(vii) In liquid level and electrical system analogy, voltage is considered analogous to
(a) head (b) liquid flow
(c) liquid flow rate (d) none of the above.

(viii) The discrete-time signal x (n) = $(-1)^n$ is periodic with fundamental period
(a) 6 (b) 4 (c) 2 (d) 0.

(ix) Given a unit step function u (t), its time-derivative is
(a) a unit impulse (b) another step function
(c) a unit ramp function (d) a sine function.

(x) Sampling can be done by
(a) impulse train sampling (b) natural sampling
(c) flat-top sampling (d) all of the above.

Group – B

2. (a) What are the advantages of using digital control systems in process industries?

(b) What is the difference between natural sampling and flat-top sampling? Show the scheme for the generation of flat top sampled PAM signals. Explain the scheme.

4 + (4 + 4) = 12

3. (a) Find the inverse z-transform of the function $F(z)=\frac{z}{(z+0.1)(z+0.2)(z+0.3)}$.

(b) Derive the magnitude and phase at frequency ω =1 of a zero-order hold with sampling time T = 0.1s.

(c) Draw the block diagram of a drug delivery system using digital control system.

4 + 4 + 4 = 12

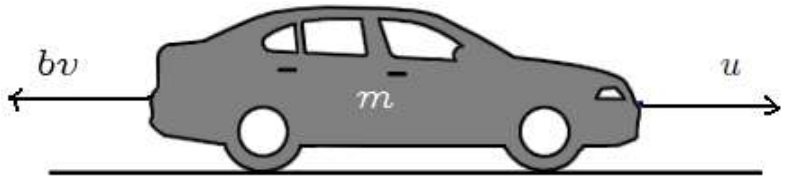
Group – C

4. (a) Find the equivalent sampled impulse response sequence and the equivalent z-transfer function for the cascade of the two analog systems with sampled inputs

$H_1(s)=\frac{1}{S+2}$ and $H_2(s)=\frac{2}{S+4}$

(i) if the systems are directly connected
(ii) if the systems are separated by a sampler

(b) Find $G_{ZAS}(z)$ for the vehicle position control system shown, where u is the input force, m is the mass of the car, y is the position of the car, b is the viscous friction coefficient and $v = dy/dt$.

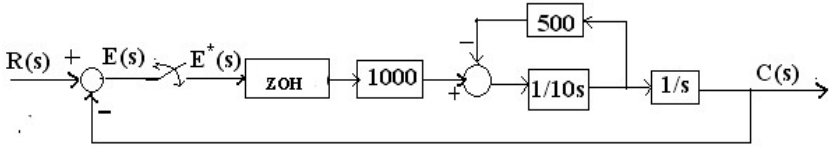


(3 + 3) + 6 = 12

5. (a) Derive the correlation between root locations in s-plane and z-plane.

(b) What are dominant roots? Explain dominant roots in z-plane with proper diagram.

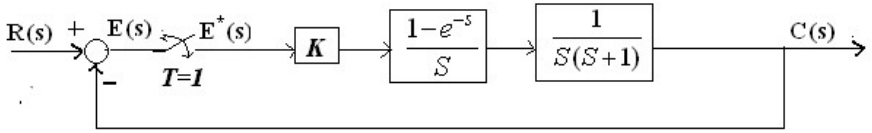
(c) Calculate the steady state errors for unit step, unit ramp and unit parabolic inputs for the system shown below:



4 + 2 + 6 = 12

Group – D

6. (a) Determine the closed loop stability from the characteristic equation of the system shown in Fig. below for K=1.



(b) Find out the range of *K* for which system is stable using Jury Stability criterion and also find the frequency of sustained oscillation for sampling period T = 1 sec.

(2 + 4) + (4 + 2) = 12

7. (a) The characteristic equation of a system is given as: $1+\frac{Kz(1-e^{-T})}{(z-1)(z-e^{-T})}=0$; Draw the root locus of the system for T = 1 sec. Also find the following parameters:
(i) Break away / break in points.
(ii) Critical gain (Kc).

(b) Investigate the stability of the given characteristic equation $P(z)$ using bilinear transformation and Routh stability criterion:

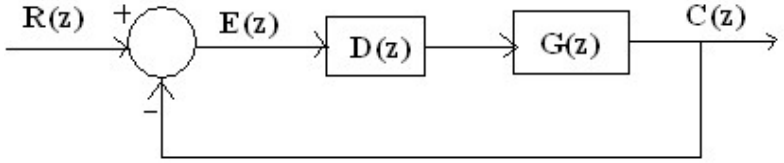
$$P(z) = z^4 - 1.2z^3 + 0.07z^2 + 0.3z - 0.08 = 0$$

(4 + 2 + 2) + 4 = 12

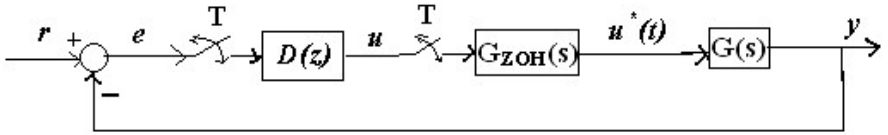
Group – E

8. As shown in Fig. below, a digital controlled process G(z) is described by $G(z) = \frac{0.0125(z+0.195)(z+2.821)}{z(z-1)(z-0.368)(z-0.8187)}$;

Design a dead beat response controller D(z) so that the output sequence c(KT) will follow a unit step input in minimum time.



12

9. 

The plant of sampled-data system of above Fig. is described by the transfer function $G(s) = \frac{1}{s(10s+1)}$ and the sampling period is 1 sec. Design a digital controller $D(z)$ to realize the following specifications:

(i) $K_v \geq 1$

(ii) $\zeta = 0.5$ and

(iii) t_s (2% tolerance band) ≤ 8 sec.

(2 + 6 + 4) = 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) For the successful reconstruction of a signal
(a) sampling frequency must be equal to the message signal
(b) sampling frequency must be greater than the message signal
(c) sampling frequency must be less than the message signal
(d) sampling frequency must be greater than or equal to the message signal.

(ii) Stability of a system implies that
(a) small changes in the system input does not result in large change in system output
(b) small changes in the system parameters does not result in large change in system output
(c) small changes in the initial conditions does not result in large change in system output
(d) all of the above mentioned

(iii) The first step required to convert analog signal to digital is
(a) sampling (b) holding
(c) reconstruction (d) quantization.

(iv) What is the number of roots of the polynomial $F(z) = 4z^3 - 8z^2 - z + 2$, lying outside the unit circle?
(a) 0 (b) 1 (c) 2 (d) 3.

(v) Inverse z-transform of the system can be calculated using
(a) partial fraction method (b) long division method
(c) basic formula of the z-transform (d) all of the above.

(vi) In P-I controller, what does an integral of a function compute?
(a) Density of curve (b) Area under the curve
(c) Volume over the curve (d) Circumference of curve.