Registration No.: | | | | | | | | | | |

Total Number of Pages: 02 **IDD (B.Tech and M.Tech)**
EOPC2007

4^{th} Semester Regular Examination: 2024-25
SUBJECT: Control System
BRANCH: AEIE, ECE, EEVDT, ETC, ECE
Time: 3 Hours
Max Marks: 100
Q.Code: S427

Answer Q1 (Part-I) which is compulsory, any eight from Part-II and any two from Part-III.
The figures in the right-hand margin indicate marks.
Graph/Semilog Sheets are to be used wherever necessary.

Part-I

Q1 Answer the following questions: **(2 x 10)**

a) A first-order system has a transfer function $G(s) = 5/(s + 3)$. Find the steady-state value for a unit step input.

b) If $G(s) = 10/ s (s + 5)$, and feedback $H(s) = 1$, find the closed-loop transfer function.

c) For a second-order system with damping ratio $\zeta = 0.5$, find the percent overshoot.

d) What is the effect of adding a zero close to the origin in a system's transfer function?

e) Define gain margin and phase margin. What do they indicate about system stability?

f) Draw the pole zero plot for a lead and lag compensator.

g) Define the term 'breakaway point' in root locus analysis.

h) List two advantages of feedback in control systems.

i) What does the observability matrix tell us about a system?

j) Find the eigen values of the system matrix $A = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}$

Part-II

Q2 Only Focused-Short Answer Type Questions- (Answer Any Eight out of Twelve) **(6 x 8)**

a) Construct a signal flow graph for the following equations and find the transfer function using Mason's gain formula: $x_2 = a_{21}x_1$, $x_3 = a_{32}x_2 + a_{31}x_1$, $x_4 = a_{43}x_3$. Assume input is x_1 and output is x_4.

b) For a mass-spring-damper system with M = 2kg, B = 4 Ns/m, K = 8 N/m, write the equation of motion and obtain its Laplace form.

c) Explain the role of feedback in improving system performance (accuracy, stability).

d) A second-order system has $\omega_n = 5$ rad/s and $\zeta = 0.3$. Calculate: I) Peak time II) Settling time (2 % criterion) III) Overshoot.

e) Define and compare the performance indices: ISE, ITSE, IAE, and ITAE.

f) Explain with examples: How system type affects steady-state error for standard inputs (step, ramp, parabolic)?

g) Draw the bode plot for the following unity feedback system having open loop transfer function, $G(s) = \frac{k}{S(0.02s+1)(0.04s+1)}$

h) Construct the complete Routh array and determine the stability of the system with characteristic equation $s^4 + 2s^3 + 3s^2 + 4s + 5 = 0$

i) Design a PI controller for a system $G(s) = \frac{1}{S(s+2)}$ to achieve zero steady-state error for a unit ramp input.

j) Using root locus, find the value of gain K such that the system $G(s)H(s) = \frac{k}{S(S+4)(S+6)}$ Has dominant poles at $s = -2 \pm j2$.

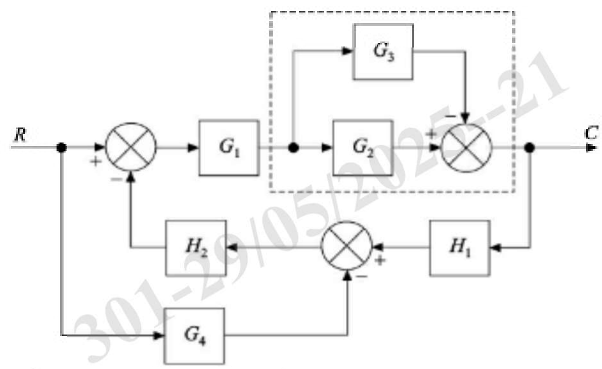
k) Explain the significance of state transition matrix. Also, find it for $A = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}$

l) Convert the transfer function $G(s) = 5/(s + 2)$ into a first-order state-space model.

Part-III

Only Long Answer Type Questions (Answer Any Two out of Four) **(16 x 2)**

Q3 **(16)**



Obtain the transfer function of the control system whose block diagram is shown in Figure above by (a) block diagram reduction technique and (b) Signal flow graph method.

Q4 **a)** What are the standard test signals employed for time domain studies? Describe their mathematical expression. **(6)**

b) Given two second-order systems: $G_1(s) = \frac{10}{s^2 + 4s + 10}$, $G_2(s) = \frac{10(s+5)}{s^2 + 4s + 5)}$ **(5 + 5)**

i) Compare their step responses. ii) Explain how the added zero affects overshoot, rise time, and stability.

Q5 **a)** Given: $A = \begin{bmatrix} 0 & 1 \\ -4 & -5 \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ **(8 + 8)**

Check if the system is controllable.

b) Given: $A = \begin{bmatrix} 0 & 1 \\ -3 & -2 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 0 \end{bmatrix}$

Check observability of the system.

Q6 Write short notes on the following: **(4 x 4)**

a) Open-loop versus Closed Loop Control System
b) Steady-State Error and Error Constants
c) Stability Analysis using Nyquist Criteria
d) Advantages of state-space representation over transfer function methods.