ST.ANNE'S

COLLEGE OF ENGINEERING AND TECHNOLOGY
ANGUCHETTYPALAYAM, PANRUTI – 607106.

QUESTION BANK

JUNE 2023 - DEC 202023 / EVEN SEMESTER

BRANCH: EEE **YR/SEM:** III/V **BATCH**: 2021 - 2025

SUB CODE/NAME: EE- 3503 CONTROL SYSTEMS

UNIT I

CONTROL SYSTEM MODELING

PART - A

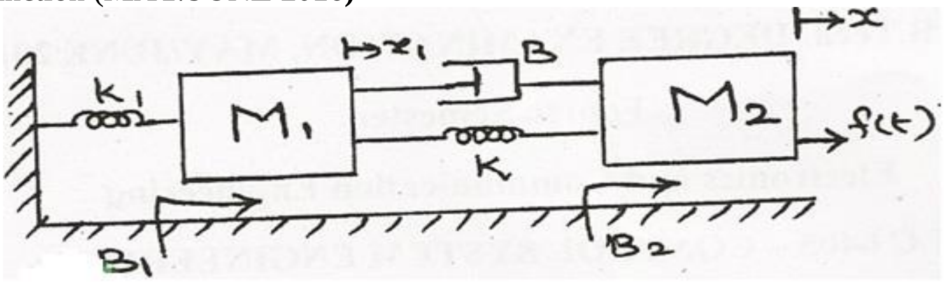
1. What is meant by a system?
2. Write Mason's Gain formula. **(NOV/DEC 2011, NOV/DEC 2010, MAY/JUNE 2013, MAY/JUNE 2014, NOV/DEC 2014, MAY/JUNE 2015, MAY/JUNE 2016)**
3. What are the three basic elements in electrical and mechanical system? **(NOV/DEC 2010)**
4. How will you get closed loop frequency response from open loop response? **(NOV/DEC 2010)**
5. List out the advantages of closed loop and open loop control system. **(APR/MAY 2010, MAY/JUNE 2012, NOV/DEC 2012, MAY/JUNE 2014, APR/MAY 2015, APR/MAY 2017)**
6. State ''transfer function'' of a system. **(APR/MAY 2010, NOV/DEC.2010, NOV/DEC 2013, NOV/DEC 2014, APR/MAY 2017)**
7. What is analogous systems? **(NOV/DEC 2013)**
8. What are the basic elements of a control systems? **(NOV/DEC 2014, MAY/JUNE 2016, NOV/DEC 2016)**
9. Write the force balance equation for ideal dashpot and ideal spring. **(APR/MAY 2015)**
10. What is Control Systems? **(NOV/DEC 2016)**
11. Differentiate between open loop and closed loop control systems. **(NOV/DEC 2010, NOV/DEC 2014, MAY/JUNE 2016, APR/MAY 2017)**
12. Prove the rule for eliminating negative and positive feedback loop.
13. Name any two dynamic models used to represent control systems. **(MAY/JUNE 2013)**
14. What are the characteristics of negative feedback? **(MAY/JUNE 2014, APR/MAY 2017)**
15. What is translational system?
16. Give the types of friction.
17. What is block diagram?**(APR/MAY 2017)**
18. What is signal flow graph?
19. What is the need for signal flow graph?

20. Why negative feedback is preferred over positive feedback system? **(NOV/DEC 2016)**

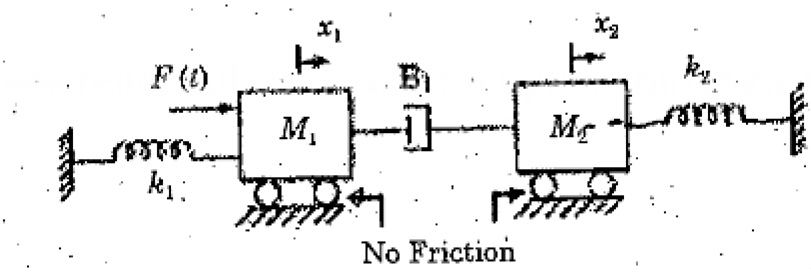
PART - B

Mechanical Translational System (16 Marks)

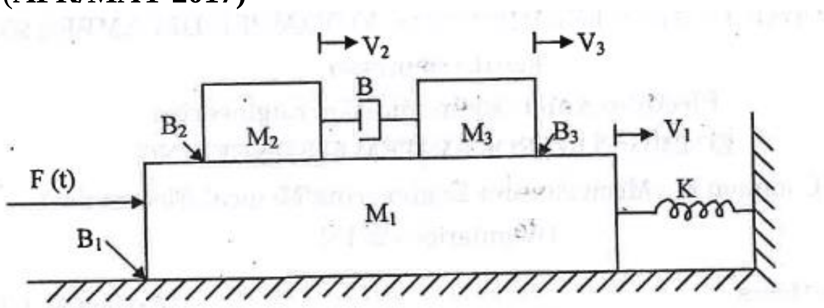
1. Write the differential equation governing the mechanical rotational systems shown in the figure and find the transfer function (**MAY/JUNE 2016)**



2. Write the differential equation governing the mechanical rotational systems shown in the figure and find the transfer function (**NOV/DEC 2013)**

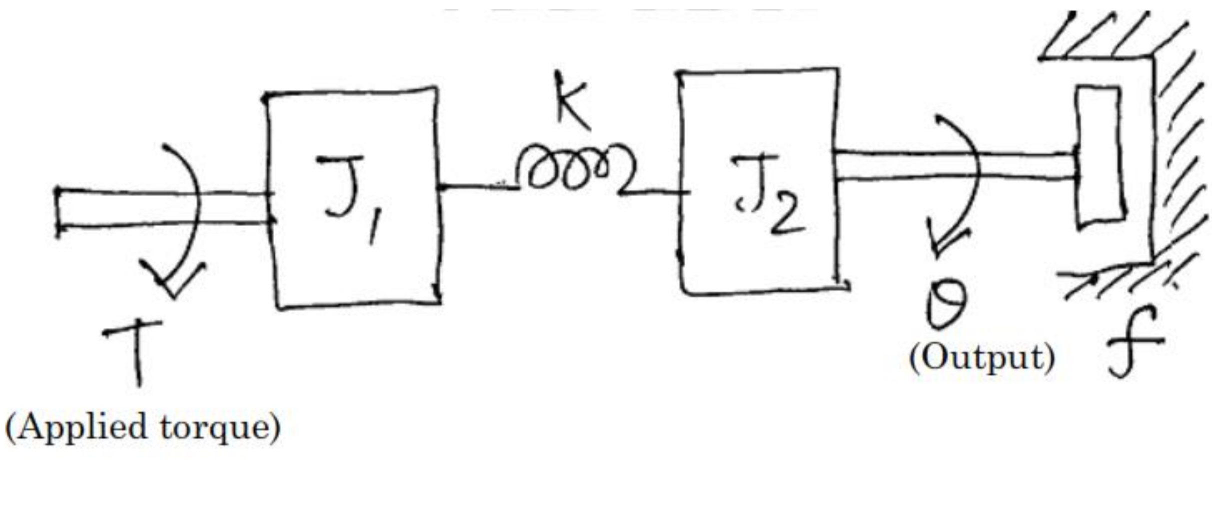


3. Write the differential equation governing the mechanical rotational systems shown in the figure and find the transfer function (**APR/MAY 2017)**



