Reg. No.										

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

DEPARTMENT OF MECHATRONICS ENGINEERING

IV SEMESTER B.TECH. (MECHATRONICS)

END SEMESTER EXAMINATIONS, MAY 2024

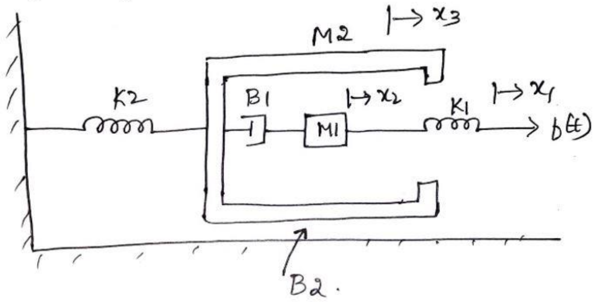
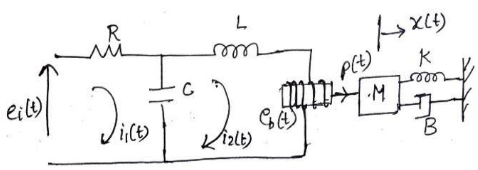
SUBJECT: LINEAR CONTROL THEORY [MTE 2224]

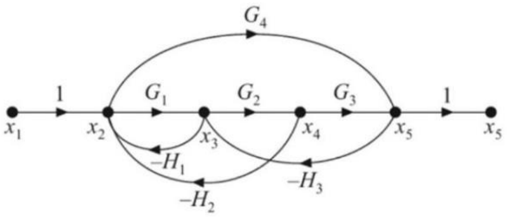
11/05/2024

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

Instructions to Candidates:

- Answer **ALL** the questions.

Q. No		M	CO	PO	LO	BL
1A.	Obtain the mechanical network and the differential equations for the mechanical translational system shown in **Fig. 1A.** Draw the equivalent force-voltage analogous network based on the mechanical network and obtain its analogous equations.  **Fig. 1A**	4	1	1	1	3
1B.	Compute the transfer function $X(s)/E_i(s)$ for the system shown in **Fig. 1B**. The following relations apply a. Force acting on mass M, is $P(t) = K_2 i_2(t)$ b. Back emf of coil $e_b = K_1 \frac{dx}{dt}$  **Fig. 1B**	3	1	1	1	3
1C.	A unity feedback servo-driven instrument has an open loop transfer function $G(s) = 10/(s(s+2))$. Compute a. Time domain response for unit step input b. Natural Frequency of oscillation and damping ratio	3	2	1	1	3

2A.	Apply Masons gain formula to obtain the transfer function of a certain control system whose signal flow graph is given in **Fig. 2A.**  **Fig. 2A**	**4**	**1**	**1**	**1**	**3**
2B.	A unity feedback control system has an amplifier with a gain K_A=10 and gain ratio G(s) = 1/(s(s+2)) in the feedforward path. A derivative feedback H(s)= sK_0 is introduced as minor loop around G(s). Determine the natural frequency of oscillations and derivative feedback constant K_0 so that the system has a damping factor of 0.6.	**3**	**2**	**1**	**1**	**3**
2C.	The open loop transfer function of a certain unity feedback system is given by $G(s) = \frac{K}{(s+2)(s+4)(s^2+6s+25)}$. Determine the range of K for stability. What is the value of K for sustained oscillations? compute the oscillation frequency using R-H criteria.	**3**	**3**	**3**	**5**	**3**
3A.	Compute all the necessary values to draw root locus for the unity feedback open loop transfer function G(s) = $\frac{K}{s(s+2)(s^2+6s+25)}$	**5**	**3**	**3**	**5**	**3**
3B.	Draw the root locus for **Q.3A** and comment on stability.	**3**	**3**	**3**	**5**	**4**
3C.	Illustrate how the transient response of the system can be improved using lead compensator	**2**	**3**	**1**	**2**	**4**
4A.	Compute the necessary values to draw bode plot for the open loop transfer function given by G(s) = $\frac{(0.2s+1)(0.025s+1)}{s^3(1+0.01s)(1+0.005s)}$	**4**	**4**	**3**	**5**	**3**
4B.	Draw the bode plot for the values computed in **Q. 4A** and comment on stability based on the observations from the plot.	**3**	**4**	**3**	**5**	**4**
4C.	Illustrate with an example on how PID controller improves the steady state response of the system.	**3**	**4**	**1**	**2**	**4**
5A.	A system is described by $\dot{X} = \begin{bmatrix} -1 & -4 & -1 \\ -1 & -6 & -2 \\ -1 & -2 & -3 \end{bmatrix}x + \begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix}u$ and y=$[1 \quad 1 \quad 1]$x. Compute the transfer function from the state model shown.	**5**	**4**	**1**	**1**	**3**
5B.	A LTI system is characterized by homogenous equation $\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -3 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$. Compute the solution of state equation assuming that the initial state vector is $x_0 = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$.	**3**	**4**	**1**	**1**	**3**
5C.	Illustrate with an example, the importance of safety measures to be taken care while handling any systems	**2**	**5**	**6**	**9**	**4**