Total No. of printed pages = 6

19/5th Sem/UIE502

2021

CONTROL SYSTEM

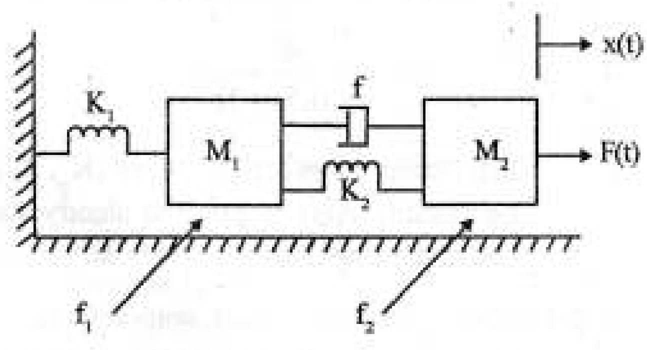
Full Marks – 100

Time – Three hours

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

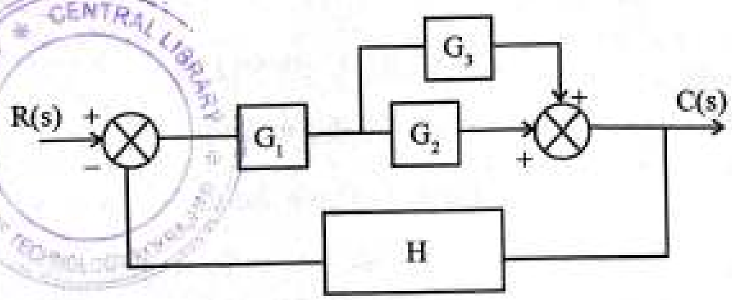
Answer any *five* question.

1. (a) Define transfer function. Derive the transfer function of the following system. Where x(t) is the output and F(t) is the input of the system. 5



[Turn over

(b) Determine the overall transfer function of the following block diagram using block diagram algebra and signal flow graph technique. 5+5=10



(c) Define the following with respect to signal flow graph. 5

(i) Forward path

(ii) Non touching loop

2. (a) A unity feedback system is characterized by an open loop transfer function

$$G(s) = \frac{40}{s(0.5s+1)}.$$

Determine the error constants (K_p, K_v, K_a) for the system. Also obtain the steady state error when the input is $r(t) = 1 + 3t$. 5

(b) Derive the unit ramp response to a typical first order feedback control system. 5

(c) A unit feedback system is characterised by an open loop transfer function G(s)=K/s(s+10). Determine the gain K, so that the system will have a damping ratio of 0.5. For this value of K determine the settling time, peak overshoot and time to reach the peak overshoot for a unit step input. 5

(d) Using the Routh's criterion, calculate the range of 'K' for which the following system become stable for unity feedback. 5

$$G(s)=\frac{K(s+13)}{s(s+3)(s+7}$$

3. (a) Why root locus plot is necessary in control system ? Discuss two basic conditions for plotting a root locus. 5

(b) A unity feedback control system has an open-loop transfer function

$$G(s)H(s)=\frac{K(s+1)}{s^2+0.4s+0.4}.$$

Sketch the root locus plot of the system. Determine the value of K at s = – 2. Comment on the stability and time response of the system. 15

4. (a) Sketch the Bode plot for a unity feedback system characterised by a open-loop transfer function $G(s)=\frac{K(1+0.2s)(1+0.025s)}{s^3(1+0.001s)(1+0.005s)}$.

Show that the system is conditionally stable. Find the range of 'K' for which the system is stable. 15

(b) Define gain cross over and phase cross over frequency with respect to previous problem [4(a)]. 5

5. (a) State and prove the Nyquist stability criterion. 5

(b) The open-loop transfer function of a unity feedback control system is

$$G(s)=\frac{(s+0.25)}{s^2(s+1)(s+0.5)}.$$

Determine the closed-loop stability by applying Nyquist criterion. 15

6. (a) What is state space ? Why the state space representation is advantageous than transfer function ? 3

(b) Consider the system which is defined by

$$\begin{cases} \dot{x} = Ax + Bu \\ y = Cx \end{cases} \quad \text{where,} \quad A = \begin{bmatrix} -1 & 0 & 1 \\ 1 & -2 & 0 \\ 0 & 0 & -3 \end{bmatrix},$$

$B = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$, $C = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix}$. Obtain the transfer function $\frac{Y(s)}{U(s)}$. 7

(c) A feedback system is characterized by the closed loop transfer function

$$\frac{C(s)}{R(s)} = \frac{s^2 + 3s + 3}{s^3 + 2s^2 + 3s + 1}.$$

Obtain the state space model. 5

(d) Check the observability of the system.

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u \quad \text{and}$$

$$y = \begin{bmatrix} 20 & 9 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$ 5

7. (a) The open-loop transfer function of a system is given by $G(s)H(s) = \frac{K}{s^2}$. It is desired to compensate the system as to meet the specifications such as settling time ≤ 4 sec and peak overshoot for step input $\leq 20\%$. Design a suitable lead compensator and sketch the root locus plot of the uncompensated and compensated systems. 10

(b) Write short notes on any two : 2×5=10

(i) Lag compensator

(ii) Back lash nonlinearity

(iii) Describing function.