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.

<table>
<tr><th>Q. No</th><th></th><th>M</th><th>CO</th><th>PO</th><th>LO</th><th>BL</th></tr>
<tr><td>1A.</td><td>Obtain the mechanical network and the differential equations for the mechanical translational system shown in Fig. 1A. Obtain the transfer function $X_3(s)/F(s)$.

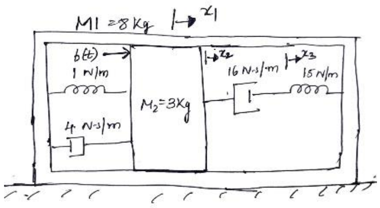



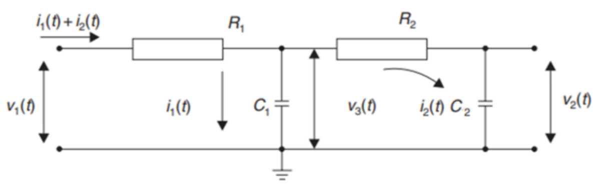
Fig. 1A</td><td>5</td><td>1</td><td>1</td><td>1</td><td>3</td></tr>
<tr><td>1B.</td><td>Compute the transfer function for the electrical circuit shown below.


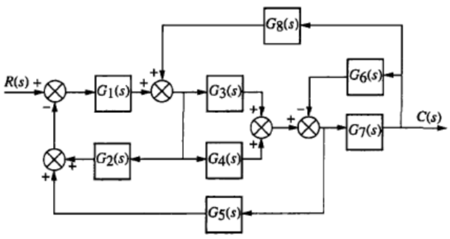
Fig. 1B</td><td>3</td><td>1</td><td>1</td><td>1</td><td>3</td></tr>
<tr><td>1C.</td><td>For a unity feedback control system with $G(s) = \frac{4}{s^2+0.4s}$ when subjected to unit step input, it is required that the system response should be settled with 2% tolerance band. Determine the transfer function and settling time.</td><td>2</td><td>2</td><td>1</td><td>1</td><td>3</td></tr>
<tr><td>2A.</td><td>Use block diagram reduction technique in Fig. 2A. to obtain the transfer function C(s)/R(s) of a certain control system.


Fig. 2A</td><td>4</td><td>1</td><td>1</td><td>1</td><td>3</td></tr>
</table>

2B.	The open loop transfer function of a unity feedback system is given by G(s) = $\frac{K}{s(sT+1)}$, where K and T are constants. By what factor should the amplifier gain 'K' be reduced so that the peak overshoot of unit step response is reduced from 60% to 20%.	**3**	**2**	**1**	**1**	**3**
2C.	The open loop transfer function of a unity feedback system is given by G(s) = $\frac{K}{s(1+sT_1)(1+sT_2)}$. Obtain the expression of 'K' to determine the stability of the system 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) = $\frac{K}{s(s+3)(s^2+3s+4.5)}$	**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 steady state response of the system can be improved using lag compensator	**2**	**3**	**2**	**2**	**4**
4A.	Compute the necessary values to draw bode plot for the open loop transfer function given by G(s) = $\frac{4}{(0.1s+1)^2(1+0.01s)}$	**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**	**3**
4C.	Illustrate with an example on how PI controller improves the steady state response of the system.	**3**	**4**	**2**	**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 $\dot{X} = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$. 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**	**3**	**5**	**5**