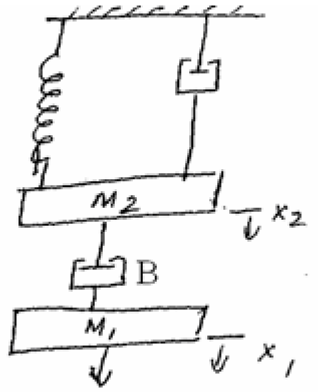
UNIT I – CONTROL SYSTEM MODELLING

PART A

1. Compare the Open loop System with Closed loop System.
2. Draw the Electrical analogous network for the mechanical system shown in the fig. using Force-Voltage Analogy.

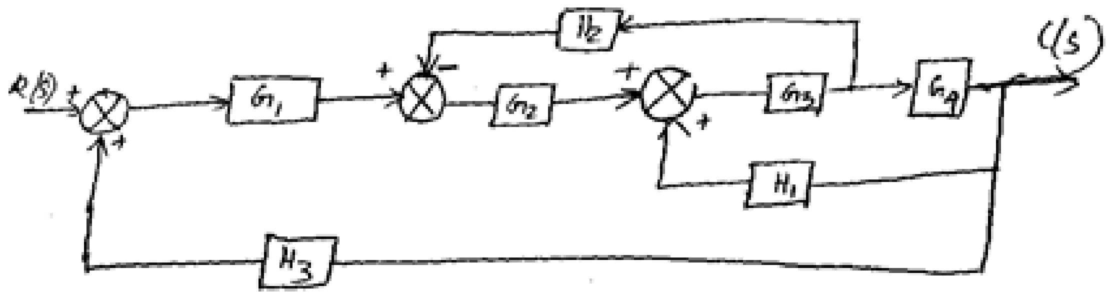


3. Define Transfer Function of the System.
4. What are the advantages of Closed loop System?
5. What are the Properties of Signal flow graphs?
6. Write Mason's gain formula of Signal flow graph.
7. Name any two dynamic models to represent control system.
8. What is meant by block diagram of a control system? What are the basic components of block diagram?
9. List the basic elements used for modelling a mechanical rotational system.
10. What is feedback? What type of feedback is employed in Control system?
11. Why negative feedback is preferred in control system?
12. Write F-V Analogy for the elements of mechanical rotational system?
13. Write any two rules to be followed in block diagram reduction techniques.
14. Define non-touching loop.
15. What is Control System?
16. What is signal flow graph?
17. Name the two types of electrical analogous for mechanical system.
18. Write force balance equation of ideal spring, ideal mass.

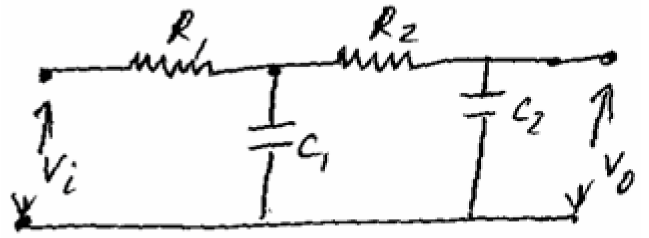
19. Define open loop System and Closed loop System.
20. What is mathematical model of a system?

