Jadavpur University
B. Power Engineering 4th Year Second Semester Examination 2023
Digital Control Systems

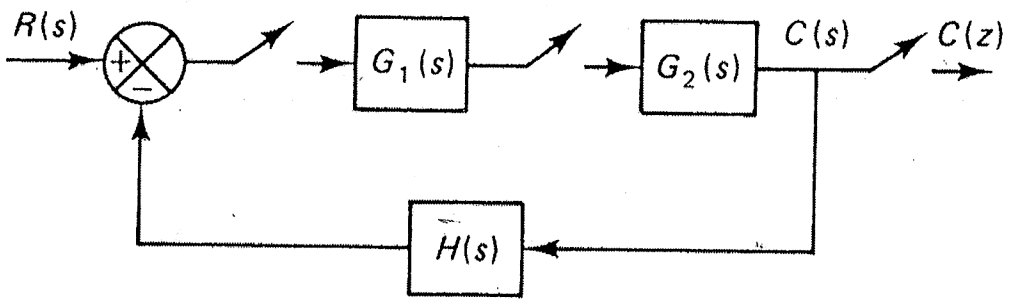
Full Marks :70 **Time: 4 hrs**

Group A
(Answer Q1 and any one of Q2 or 3)

1. Derive the Z transform of an **impulse train of height H** with a periodicity **T.** Deduce the ROC, if any. **20** CO(1)
2. Deduce a map between s and z plane for a sample time **T** using Tustin substitution. Hence deduce the discrete equivalent of $G(s) = \frac{5}{(s+1)(10s+1)}$ with suitable choice of a sampling time. **10+10** CO(2)
3. Is it possible to map a pole at $z = -0.5$ to the s plane? If so what is /are the s plane equivalent(s)? Derive the result. **20** **CO(2)**

Group B

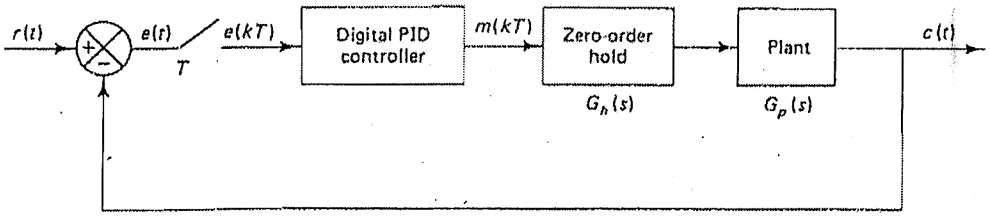
4. Derive the Pulse Transfer function $\frac{C(z)}{R(z)}$ for the closed-loop sampled-data system shown below



20 **CO(3)**

OR

Consider a closed loop control system shown below:



If the sampler is a Zero-order hold sampler and the plant matrices are $[A, B, C, D = 0]$ deduce

(i) The loop CT transfer function with the Zero-order Hold

(ii) Prove that sampling introduces additional phase lag

(iii) Investigate the nature of variation of the phase lag with variation in sampling time T .
(iv) Deduce the discrete state-space representation of the plant. **5+5+5+5 CO(3)**

5. Examine the stability of the following characteristic equation using Jury Test

$$Q(z) = z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08 = 0$$ **20 CO(4)**

Or

Consider the discrete system $G(z) = \frac{z+1}{z^2+1.3z+0.4}$.
Deduce the discrete state-space representation of the system in (i) **controller canonical form** and (ii) **diagonal canonical form.** **10+10 CO(4)**

6. Consider a CT system $G(s) = \frac{5}{(0.2s+1)(5s+1)}$ which is controlled by a controller $2\left(1+\frac{10}{s}\right)$. Assume the closed loop system is as shown in 4 part (ii) i.e with a ZoH sampler. Can you calculate the maximum permissible sampling time for the sampler for the closed loop discrete system to be stable? What sample time would you recommend for discretization **12+8 CO(5)**

Or

With suitable assumption of a skew between the input and output samplers, and a discrete system with z-plane complex poles at $(z_1, z_2) = a \pm jb$, derive the discrete PID parameters $\hat{k}_p, \hat{k}_i, \hat{k}_d$ for a sample time T to place closed loop poles at $(z_1, z_2) = u \pm jv$ and a real pole at $z_3 = \alpha, \alpha < 1$. What condition must be satisfied by the sample time T for the system to be stable and the closed-loop system to function satisfactorily? What are the corresponding z-plane closed-loop poles? **10+10** CO(5)