Total number of printed pages: **Programme(UG)/5TH SEM/UECE502**

2024

Control System (UECE502)

Full Marks : 100 Time : Three hours

*Answer Q1 and **any four** questions from the rest.*

1.A) Select the correct alternatives (1x10)

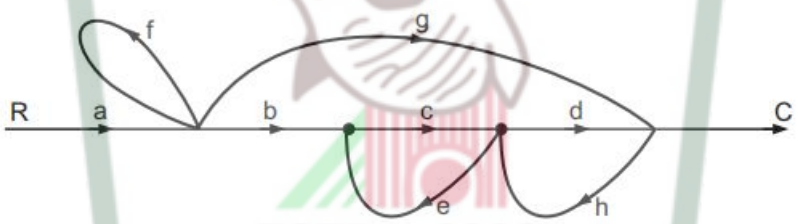
i) The value of function $F(s)=\frac{2}{s^2+3}$ **at t=0+**

(a) 3 (b) 2 (c) 3/2 (d) 0

ii) For the system $\frac{C(s)}{R(s)}=\frac{25}{s^2+6s+25}$**, the damping factor and the natural frequency are**

(a) 0.6 and 5 rad/sec (b) 0.4 and 4 rad/sec (c) 0.5 and 3 rad/sec (d) 0.3 and 5 rad/sec Respectively.

iii) The graph determinant for the signal flow graph shown below is :



(a) $\Delta = -f - ce - dh$ (b) $\Delta = 1 + f + ce + dh + fce + fdh$

(c) $\Delta = 1 - f - ce - dh$ (c) $\Delta = 1 - f - ce - dh + fce + fdh$

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

(a) $\frac{1}{(s+1)^2}$ (b) $\frac{1}{s(s+1)^2}$

(c) $\frac{s}{(s+1)^2}$ (d) $\frac{1}{s(s+1)}$

v) **The forward path transfer function of a unit feedback control system is given by** $G(s)=\frac{20}{s^2+3s+60}$**. The steady state error to unit step input is**

(a) 0 (b) 1
(c) 0.75 (d) ∞

Vi) **With the increase of type of a system the steady state error for a particular input function**

(a) Increases (b) decreases (c) remains changed (d) first increases then decreases.

Vii) **A second order control system with ξ=0 is always**

(a) marginally stable (b) stable
(c) unstable (d) none of these

Viii) **The value of K at which the root locus crosses the imaginary axis makes the system**

(a) stable (b) underdamped
(c) marginally stable (d) unstable

Ix) **The transfer function of an integral compensator is given by 3.**

(a) $\frac{1}{s}$ (b) $\frac{1}{s^2}$
(c) $\frac{K}{s}$ (d) Ks

X) **A system is described by** $\dot{X} = AX + Bu$ **. The controllability test matrix is given by**

(a) ... : $\mathbf{A^2B : AB : B}$ (b) $\mathbf{B : AB : A^2B : ...}$
(c) $\mathbf{B : BA : BA^2}$: ... (d) ... $\mathbf{BA^2 : BA : B}$

1.B) Answer all short answer type questions below:

i) The close loop transfer function is given below:

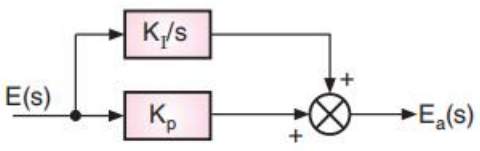
$$\frac{C(s)}{R(s)} = \frac{25}{s^2 + 4s + 25}$$

determine ω_n and ξ.

ii) If damping ratio is increased, how will it affect the settling time?

iii) Obtain the transfer function for the following PI controller.