PART B

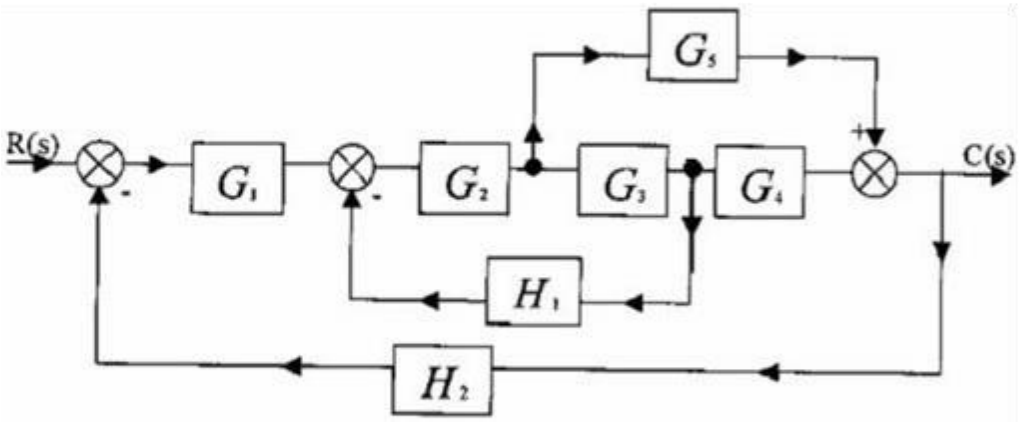
1. i. Determine the Transfer Function of the system Shown in the fig.



ii. Determine the Transfer function of the electrical network shown in the fig.

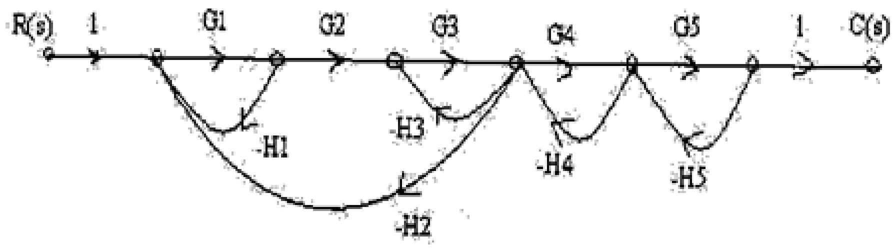


2. i. Reduce the Block diagram to its Canonical form and obtain C(s)/R(s).

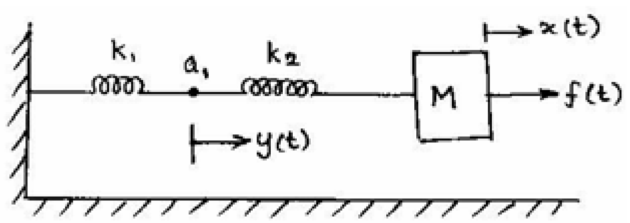


ii. Give the Comparison between block diagram and Signal flow graph methods.

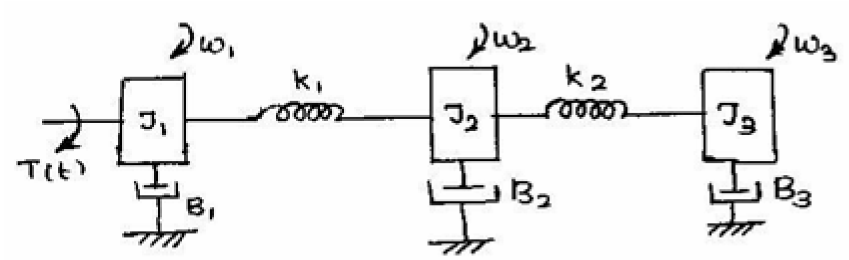
3. Find C/R for the signal flow graph shown below.



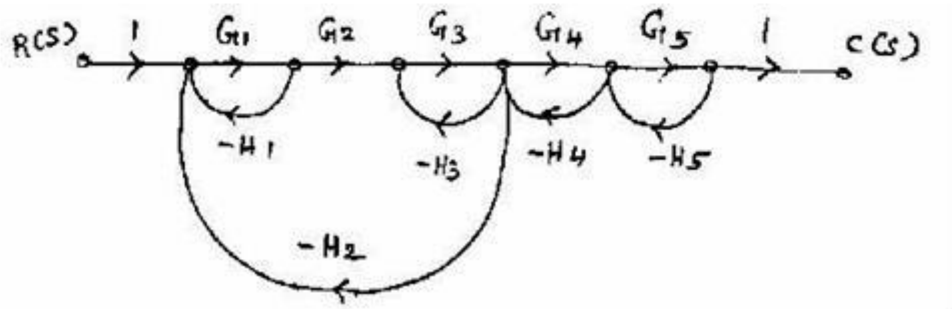
4. i. Consider the Mechanical system show below and write the Differential equation.



