Computer Control of Industrial Processes (CS 702)

Full Marks: 70   **Time: 3 hrs**

Answer any five questions. All questions carry equal marks.

1. Briefly explain the terms controllability and observability. State and prove the controllability criterion. Investigate controllability and observability of the following system:

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

$$y(k) = \begin{bmatrix} 0 & 1 \end{bmatrix} x(k).$$

                                             4+4+6

2. Explain mathematically the difference between prediction, smoothening and filtering in connection with state estimation. Why do we need to design adaptive controller? Suggest suitable schemes for adaptive controller design.

                                             4+4+6

3. What are the steps to be followed for state feedback controller design? Find the gain matrix for state feedback control to place Eigenvaules at $0.5 \pm j0.5$ for the system

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

                                             6+8

4. What are the properties of state transition matrix? How is it obtained from the differential equations resembling a dynamical system? Find the state transition matrix for the system

$$x(k+1) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -0.5 & 1.5 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u(k).$$

4+4+6

5. What are the different ways of choosing state variables for a discrete dynamical system? The difference equation governing a discrete dynamical system is $y(k+3) + 5y(k+2) + 7y(k+1) + 3y(k) = 6u(k)$. Obtain its state variable representation.

6+8

6. What do you understand by stability of a dynamical system. Briefly describe the following methods of stability analysis of a discrete dynamical system: (a) Pseudo continuous time system; (b) Bilinear transformation

4+5+5

7. Enlist the main properties of Z-transform. State and prove the initial value theorem and final value theorem in z domain. Obtain the z-transform of $sin(\omega t)$. Obtain inverse Z-transform of $F(z) = \frac{7z^2 - 13z + 6}{z^3 - 4z^2 + 5z - 2}$ upto the 4th sampling instant.

4+4+3+3

8. Write short notes on any two of the following:

   - Industry application of programmable logic controller
   - Representation of dynamical systems in Matlab.
   - Design aspects of computer control of industrial processes

7+7