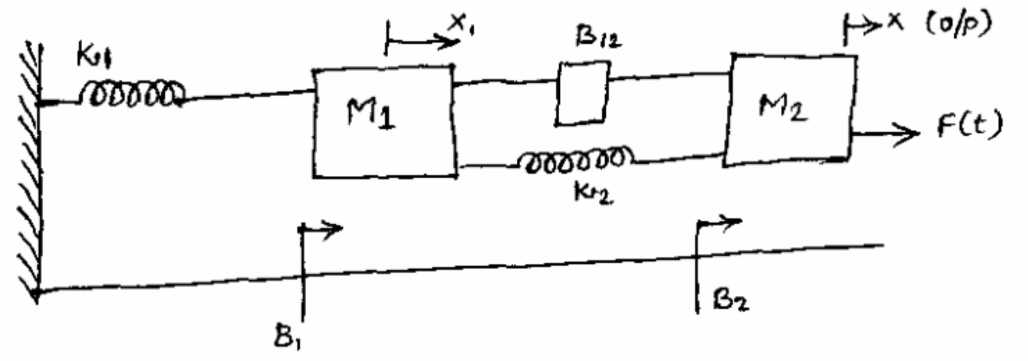
Mechanical Rotational System (16 Marks)

1. Write the differential equation governing the mechanical rotational systems shown in the figure and find the transfer function. Consider the angular displacement in J_1 as θ_1 (**MAY/JUNE 2013)**

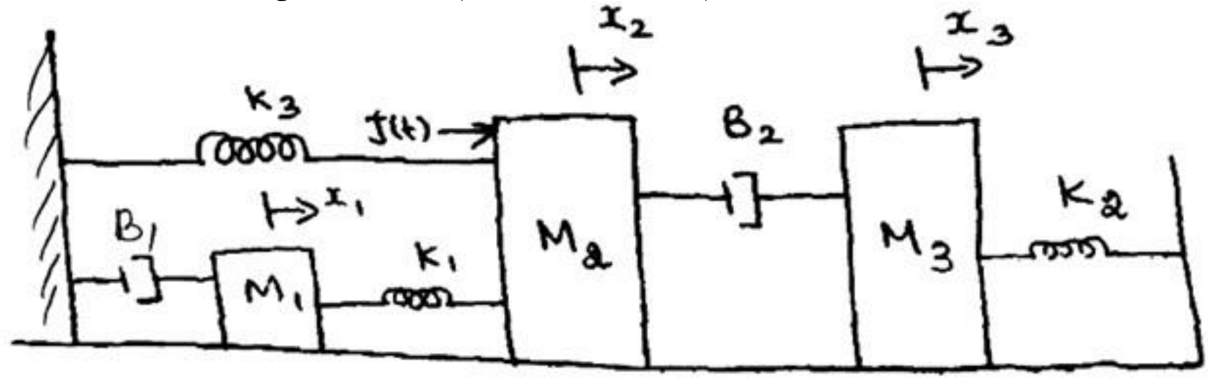


Electrical Analogous Circuits (MTS) (16 Marks)

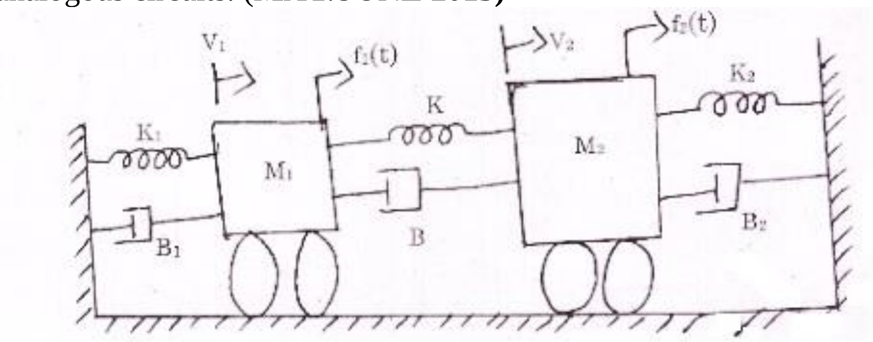
1. Obtain the transfer function of the given mechanical system. Hence the draw electrical analogous circuits. **(NOV/DEC 2014)**



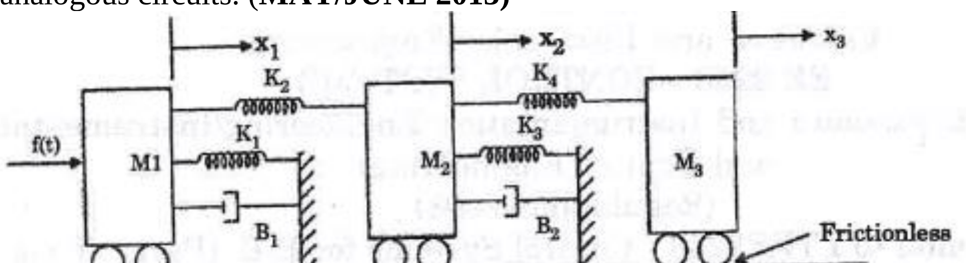
2. Write the differential equation governing the mechanical translational systems shown in the figure. Draw the Electrical analogous circuits. (**MAY/JUNE 2015)**



3. Write the differential equation governing the mechanical translational systems shown in the figure. Draw the Electrical analogous circuits. (**MAY/JUNE 2013)**



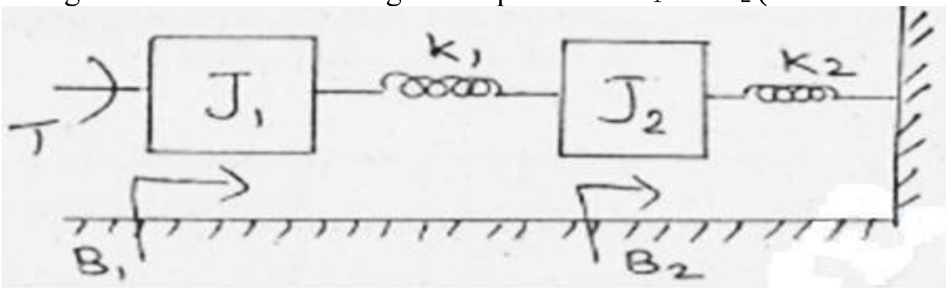
4. Write the differential equation governing the mechanical translational systems shown in the figure. Draw the Electrical analogous circuits. (**MAY/JUNE 2013)**



