**II B. Tech II Semester Regular Examinations, April - 2018**
**CONTROL SYSTEMS**
(Electrical and Electronics Engineering)

Time: 3 hours Max. Marks: 70

Note: 1. Question Paper consists of two parts (**Part-A** and **Part-B)**
2. Answer **ALL** the question in **Part-A**
3. Answer any **FOUR** Questions from **Part-B**

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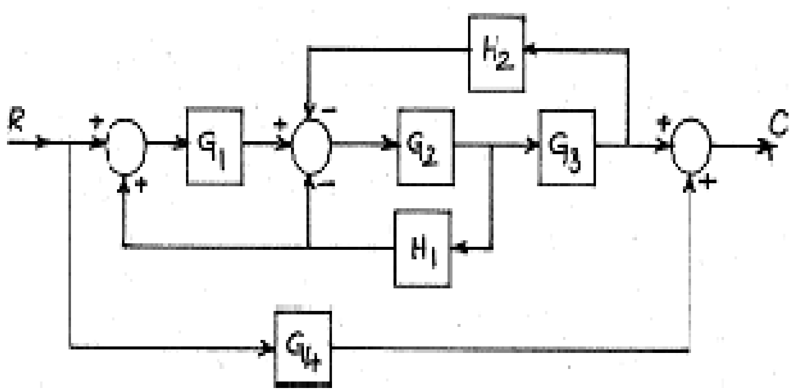
**PART –A**

1. a) Write the transfer function of AC servo motor. (3M)
   b) What are the standard test signals? (2M)
   c) What is the necessary and sufficient condition for stability? (2M)
   d) Define the Phase cross over frequency and gain cross over frequency. (2M)
   e) Draw the electrical equivalent circuits of lead-lag and lag-lead compensator. (3M)
   f) Explain the concept of state and state variable? (2M)

**PART -B**

2. a) For the given block diagram shown in Fig, find the transfer function and verify the same through signal flow graph. (7M)




   b) Draw the signal flow graph for the following equations: (7M)
   i) $x_1+5x_2-2x_3=0$ ii) $x_3+2x_4-4x_2=0$ iii) $x_4-8x_3=0$.

3. a) Illustrate the effects of proportional derivative control on transient performance of feedback control systems. (7M)
   b) The open-loop transfer function of a negative unity feedback control system is $G(S) = \frac{K}{S\,(S+10)}$. Find the range of K for which the peak overshoot is less than 12 %. For K = 64, obtain rise time, percentage overshoot, peak time and settling time when subjected to unit step input. (7M)

4. a) Briefly explain about Routh-Hurwitz criterion. (7M)
   b) Determine the range of 'K' for which the system having the characteristic equation: $S^4 + 20KS^3+5\,S^2+10S+15=0$ is stable. (7M)
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5. State and explain Nyquist stability criterion. Draw the Nyquist plot for the open loop transfer function $G(s) = \frac{1}{S(1+0.1S)(1+S)}$ and discuss the stability of the closed loop system and determine its relative stability. (14M)

6. The open loop transfer function of a unity feedback system is $G(s) = \frac{K}{S(S+2)}$ Design a lead compensator to have a velocity-error constant of $20S^{-1}$ and a phase margin of at least 50°. (14M)

7. The state equation of a linear time-invariant system is given below: (14M)

$$\begin{bmatrix} \dot{X_1} \\ \dot{X_2} \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u$$

Determine the following:
i) State transition matrix
ii) Controllability and observability of the system

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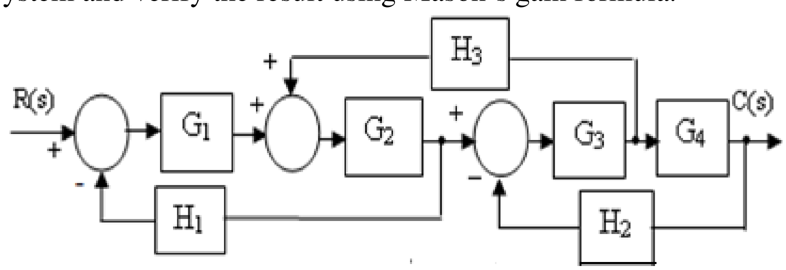
## PART –A

