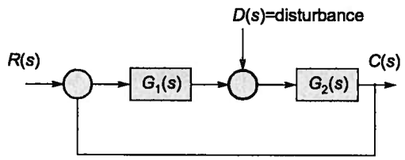
2 Time Response Analysis

Multiple Choice Questions

Q.1 For the given system, how can be steady state error produced by step disturbance be reduced?



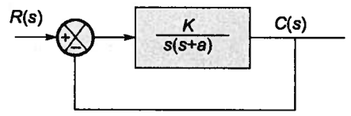
(a) By increasing dc gain of $G_1(s)G_2(s)$
(b) By increasing dc gain of $G_2(s)$
(c) By increasing dc gain of $G_1(s)$
(d) By removing the feedback **[ESE-2005]**

Q.2 A ramp input applied to an unity feedback system results in 5% steady state error. The type number and zero frequency gain of the system are respectively
(a) 1 and 20 (b) 0 and 20
(c) 0 and $\frac{1}{20}$ (d) 1 and $\frac{1}{20}$
[GATE-2005]

Q.3 Which one of the following is the steady state error of a control system with step error, ramp error and parabolic error constants k_p, k_v and k_a respectively for the input $(1 - t^2)\,3u(t)$?
(a) $\frac{3}{1+k_p} - \frac{3}{2k_a}$ (b) $\frac{3}{1+k_p} + \frac{6}{2k_a}$
(c) $\frac{3}{1+k_p} - \frac{3}{k_a}$ (d) $\frac{3}{1+k_p} - \frac{6}{k_a}$
[ESE-2005]

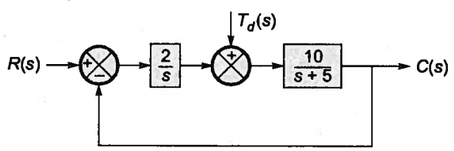
Q.4 A particular control system yielded a steady-state error of 0.20 for unit step input. A unit integrator is cascaded to this system and unit ramp input is applied to this modified system. What is the value of steady-state error for this modified system?
(a) 0.10 (b) 0.15
(c) 0.20 (d) 0.25
[ESE-2006]

Q.5 Consider the unity feedback system as shown below. The sensitivity of the steady state error to change in parameter K and parameter a with ramp inputs are respectively



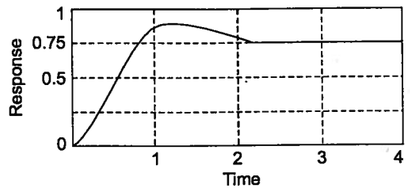
(a) 1, –1 (b) –1, 1
(c) 1, 0 (d) 0, 1
[ESE-2003]

Q.6 The steady state error when the torque (T_d) changes at a rate of 2 N-m/sec, will be _____.



(a) 0.5 units (b) 0.75 units
(c) 1 unit (d) 1.25 units

Q.7 The unit-step response of a unity feedback system with open loop transfer function $G(s) = K/((s + 1)(s + 2))$ is shown in the figure. The value of K is



(a) 0.5 (b) 2
(c) 4 (d) 6

Q.8 The transfer function of a system is $G(s) = \frac{100}{(s+1)(s+100)}$. For a unit-step input to the system the approximate settling time for 2% criterion is
(a) 100 sec (b) 4 sec
(c) 1 sec (d) 0.01 sec
[GATE-2002]

Q.9 A linear network has the system function

$$H\frac{(s+c)}{(s+a)(s+b)}$$

The outputs of the network with zero initial conditions for two different inputs are tabled as

Input $x(t)$	Output $y(t)$
$u(t)$	$2+De^{-t}+Ee^{-3t}$
$e^{-2t}\,u(t)$	$Fe^{-t}+Ge^{-3t}$