Electrical Analogous Circuits (MRS) (16 Marks)

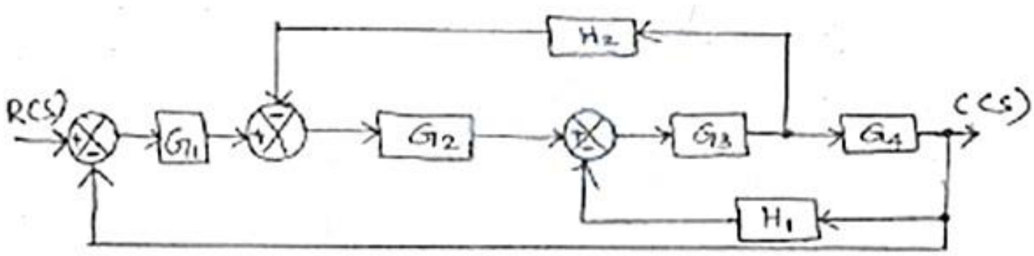
1. Write the differential equation governing the mechanical rotational systems shown in the figure.

Draw the Electrical analogous circuits with two angular displacement θ_1 and θ_2 (**NOV/DEC 2016)**

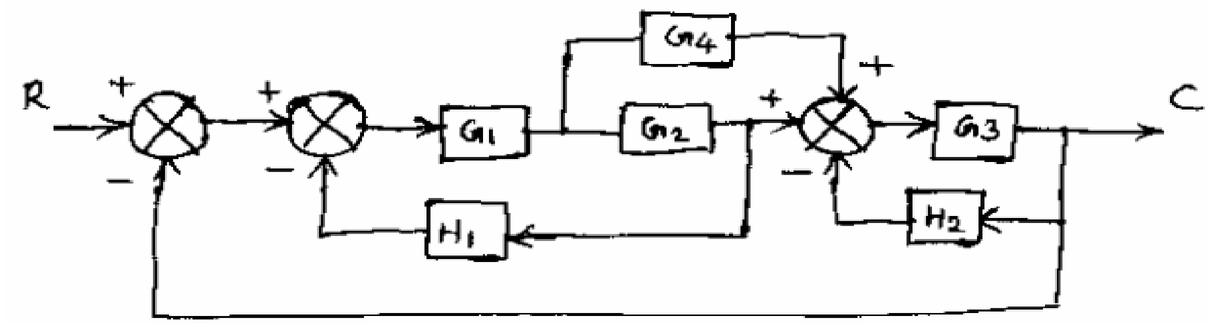


Block Diagram Reduction Technique (8 Marks)

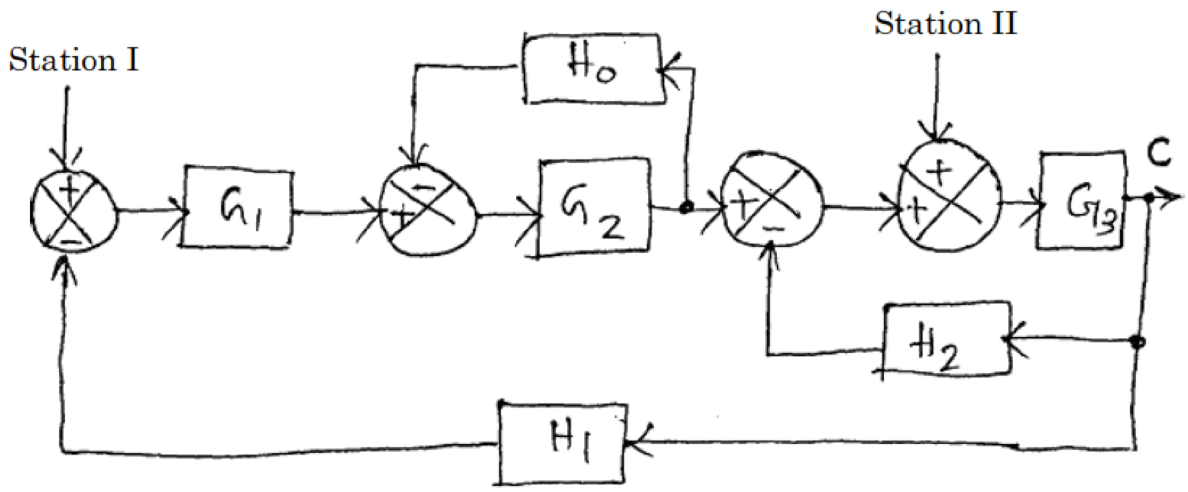
1. Reduce the given block diagram and find the overall transfer function. (**NOV/DEC 2016)**



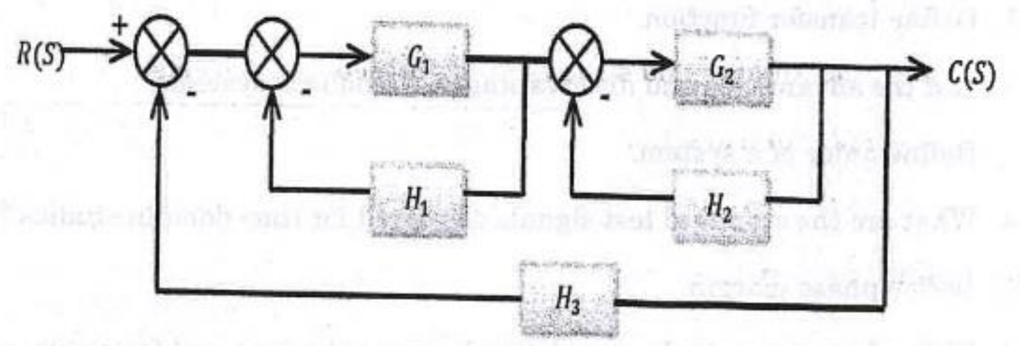
2. Reduce the given block diagram and find the overall transfer function. (**NOV/DEC 2014)**