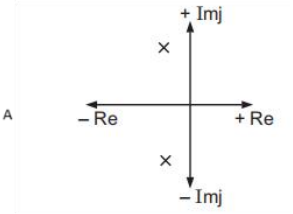
‘

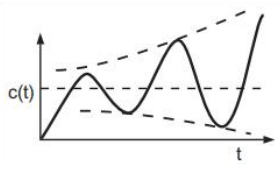


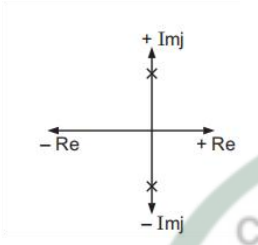
4

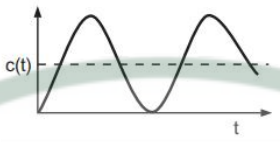
iv) Define Gain and phase margin

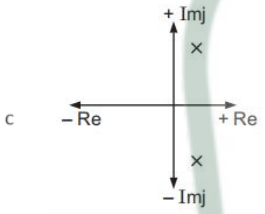
v) Match the following

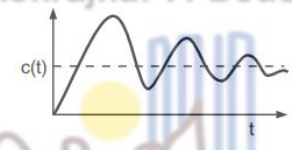
A 

i 

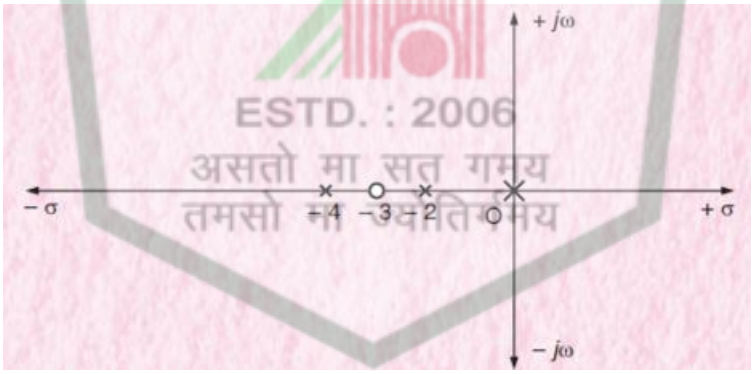
B 

ii 

C 

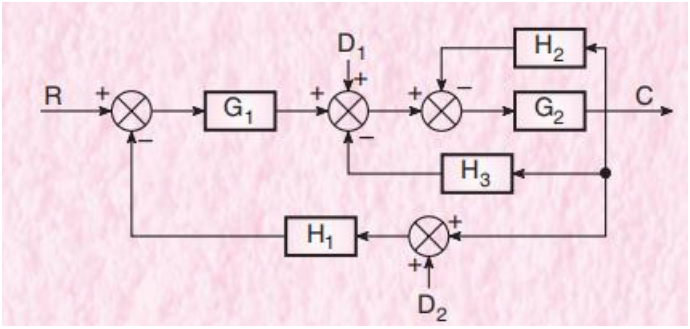
iii 

2. (a) The pole-zero configuration of a transfer function is given below:
5



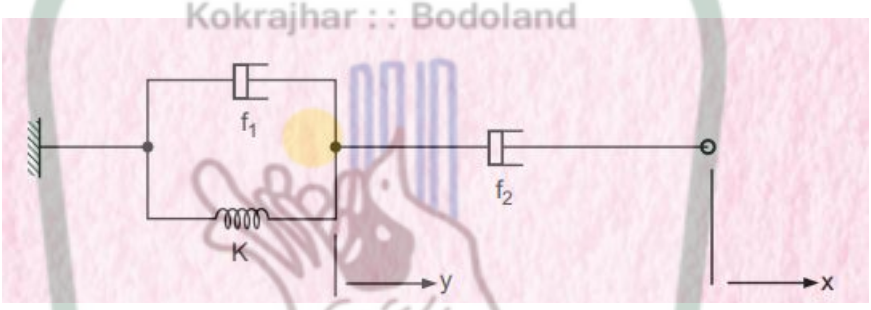
The value of the transfer function at s=1 is found to be 3.2. Determine the transfer function and gain factor K.

2(b) Draw the signal flow graph from the following block diagram



Calculate its transfer function $\frac{C(s)}{R(s)}$ using Masson's gain formula. 10

2.(c) Find the transfer function relating displacements y and x for the mechanical system shown in the following figure. 5



3. (a) Derive the expressions of the following terminologies in a second order underdamped control system

I) Damped frequency

II) Expression of output signal in time domain

III) Rise time

IV) Settling time 12

(b) Explain how the damping constant is affected in derivative feedback control system.