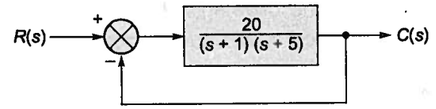
Then the values of c and H are, respectively
(a) 2 and 3 (b) 3 and 2
(c) 2 and 2 (d) 1 and 3
[ESE-2005]

Q.10 A second order system has a transfer function

$$\frac{16}{s^2+4s+16}$$

The time for second overshoot is
(a) $\frac{\pi}{2\sqrt{3}}$ secs. (b) $\frac{1.5\pi}{2\sqrt{3}}$ secs.
(c) $\frac{\pi}{\sqrt{3}}$ secs. (d) $\frac{1.5\pi}{\sqrt{3}}$ secs.

Q.11 The block diagram of a unity feedback control system is shown below:



Determine the time at which first undershoot occurs.
(a) 0.78 sec (b) 2.69 sec
(c) 3.14 sec (d) 1.56 sec

Q.12 A system described by the following differential equation $\frac{d^2y}{dt^2}+3\frac{dy}{dt}+2y = x(t)$ is initially at rest. For input $x(t) = 2u(t)$, the output $y(t)$ is
(a) $(1 - 2e^{-t} + e^{-2t})\,u(t)$
(b) $(1 + 2e^{-t} - 2e^{-2t})\,u(t)$
(c) $(0.5 + e^{-t} + 1.5e^{-2t})\,u(t)$
(d) $(0.5 + 2e^{-t} + 2e^{-2t})\,u(t)$ **[GATE-2004]**

Q.13 A second order control system is defined by the following differential equation :

$$4\frac{d^2c(t)}{dt^2}+8\frac{dc(t)}{dt}+16c(t) = 16u(t)$$

The damping ratio and natural frequency for this system are respectively
(a) 0.25 and 2 rad/s
(b) 0.50 and 2 rad/s
(c) 0.25 and 4 rad/s
(d) 0.50 and 4 rad/s **[ESE-2001]**

Q.14 A position control system having u.f.b. has

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

(*i*) The minimum value of amplifier gain 'K' so that when the input shaft rotates at 1/2 rps the steady state error is less than 0.2° will be
(a) $K = 60$ (b) $K = 70$
(c) $K = 80$ (d) $K = 90$

(*ii*) With above value of 'K' the damping ratio and natural frequency of oscillations are
(a) $g = 0.05$, $\omega_n = 95\ r/s$ (b) $g = 0.05$, $\omega_n = 85\ r/s$
(c) $g = 0.02$, $\omega_n = 95\ r/s$ (d) $g = 0.02$, $\omega_n = 85\ r/s$

Q.15 The unit step response of a second order system is $= 1 - e^{-5t} - 5t\,e^{-5t}$

Consider the following statements:

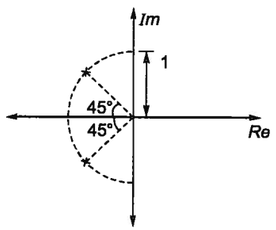
1. The undamped natural frequency is 5 rad/s.
2. The damping ratio is 1.
3. The impulse response is $25te^{-5t}$

Which of the statements given above are correct?

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

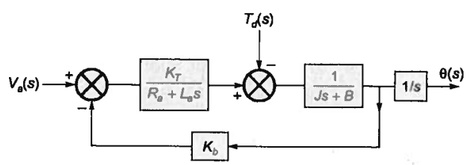
[ESE-2006]

Q.16 A transducer has 2 poles as shown is the figure. The zeros are at infinity. The steady state output of transducer for unit step input will be



(a) 1 (b) $\frac{1}{\sqrt{2}}$
(c) $\sqrt{2}$ (d) 0

Q.17 The position control of a DC servo-motor is given in the figure. The values of the parameters are K_T = 1 N-m A, R_a = 1 Ω, L_a = 0.1 H. J = 5 kg-m^2, B = 1 N-m (rad/sec) and K_b = 1 V/(rad/sec). The steady-state position response (in radians) due to unit impulse disturbance torque T_d is _____.



