MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

I SEMESTER M. TECH (EMBEDDED CONTROL AND AUTOMATION)
END SEMESTER EXAMINATION DECEMBER 2023/JANUARY 2024

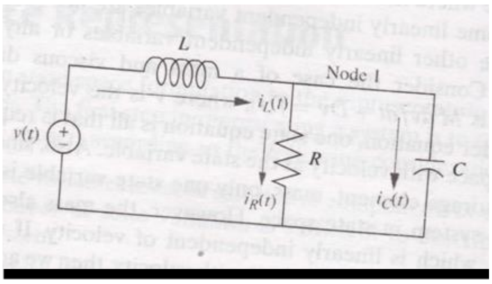
Advanced Control Theory (ICE 5114)

Note: Answer All questions.

Time:3 Hours **MAX. MARKS: 50**

Instructions to Candidates:

- Answer **ALL** the questions.

Q.No.	Description	M	CO	PO	BL
!A	Consider the unity feedback system with G(s)=$\frac{K}{(s+3)(s+6)}$. Design a lead compensator so that the closed loop system meets a settling time 2/3 second and a percent overshoot of 1.5%. Specify the compensators' pole, zero and required gain.	5M	1	1,3	5
1B	With the help of an electrical network, derive the transfer function, and demonstrate the frequency response characteristics of a lag compensating network. Qualitatively present the design procedure of the same.	5M	1	1,2	2
2A	Explain the procedure of PID controller tuning using ultimate gain or Ziegler-Nichols second method.	4M	2	1-2	3
2B	 Fig Q 2B For the electrical network shown in Fig Q2B determine the state space model representing the system.	4M	2	1,2	3

2C	Determine the transfer function of the system represented by the state space model $\dot{x}(t) = \begin{bmatrix} -5 & 0 \\ 0 & -1 \end{bmatrix} X(t) + \begin{bmatrix} 3 \\ 1 \end{bmatrix} u(t)$; y(t)=$[7 \quad 0] X(t)$.	**2 M**	**2**	**1,2**	**2**
3A	Diagonalize the following system matrix $A = \begin{bmatrix} -3 & 1 \\ 1 & -3 \end{bmatrix}$ using eigen vector to determine transformation matrix P.	**3 M**	**2**	**1-3**	**3**
3B	Derive an expression for steady state error for a system represented in state space model using final value theorem.	**3 M**	**2**	**2**	**2**
3C	For the state equation and initial state vector shown, find the state transition matrix and the solution for x(t) where u(t) is a unit step function. $\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ -8 & -6 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$ X(0)= $\begin{bmatrix} 1 \\ 0 \end{bmatrix}$	**4 M**	**2**	**1-3**	**3**
4A	Given a plant $\frac{y(s)}{U(s)} = \frac{10}{(s+2)(s+1)}$, check whether the system is completely state controllable. Also design a state feedback control law to yield 1.5% overshoot and 0.5 s settling time.	**5M**	**3**	**1-3**	**5**
4B	Given a unity feedback continuous time control system $\dot{x}(t) = \begin{bmatrix} 0 & 1 \\ 0 & -2 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 2 \end{bmatrix} u(t)$; y(t)=$x_1$. Discretize the system with a sampling time of T=3 seconds introducing a sampler and zero order hold. Comment on stability of continuous time and discrete time system.	**5M**	**3**	**1-3**	**3**
5A	Considered the system x(k+1)=$\begin{bmatrix} 0 & 1 \\ -0.16 & -1 \end{bmatrix} x(k) + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u(k)$ X(0)= $\begin{bmatrix} 1 \\ -1 \end{bmatrix}$; y(k)= $[1 \quad 0]$x(k). Find closed form of solution for y(k), when u(k) is unit step input, using z transform approach.	**6M**	**4**	**1-4**	**3**
5B	Using Cayley Hamilton theorem, determine the state transition matrix of the discrete time system matrix F= $\begin{bmatrix} 0 & 1 \\ -1 & -2 \end{bmatrix}$.	**4M**	**4**	**1-3**	**3**