Total number of printed pages: **4** **Programme(UG)/5th Semester/UIE502**

2022

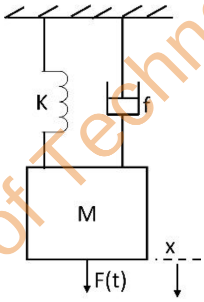
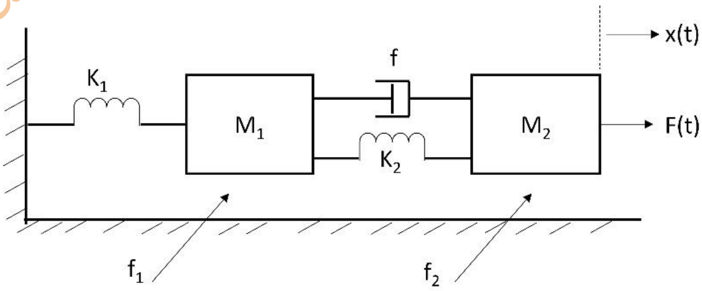
CONTROL SYSTEM

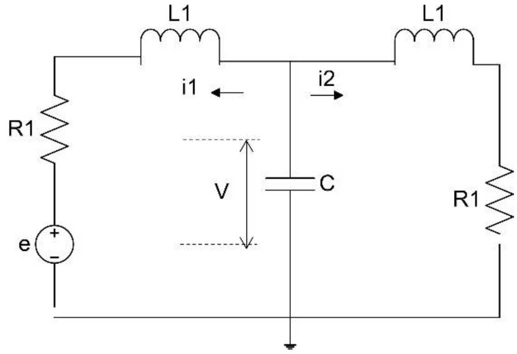
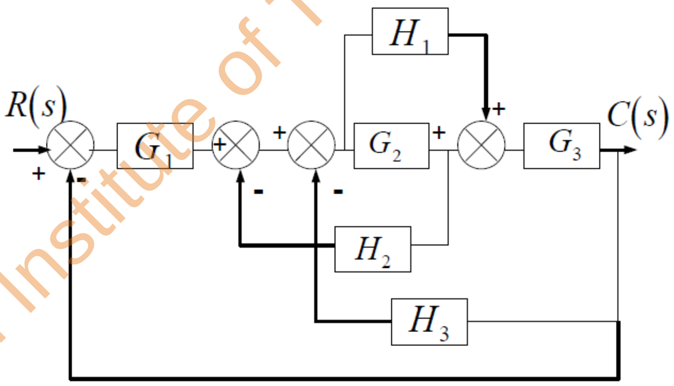
Full Marks : 100

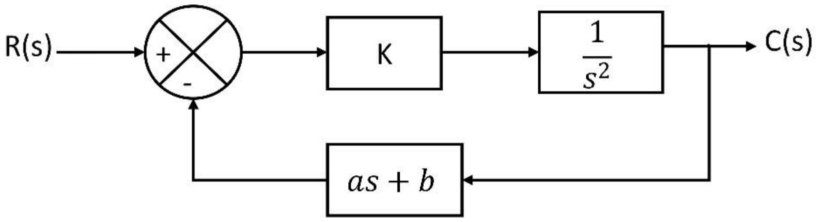
Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1.	a)	How an open loop control system is different from a closed loop control system? Explain with the help of suitable example.	6
	b)	Define transfer function and obtain the transfer function of the following system. 	2+2 = 4
	c)	Write the differential equations governing the behaviour of the mechanical system as shown in following mechanical arrangements. Also obtain the analogous electrical circuits based on i) Force-current analogy and ii) Force-voltage analogy. 	10
2.	a)	Determine the state model for the electrical circuit shown below.	5

			
	b)	Draw the state block diagram and model for the transfer function $G(s)=\dfrac{1}{(s+1)(s+3)}$.	5
	c)	Determine the time response using the Laplace Transform method for the state model assuming all initial conditions to be zero. $\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-3 & 1\\ -4 & 0\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}1\\ 0\end{bmatrix}u(t)$ and $y(t)=\begin{bmatrix}1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$	10
3.	a)	What happens if a takeoff point has been moved before a block, describe with suitable example. Determine the overall transfer function of the following block diagram using block diagram algebra. 	2+8=10
	b)	Represent the following set of equations by a signal flow graph and determine the overall transfer function using Mason's gain formula. $x = x_1 + \alpha_3 u$ $\dot{x}_1 = -\beta_1 x_1 + x_2 + \alpha_2 u$ $\dot{x}_2 = -\beta_2 x_1 + \alpha_1 u$	5
	c)	Obtain the time response expression of a second order control system subjected to unit step input.	5

4.	a)	The block diagram of a simple servomechanism is shown in following figure. Determine the value of ‘a’ and ‘b’ to provide an overshoot of 16% with time constant of 0.1 sec for a unit step input. Find also the damping ratio when K = 40.  	5
	b)	A second order control system is represented by a transfer function given below: $$\frac{\theta_0(s)}{T(s)} = \frac{1}{Js^2 + fs + K}$$ Where θ_0 is the proportional output and T is the input torque. A step input 10 Nm is applied to the system and test results are given below: (a) $M_p = 6\%$, (b) $t_p = 1\text{sec}$ and (c) the steady state value of the output is 0.5 radian. Determine the values of J, f and K.	6
	c)	What are steady state errors and error constants? Discuss the effect of type and order of a system to obtain those values.	4
	d)	By means of the Routh criterion, determine the stability of the system represented by the following characteristics equation. $$s^6 + 3s^5 + 5s^4 + 9s^3 + 8s^2 + 6s + 4 = 0$$	5
5.	a)	The open-loop transfer function of a control system is given by: $$G(s)H(s) = \frac{K}{s(s+6)(s^2+4s+13)}$$ Sketch the root locus and determine the stability condition.	14
	b)	From the above root locus determine the centroid, angle of departure, break away point, value of K and the frequency at which the root loci cross the $j\omega$ axis.	6
6.	Write short notes on any two of the following (any four)		5×4=20
	a)	Lag-Lead compensator	

	b)	Nyquist stability criterion	
	c)	Describing function	
	d)	Controllability	
	e)	Saturation Nonlinearity	
7.	a)	Sketch the bode plot for the open loop transfer function, $G(s)H(s)=\frac{2000}{s(s+2)(s+100)}$. Obtain gain and phase cross over frequency from the plot. Also comment on the system stability.	15
	b)	Determine the transfer function of a lead compensator that will provide phase lead of 45° and gain equal to 10dB at the angular frequency ω=8 rad/sec.	5