Code No: NR411005 **NR**

IV B.Tech I Semester Supplementary Examinations, April/May 2005
DIGITAL CONTROL SYSTEMS
(Common to Electronics & Instrumentation Engineering and Electronics & Control Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks

⋆ ⋆ ⋆ ⋆ ⋆

1. Given the discrete-time system
$y(k) - \frac{1}{\sqrt{2}}y(k-1) + \frac{1}{4}y(k-2) = u(k) + \frac{1}{3}u(k-2)$
Determine the pulse transfer function and the unit pulse response.

2. Consider the following system given in the controllable canonical form
$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \\ x_3(k+1) \end{bmatrix} \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -a_3 & -a_2 & -a_1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} = + \text{u(k)}$$
$$\text{y(k)}=[b_3 - a_3\ b_0 \quad b_2 - a_2\ b_0 \quad b_1 - a_1\ b_0] \begin{bmatrix} x_1(k) \\ x_2(k) \\ x_3(k) \end{bmatrix} + b_0 u(k)$$
It is desired to transfer the system equation into the observable canonical form by means of the transformation of the state vector. Determine a transformation matrix T that will give the desired observable canonical form.

3. Investigate the controllability and observability of the following system
$$\begin{bmatrix} x_1(k+1) \\ x_2(k+1) \end{bmatrix} = \begin{bmatrix} 1 & -2 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix} + \begin{bmatrix} 1 & -1 \\ 0 & 0 \end{bmatrix} u(k)$$
$$\begin{bmatrix} y_1(k) \\ y_2(k) \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

4. Determine the stability of the following characteristic equations by using suitable tests.
   (a) $5\text{z}^2 - 2\text{z} + 2 = 0$
   (b) $\text{z}^3 - 0.2\text{z}^2 - 0.25\text{z} + 0.05 = 0$
   (c) $\text{z}^4 - 1.7\text{z}^3 + 1.04\text{z}^2 - 0.268\text{z} + 0.024 = 0$

5. (a) What are the two basic transformations used to convert an analog system transfer function to a digital system transfer function? Explain each procedure.
   (b) Explain the design of digital controllers through bilinear transformation.

6. Consider the system defined by

   $$\dot{X} = Ax + Bu$$

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

   by using the state feedback control u = -Kx, it is desired to have the closed loop poles at s = -2 ± j 4 and s= -10. Determine the state feedback gain matrix K.

7. The plant model of a servo system system is given as

   X(k+1) = GX(k) + Hu(k) Y(k) = CX(k)

   where $G = \begin{bmatrix} 1 & 0.0952 \\ 0.0 & 0.905 \end{bmatrix}$; $H = \begin{bmatrix} 0.00484 \\ 0.0952 \end{bmatrix}$; C = [1 0]

   Find the state feedback control law for the system that places the closed loops at z1,2 = 0.888± j0.173. The control law is to be realized using a state observer. Choosing the roots of the characteristic equation of the observer as z= 0.82, design the observer.

8. Consider the mixing tank system, x(k+1) = Fx(k) + Gu(k); y(k) = Cx(k)

   Where $F = \begin{bmatrix} 0.9512 & 0 \\ 0 & 0.90480 \end{bmatrix}$; $G = \begin{bmatrix} 4.88 & 4.88 \\ -0.019 & 0.0095 \end{bmatrix}$; $C = \begin{bmatrix} 0.01 & 0 \\ 0 & 1 \end{bmatrix}$

   Find the optimal control law that minimizes the performance index

   $$J = \sum_{k=0}^{\infty} \left[y^T(k)\, Qy(F) + u^T(k) \right],$$

   where $Q = \begin{bmatrix} 25 & 0 \\ 0 & 0.1 \end{bmatrix}$; $R = \begin{bmatrix} 2 & 0 \\ 0 & 0.5 \end{bmatrix}$

⋆⋆⋆⋆⋆