(c) Analyze the stability of the system using Jury's stability criterion having characteristic polynomial : $C(z) = 2z^4 + 7z^3 + 10z^2 + 4z + 1$.

2 + 5 + 5 = 12

7. (a) (i) Draw the root loci of the given transfer function: $G(s) = \frac{k}{(z+0.1)(z+0.3)(z+0.5)}$, and

(ii) find the value of *k* for which system will be stable.

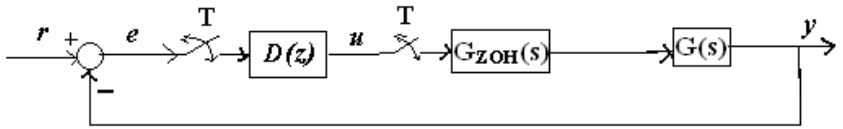
(iii) for which value of *k* system gives sustained oscillation.

(b) Discuss the effect of sampling period (T) on the steady state error.

(6 + 2 + 1) + 3 = 12

Group - E

8.



For the plant transfer function $G(s) = 1/S^2$, design a digital controller *D*(*z*) that meets the following control requirements:

(i) Zero steady state error to ramp input.

(ii) Finite settling time and

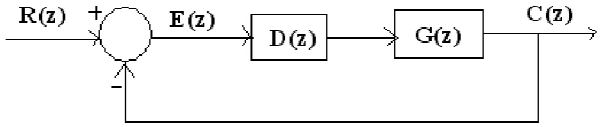
(iii) Sampling period T=0.1 sec.

12

9. (a) What is dead beat response?

(b) As shown in Figure below, a digital controlled process G(z) is described by $G(z) = \frac{0.01(z+0.2)(z+2.8)}{z(z-1)(z-0.4)(z-0.8)}$;

Design a dead beat response controller D(z), so that the output sequence c(*KT*) tracks the unit step perfectly after few sampling periods.



(i) Design a dead beat response controller D(z)

(ii) Derive the output sequence c(z) or c(*KT*) which will track the unit step perfectly after few sampling periods.

2 + (7+ 3) = 12

DIGITAL CONTROL SYSTEMS
(AEIE 4243)

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

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Which of the following quantities give a measure of the transient characteristics of a control system, when subjected to unit step excitation?

1. Maximum overshoots 2. Maximum undershoot 3. Overall gain
4. Delay time 5. Rise time 6. Fall time

(a) 1,3 and 5 (b) 2, 4 and 5
(c) 2,4 and 6 (d) 1,4 and 5.

(ii) A linear time invariant system is stable if

(a) System in excited by the bounded input, the output is also bounded
(b) In the absence of input, output tends zero
(c) Both a and b
(d) System in excited by the bounded input, the output is not bounded.

(iii) Roots with higher multiplicity on the imaginary axis makes the system

(a) absolutely stable (b) unstable
(c) linear (d) stable.

(iv) If an error signal e(t) of an ON-OFF controller is found to be greater than zero, what would be its output?

(a) 10% (b) 50% (c) 80% (d) 100%.

(v) A sampled system is stable if all the poles of the closed-loop transfer function lie _____ the unit circle of the z-plane.

(a) on the periphery of unit circle (b) inside the unit circle
(c) not depends on the pole position (d) outside the unit circle.

(vi) The impulse function is a derivative of _____ function
(a) parabolic (b) step (c) ramp (d) linear.

(vii) The z-transform is a conformal mapping from the s-plane to the z-plane by the relation:
(a) $Z = e^{-ST}$ (b) $Z = e^{-S/T}$ (c) $Z = e^{ST}$ (d) $S = e^{ZT}$.

(viii) A system has a single pole at origin. Its impulse response will be
(a) constant (b) ramp
(c) decaying exponential (d) oscillatory.

(ix) If the gain of the system is reduced to a zero value, the roots of the system in the s-plane,
(a) coincide with the poles (b) move away from zero
(c) move away from poles (d) coincide with zero.

(x) Transfer function of a system is used to calculate which of the following?
(a) The order of the system (b) The time constant
(c) The output for any given input (d) The steady state gain.

Group - B

2. (a) How an analog feedback control system is different from digital feedback control system? Explain with diagram.

(b) Write the disadvantages of analog control system. Are there any disadvantages of digital control? If any, mention the disadvantage / disadvantages.

(c) Map the left hand side of the s-plane into the z-plane and justify the mapping in terms of stability.

4 + (2 + 2) + 4 = 12

3. (a) Find the z-transform of the sampled ramp sequence $f(k)=k$, $k=0,1,2,....$

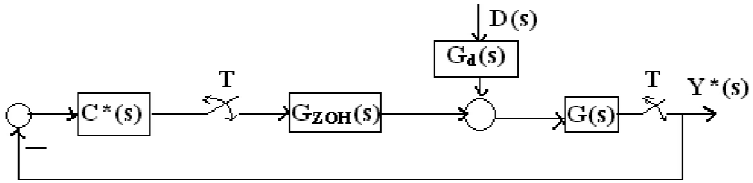
(b) Derive the inverse z-transform of $F(z) = \dfrac{2z^2 - 1.5z}{z^2 - 1.5z + 0.5}$

(c) Calculate the z-transform and inverse z-transform of $x(k+2) + 0.4x(k+1) + 0.1x(k) = -(0.5)^{k+1}$; for $x(0)=x(1)=0$.

3 + 4 + (3 + 2) = 12

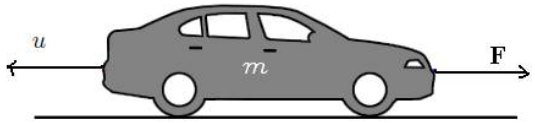
Group - C

4. (a)



Determine the output Y(z) from the block diagram in terms of other open loop transfer functions and for the analog disturbance D(s).

(b) Calculate z-domain transfer function of a four-wheeler of mass m, running at a velocity u for application of an input force F. Consider B is the viscous friction coefficient.



(c) With proper diagram explain the correlation between root locations in z-plane and corresponding natural response of a second order system.

4 + 4 + 4 = 12

5. (a) Find $G_{ZAS}(z)$ for the series R-C circuit with the capacitor voltage as output and V_{in} is the input voltage.

(b) Derive the error transfer function E(z) in terms of input, feedback gain and feedforward gain in z-domain.

(c) Find the steady-state position error for the digital position control system with unity feedback and with the transfer functions

$$G_{ZAS}(z) = \frac{K(z+a)}{(z-1)(z-b)}; C(z) = \frac{K_1(z-b)}{z-c}; 0 < a, b, c < 1$$

(i) For a sampled unit step input
(ii) For a sampled unit ramp input.

4 + 3 + (2 + 3) = 12

Group - D

6. (a) Write the conditions of stability in z-plane.

(b) Explain Jury stability test for the given characteristic equation to find the conditions of system stability :

$C(z) = a_0 z^n + a_1 z^{n-1} + ------ + a_{n-1} z + a_n$; where $a_0 > 0$.