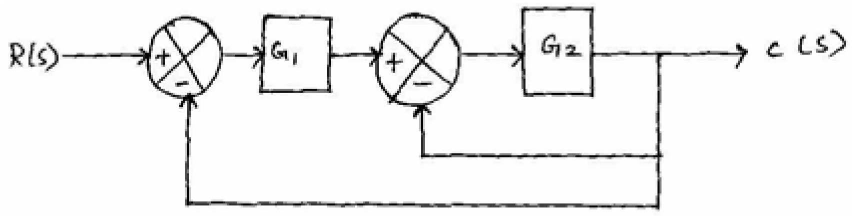
ii. Draw the torque-voltage electrical analogous circuit for the mechanical system shown below.



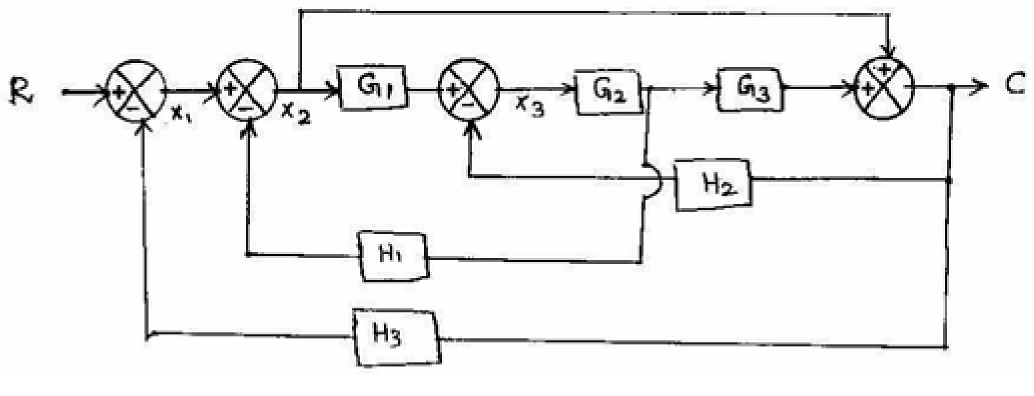
5. i. For the Signal flow graph shown below find C/R, using Mason's gain formula.



ii. Find the Transfer Function C(S)/R(S) of block diagram shown below.

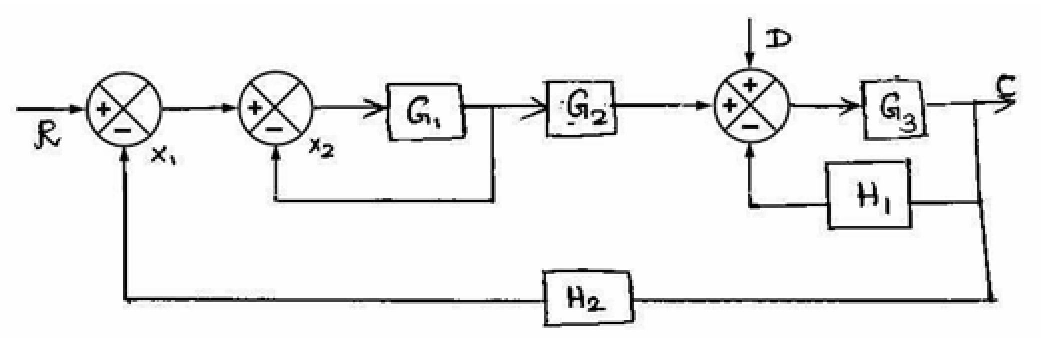


6. i. A block diagram show below.

