturbance response at the output y(t) is zero mean, is



1. 1

2. -1

3. 2

4. -2

Answer (Detailed Solution Below)

Option 4 : -2

Control Systems MCQ Question 4 Detailed Solution

$$Y(s) = [-50\,Y(s) + K\,D(s)]\frac{1}{s+2} + D(s)$$

$$Y(s)\left[1 + \frac{50}{s+2}\right] = \left[\frac{K}{s+2} + 1\right]D(s)$$

$$\Rightarrow Y(s) = \frac{K+s+2}{s+52}D(s)$$

$$\Rightarrow Y(j\omega) = \frac{K+2+j\omega}{52+j\omega}D(j\omega)$$

The disturbance response at the output y(t) is zero mean.

At ω = 0, Y(j0) = 0

$$\Rightarrow \frac{K+2+0}{52+0} = 0$$

⇒ K = -2

MCQ Question 5

View this Question Online >

An open loop system represented by the transfer function $G(s) = \frac{(s-1)}{(s+2)(s+3)}$ **is**

1. Stable and of the minimum phase type
2. Stable and of the non-minimum phase type
3. Unstable and the minimum phase type
4. Unstable and of the non-minimum phase type

Answer (Detailed Solution Below)

Option 2 : Stable and of the non-minimum phase type

Control Systems MCQ Question 5 Detailed Solution

Concept:

Minimum phase system: It is a system in which poles and zeros will not lie on the right side of the s-plane. In particular, zeros will not lie on the right side of the s-plane.

For a minimum phase system,

$$\lim_{\omega \to \infty} \angle G(s)H(s) = (P - Z)(-90^\circ)$$

Where P & Z are finite no. of poles and zeros of G(s)H(s)

Non-minimum phase system: It is a system in which some of the poles and zeros may lie on the right side of the s-plane. In particular, zeros lie on the right side of the s-plane.

Stable system: A system is said to be stable if all the poles lie on the left side of the s-plane.

Application:

$$G(s) = \frac{(s-1)}{(s+2)(s+3)}$$

As one zero lies in the right side of the s-plane, it is a non-minimum phase transfer function.

As there no poles on the right side of the s-plane, it is a stable system.

MCQ Question 6

View this Question Online >

The steady-state error due to unit step input to a type-1 system is:

1. 1/ (1 + kp)
2. Zero
3. 1/ Kp
4. Infinity

Answer (Detailed Solution Below)

Option 2 : Zero

Control Systems MCQ Question 6 Detailed Solution

Concept:

K_p = position error constant = $\lim_{s\to 0} G(s)H(s)$

K_v = velocity error constant = $\lim_{s\to 0} sG(s)H(s)$

K_a = acceleration error constant = $\lim_{s\to 0} s^2G(s)H(s)$

Steady-state error for different inputs is given by

Input	Type -0	Type - 1	Type -2
Unit step	$\frac{1}{1+K_p}$	0	0
Unit ramp	∞	$\frac{1}{K_v}$	0
Unit parabolic	∞	∞	$\frac{1}{K_a}$

From the above table, it is clear that for type – 1 system, a **system shows zero steady-state error for step-input.**

MCQ Question 7 View this Question Online >

The open loop DC gain of a unity negative feedback system with closed-loop transfer function $\frac{s+4}{s^2+7s+13}$ is

1. 4/13
2. 4/9
3. 4
4. 13

Answer (Detailed Solution Below)

Option 2 : 4/9

Control Systems MCQ Question 7 Detailed Solution

Concept:

Closed-loop transfer function = $\frac{G(s)}{1+G(s)H(s)}$

For unity negative feedback system Open-loop transfer function (G(s) H(s)) can be found by subtracting the numerator term from the denominator term

Application:

Open-loop transfer Function

$= \frac{s+4}{s^2+7s+13-s-4} = \frac{s+4}{s^2+6s+9}$

For DC gain s = 0

$\therefore$ open-loop gain $= \frac{4}{9}$

MCQ Question 8

View this Question Online >

A second-order real system has the following properties:
The damping ratio $\xi = 0.5$ and undamped natural frequency $\omega_n = 10\ rad/s$, the steady state value at zero is 1.02.
The transfer function of the system is

1. $\frac{1.02}{s^2+5s+100}$
2. $\frac{102}{s^2+10s+100}$
3. $\frac{100}{s^2+10s+100}$
4. $\frac{102}{s^2+5s+100}$

Answer (Detailed Solution Below)

Option 2 : $\frac{102}{s^2+10s+100}$

Control Systems MCQ Question 8 Detailed Solution

Standard 2nd order system is $\mathrm{T}(\mathrm{s}) = \frac{\mathrm{K}\omega_n^2}{\mathrm{s}^2+2\xi\omega_n \mathrm{s}+\omega_n^2}$

Given $\xi = 0.5 \text{ and } \omega_n = 10$

Steady state value $\mathrm{T}(\mathrm{s})|_{\mathrm{s}=0} = \mathrm{K} = 1.02$

$\therefore \mathrm{T}(\mathrm{s}) = \frac{(1.02)(100)}{\mathrm{s}^2+10\mathrm{s}+100} = \frac{102}{\mathrm{s}^2+10\mathrm{s}+100}$

MCQ Question 9

View this Question Online >

Settling time is the time required for the system response to settle within a certain percentage of

