MSMF GATE CENTRE

Subject: Control Systems

Time response analysis

Time: 30 min **Marks= 15**

1) $TF = \frac{20}{(S+1)(S+10)}$ The approximated TF is

(a) $\frac{20}{(S+1)}$ (b) ∞

(c) $\frac{2}{(S+10)}$ (d) $\frac{2}{(S+1)}$

2) $TF = \frac{20}{(S+1)(S-10)}$

The steady state value to an impulse input is

(a) 20 (b) -2

(c) ∞ (d) 0

3) If the transfer function of a control system is $T(s) = \frac{50}{(s^2+4)^2(s+2)^2(s+4)}$ initial value to a step input is

(a) 50 (b) 0

(c) ∞ (d) none of the above

4) Dominant pole is a

(a) fast pole

(b) slow pole

(c) insignificant pole

(d) a pole with large real part

5) Open loop TF of an unity feedback system is $\frac{20}{S^2(S+1)}$ the steady state error to a step input is

(a) 0 (b) 2

(c) 1 (d) none of the above

6) $TF = \frac{80}{(S+4)(S+10)}$ the peak overshoot to a step input is

(a) Mp (b) 2Mp

(c) 4Mp (d)none of the above

where $Mp = e^{-\left(\frac{\zeta\pi}{\sqrt{1-\zeta^2}}\right)}$

7) Impulse response of a system is $(4e^{-2t} + 6e^{-20t})u(t)$,the approximate settling time to reach 95% of response to a step input is

(a) 1.5sec (b) 3sec

(c) 6sec (d) 10sec

8) $CLTF = \frac{10(s+2)}{s^2+s+1}$

With respect to the above system consider the following statements

1. Steady state error to a step input is non zero.

2. In the steady state, response contains damped sinusoidal oscillations with damping ratio 0.5
3. steady state value to a step input is 20.

of the above the true statement(s) is/are

(a) 1,2 (b) 2,3
(c) 1 (d) 3,1

9) The velocity error coefficient of a system is 10, now the type of system is increased by one, then the steady state error to a parabolic input is

a) 0 (b) 0.1
c) 20 (d) none

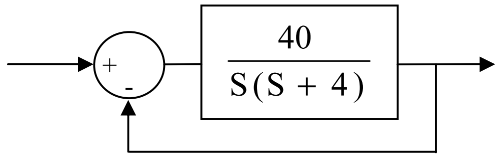
10) The position error coefficient of a system is 10, now the type of system is increased by one, then the steady state error to a ramp input is

a) 0 (b) 0.1
c) 20 (d) none

11) Choose the correct statement from the following

(a) Time response is decided by slow and fast poles
(b) Transient response is decided by fast poles
(c) Steady state response is decided by fast poles
(d) Steady state response is decided by dominant poles

Linked data questions 12 and 13



12) The damping ratio of the above system, if a step of two units is applied is

(a) 0.32 (b) 0.56
(c) 1.34 (d) 1.5

13) The peak overshoot of the above system to a step of two is

(a) 25% (b) 62%
(c) 50% (d) 31%

Common data questions 14 and 15

1) $TF = \frac{2000}{(S+20)(S+200)}$

2) $TF = \frac{200}{(S+10)(S+2)^2}$

3) $TF = \frac{40(s+4)}{(S+20)(S+1)}$

4) $TF = \frac{200(S+1)}{(S-1)(S+50)}$

14) Among the above the fastest system is

(a) 1 (b) 2
(c) 3 (d) 4

15) The steady state gain of the slowest system is

(a) 0.5 (b) 5
(c) 8 (d) -4

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(Solutions)

1. **Ans: (d)**
   Sol:

   $$TF = \frac{20}{(S+1)(S+10)}$$

   $$\text{Steady state gain} = \frac{20}{(1)(10)} = 2$$

Without change in steady state gain neglecting the fast pole, S = –10

the TF is $\frac{2}{2+1}$

$$\text{Now also steady state gain} = \frac{2}{(1)} = 2$$

2. **Ans: (c)**
   Sol:

   $$TF = \frac{20}{(S+1)(S-10)} \text{ unstable system}$$

   ∴ For any input output is '∞'

3. **Ans: (b)**
   Sol:

$$C(s) = \frac{50}{(s^2+4)^2(s+2)^2(s+4)} R(s)\Bigg|_{R(s)=\frac{1}{s}(\text{step input})}$$

$$\text{Initial value}=C(0) = \underset{s\to\infty}{Lt}$$

$$S\,\frac{50}{(s^2+4)^2\,(s+2)^2\,(s+4)}\,\frac{1}{s} = 0$$

4. **Ans: (b)**
   Sol:
   Dominant poles are nearer to the imaginary axis and dominates the transient response . Their time constant is large hence they are called as slow poles.

