

R18

Code No: 155AR

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B. Tech III Year I Semester Examinations, January - 2025

CONTROL SYSTEMS

(Common to ECE, EIE)

Time: 3 Hours

Max. Marks: 75

Note: i) Question paper consists of Part A, Part B.

ii) Part A is compulsory, which carries 25 marks. In Part A, Answer all questions.

iii) In Part B, Answer any one question from each unit. Each question carries 10 marks and may have a, b as sub questions.

PART - A

(25 Marks)

- 1.a) Write the differences between open loop and closed loop control systems. [2]
- b) Write the rule for moving the summing point ahead and before of a block. [3]
- c) Measurement conducted on a servomechanism shows the error response to be $e(t) = 6e^{-8t} \sin(6t + 37^\circ)$ where the input is sudden unit displacement. Determine the natural frequency and damping ratio of the system. [2]
- d) Summarize the limitations of Routh-Hurwitz criterion. [3]
- e) If a system open loop transfer function has the factor $G(s) = 1 + 0.5s$. Then, what is the slope contribution by this factor on bode plot before and after the corner frequency. [2]
- f) Explain how to find stability of closed loop system using Nyquist stability criterion? [3]
- g) What is the need of PID controller? [2]
- h) Write the significance of compensation in dynamical systems and list out existing compensating techniques in the literature. [3]
- i) Whether the state model of a system is unique or not? Justify your answer. [2]
- j) What are the properties of state transition matrix? [3]

PART - B

(50 Marks)

2.a) For the circuit shown in Figure 1

i) Apply KVL and write the equation for input voltage $e_1(t)$

ii) Write the equation for output voltage $e_0(t)$

iii) Determine the transfer function $e_0(s)/e_1(s)$ for the electrical network shown in the Figure 1.

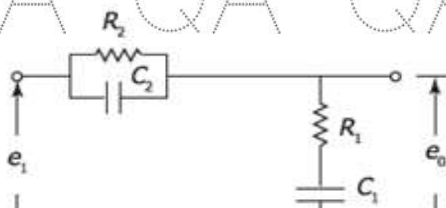


Figure 1

- b) Find the closed loop transfer function of the system whose block diagram is given in Figure 2. [5+5]

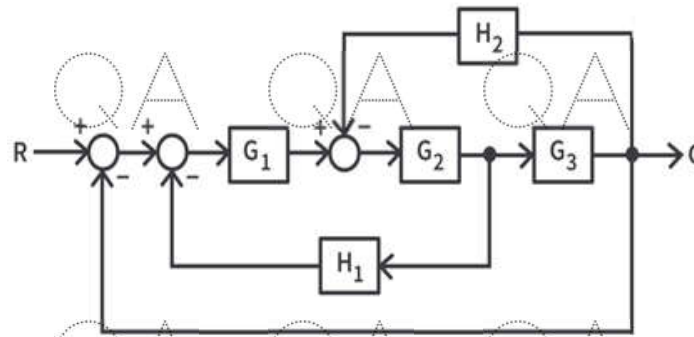


Figure 2
OR

- 3.a) For the mechanical system shown in Figure 3. Write the differential equations governing the system.

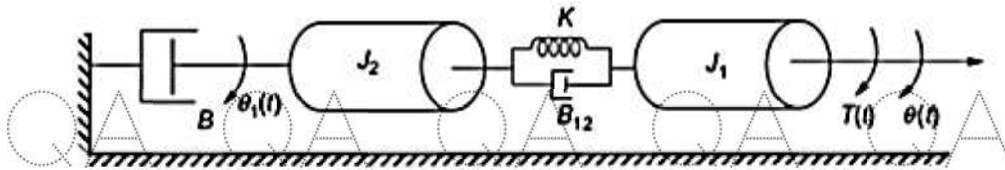


Figure 3

- b) Using block diagram reduction techniques, find the closed loop transfer function of the system whose block diagram is given in Figure 4. [5+5]