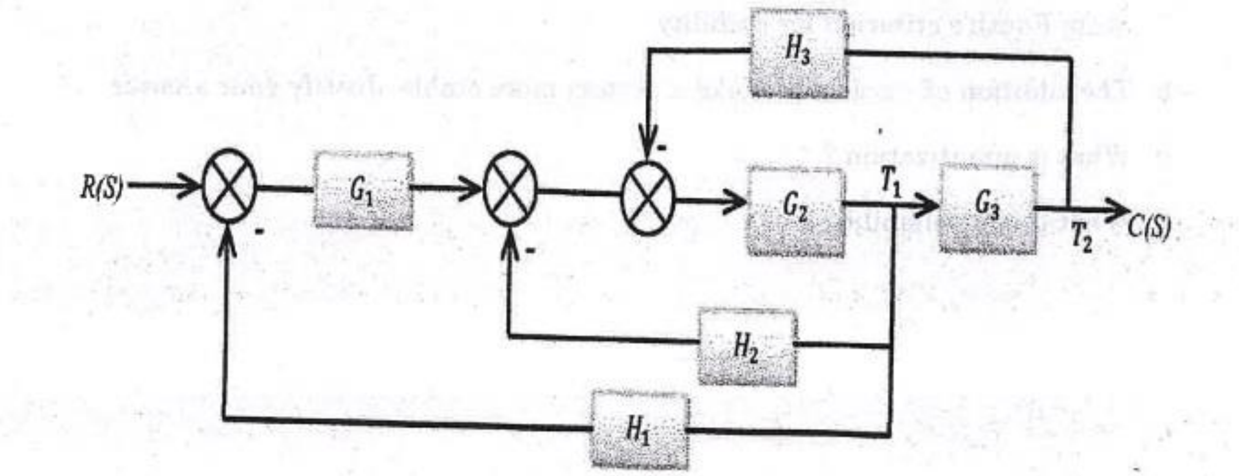
3. For the system represented by the block diagram given below, evaluate the closed loop transfer function, when input R is (i) at Station 1 and (ii) at Station 2 (**NOV/DEC 2013)** **(16 Marks)**



4. Reduce the given block diagram and find the overall transfer function. (**APR/MAY 2017) (8 MARKS)**

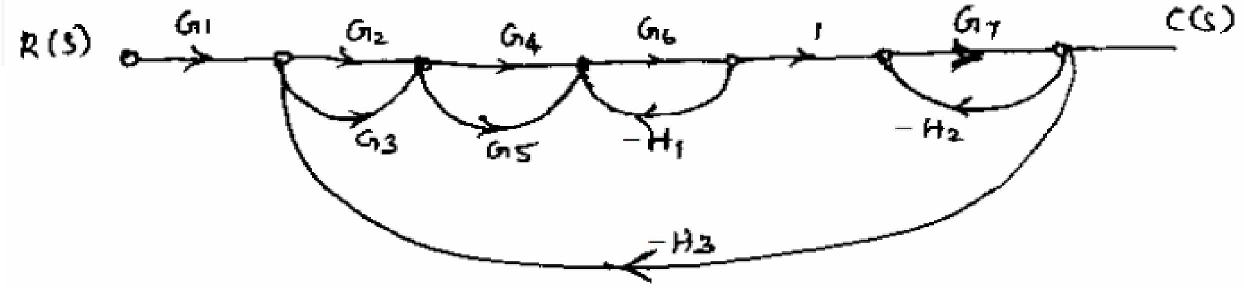


5. Reduce the given block diagram and find the overall transfer function. (**APR/MAY 2017) (8 MARKS)**

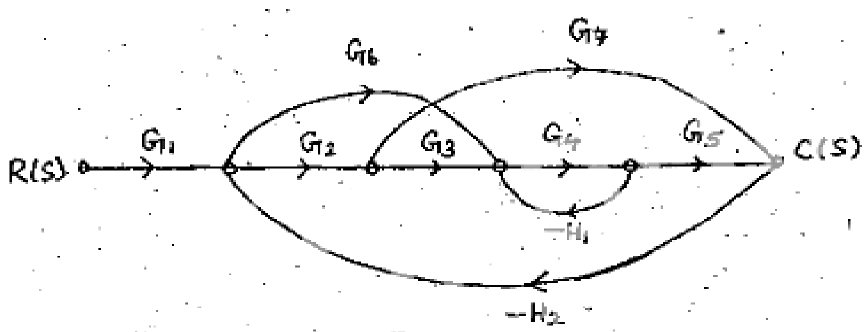


Signal Flow Graph Technique (8 Marks)

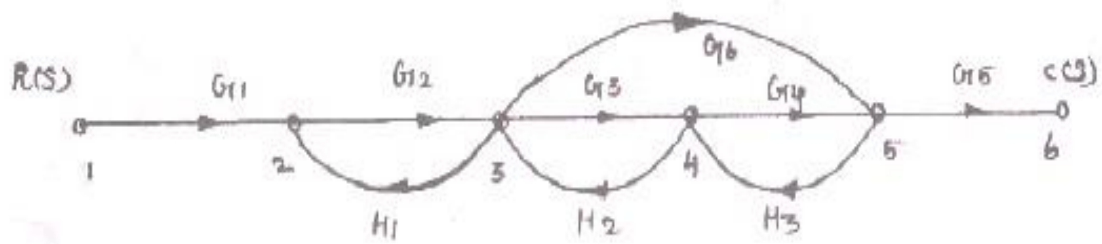
1. For the given signal flow graph find C(S)/R(S) using Mason's Gain formula. (**NOV/DEC 2014)**



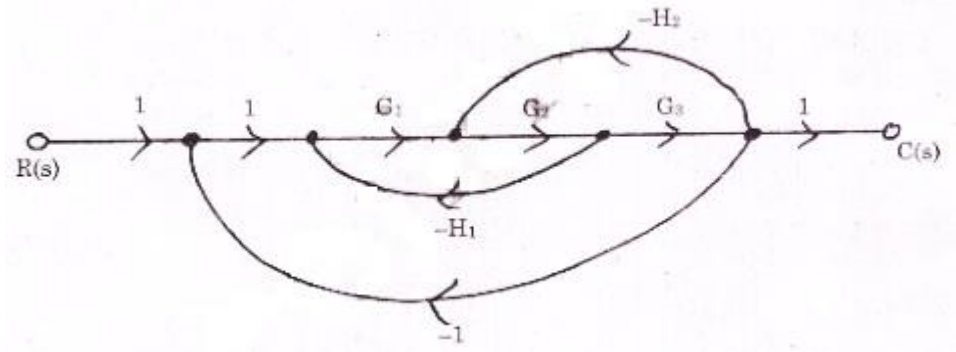
2. For the given signal flow graph find C(S)/R(S) using Mason's Gain formula. (**NOV/DEC 2013, APR/MAY 2017)**



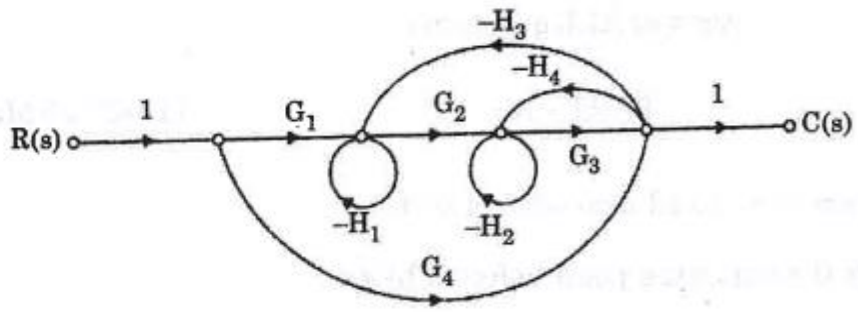
3. For the given signal flow graph find C(S)/R(S) using Mason's Gain formula. **(NOV/DEC 2013)**



