Reg. No.									

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

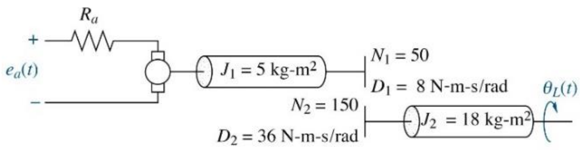
IV SEMESTER B.TECH. (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, MAY 2023

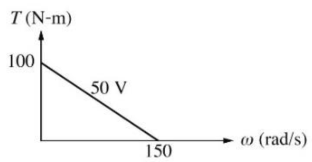
LINEAR CONTROL THEORY [ELE 2253]
REVISED CREDIT SYSTEM

Time: 3 Hours **26 May 2023** **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- If using semi-log graph sheet, under question no. mention that

1A. Derive the transfer function $G(s) = \dfrac{\theta_L(s)}{E_a(s)}$ of the motor with load, torque speed characteristics is given below.





(04)

1B. Analyse the stability of the system with open loop transfer function $G(s)H(s) = \frac{K}{s(s+1)(s+3)}$ using Root locus. ***(04)***

1C. A second order servo mechanism with unity feedback, has the open loop transfer function $G(s) = \frac{K}{s(s+4)}$, determine the gain K so that the steady state error shall not exceed 0.4 deg when the input shaft is rotated at 3rpm. ***(02)***

2A. The open loop transfer function of a Floppy drive system consist of motor and load is given by $G(s)H(s) = \frac{K}{s(s+3(s+5)}$ i) draw the Nyquist plot ii) determine limiting value of gain K for stability iii) Mark phase margin on the plot.

(05)

2B. Design a stable PID controller in the form

$$K\frac{(s+a)^2}{s}$$

using Zeigler – Nichols tuning method for the plant with transfer function

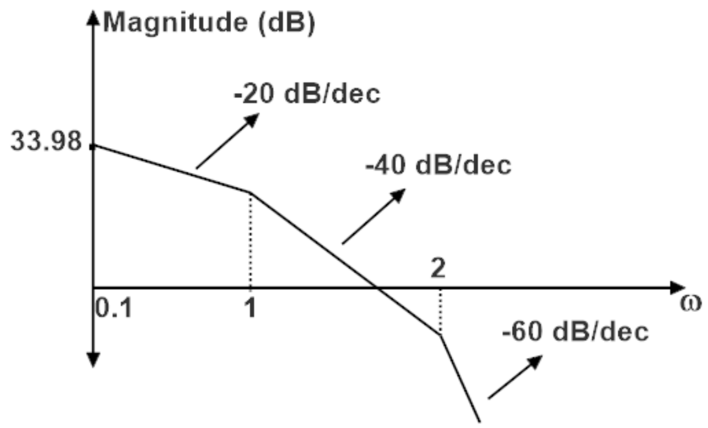
$$G(s) = \frac{4}{s^3 + 6s^2 + 8s + 4}$$

(03)

2C. Realize a PID controller using OPAMP circuit, with a suitable example. ***(02)***

3A. For the asymptotic bode magnitude plot shown in **Figure**

Determine the gain margin (dB) of the system



(04)

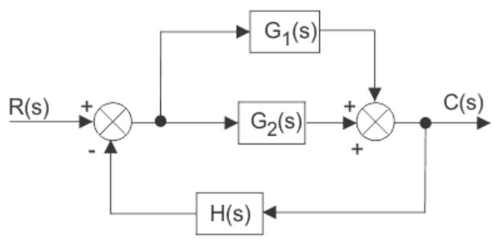
3B. A position control system can be represented by the unity feedback system with plant transfer function

$$G(s)H(s) = \frac{6}{s(s+1)(s+2)}$$

Design a lag compensator using frequency domain methods so that the compensated system has a phase margin of 45°. (Use Bode plot or analytical method)

(04)

3C. Obtain the transfer function of the block diagram given in Figure.

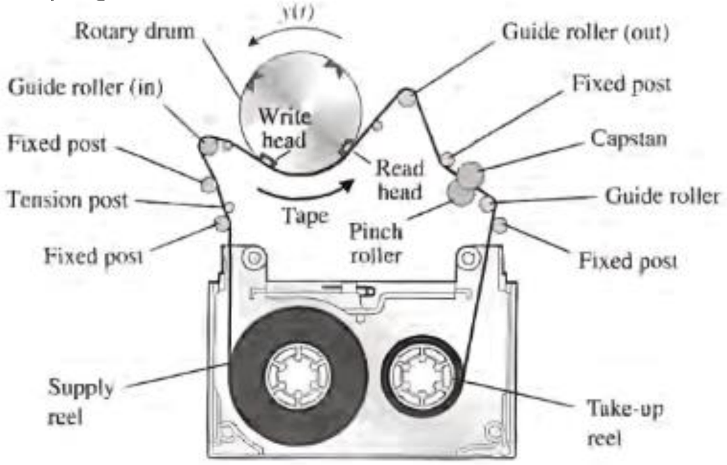


(02)

4A. Consider the audio tape driver mechanism shown in the figure. The open loop transfer function for the negative feedback system is

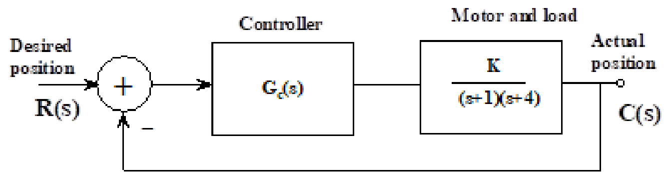
$$G(s)H(s) = \frac{K}{(s+1)(s+4)}$$

Determine the peak time and settling time for a step input. Maintain a damping ratio of 0.8 .



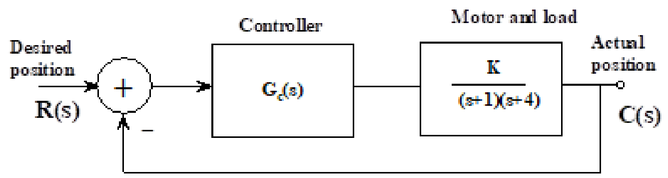
(03)

4B. Consider the audio tape speed control system shown in figure. Design a PD controller that will yield a peak time of 1.047 seconds and a damping ratio 0.8 for a step input.



(04)

4C. Consider the audio tape speed control system shown in figure 2. Design a PI controller that will yield a damping ratio 0.8 with zero error for a step input.



(03)

5A. Obtain the state model in physical variable form of an armature voltage-controlled DC motor used for robotic application. Take armature current and angular velocity $\frac{d\theta}{dt}$ as the state variables and output as angular velocity, $\frac{d\theta}{dt}$. **(04)**

5B. The state model of a sun tracker used for solar photovoltaic array system is represented by $\dot{x}(t) = \begin{bmatrix} 0 & 1 & 1 \\ 0 & -2 & 2 \\ -1 & -1 & -4 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix} r(t);\ y(t) = [1\ 0\ 0]x(t);$ Estimate the transfer function of the system and draw the state diagram. **(03)**

5C. The state model of a satellite control system is represented by

$$\dot{x}(t) = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} x(t) + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} r(t);\ y = [0\ 0\ 1]x(t)$$

Verify complete state controllability and observability of the system. **(03)**