Q.P.Code: 36370

(3 Hours) **Total Marks : 80**

Note: (1) **Q1 is compulsory**

(2) Attempt **any three** from the remaining

(3) Assume suitable data wherever necessary.

Q.1 Answer **any four** from the following: **20**

a. Differentiate between zero order hold and first order hold.

b. Obtain the pulse transfer function for the system described by the discrete time state model

$$x(k+1) = \begin{bmatrix} 0 & 1 \\ -0.13 & 0.75 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = \begin{bmatrix} -0.5 & 1 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

c. Why is it necessary to perform bilinear transformation in order to perform Routh-Hurwitz test on a discrete time system?

d. Analyze the controllability and observability of the system described by

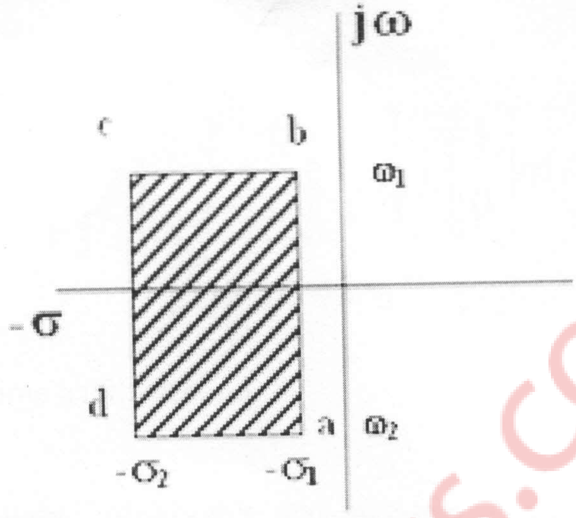
$$x(k+1) = \begin{bmatrix} 1 & -2 \\ 1 & -1 \end{bmatrix} x(k) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = \begin{bmatrix} -0.5 & 0.5 \end{bmatrix} \begin{bmatrix} x_1(k) \\ x_2(k) \end{bmatrix}$$

e. Justify the statement 'Internal stability ensures controller realizability'

[Turn over

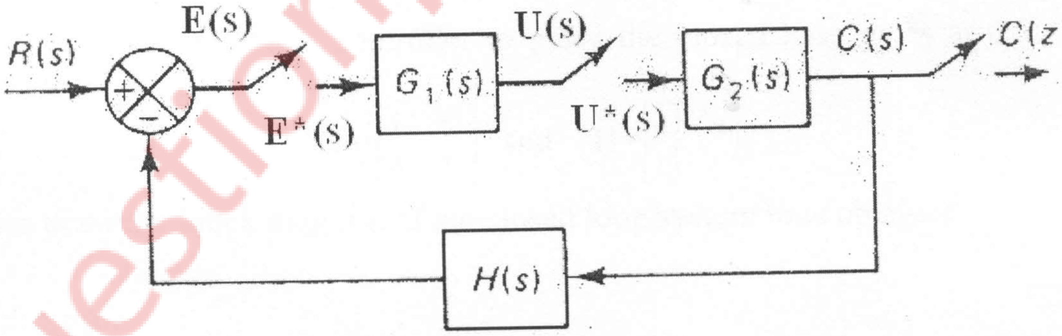
Q.2 a. Show the image of the following in Z plane **10**



s plane

where $-\sigma_1 = -1, -\sigma_2 = -4.5, w_1 = j7$ and $w_2 = -j7$

b. Find the pulse transfer function of the following system using sampled signal flow graph approach. **10**



Q.3 a Determine the stability of a discrete time system with a characteristic equation **10**

$$z^4 - 1.7z^3 + 1.04z^2 - 0.286z + 0.024 = 0$$

using Jury's stability test.

[Turn over

b. Obtain the discrete time state equation and output equation for the following continuous time system **10**

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ -1 & 0 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \end{bmatrix} u(t)$$

$$y(t)=[0\ 4]\ x(t)$$

Take sampling time as 0.1 second.

Q.4 a. Give the controllable, observable and diagonal realization for the pulse transfer function **10**

$$G(z) = \frac{4z^3 - 12z^2 + 13z - 7}{(z-1)^2 (z-2)}$$

b. Consider system **10**

$$x(k+1) = G\,x(k) + H\,u(k)$$

Design a state feedback controller to place the closed loop poles at 0.5 and 0.6 of

$$G = \begin{bmatrix} 1 & -1 \\ 0 & 1 \end{bmatrix} \text{ and } H = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

Also draw the block diagram of the closed loop system thus obtained.

Q.5 a. A PID controller is described by the following relation between input e(t) and output u(t): **10**

$$u(t) = k_p\left(e(t) + \frac{1}{T_I}\int_0^t e(t)dt + T_D\frac{de(t)}{dt} \right)$$

Obtain the discrete time PID controller transfer function U (z)/ E (z)

[Turn over

b. Design a prediction observer for dead beat response for the following system **10**

$$x(k+1) = \begin{bmatrix} 0.16 & 2.16 \\ -0.16 & -1.16 \end{bmatrix} x(k) + \begin{bmatrix} -1 \\ 1 \end{bmatrix} u(k)$$

$$y(k) = [1\ 1\ ]x(k)$$

Q.6 a. Define position, velocity and acceleration error coefficient for a discrete time system. Also find the steady state error for step, ramp and parabolic inputs for a system with open loop transfer function **10**

$$GH(z) = \frac{10(z+1)}{(z-1)(z^2-0.25z)(z+0.1)}$$

b. Design a discrete time PID controller for the following continuous time PID settings: K=1, T_d=2.5s, T_i=40s and sampling time T_s=1s to obtain bumpless transfer. Draw the block diagram of the system with the 2 degree of freedom controller so obtained. **10**
