Q. P. Code: 24358

Duration: 3 Hours **Max. Marks 80**

N.B.

1. **Q.1** is compulsory. Attempt **any three** from the remaining questions.
2. All questions carry equal marks.
3. Figures to the Right indicate full marks.
3. Assume suitable data if necessary

Q.1 Attempt **any four** — 20

a. Define state transition matrix (STM). Write the properties of STM.

b. Obtain the transfer function for the following system.

$$\dot{x} = Ax + Bu$$
$$y = Cx + Du$$

c. What is lead compensator? Why it is required?

d. Construct the Vandermonde matrix M to diagonalize the matrix

$$F = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -4 & -9 & -6 \end{bmatrix}$$

e. Define stabilizability and detectability of the system.

f. For the system

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

the desired pole locations are $-1.5 \pm 0.5j$. Check if the desired poles are on root locus or not.

Q.2 A. Check for the controllability and observability of the system, — 10

$$\dot{z}_1 = z_2$$
$$\dot{z}_2 = 5z_1 + u_2$$
$$\dot{z}_3 = z_1 + 3z_3 + u_1$$

having the outputs $y_1 = z_1$ and $y_2 = z_2$.

B. Represent the following system into controllable canonical state representation. — 10

$$G(s) = \frac{s+4}{s^4 - 3s^3 - 15s^2 + 19s + 30}$$

Q.3 A. Design the lag compensator $G_c(s)$ using root-locus for the system in Figure 1 so as to achieve the velocity error constant of $50 sec^{-1}$ without appreciably changing the original closed loop pole locations. — 10

B. Draw typical circuit diagram and corresponding transfer function for lag-lead compensator. Write the steps to design lag-lead compensator using Bode plot. — 10

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Q.4 A. Design the state feedback control for the system **10**

$$\dot{x} = \begin{bmatrix} 0 & 1 \\ -1 & 1.5 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

to place the poles at $-3, -4$.

B. Obtain $x(t)$ for the system **10**

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

if initial condition is $x(0) = [1 \ 1]^{\top}$.

Q.5 A. Prove via linear transformation that state space representation of the system is not unique and eigen values of system matrix are invariant under linear transformation. **10**

B. Explain with neat diagram Full order state observer. **10**

Q.6 Write short notes on **20**

A. Ziegler-Nichols method for PID controller tuning.

B. PD compensator.

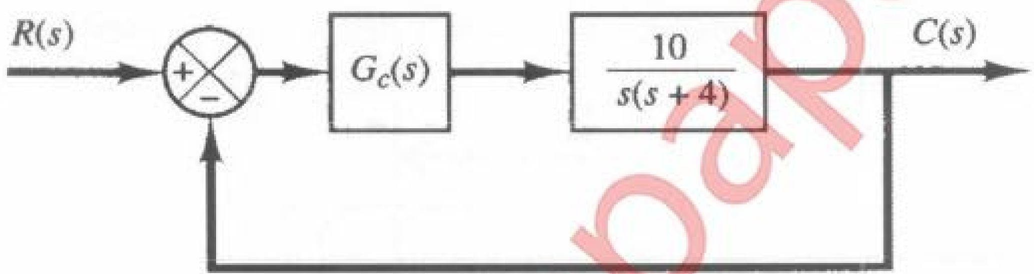

Figure 1:

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