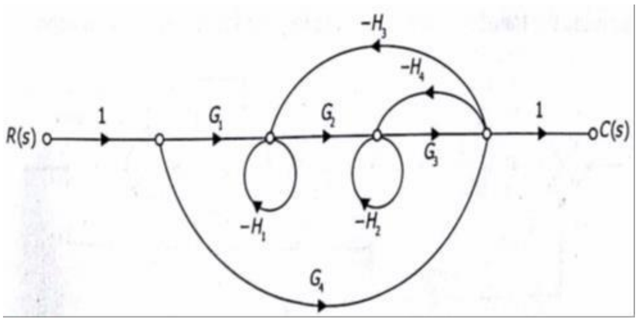


Construct the Equivalent signal flow graph and obtain C/R using mason's gain formula.

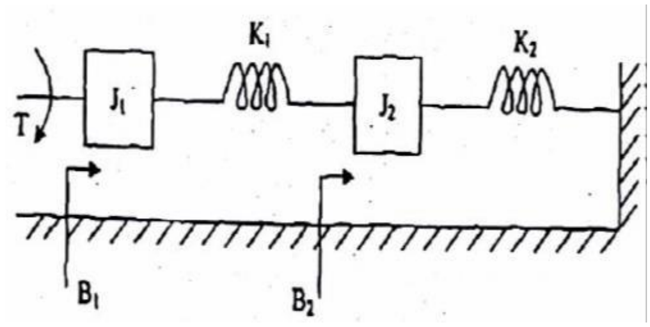
ii. For the block diagram shown below, Find the output C/R .



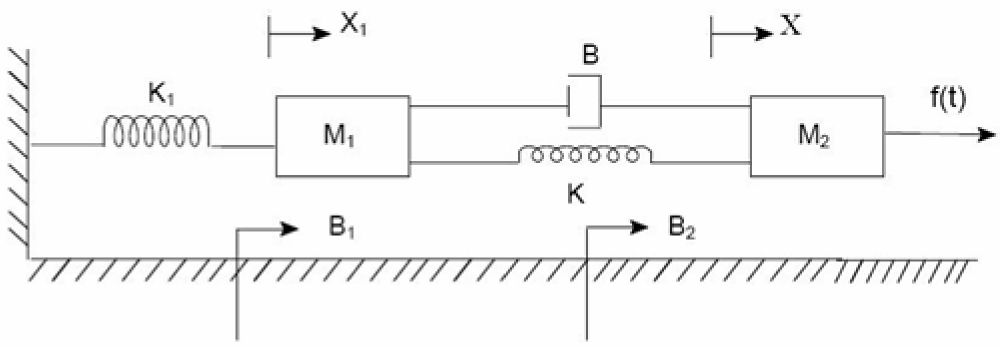
7. Using SFG, Find the overall Transfer function for the system shown in the fig.



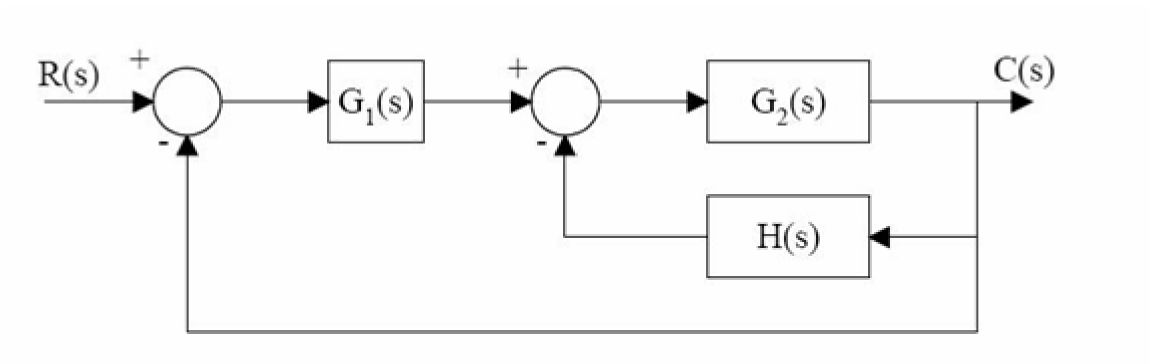
8. Write the differential equations governing the mechanical rotational system shown in Fig. Draw the T-V and T-I electrical analogous circuits.