1. a) What are the advantages and disadvantages of closed loop control system? (3M)
   b) How damping ratio affects the time response of a second order system. (2M)
   c) What are the advantages and disadvantages of Root Locus? (3M)
   d) State the Nyquist Stability criterion. (2M)
   e) What is the need of lag-lead compensator? (2M)
   f) What are the properties of state transition matrix? (2M)

## PART -B

2. a) What is the classification of control systems and discuss the importance of mathematical modeling of a control system. (7M)
   b) Obtain overall transfer function C(s)/R(s) of the system shown in figure using block diagram reduction technique. Draw the signal flow graph for the same system and verify the result using Mason's gain formula. (7M)




3. a) Derive the expressions for peak time and settling time of standard 2nd order system when subjected to a unit step input. (7M)
   b) For a unity feedback system the open loop transfer function is given by (7M)
   $G(s) = \frac{200}{S(S+10)}$ Determine: i) maximum overshoot ii) rise time iii) settling time and iv) steady state error if the input is a unit step.

4. a) Briefly explain the Root Locus concept. (7M)
   b) Explain the effects of adding poles and zeros to G(s) H(s) on the root loci. (7M)

5. Sketch the bode plot and determine the following i) gain cross over frequency ii) phase cross over frequency iii) gain margin iv) phase margin for the transfer function is given by G(s) = $\frac{K}{S(S+1)(S+2)}$ and determine the K for stability. (14M)
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6. A system has $G(s) = \frac{0.035}{S(1+0.5S)(1+0.04S)}$ Design a suitable lag compensator to give velocity error constant 27.3 $S^{-1}$ and phase margin = 45°. (14M)

7. Explain the properties of state transition matrix. A linear time invariant system is described by the state equation: (14M)

$\dot{X} = \begin{bmatrix} 0 & 6 \\ -1 & 5 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U$ and $y = \begin{bmatrix} 1 & 0 \end{bmatrix} X$, $X(0) = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

Obtain the state transition matrix, hence obtain the output response y(t) , t ≥ 0 for a unit step input.

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**PART –A**

1. a) What is a synchro? Write its transfer function. (3M)
   b) What is the difference between type and order of a system? (2M)
   c) Define the term Angle of Departure? (2M)
   d) Define phase margin and gain margin. (2M)
   e) Write the properties of lag compensator. (3M)
   f) What is controllability? (2M)

**PART -B**

2. a) Derive the transfer function of armature controlled DC Servo motor. (7M)
   b) For the geared system shown below in Figure 1, find the transfer function relating the angular displacement θL to the input torque $T_1$, where $J_1$, $J_2$, $J_3$ refer to the inertia of the gears and corresponding shafts. $N_1$, $N_2$, $N_3$, and $N_4$ refer to the number of teeth on each gear wheel. (7M)

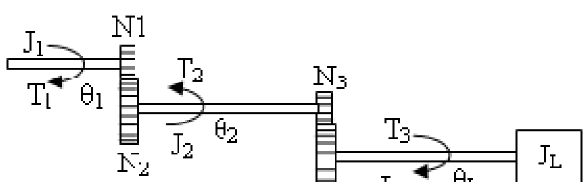


**Figure 1**

3. a) Define position, velocity and acceleration error constants. Express steady-state error in terms of error constants for type-1 and type-2 systems. (7M)
   b) For a system having, G(s) H(s) = $\frac{20}{S^2 + 7S + 25}$ find its time response specifications. (7M)