1. maximum value
2. final value
3. input amplitude value
4. transient error value

Answer (Detailed Solution Below)

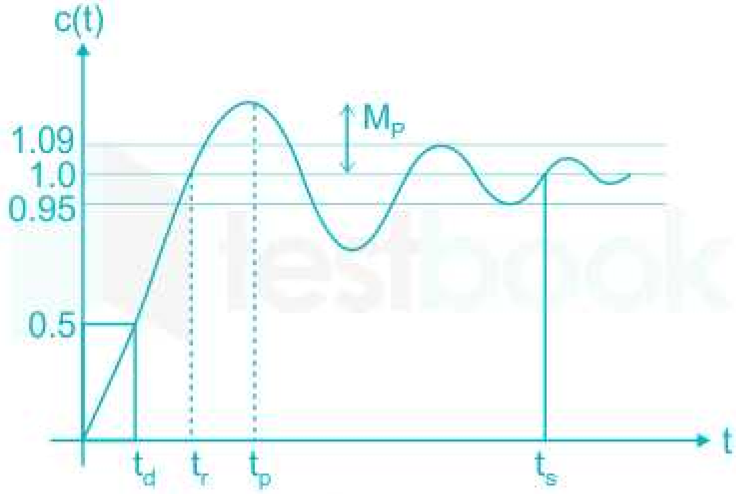
Option 2 : final value

Control Systems MCQ Question 9 Detailed Solution

Settling time:

It is the time required for the response to reach the **steady-state (or) final value** and stay within the specific tolerance bands around the **final value.**

This is explained with the help of the following:



The settling time for 5% tolerance band is given by:

$t_s = \frac{3}{\zeta\omega_n} = 3T$

Similarly, for 2% tolerance, the settling time is given by:

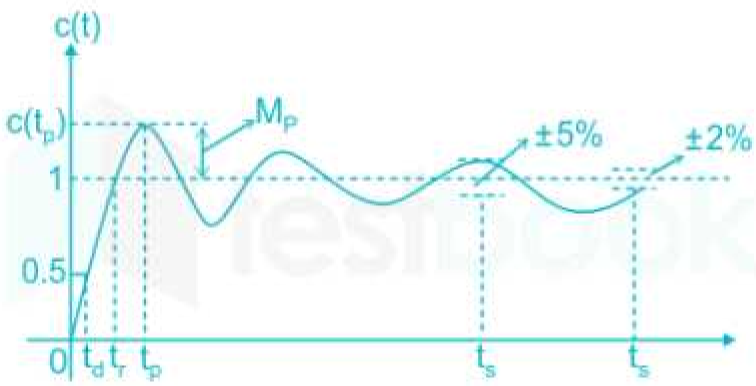
$t_s = \frac{4}{\zeta\omega_n} = 4T$

ζ = Damping ratio

ω_n = Natural frequency

Important Point

Time-domain specification (or) transient response parameters:



Rise time (t_r): It is the time taken by the response to reach from 0% to 100% Generally 10% to 9% for overdamped and 5% to 95% for the critically damped system is defined.

$c(t)|_{t=t_r} = 1 = 1 - \frac{e^{-\xi\omega_n t_r}}{\sqrt{1-\xi^2}} \sin(\omega_n t_r + \varphi)$

$t_r = \frac{\pi - \varphi}{\omega_d}$

Peak Time (t_p): It is the time taken by the response to reach the maximum value.

$\frac{dc(t)}{dt}\Big|_{t=t_p} = 0, t_p = \frac{\pi}{\omega_d}$

Delay time (t_d): It is the time taken by the response to change from 0 to 50% of its final or steady-state value.

$$c(t)|_{t=t_d} = 0.5$$

$$t_d \simeq \frac{1+0.7\xi}{\omega_n}$$

Maximum (or) Peak overshoot (M_p): It is the maximum error at the output.

$$M_p = c(t_p) - 1,\ M_p = e^{\left(\frac{-\xi\pi}{\sqrt{1-\xi^2}}\right)}$$

$$\%M_p = \frac{c(t_p)-c(\infty)}{c(\infty)} \times 100\%$$

If the magnitude of the input is doubled, then the steady-state value doubles, therefore M_p doubles, but $\% M_p$, t_r, t_p remains constant.

MCQ Question 10 View this Question Online >

A closed loop system has the characteristic equation given by $s^3 + Ks^2 + (K + 2)s + 3 = 0$. For this system to be stable, which one of the following conditions should be satisfied?

1. $0 < K < 0.5$
2. $0.5 < K < 1$
3. $0 < K < 1$
4. $K > 1$

Answer (Detailed Solution Below)

Option 4 : $K > 1$

Control Systems MCQ Question 10 Detailed Solution

Given that characteristic equation is,

$s^3 + Ks^2 + (K + 2)s + 3 = 0$

$$\begin{array}{lll} s^3 & 1 & (K+2) \\ s^2 & k & 3 \\ s^1 & \frac{K(K+2)-3}{K} & 0 \\ s^0 & 3 & \end{array}$$

For system to be stable,

$K > 0, K (K + 2) - 3 > 0$

$\Rightarrow K > 0, K^2 + 2K - 3 > 0$

$\Rightarrow K > 0, (K + 3) (K - 1) > 0$

$\Rightarrow K > 0, K > -3, K > 1 \Rightarrow K > 1$