$$\text{E.g. } TF = \frac{10}{(s+1)(s+10)}$$

s = –1, T = 1sec (slow pole)
s = –10, T = 0.1 sec (fast pole)

5. **Ans: (d)**
Sol:

$$\text{OLTF} = \frac{20}{s^2(s+1)}$$

Characteristics equation is

$$S^3 + S^2 + 20 = 0$$

Unstable system as there is a missing coefficient

∴ Steady state error is '∞' or unbounded

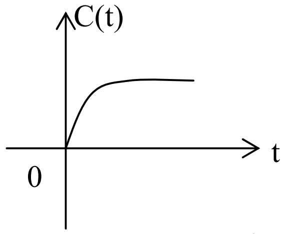
6. **Ans: (d)**
Sol:

$$\text{T F} = \frac{80}{(s+4)(s+10)}$$

System is over damped, as the poles are real & unequal

∴ Overshoot does not exist

Response is shown below



7. **Ans: (a)**
Sol:

IR = $(e^{-2t} + 6\,e^{-20t})\mu(t)$

Poles are –2 & –20

Settling time is determined by the slow pole, S = –2, Time constant is $\frac{1}{2}$ sec

To reach is 95% system takes 3T = $3\frac{1}{2}$ = 1.5 sec

8. **Ans: (d)**
Sol:

Sol. $\text{OLTT} = \frac{10(s+2)}{s^2+5s+1}$

$$C(\infty) = \frac{10(2)}{(1)} = 20$$

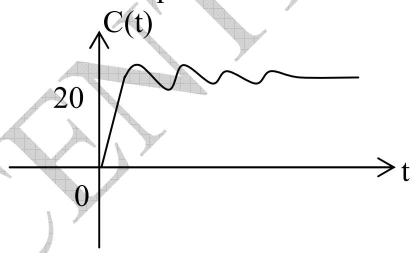
Input = 1 (step)

∴ Error 1 – 20 = – 19

Error is non zero

& steady state value = 20

In the steady state there are no oscillations in the response



9. **Ans: (d)**
Sol:

It depends on the OLTF

Let $\text{OLTF} = \frac{10(s+1)}{s}$ & H (s) = 1

$K_v = 10$

And the type increased by one

$\text{OLTF} = \frac{10(s+1)}{s^2}$ & H(s) = 1

Now $K_a = 10$ error = 0.1

but if OLTF $\frac{10}{s(s+1)}$ & H(s) = 1

$K_v = 10$

And if the type increased by one

$\text{OLTF} = \frac{10}{s^2(s+1)}$ & H(s) =1

System becomes unstable error can't be determined.

∴ It can't be decided

10. **Ans: (b)**

Sol:

If OLTF = $\frac{10}{(s+1)}$ & H(s) = 1

$K_p = 10$

If the type is increased by one

OLTF = $\frac{10}{s(s+1)}$ & H (1) = 1

$K_v = 10$

Error = $\frac{1}{10} = 0.1$

11. **Ans: (a)**

Sol:

Time response = Transient +steady state response, transient response is decided by slow poles and steady state response is decided by slow & fast poles

12. **Ans: (a)**

Sol:

OLTF = $\frac{40}{S(S+4)}$

Characteristics equation is

$S^2 + 4S + 40 = 0$

$\omega_n^2 = 40$

$\omega_n = \sqrt{40}$

$2\xi\omega_n = 4$

$\xi = \frac{4}{2\sqrt{40}} = 0.32$

13. **Ans: (d)**

Sol:

$M_p = 2\ e\left(\frac{\xi \Pi}{\sqrt{1-\xi^2}}\right) = 0.62$

$\therefore$ % M_p = 31%

14. **Ans: (a)**

Sol:

TF= $\frac{2000}{(s+20)(s+200)}$

The poles one very far from the jω axis, therefore system is faster

$\therefore$ (Time constant is short $\frac{1}{20}$ & $\frac{1}{200}$)

15. **Ans: (c)**

Sol:

$T_F = \frac{40(s+4)}{(s+20)(s+1)}$

Pole S = –1 is very nearest

$\therefore$ System is slowest

Steady state gain or DC gain

$\left.\right|_{s=0} = \frac{(40)(4)}{(20)(1)} = 8$