4. a) Write the limitations of the Routh's stability. (5M)
   b) Draw the complete root locus for $G(s)\,H(s) = \frac{K}{S(S+2)(S+4)}$ from the root locus plot, find the range of values of K for which the system will have damped oscillatory response. Also, determine the value of K for a damping ratio of ξ=0.5. (9M)
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5. a) Explain the procedure for constructing the polar plots. (7M)

   b) Determine the resonant frequency $\omega_r$, resonant peak MP and bandwidth for the system whose transfer function is $G(j\omega)= \frac{5}{5+j2\omega+(j\omega)^2}$ (7M)

6. a) Explain the design of phase –lag controller (7M)

   b) Draw the characteristic Bode plots of lag lead compensator. Give the procedural steps. (7M)

7. a) Find the state transition matrix for (7M)

$$\dot{x} = \begin{bmatrix} -2 & 1 & 0 \\ 0 & -2 & 1 \\ 0 & 0 & -2 \end{bmatrix} x$$

   b) Determine the state model of the system characterized by the differential equation $(S^4 + 8S^3 + 2S^2 + 4S + 3)\ Y(s) = 10\ U(s)$ (7M)

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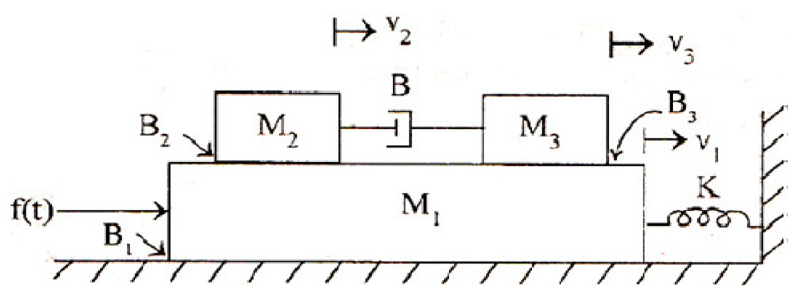
**PART –A**

1. a) State and explain the Mason's gain formula (3M)
   b) Define what is meant by steady state error. (2M)
   c) What are the limitations of Routh Criterion? (2M)
   d) What is the effect on polar plot if a non-zero pole is added to the transfer function? (2M)
   e) What are the different types of electrical compensators? (3M)
   f) What is observability? (2M)

**PART -B**

2. a) Determine the transfer function $V_1(s) / F(s)$ for the system show in below figure (7M)




   b) Explain the working of a synchro transmitter receiver pair. (7M)

3. a) What are integral controllers and why are they used in combination with proportional controllers? (7M)
   b) A unity-feedback system is characterized by the open loop transfer function $G(s) = \frac{1}{S(1+0.5S)(1+0.2S)}$. Determine the rise time, peak time, peak overshoot, and settling time of the unit-step response of the system. (7M)

4. a) Define and derive the breakaway point on the root locus. (7M)
   b) Determine the stability of the closed loop system whose open loop transfer is $\frac{5(2S+1)}{S(S+1)(1+3S)(1+0.5S)}$ using Routh-Hurwitz criterion. (7M)
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5. a) Define frequency domain specifications. (5M)

b) Draw the Nyquist plot for a given transfer function G(s) = $\frac{(S+2)}{(S+1)(S-1)}$ . (9M)

6. a) What is the need of compensation? What are the various types of compensators (7M)

b) Explain the effects of proportional, integral, and derivative terms of PID controllers on system performance. (7M)

7. a) Find the observability and controllability of the system given by given by $\dot{x}$ = A x + Bu , y = cx, where (10M)

$$A=\begin{bmatrix}-1 & -4 & -1\\ -1 & -6 & -2\\ -1 & -2 & -3\end{bmatrix}, B=\begin{bmatrix}0\\1\\1\end{bmatrix} \& C=\begin{bmatrix}1 & 1 & 1\end{bmatrix}$$

b) What are the advantages of state space representation? (4M)