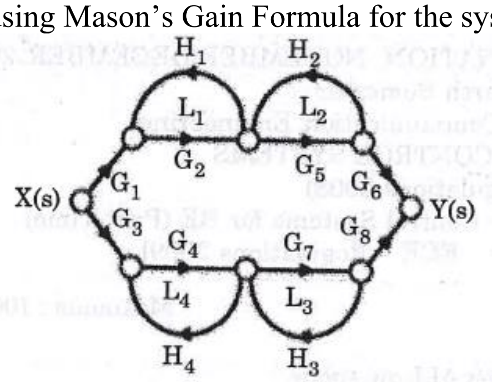
4. Obtain the transfer function using Mason's Gain Formula for the system**(MAY/JUNE 2013)**



5. Obtain the transfer function using Mason's Gain Formula for the system**(APR/MAY 2017)**

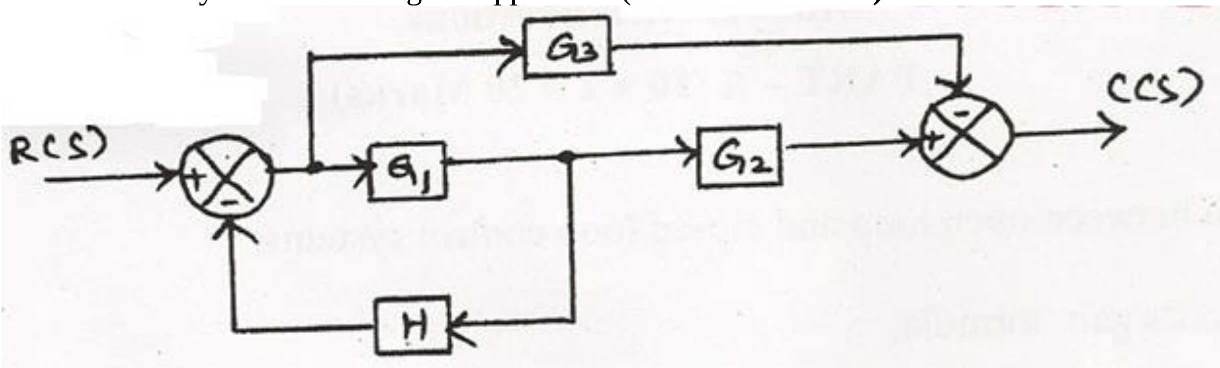


6. Obtain the transfer function using Mason's Gain Formula for the system**(APR/MAY 2017)**

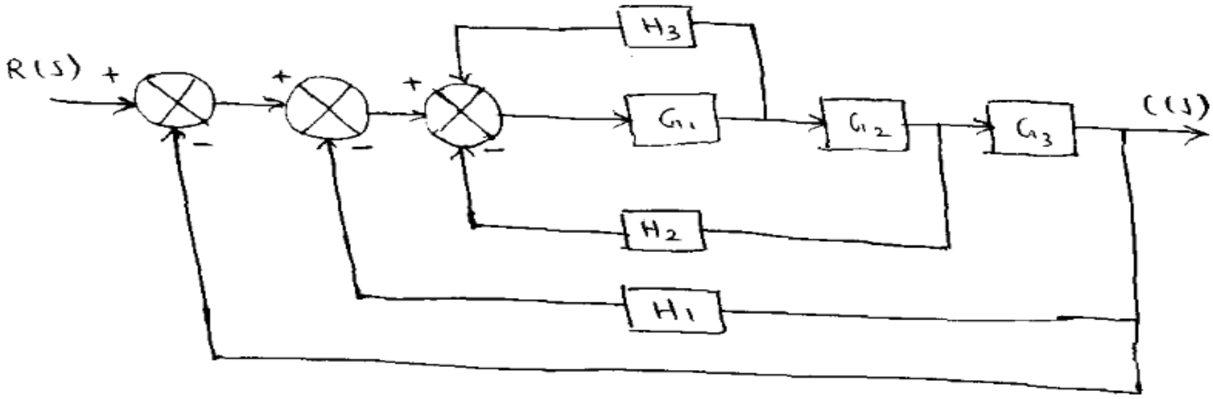


Block Diagram Reduction to Signal Flow Graph Technique (16 Marks)

1. Convert the given block diagram to signal flow graph and find the transfer function using mason's gain formula and verify with block diagram approach. (**MAY/JUNE 2016)**



2. Convert the given block diagram to signal flow graph and find the transfer function using mason's gain formula and verify with block diagram approach. (**MAY/JUNE 2016)**



UNIT II

TIME RESPONSE ANALYSIS

PART - A

1. Specify the time domain Specification? **(NOV/DEC 2016, MAY/JUNE 2016)**
2. What is meant by steady state error? **(NOV/DEC 2016, NOV/DEC 2015)**
3. List the Standard test signal used in time domain analysis. **(MAY/JUNE 2016, MAY/JUNE 2014, NOV/DEC 2015)**
4. State the effect of PI Compensation in system performance. **(MAY/JUNE 2016)**
5. How do you find the type of the system? **(MAY/JUNE 2015)**
6. Find the unit impulse response of the system H(s) = 5s/(s+2) with zero initial conditions. **(MAY/JUNE 2015)**
7. For the system described by $\frac{C(S)}{R(S)} = \frac{16}{S^2+8S+16}$;find the nature of the time response? **(NOV/DEC 2015)**
8. Why is the derivative control not used in control system? **(NOV/DEC 2015)**
9. Give the relation between static and dynamic error coefficents. **(NOV/DEC 2016)**
10. What is type and order of the system? **(NOV/DEC 2014, MAY/JUNE 2015)**
11. What are the advantages of generalized error series? **(NOV/DEC 2014)**
12. Give the transfer function of the PID Controller. **(NOV/DEC 2013)**
13. State the effect of PD Compensation in system performance. **(MAY/JUNE 2014)**
14. What do you mean by peak over shoot? **(NOV/DEC 2010)**
15. Define settling time. **(MAY/JUNE 2010)**
16. Differentiate between steady state and transient response of the system? **(MAY/JUNE 2010)**
17. What is the effect of system performance when a proportional controller is introduced in a system? **(MAY/JUNE 2015)**
18. What is type and order of the given system $G(S) = \frac{K}{S(ST+1)}$? **(NOV/DEC 2014)**
19. Define Rise time.
20. Define peak time.