Show that for a derivative feedback $\zeta' = \zeta \frac{\omega_n K_t}{2}$. Where symbols have their usual meanings.

4.(a) The open loop transfer function of a unity feedback system is given by

$$G(s) = \frac{K}{s(sT_1+1)(sT_2+1)}$$

Applying Routh-Hurwitz criterion determine the value of K in term of T_1 and T_2 for the system to be stable. 10

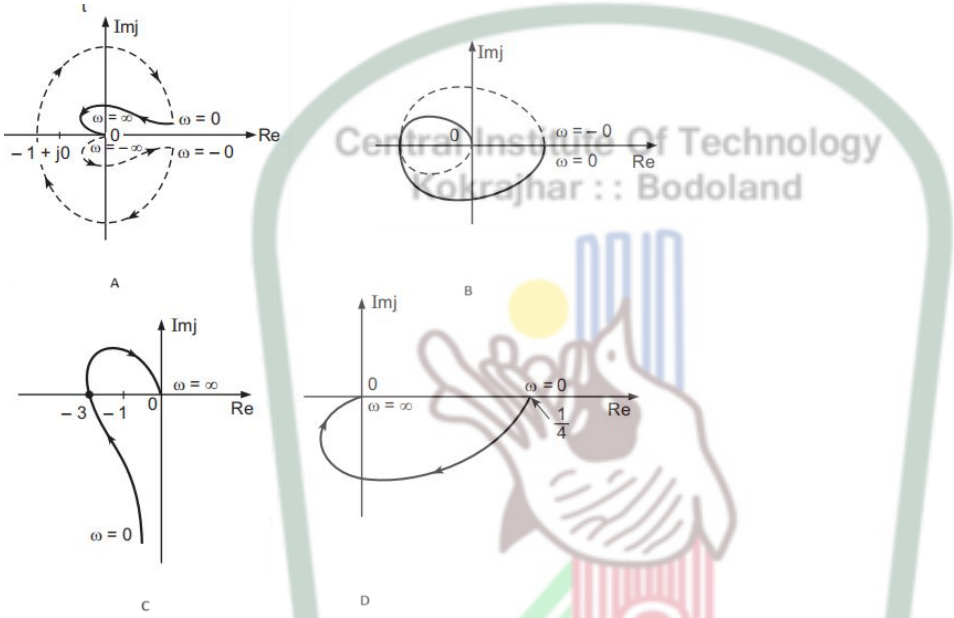
4,(b) The open loop gain of a closed-loop system is given by

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

Find the range of values of K for which the system if stable, marginally stable and unstable. 5

4.(c) Explain with suitable example number of encirclement of (-1+j0) in a nyquist plot. How it is estimated. What is the condition of stability in a Nyquist plot .

5(a) Find out number of poles from the following Nyquist plots. Assume there is no zero in the open loop transer function. Discuss which are stable control system. (3x4)



5(b) Define Gain and phase margin. How can we estimate it from a Nyquist plot. Explain with example 8

6(a) Draw the Bode plot for the following open loop transfer function

$$G(s)H(s)=\frac{K}{s(1+.1s)(1+s)}$$

Determine the value of gain K when a) The gain is 15dB and b) The phase margin of 60^o (10)

6.(b) The open-loop transfer function of a control system is given by

$$G(s)H(s)=\frac{K}{s(s+6)(s^2+6s+13)}$$

Sketch the root locus and determine

i) the breakaway point ii) the angle of departure from the complex poles and (4+6)

7(a). A second order control system s characterized by the differential equation

$$a\frac{d^2x(t)}{dt^2} + b\frac{dx(t)}{dt} + cx(t) = u(t)$$

Find its state-space representation. (8)

7(b) Use the direct decomposition method for expressing the following transfer function with state-space representation.

$$\frac{Y(s)}{U(s)} = \frac{1}{s^3 + 9s^2 + 26s + 24} \quad (12)$$