Q. P. Code : 24123

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

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

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

(3) Assume suitable **data** wherever **necessary**.

Q1. Answer **any four** from the following: **(20)**

a. Map $\alpha_1 = -0.5$ and $\alpha_2 = 1$ lines from s-plane to Z-plane using impulse invariance method.

b. A first order discrete time LTI system is represented by the state model

$$x(k+1) = -x(k) + 2u(k)$$

$$y(k) = 0.5x(k)$$

Obtain its pulse transfer function.

c. Give the Kalman's test to find controllability and observability of a system.

d. What do you mean by state transition matrix? List its properties.

e. Explain 1-DOF (degree of freedom) and 2-DOF feedback controller.

Q2. (a) Obtain state space representation of the following systems in both first companion and second companion form. **(10)**

$$G(z) = \frac{z^3 + z^2 + z + 2}{z^4 + 0.2z^3 + 0.5z^2 + z + 5}$$

(b) A system with transfer function $G(s) = \frac{4}{s(s+1)}$ is sampled at instants with sampling time 0.1 sec. If the hold circuit used is of zero order, obtain the equivalent discrete data system. **(10)**

TURN OVER

Q3. (a) Derive the solution of the following system **(10)**

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

using Z-transform method. Assuming input to a discrete system as zero but

$x(0)=\begin{bmatrix}1\\1\end{bmatrix}$, $G=\begin{bmatrix}-1 & -1\\-1 & 1\end{bmatrix}$, $H=\begin{bmatrix}0\\1\end{bmatrix}$, $C = [1\ \ 1]$ and $D = [\,0]$.

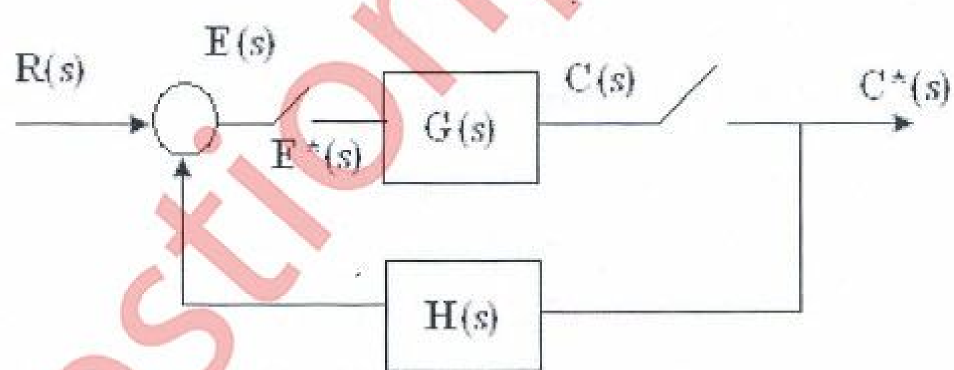
Determine x(k) for all k > 0.

(b) Given the closed loop transfer function $T(z) = N(z)/D(z)$, where,

$$D(z) = z^3 - z^2 - 0.2z + 0.1$$

Use Routh's Hurwitz criteria to find the number of z-plane poles of T(z) inside, outside and on the unit circle, Is the system stable? **(10)**

Q4 (a) Explain the Mason's gain formula to obtain transfer function from a signal flow graph. Find the pulse transfer function of the following system using sampled signal flow graph approach. **(10)**



(b) Design a state feedback controller for the system

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

with $G=\begin{bmatrix}1 & 0.08\\0 & 0.7\end{bmatrix}$ $H=\begin{bmatrix}0.004\\0.08\end{bmatrix}$

for deadbeat response **(10)**

TURN OVER

Q5. (a) Design a full order state observer so that observer poles are located at -0.2 and - 0.4 for the system **(10)**

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

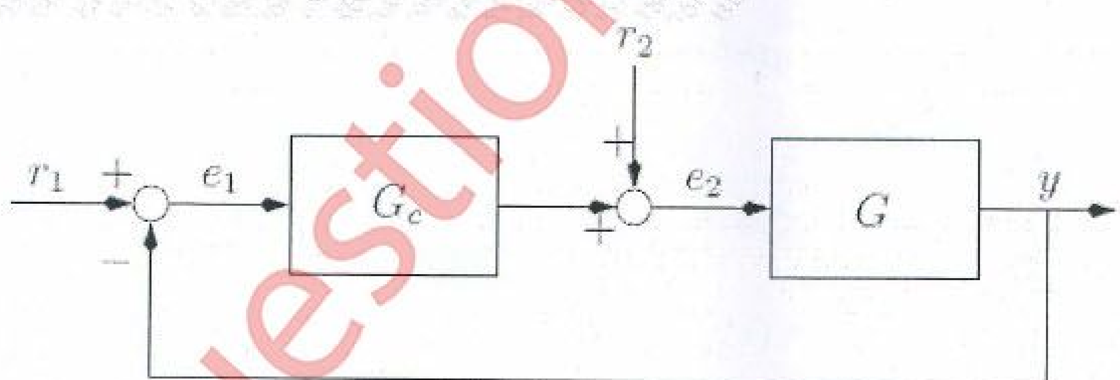
$$y(k) = [0 \;\; 1]\, x(k).$$

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

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

Using the trapezoidal rule for integration and backward-difference approximation for the derivative, obtain the difference equation model of the PID algorithm. . Also obtain the transfer function U (z)/ E (z)

Q6. (a) What do you mean by internal stability? How is it different from bounded input bounded output (BIBO) stability? For the system shown in the block diagram:



Determine the internal stability if $G = \frac{1}{z-1}$ and $G_c = \frac{1.5z-1}{z-1}$ **(10)**

TURN OVER

(b) Define static position, velocity and acceleration error coefficient for a discrete time LTI system and find the steady state error for step, ramp and parabolic input for a unity feedback system characterized by the open loop transfer function

$$G_{ho}G(z) = \frac{0.5(z+1)}{(z-1)(z-0.5)(z-0.9)}$$

The sampling period is T=0.1 sec. **(10)**