PART – B

Time response analysis

1. Define and Derive the time domain specifications of a second order system subjected to a step input (**NOV/DEC 2016, MAY/JUNE 2016, NOV/DEC 2011, NOV/DEC 2015)**
2. Derive the expression for unit step response for the second order
   a. Underdamped, and
   b. Undamped systems. (**NOV/DEC 2015, NOV/DEC 2014, NOV/DEC 2013)**
3. Derive the time response of a first order system for unit step input **(MAY/JUNE 2016) (8 Marks)**
4. The unity feedback control system is characteristic by an open loop transfer function $G(S) = \frac{K}{S(S+10)}$. Determine the gain K, so that the system will have damping ratio of 0.5 for this value of K. Determine the peak overshoot and peak time for a unit step input. **(MAY/JUNE 2016, MAY/JUNE 2015, MAY/JUNE 2014, NOV/DEC 2014)**
5. The overall transfer function of a control system is given by $\frac{C(S)}{R(S)} = \frac{16}{S^2+1.6S+16}$. It is desired that the damping ratio be 0.8. Determine the derivative rate feedback constant K_1 and compare rise time, peak time, maximum overshoot and steady state error for unit ramp input function without and with derivative feedback control. (**NOV/DEC 2016)**

Static and dynamic error

1. For a unity feedback control system the open loop transfer function is given by $G(s) = \frac{10(S+2)}{S^2(S+1)}$, find

- **a.** The position, velocity, acceleration error constants
- **b.** The steady state error when R(s) = $\frac{3}{S} - \frac{2}{S^2} + \frac{1}{3S^3}$ (**NOV/DEC 2016, MAY/JUNE 2016)**

2. The open loop transfer function of a unity feedback control system is given by $G(S) = \frac{K}{S(S+1)}$. The input of the system is described by r(t)=4+6t. Find the generalized error coefficients and steady state error. (**NOV/DEC 2015)**

3. The unity feedback control system has the forward transfer function $G(S) = \frac{KS}{(S+1)^2}$. For the input r(t)=1+5t. Find the Minimum value of K so that the steady state error is less than 0.1. (**MAY/JUNE 2015)**

4. The open loop transfer function of a servo system with unity feedback is $G(S) = \frac{10}{S(0.1S+1)}$. Evaluate the static error constants (Kp, Kv, Ka) for the system. Obtain the steaty stae error of the system when subjected to an input given by the polynomial $r(t) = a_0 + a_1 t + \frac{a_2}{2} t^2$ **(MAY/JUNE 2015, MAY/JUNE 2014, NOV/DEC 2010)**

5. For the open loop system with $G(S) = \frac{1}{(S+1)}$ and $H(S) = 5$, Calculate the generalized error coefficients and error series **(NOV/DEC 2013) (8 Marks)**

UNIT III

FREQUENCY RESPONSE ANALYSIS

PART - A

1. What is bode plot? **(APR/MAY 2016)**
2. Define gain margin and phase margin. **(NOV/DEC 2011, APR/MAY 2010, NOV/DEC 2014, APR/MAY 2015)**
3. Define Resonant Peak and Resonant Frequency. **(MAY/JUNE 2014, NOV/DEC 2014)**
4. Mention any four frequency response specifications. **(NOV/DEC 2010)**
5. What are m & n circles? **(NOV/DEC 2011, MAY/JUNE 2014)**
6. Define Corner Frequency. **(NOV/DEC 2012)**
7. What is Nichol's chart? **(NOV/DEC 2012)**
8. What is Gain and Phase Crossover Frequency? **(NOV/DEC 2013)**
9. List the advantages of Nichol's chart? **(NOV/DEC 2010).**
10. What are the Frequency Domain Specifications. **(NOV/DEC 2016).**
11. Define –Resonant Peak
12. What is bandwidth?
13. Define Cut-off rate?
14. What are the main advantages of Bode plot?
15. Define Phase cross over?
16. Define Gain cross over?
17. What is a polar plot?
18. What are compensators?
19. What are the two types of compensation techniques write short notes on them?
20. Define Lead compensator.
21. What is a lag compensator?
22. What is a lag lead compensator?
23. What is the need for compensator? **(NOV/DEC 2011, MAY/JUNE 2014, MAY/JUNE 2015, NOV/DEC 2014, NOV/DEC 2010)**
24. Sketch the electrical circuit of a Lag, Lead, lag-lead compensator. **(NOV/DEC 2011, NOV/DEC 2010)**
25. Write the transfer function and pole zero plot of lag, lead and lag-lead compensator. **(MAY/JUNE 2014, NOV/DEC 2010)**
26. What is the relation between φ_m *and* α? **(APR/ MAY 2010)**
27. What type of compensator suitable for high frequency noisy environment? **(APR/ MAY 2010)**
28. What is desired performance criteria specified in compensator design?

PART B

BODE PLOT

1. Plot the Bode diagram for the following transfer function and obtain the gain and phase cross over frequencies. (**APR/MAY 2011, NOV/DEC 2014)**

$$G(S) = \frac{10}{S\,(1+0.4S)(1+0.1S)}$$

2. Sketch the Bode plot and hence find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin.**(NOV/DEC 2011, APR/MAY 2010, APR/MAY 2013, NOV/DEC 2014, APR/MAY 2015)**

$$G(S) = \frac{0.75(1+0.2S)}{S\,(1+0.5S)(1+0.1S)}$$

3. Sketch the Bode plot and hence find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin. **(NOV/DEC 2013, NOV/DEC 2016)**

$$G(S) = \frac{10(S + 3)}{S(S + 2)\ (S^2\ + 4S + 100)}$$

4. Plot the Bode diagram for the following transfer function and obtain the gain and phase cross over frequencies

$$G(S) = \frac{KS^2}{(1 + 0.2S)(1 + 0.02S)}$$

   Determine the value of K for a gain cross over frequency of 20 rad/sec.

5. Sketch the Bode plot and hence find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin. **(NOV/DEC 2010, APR/MAY 2015)**

$$G(S) = \frac{10(1 + 0.1S)}{S\ (1 + 0.01S)\ (1 + S).}$$

POLAR PLOT

1. The open loop transfer function of a unity feedback system is

$$G(S) = \frac{1}{S\ (1 + S)(1 + 2S)}$$

   Sketch the Polar plot and determine the Gain margin and Phase margin. **(NOV/DEC 2010, NOV/DEC 2014)**

2. Sketch the polar plot for the following transfer function and find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin. **(APR/MAY 2010, NOV/DEC 2016)**

$$G(S) = \frac{10(S + 2)\ (S + 4)}{S\ (S^2 + 3S + 10)}$$

3. Sketch the polar plot for the following transfer function .and find Gain cross over frequency, Phase cross over frequency, Gain margin and Phase margin. **(APR/MAY 2015)**

$$G(S) = \frac{400}{S\ (S + 2)\ (S + 10)}$$

NICHOL'S PLOT

1. A unity feedback system has open loop transfer function

$$G(S) = \frac{20}{S\ (S+2)(S+5)}.$$

   Using Nichol's chart. Determine the closed loop frequency response and estimate all the frequency domain specifications. **(NOV/DEC 2013, APR/MAY 2014)**

2. Draw the Nichol's plot for the system whose open loop transfer function is G(S) H(S) =K / S (S+2) (S+10). Determine the range of K for which closed loop system is stable.

