Reg. No

B.Tech DEGREE EXAMINATION, NOVEMBER 2023

Fifth Semester

18MHC201J - LINEAR AND DIGITAL CONTROL SYSTEMS

(For the candidates admitted during the academic year (2020-2021 & 2021-20222))

Note:

i. **Part - A** should be answered in OMR sheet within first 40 minutes and OMR sheet should be handed over to hall invigilator at the end of 40th minute.
ii. **Part - B** and **Part - C** should be answered in answer booklet.

Time: 3 Hours **Max. Marks: 100**

PART - A (20 × 1 = 20 Marks)

Answer **all** Questions

Marks BL CO

1. The open loop transfer function of a system is $\frac{1}{s(s+0.5)}$. The lead compensator is designed such that the damping ratio is 0.6 and undamped natural frequency is 0.8 rad/s. The real part of dominant pole is ______ 1 2 1
   (A) -0.6 (B) 0.6
   (C) -0.48 (D) 0.48

2. With regard to the filtering capacity the lead compensator and lag compensator are respectively 1 1 1
   (A) Low pass and high pass filter (B) High pass filter and low pass filter
   (C) Both high pass filter (D) Both low pass filters

3. If the transfer function of the phase lead compensator is $\frac{s+a}{s+b}$ and that of a lag compensator is $\frac{s+p}{s+q}$ then which of the following condition is satisfied. 1 1 1
   (A) a > b and p > q (B) a < b and p < q
   (C) a < b and p > q (D) a > b and p < q

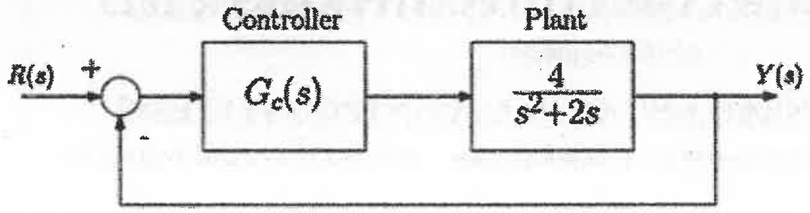
4. The steady state error of a Type 1 system for an acceleration input is ---------- 1 2 1
   (A) Zero (B) A/K_v
   (C) $A/(1+K_p)$ (D) Infinity

5. The constant steady state error is the drawback of.......... controller 1 1 2
   (A) P (B) PI
   (C) PD (D) PID

6. The transfer function of PI controller is 1 2 2
   (A) K_p (B) $K_p(1+K_i s)$
   (C) $K_p(1+\frac{K_i}{s})$ (D) $K_p(1+\frac{T_i}{s})$

7. What is the effect on natural frequency, ω_n and damping factor, ς in the control system when derivative controller is used? 1 2 2
   (A) ω_n increases and ς decreases (B) ω_n remains unchanged and ς decreases
   (C) ω_n remains unchanged and ς increases (D) ω_n decrease and ς increases

8. Consider the system in figure below 1 2 2



If a proportional controller $G_c(s) = K_P$, find the value of controller gain K_p to have steady state error of 0.25 for a unit ramp input.

(A) 1 (B) 2
(C) 3 (D) 4

9. In the diagonalized system matrix, the elements on the diagonal are …….. of the transfer function of the system. 1 1 3

(A) Zeros (B) Poles
(C) either poles or zeros (D) neither poles or zeros

10. What does "D" represent in output equation of state model? 1 1 3

(A) System matrix (B) Input matrix
(C) Output matrix (D) Feedback matrix

11. The number of …….. in a state diagram is equal to number of ……… 1 2 3

(A) integrator, state variable (B) state variable, output variable
(C) output variable , state variable (D) state variable, integrator

12. The eigen values of the state matrix $\begin{bmatrix} 0 & 1 \\ 3 & -2 \end{bmatrix}$ are 1 2 3

(A) 2 and -3 (B) -1 and -3
(C) -2 and 3 (D) 1 and -3

13. A transfer function of a control system does not have pole-zero cancellation. Which one of the following statement is true? 1 1 4

(A) system is controllable but unobservable
(B) system is observable but uncontrollable
(C) system is completely controllable and observable
(D) system is neither controllable nor observable

14. The controller gain with desired pole location -1±j for the system below is 1 2 4

$$\dot{x} = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} x + \begin{pmatrix} 0 \\ 1 \end{pmatrix} u$$

$$y = \begin{pmatrix} 1 & 0 \end{pmatrix} x$$

(A) $(3 \quad 1)$ (B) $(5 \quad 2)$
(C) $(3 \quad 2)$ (D) $(1 \quad 2)$

15. What will happen to a system in a closed loop with the observer's poles "slower" than the system's poles? 1 1 4

(A) The transient system's response will be longer
(B) The correct state can be estimated quickly
(C) The transient system's response will be shorter
(D) The correct state can be estimated slowly

16. Consider a second order system whose state space representation is of the form $\dot{x} = Ax + Bu$. If x1(t) = x2(t), then system is 1 2 4

