Reg. No.									

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

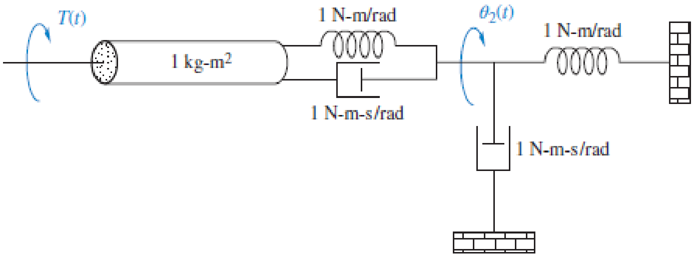
DEPARTMENT OF ELECTRICAL & ELECTRONICS ENGINEERING
I SEMESTER M.TECH. (ELECTRIC VEHICLE TECHNOLOGY)
END SEMESTER EXAMINATIONS, NOVEMBER-DECEMBER 2023
ADVANCED CONTROL SYSTEMS [ELE 5116]

Time: 3 Hours **Date: 02 December 2023** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. Determine the transfer function $\theta_2(s)/T(s)$ for the rotational mechanical system shown in figure.



(03)

1B. Estimate the range of K for system stability and the gain margin if K = 30 for the following characteristic polynomial using Routh Hurwitz criterion.

$q(s)=s^3+10s^2+(21+K)s+13K$. ***(02)***

1C. An armature-controlled separately excited DC motor is used for printing machines. Develop the state model in physical variable form assuming armature current and $d\theta/dt$ as state variables and with output as angular velocity, $d\theta/dt$. Also draw the state diagram. ***(05)***

2A. The open loop transfer function of a unity feedback vehicle system is given by $G(s)=\dfrac{K}{s(s+5)(s+15)}$. Design a PD controller to reduce the settling time by a factor of 4 while continuing to operate the system with 20% overshoot. ***(07)***

2B. Discuss the procedure for designing a stable PID controller using Zeigler Nichols tuning method. ***(03)***

3A. Design a linear state feedback controller using Ackermann's formula for an industrial robot system represented as below so that the closed loop poles are placed at s=-1±j1 and s=-4

$$= \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -5 & -6 \end{bmatrix} x + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u \qquad y = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} x$$

(06)

3B. Check for the sign definiteness of the following

$$V(x) = 2x_1^2 - 4x_2^2 - 8x_3^2 - 4x_1x_2 + 8x_2x_3 + 8x_1x_3$$ ***(02)***

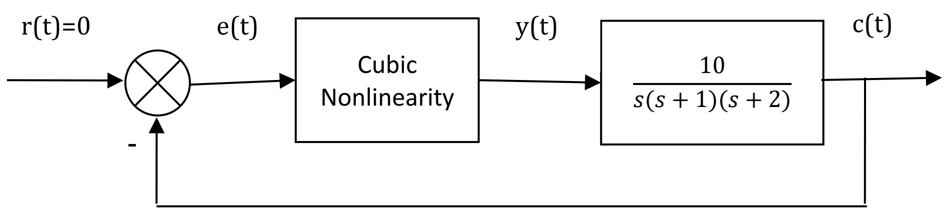
3C. Derive the describing function of the non-linear control system with ideal relay (on-off element). ***(02)***

4A. Investigate the controllability and observability of the aircraft in the heavy wind represented by the state model

$$\dot{x} = \begin{bmatrix} -5 & 0 & 0 \\ 1 & -4 & 0 \\ 0 & 5 & -1 \end{bmatrix} x + \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix} u; \quad y = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix} x$$ ***(03)***

4B. Design a sliding mode control scheme with appropriate example. ***(03)***

4C. For the non-linear system shown in figure below, investigate the possibility of the limit cycle. If the limit cycle exists, estimate the amplitude and frequency of limit cycle for the system. Assume the describing function for cubic non-linearity is $N=0.75E^2$.



(04)

5A. The DC-DC converter is represented by the state equation $\dot{x} = \begin{bmatrix} -1 & 1 \\ 2 & 3 \end{bmatrix} x$. Estimate a suitable Lyapunov function and assess the stability of the equilibrium state at the origin. ***(05)***

5B. Derive model reference control with suitable example. ***(02)***

5C. A series RLC circuit is described by the equations

$$\dot{x}_1 = x_2$$

$$\dot{x}_2 = -x_1 - x_2 + 5u$$

Investigate the stability of the equilibrium state by direct method of Lyapunov. **(03)**