3. Construct Nichol's plot for a feedback control system whose open loop transfer function is given by G(S) H(S) =5/ S(1+S).Comment on the stability of open loop and closed loop transfer function.

4. Sketch the Nichol's plot for a system with the open loop transfer function G(S) H(S) =K (1+0.5S) (0.01+S) / (1+10S) (S+1). Determine the range of values of K for which the system is stable.

LEAD COMPENSATOR (13 MARKS)

1. Explain the design procedure of a lead compensator with suitable example. **(NOV/DEC 2011)**

2. The open loop transfer function of the uncompensated system is $G(s) = \frac{5}{S(S+2)}$. Design a suitable compensator for the system so that the static velocity error constant $K_V = 20sec^{-1}$, the phase margin is atleast 55° and the gain margin is atleast 12dB **(NOV/DEC 2013, APR/MAY 2010, MAY/JUNE 2016)**

3. Consider the unity Feedback system has an open loop transfer function is

$$\boldsymbol{G(s) = \frac{K}{S(0.1S+1)(0.2S+1)}}.$$

The system is compensated using a suitable lead compensator to meet the following specifications:

i. Phase Margin of atleast 50°;
ii. Bandwidth = 12 rad/sec;
iii. Velocity error constant $K_V \geq 30sec^{-1}$ **(MAY/JUNE 2016)**

LAG COMPENSATOR (13 MARKS)

1. Explain the design procedure of a lag compensator with suitable example. **(MAY/JUNE 2014, MAY/JUNE 2015)**

2. To open transfer function of a system is given below $\boldsymbol{G(s) = \frac{K}{S(S+1)(S+4)}}$.
Design a suitable lag compensator to meet the following specifications. Phase Margin = 43°; Bandwidth = 1.2 rad/sec; Velocity error constant $K_V \geq 5sec^{-1}$ **(NOV/DEC 2011)**

3. A Unity Feedback system has an open loop transfer function $\boldsymbol{G(s) = \frac{K}{S(S+1)(0.5S+1)}}$.
Design a suitable lag compensator to maintain the Phase Margin of atleast 40°; Bandwidth = 1.2 rad/sec; Velocity error constant $K_V \geq 5sec^{-1}$ **(MAY/JUNE 2016)**

LAG - LEAD COMPENSATOR (13 MARKS)

1. Explain the design procedure of a Lag- Lead compensator with suitable example. **(MAY/JUNE 2010, MAY/JUNE 2015)**

2. The open loop transfer function of the uncompensated system is $\boldsymbol{G(s) = \frac{1}{S(S+1)(S+2)}}$. Compensate the system by cascading suitable lag – lead compensator for the system so that the static velocity error constant $K_V = 10sec^{-1}$, the phase margin is atleast 45° and the gain margin is atleast 10dB or more. **(NOV/DEC 2013)**

UNIT IV

STABILITY ANALYSIS

PART - A

1. Define stability. **(MAY/JUNE 2016)**
2. What is nyquist contour
3. Define Relative stability.
4. What will be the nature of impulse response when the roots of characteristic equation are lying on imaginary axis?
5. What is the relationship between Stability and coefficient of characteristic polynomial?
6. What is limitedly stable system?
7. In routh array what conclusion you can make when there is a row of all zeros?
8. What are the two segments of Nyquist contour?
9. State any two limitations of routh stability criterion.**(NOV/DEC 2012)**
10. State the advantages of nyquist stability criterion over routh criterion**.(NOV/DEC 2012)**
11. What is BIBO stability criterion? **(NOV/DEC 2011)**
12. State Nyquist Stability Criterion. **(APR/ MAY 2010, NOV/DEC 2013, MAY/JUNE 2014, NOV/DEC 2010)**
13. How are the location of roots of the characteristic equation related to stability? **(MAY/JUNE 2014, MAY/JUNE 2015, NOV/DEC 2014)**
14. Define Routh Stability Criterion? **(MAY/JUNE 2014, MAY/JUNE 2015, NOV/DEC 2014)**
15. What is dominant pole? **(NOV/DEC 2016, NOV/DEC 2015, MAY/JUNE 2015)**
16. How will you find the root locus on real axis? **(MAY/JUNE 2016)**
17. State the basic properties of root locus. **(NOV/DEC 2016)**
18. What is the condition for the system $G(s) = \frac{K(s+a)}{s(s+b)}$ to have a circle in root locus? **(NOV/DEC 2013)**
19. What is the value of K at any given point in root locus? **(MAY/JUNE 2015, NOV/DEC 2010)**
20. What will be the nature of Step response when the roots of characteristic equation are lying on imaginary axis?

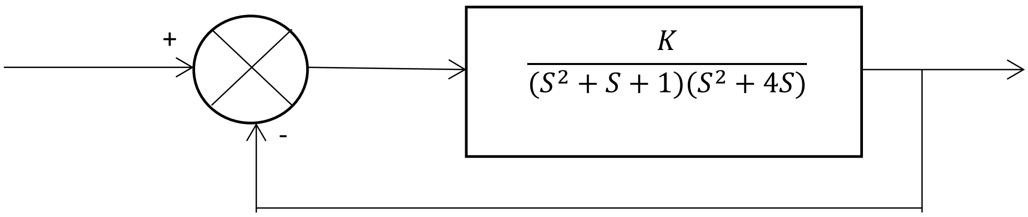
PART – B

ROUTH HURWITZ CRITERION (8 MARKS)

1. Determine the range of K for stability of unity feedback system whose open loop transfer function in $\boldsymbol{G(s) = \frac{K}{s(s+1)(s+2)}}$ using Routh Stability Criterion. **(NOV/DEC 2012)**
2. Construct Routh Array and determine the stability of the system whose characteristic equation is $\boldsymbol{S^6+2S^5+8S^4+12S^3+20S^2+16S+16=0}$. Also determine the number of roots lying on right half of s – plane, left half of s-plane and on imaginary axis. **(NOV/DEC 2011)**

3. Determine the stability of the given system of the given characteristic equation using Routh-Hurwitz Criterion
   i. $S^5+4S^4+8S^3+8S^2+7S+4=0$
   ii. $S^6+S^5+3S^4+3S^3+3S^2+2S+1=0$ **(16 Marks) (MAY/JUNE 2015)**

4. The open loop transfer function of a unity feedback control system is given by $\boldsymbol{G(s)} = \frac{\boldsymbol{K}}{\boldsymbol{(s+2)(S+4)(S^2+6S+25)}}$. By applying Routh criterion, dicuss the stability of the closed loop system as a function of K. Determine the values of K which will cause sustained oscillations in the closed loop system. What are the corresponding oscillation frequencies? **(16 Marks) (MAY/JUNE 2014)**
5. Consider the closed – loop system shown in the figure, determine the range of K for which the stable. **(MAY/JUNE 2016)**



NYQUIST STABILITY CRITERION (13 MARKS)

1. The open loop transfer function of a unity feedback system is given by

$\boldsymbol{G(s)H(s)} = \frac{\boldsymbol{5}}{\boldsymbol{S(S+1)(S+2)}}$. Draw the nyquist plot and hence find out whether the system is stable or not.