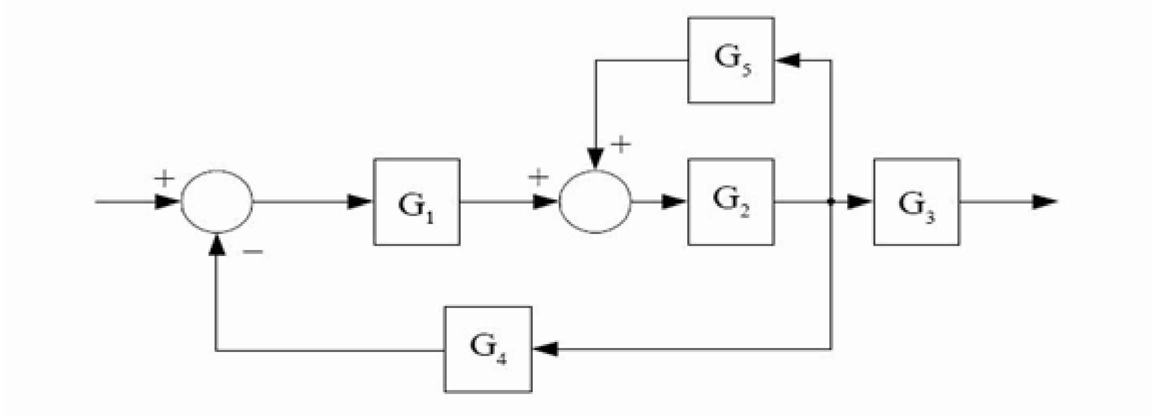
9. Write the differential Equations governing the mechanical system shown in the fig. and determine the transfer function.



10. Determine the overall transfer function of the system shown in the fig.



Fig(i)



Fig(ii)

UNIT II – TIME RESPONSE ANALYSIS

PART A

1. How a Control system is classified depending on the value of damping ratio?
2. List the advantages of generalized error coefficients.
3. Why derivative controller is not used in Control systems?
4. Give steady state errors to a various standard inputs for type 2 systems.
5. The closed loop transfer function of a second order system is given by $\frac{400}{s^2+2s+400}$. Determine the Damping ratio and natural frequency of oscillation.
6. What is meant by peak overshoot?
7. What is meant by steady state error?
8. Define rise time.
9. The damping ratio and natural frequency of a second order system are o.5 and 8 rad/sec respectively. Calculate resonant peak and resonant frequency.
10. With reference to time response, define peak time.
11. What are transient and steady state response of control system?
12. What are the units of k_p, k_v, $k_{a?}$

13. Sketch the response of the second order under damped system.
14. List the time domain specifications.
15. What are generalized error and static error constants?
16. Define position, velocity error constants.
17. Define damping ratio.
18. Name the test signals used in time response analysis.
19. Define step signal.
20. Define ramp, parabolic and impulse signal.

PART B

1. With the Suitable block diagrams and Equations, Explain the following type of controllers employed in Control Systems.
   i. Proportional controller
   ii. Proportional – plus – integral controller
   iii. PID controller
   iv. Integral controller

2. The Unity feedback system is characterized by the open loop transfer function $G(S) = \frac{k}{s(s+10)}$. Determine the gain K, so that the system will have the damping ratio of 0.5. For this value of K, Determine the settling times, peak overshoot, and time to peak overshoot for a unit step input.