(a) 0.5 (b) –0.5
(c) 1 (d) –1 **[GATE-2015]**

Q.18 The characteristic equation of a control system is $s(s^2 + 6s + 13) + k = 0$. The value of 'k' such that the characteristic equation has a pair of complex roots with real part –1 will be

(a) 10 (b) 20
(c) 30 (d) 40

Q.19 The transfer function of a control system is

$$T(s) = \frac{10}{(s+5)(s^2+s+1)}$$

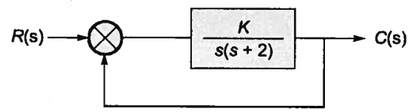
The II order approximation using dominant pole concept is

(a) $\frac{2}{s^2+s+1}$ (b) $\frac{2}{(s+5)(s+1)}$
(c) $\frac{10}{s^2+s+1}$ (d) $\frac{10}{(s+5)(s+1)}$

Numerical Data Type Questions

Q.20 The steady state error is_____ for an input of $r(t) = 2 + 3t + 4t^2$ for the given system

Q.21 The block diagram of control system is shown in figure



The ratio of output frequencies for K = 32 and K = 16 would be for unit step input_____.

Q.22 A causal system having the transfer function

$H(s) = \frac{1}{s+2}$ is excited with $10u(t)$. _____sec.

time at which the output reaches 99% of its steady state value is

[GATE-2004]

Q.23 The open loop transfer function of a unity feedback control system is given by

$G(s) = \frac{k}{s(s+1)}$. If gain k is increased to infinity,

then damping ratio will tend to become_____.

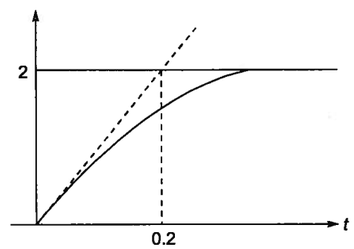
[ESE-2005]

Q.24 The closed-loop transfer function of a system is

$T(s) = \frac{4}{(s^2+0.4s+4)}$. The steady state error due to unit step input is _____.

[GATE-2014]

Q.25 The step response of a system having transfer function $H(s) = \frac{K}{s+A}$ is shown in figure



The value of 'K' and 'A' are _____ and _____.

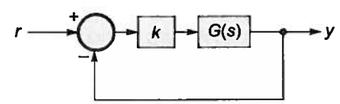
Q.26 A unity negative feedback system has an open-loop transfer function $G(s) = \frac{K}{s(s+10)}$. the gain K for the system to have a damping ratio of 0.25 is _____.

[GATE-2015]

Q.27 In the feedback system shown below

$G(s) = \frac{1}{(s^2+2s)}$.

The step response of the closed-loop system should have minimum settling time and have no overshoot.



The required value of gain k to achieve this is____.

[GATE-2016]

Try Yourself

T1. A unity feedback system has the open-loop transfer function $G(s) = \frac{K}{s(s+p)}$.

Determine the values of K and p so that the settling time and peak overshoot will be 4 seconds and 10% respectively. Take ±2% of the steady-state value definition for settling time.

[Ans: p = 2, K = 2.85]

T2. A control system is defined by the following mathematical relationship

$$\frac{d^2x}{dt^2} + 6\frac{dx}{dt} + 5x = 12(1 - e^{-2t})$$

The response $x(t)$ of the system as $t \to \infty$ is _____

[Ans: 2.4]

T3. The unit step response of a system is given below

$$c(t) = 1 + 0.2e^{-60t} - 1.2e^{-10t}$$

The damping ratio (ξ) of the system is _____

[Ans: 1.43]

T4. Transfer function of a control system is

$$T(s) = \frac{14.45}{(s^2+1.204s+2.829)(s+5)}$$

The peak time for the unit step response is _____ sec.

[Ans: 2]