(NOV/DEC 2013)

ROOT LOCUS (13 MARKS)

1. With neat steps write down the procedure for construction of root locus. Each rule give a example. (**NOV/DEC 2016, NOV/DEC 2015)**

2. A unity Feedback Control system has an open loop transfer function

$$G(s) = \frac{K}{S(S^2+4S+13)}$$

Sketch the root locus. **(MAY/JUNE 2016, NOV/DEC 2010)**

3. A single loop negative feedback system has a transfer function $G_c(s)G(s) = \frac{K(S+6)^2}{S(S^2+1)(S+4)}$. Skectch the root locus as a function of K. Find the range of K for which the system is stable. (**MAY/JUNE 2015)**

4. Draw the root locus of the system is given by $G(s) = \frac{K(S+1)}{S(S^2+5S+20)}$. (**NOV/DEC 2016)**

5. Plot the root locus for a unity feedback closed loop system whose open loop transfer function is $G(s) = \frac{K}{S(S+4)(S^2+2S+2)}$. **(NOV/DEC 2011)**

6. Sketch the root locus of a unity feedback system with an open loop transfer function $G(s) = \frac{K}{S(S+2)(S+4)}$. Find the value of K so that the damping ratio of the closed loop system is 0.5. **(MAY/JUNE 2015, MAY/JUNE 2014)**

7. Sketch the root locus of a unity feedback system with an open loop transfer function $G(s) = \frac{K(S+0.5)}{S^2(S+4.5)}$. **(NOV/DEC 2013)**

8. The open loop transfer function of a unity feedback system is given by

$$G(s) = \frac{K(S+9)}{S(S^2+4S+11)}$$

Sketch the root locus. (**NOV/DEC 2015)**

9. Sketch the root locus of a unity feedback system with an open loop transfer function $G(s) = \frac{K}{S(S+1)(S+2)}$. (**NOV/DEC 2014)**

UNIT V

STATE VARIABLE ANALYSIS PART - A

1. Define State and State Variable. **(NOV/DEC 2012, NOV/DEC 2015, APR/MAY 2016)**
2. What is controllability? **(APR/MAY 2015)**
3. What is observability? **(APR/MAY 2015)**
4. Write the properties of state transition matrix.
5. What is modal matrix?
6. State the duality between controllability and observability.
7. What are the methods available for the stability analysis of sampled data control system?
8. What is the necessary condition to be satisfied for design using state feedback?
9. What is similarity transformation?
10. What is meant by diagonalization?
11. What is the need for controllability test?
12. What is the need for observability test?
13. What is the need for state observer?
14. What is the pole placement by state feedback?
15. How control system design is carried in state space?
16. What is state transition matrix? **(NOV/DEC 2016, NOV/DEC 2015)**
17. When do you say the system is completely controllable? **(NOV/DEC 2015)**
18. State the limitations of state variable feedback? **(NOV/DEC 2016)**
19. **Define Sampling Theorem? (NOV/DEC 2012, NOV/DEC 2015, APR/MAY 2016)**
20. Draw Sample and hold circuits.

<u>Part - B</u>

Controllability and Observability (16 Marks)

1. Determine whether the system described by the following state model is completely controllable and observable **(NOV/DEC 2016, APR/MAY 2016)**

$$[\dot{x}(t)] = \begin{bmatrix} 0 & 0 & 1 \\ -2 & -3 & 0 \\ 0 & 2 & -3 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix} u(t)$$

$$y(t) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix}$$

2. Determine whether the system described by the following state model is completely controllable and observable **(APR/MAY 2015)**

$$[\dot{x}] = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -5 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 5 \\ -24 \end{bmatrix} u$$

$$y(t) = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

3. Consider the system is defined by X = Ax+Bu and Y = Cx, Where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}; B = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}; C = [10 \quad 5 \quad 1]$$

Check the controllability and observability of the system. **(NOV/DEC 2015, APR/MAY 2016)**

State Model Transformation (16 Marks)

4. Consider the the following system with differential equation given by

$$\dddot{y} + 6\ddot{y} + 11\dot{y} + 6y = 6u$$

Obtain the state model in diagonal canonical form. **(NOV/DEC 2015)**

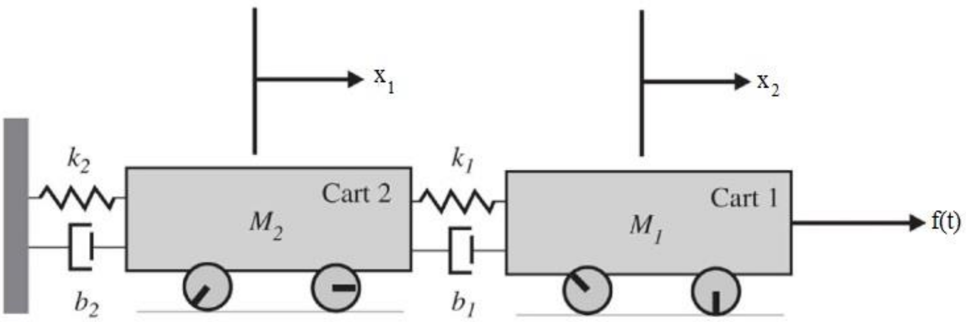
5. Construct the state model for the system characterized by the differential equation $\frac{d^3x}{dt^3} + 6\frac{d^2x}{dt^2} + 11\frac{dx}{dt} + 6x + u = 0$ (**APR/MAY 2016)**

6. Consider the system is defined by X = Ax+Bu and Y = Cx, Where

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}; B = \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix}; C = [10 \quad 5 \quad 1]$$

Obtain the diagonal canonical form of the state model by a suitable transformation matrix. **(APR/MAY 2016)**

7. Obtain the state model of the mechanical translational system in which f(t) is input and x2(t) is output. **(NOV/DEC 2015)**



State Model to Transfer Function (16 Marks)

8. Convert the given state model to transfer function

$$[\dot{x}] = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -8 & -14 & -7 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y(t) = [15 \quad 5 \quad 0] \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$

9. Consider the system is defined by X = Ax+Bu and Y = Cx, Where

$$A = \begin{bmatrix} -7 & 1 & 0 \\ -14 & 0 & 1 \\ -8 & 0 & 0 \end{bmatrix}; B = \begin{bmatrix} 20 \\ 125 \\ 185 \end{bmatrix}; C = [1 \quad 0 \quad 0]$$

Obtain the transfer function of the state model.

10. Convert the given state model to transfer function

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{bmatrix} = \begin{bmatrix} 3 & 1 & 0 \\ 0 & 3 & 1 \\ 0 & 0 & 3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} u$$

$$y(t) = \begin{bmatrix} 2 & 0 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$