3. Derive Expression for Rise time, fall time, settling time, peak overshoot.
4. The open loop transfer function of a unity feedback control system is given by $G(S) = \frac{k}{s(sT+1)}$ where K and T are positive constants. By what factor should the amplifier gain be reduced so that the peak overshoot of unit step response of the system is reduced from 75% to 25%.

5. Consider a Second order model $\frac{Y(S)}{R(S)} = \frac{\omega_n^2}{s^2+2\varepsilon\omega_n s+\omega_n^2}$; $0 < \varepsilon < 1$. Find the response y (t) to a unit step input.

6. i. Derive the Expression and Sketch the response of Second order under damped system.
   ii. For a unity feedback control system the open loop transfer function **G(s) = 10(s+2)/s² (s+1).** Find K_p, K_V, K_a and the steady state error when the input is R(s) where **R(s)** $= \frac{3}{s} - \frac{2}{s^2} + \frac{1}{3s^3}$

7. Derive an Expression to find steady state error of closed loop system.

8. A unit ramp input is applied to a unity feedback system whose transfer function is **C(s)= 100/(s^2+5s+100)**.Find the time response and steady state error

9. i. A unity feedback system with unit step input for which open loop transfer function G(s) =16/s(s+8).Find the transfer function, the natural Frequency, the damping ratio and the damped frequency of oscillation.
ii. Derive the response of undamped second order system for unit step input.

10. The unity feedback system is characterized by an open loop transfer function G(s) = K(2s+1)/ s(5s+1)$(1+s)^2$ with r(t) = (1+6t). Find the minimum value of K if the steady error is to be less than 0.1.

UNIT III - FREQUENCY RESPONSE

PART- A

1. Derive the transfer function of a lead compensator network.
2. Define Phase margin & gain margin.
3. What is the need for compensation?
4. What is Nyquist plot?
5. What is Lag-Lead compensation?
6. Sketch shape of polar plot for the open loop transfer function
   G(s)H(s) = $\frac{1}{s(1+Ts)}$
7. What are the effects of addition of open loop poles?
8. What are the advantages of Frequency Response Analysis?
9. Define gain crossover Frequency.
10. Name the Parameters which constitute frequency domain Specifications.
11. Write MATLAB Command for Plotting Bode Diagram
    Y(S)/U(S)= 4S+6/S^3+3S^2+8S+6
12. Define compensators and list types of compensators.
13. Derive the transfer function of a lead compensator network.
14. List the advantages of Nichol's chart
15. What is meant by corner frequency in frequency response analysis?
16. Draw the circuit of lead compensator and draw its pole zero diagram.
17. What are the specifications used in frequency domain analysis?
18. Compare series compensator and feedback compensator
19. Determine the Phase angle of the given transfer function
    G(S) = 10 / S (1+0.4S) (1+0.1S)
20. Determine the frequency domain specification of a second order system when closed loop transfer function is given by C(S)/R(S)=$\frac{164}{s^2+10s+64}$

PART- B

1. Given G(s) = $ke^{0.2s}/s(s+2)(s+8)$
   Draw the Bode plot and find K for the following two cases:
   (i) Gain margin equal to 6db
   (ii) Phase margin equal to 45°.

2. An UFB system has G(s) = $\frac{10}{s(s+1)}$
   Design Lead Compensator for the following specification $\mathbf{e_{ss}}$= 20sec, Phase Margin = 50 deg. and Gain Margin ≥ 10dB

3. The open loop transfer function of a unity feedback control system is
   G(s) = $\frac{k}{s(s+1)(s+2)}$ Design a suitable lag-lead compensator so as to meet the following specifications static energy velocity error constant K_v =10 sec^{-1}, phase margin =50 and gain margin ≥10db.