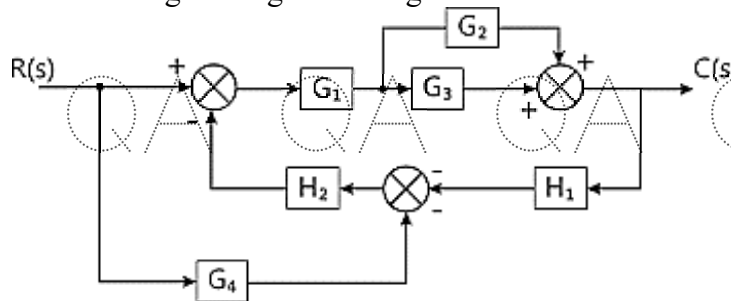


Figure 4

4. The closed-loop transfer function of a second-order system is given by

$$\frac{C(s)}{R(s)} = \frac{25}{s^2 + 6s + 25}$$

- a) Determine rise time, peak time, peak overshoot and settling time and
b) Find the output response when the system is subjected to unit step input. [5+5]

OR

- 5.a) A unity feedback system is characterized by an open loop transfer function

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

Determine the gain K so that the system will have damping ratio of 0.5 and for this value of K find settling time, peak overshoot and time to peak overshoot for a unit step input.

- b) Using Routh-Hurwitz criterion, assess the stability of the system represented by the characteristic equation, $s^4 + 2s^3 + 10s^2 + 8s + 3 = 0$. Also, comment on the location of the roots of the characteristic equation on S-plane. [5+5]

6. Sketch the Bode plot for the following loop transfer function is given by

$$G(S)H(S) = \frac{KS^2}{(1+0.2S)(1+0.02S)}$$

Determine the

- Gain crossover frequency (ω_{gc})
- Phase crossover frequency (ω_{pc})
- Gain Margin (GM)
- Phase Margin (PM).

[2+3+2+3]

OR

7. The open loop transfer function of a system with unity feedback is given by

$$G(s)H(s) = \frac{50}{(S+2)(S+4)}$$

- Draw the Nyquist plot.
- Determine the closed loop system stability from the Nyquist plot.

[5+5]

8. Design a lead compensator for the system with an open-loop transfer function

$$G(s)H(s) = \frac{K}{s^2(0.1s+1)}$$

for the specifications of acceleration error constant, $K_a=10$ and phase margin, $\Phi_{pm}=30^\circ$.

[10]

OR

9. Consider the open loop transfer function with unit feedback system,

$$G(s)H(s) = \frac{K}{S(S+3)(0.4S+1)}$$

Design the lead-lag compensator so that:

- Velocity error constant K_v is 5 sec^{-1}
- Phase margin not greater than 30°
- Gain margin not greater than 10 db.

[10]

10. The dynamics of a physical system is described by the differential equation

$$\frac{d^3y}{dt^3} + 6\frac{d^2y}{dt^2} + 11\frac{dy}{dt} + 6y = u$$

- Find the order of the state variable vector and state vector
- Find the order of the system matrix and input matrix
- Find the order of the output matrix and output vector
- Find the order of the transmission matrix and also
- Determine the state equation and output equation of the system.

[2+2+2+2+2]

OR

- 11.a) A dynamical system is represented through the state model as indicated below.

$$\dot{X}(t) = \begin{bmatrix} 0 & 2 & 0 \\ 1 & 2 & 0 \\ -1 & 1 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} u(t) \quad \text{and} \quad Y(t) = [1 \quad 0 \quad 1] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

Investigate whether the given system is completely state controllable and observable. Also, comment on the stability of the system.

- Develop the state transition matrix of the given linear time-invariant system whose state equation is represented by

[5+5]

$$\dot{X}(t) = \begin{bmatrix} -1 & 0 & 0 \\ 0 & -2 & 1 \\ 0 & 0 & -2 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} u(t)$$