(A) Controllable (B) uncontrollable
(C) observable (D) Unstable

17. If Z transform of x(n) is X(Z) then the Z transform of x(n-k) is 1 1 5

(A) $X(z^{-k} z)$ (B) $X(z^{k} z)$

(C) $z^{-k} X(z)$ (D) $z^{k} X(z)$

18. A zero order hold is used with sampled data system to 1 1 5

(A) make it critically damped (B) reconstruct the sampled signal

(C) improve the stability of the system (D) convert it to a continuous system

19. What is the z-transform of the signal $x[n] = a^n u(n)$? 1 1 5

(A) X(z) =1/z-1 (B) X(z) = 1/1-z

(C) X(z) = z/z-a (D) X(z) = 1/z-a

20. Z and s are related by: 1 1 5

(A) s = ln z (B) s =ln z/T

(C) s =z (D) s= T/ln z

PART - B (5 × 4 = 20 Marks)

Answer any 5 Questions

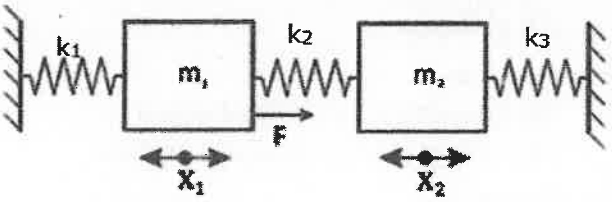
		Marks	BL	CO
21.	Draw the electrical realization of lag network and derive its transfer function	4	2	1
22.	Given that the maximum peak overshoot M_p = 9.5% and its natural frequency of oscillation is 12 rad/s. Compute the dominant poles of the system.	4	3	1
23.	List different types of controller and derive their transfer functions.	4	2	2
24.	Write the procedures for the design of PID controller using root locus technique.	4	2	2
25.	Consider the system is given by $\frac{U(s)}{Y(s)} = \frac{s+3}{s^2+3s+2}$ obtain a state space representation in controllable canonical form.	4	3	3
26.	Derive the state space representation with full state feedback control.	4	3	4
27.	Obtain the relationship between discrete state space model and pulse transfer function.	4	3	5

PART - C (5 × 12 = 60 Marks)

Answer all Questions

		Marks	BL	CO
28.	(a) A unity feedback system has an OLTF $\frac{K}{s(1+2s)}$. Design a suitable lag compensator so that the phase margin is 40 degree and the steady state error for ramp input is less than or equal to 0.2 **(OR)** (b) Design a lead compensator for a unity feedback system with open loop transfer function of a unity feedback system is given by $G(s) = \frac{K}{s(s+4)(s+7)}$ to meet the following specifications. (i) % peak overshoot = 12.63%. (ii) Natural frequency of oscillation is 8 rad/s. (iii) Velocity error constant, $K_v \geq 2.5$	12	4	1
29.	(a) Consider a unity feedback system with open loop transfer function $G(s) = \frac{100}{(s+1)(s+2)(s+10)}$. Design a PID controller so that the phase margin of the system is 45° at a frequency of 4 rad/sec and the steady state error unit ramp input is 0.1 **(OR)** (b) Consider a unity feedback system with OLTF, $G(s) = \frac{75}{(s+1)(s+3)(s+8)}$. Design a PID controller to satisfy the following specifications a) e_{ss} for unit ramp input should be less than 0.08 b) $\delta = 0.8$ c) $\omega_n = 2.5$ rad/s	12	4	2

30. (a) Obtain the state model of the mechanical system shown below 12 3 3



(OR)

(b) i) State and prove any two properties of state transition matrix

ii) Determine the diagonal canonical model of the system whose transfer function is

$$T(s) = \frac{2(s+5)}{(s+2)(s+3)(s+4)}$$

31. (a) Check the controllability and observability for the system described by : 12 4 4

$$x = \begin{bmatrix} 0 & 6 & -5 \\ 1 & 0 & 2 \\ 3 & 2 & 4 \end{bmatrix} x + \begin{bmatrix} 0 \\ 1 \\ 2 \end{bmatrix} u$$

$$y = [1 \quad 2 \quad 3]\, x$$

(OR)

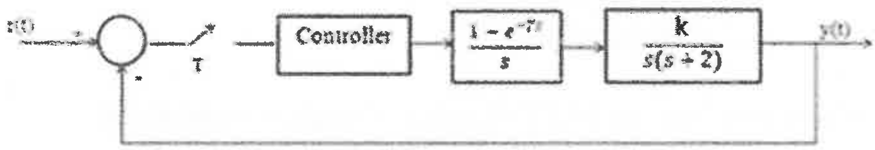
(b) Consider a linear system described by the transfer function $\frac{Y(s)}{U(s)} = \frac{10}{s(s+1)(s+2)}$. Design a feedback controller by any two methods with a state feedback so that the closed loop poles are placed at -2, $-1 \pm j$

32. (a) Check the stability of the sampled data control systems represented by the following characteristic equations. 12 4 5

$Z^3 - 1.8\, Z^2 + 1.05Z - 0.20 = 0$; $Z^3 - 0.2\, Z^2 - 1.25Z + 0.05 = 0$

(OR)

(b) Design a lag compensator and Draw roots locus diagram in the z plane for the system shown in Figure for the following sampling period: T = 0.2 sec



The given data are i) Velocity error constant of uncompensated system, $K_v = 6$ ii) Peak overshoot M_p for step input $\leq 15\%$ iii)settling time t_s (2% tolerance) ≤ 5 sec

* * * * *