(3 hours)

[Total marks 80]

N.B.: (1) **Question no. 1 is compulsory.**

(2) Write any 3 questions from remaining.

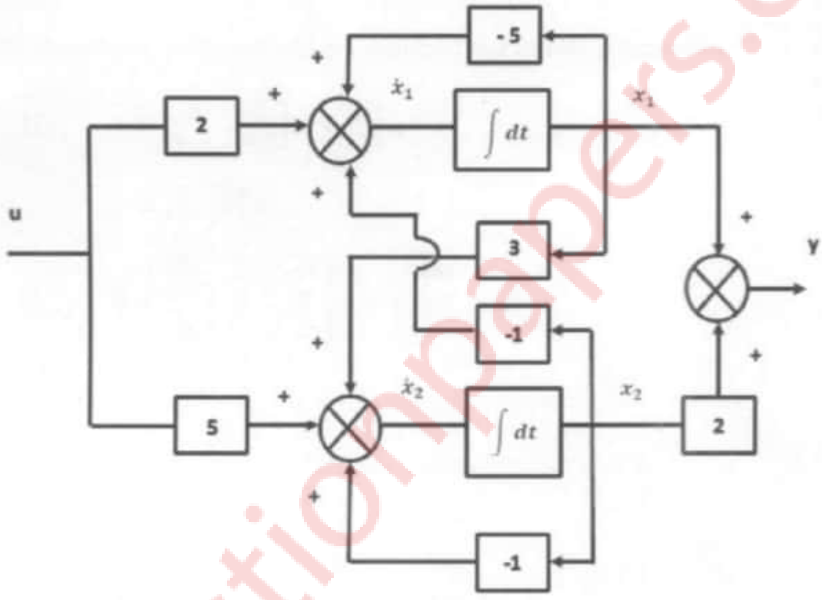
(3) Figures to the right indicates full marks.

Q 1. Attempt **any four.** **20**

a Draw Electrical Lead, Lag and Lag-Lead compensator diagrams and plot corresponding Pole-Zero plot.

b Construct the Vandermonde matrix M for system having following eigen values $\lambda_1, \lambda_1, \lambda_1, \dots, \lambda_1, \lambda_{m+1}, \lambda_{m+2}, \dots, \lambda_n$ **(Eigenvalue λ_1 of multiplicity of m)**

c For system shown in figure below obtain State model



d What is Compensator? Explain cascade and feedback compensator with neat diagram

e Define State, State variable, State Vector and State space

Q 2. a If $G(s) = \frac{k}{s(s+4)(s+6)}$ for which the PD compensator is to be designed such that the compensated system exhibits 12% peak overshoot and has settling time equal to 1 sec. **10**

b Explain design steps of Lead compensator using Root Locus. **10**

Q 3. a Explain design steps of Lag compensator using Bode Plot. **10**

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b For a unity feedback system $G(s) = \frac{4k}{s\,(s+2)}$ design a suitable compensator with following specifications, 1) Velocity error constant 20 sec^{-1} and 2) Phase margin at least 50°. **10**

Q 4. a Check for the Stabilizability and Detectability of the system **10**

$$\dot{x} = \begin{bmatrix} 2 & 0 \\ 0 & -1 \end{bmatrix} x + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u$$

$$y = [1 \quad 0]\, x$$

b Diagonalise the following matrix **10**

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & -3 & 3 \end{bmatrix}$$

Q 5. a Check controllability and observability of the following systems **10**

(I) $\dot{x} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$

$y = [1 \quad 0]\, x$

(II) $\dot{x} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$

$y = [10 \quad 0 \quad 0]\, x$

b For a regulator system the plant is given by $\dot{x} = Ax + Bu$ **10**

Where $A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -6 \end{bmatrix}$ and $B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$

The system uses state feedback control $u = -Kx$. Desired closed loop poles are at $(-2 \pm 4j)$, 10. Determine state feedback gain matrix

Q 6. a A system is given by **10**

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -6 & -5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

$$y = [1 \quad 0]\, x$$

Design the observer that has poles at -25, -30.

b Explain Ziegler Nichols tuning rules for tuning of PID controller **10**

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