4. Consider a unity feedback system having an open loop transfer function
   $$G(S) = \frac{K}{S(1+0.5S)(1+4S)}$$
   Sketch the polar plot and determine the value of K so that (i) Gain margin is 20db (ii) phase margin is 300.

5. A unity feedback control system has G(s) = $\frac{ks^2}{(1+0.2s)(1+0.02s)}$ Draw the Bode plot. Find K when GCOF = 5rad/sec.

6. A unity feedback control system has G(s) = $\frac{1}{s^2(s+1)(1+2s)}$ Sketch the polar plot and Find the gain and phase margin.

7. Design a lead compensator for a system with G(S) = $\frac{k}{s(s+2)}$ to meet the specifications.
   (i) Kv = 20 sec^{-1}
   (ii) Phase Margin = +50°
   (iii) Gain margin ≥ +10db

8. A Unity feedback system has an open loop transfer function, G(s) = $\frac{k}{s(1+2s)}$ Design a suitable lag compensator so that phase margin is 40° and the steady state error for ramp input is less than or equal to 0.2.

9. Design a Lead Compensator for a Unity feedback System with Open loop transfer function G(S) = K/S(S+1)(S+3) to Satisfy the following Specifications.
   i) Velocity error Constant, $K_v \geq 50$
   ii) Phase Margin is ≥ 20 degrees.

10. Explain in detail the procedure for Nichol's chart with M and N circles.

UNIT IV - STABILITY ANALYSIS

PART- A

1. State any two limitations of Routh-stability criterion.
2. State the advantages of Nyquist stability criterion over that of Routh's criterion.
3. Define stability of a system.
4. State Nyquist stability criterion.
5. Define Routh Hurwitz stability criterion.
6. What is the advantage of using root locus for design?
7. State the rules to obtain the breakaway point in root locus.
8. What is BIBO stability Criterion?
9. What is Centroid?
10. What is Root locus?
11. State the necessary and sufficient condition for stability.
12. What are the effects of addition of open loop poles?
13. Name the Parameters which constitute frequency domain Specifications.
14. What is characteristic equation?
15. How will you find the root locus on real axis?
16. How the roots of characteristic are related to stability?
17. What do you mean by dominant pole?
18. What are the regions of root locations for stable, unstable and limitedly stable systems?
19. What are asymptotes? How will you find the angle of asymptotes?
20. Using Routh Criterion, determine the stability of the system represented by the characteristic equation $S^4+8S^3+18S^2+16S+5=0$.

PART- B

1. Using Routh criterion,
   (i) Investigate the stability of a unity feedback control system whose open-loop transfer function is given by

$$G(s) = \frac{e^{-st}}{s(s+2)}$$

   (ii) Closed loop control system has the characteristics equation

$$S^3+4.5S^2+3.5S+1.5 = 0.$$

2. (i) Check the stability of a stability of a system with characteristics equation $S^4+S^3+20S^2+9S+100 = 0$ using Routh Hurwitz criterion.
(ii) List all the rules to construct a root locus and explain.

3. Determine the range of K for stability of unity feedback system whose OLTF is
$$G(s) = \frac{k}{s(s+1)(s+2)}$$
Using RH criterion.

4. (i) Draw the root locus of the $G(s) = \frac{k(s+2)}{s^2+2s+3}$ whose H(s) = 1.
Determine open loop gain k at $\delta = 0.7$.

(ii) Determine the range of K for which system is stable using RH Criterion.

$$S^4+ 3\,S^3 + 3\,S^2 +S +k = 0$$

5. (i) Sketch the root locus of the system whose open loop transfer function is

$G(s) = \frac{K}{s(s+2)(s+4)}$. Find the value of K so that the damping ratio of the

Closed loop system is 0.5.
(ii) Determine the range of values of K for which the unity feedback system, whose

$G(S) = K/S(S^2+S+1)(S+4)$. Is stable and determine the frequency of sustained oscillations.

6. (i) Construct Routh array and determine the stability of the system whose characteristic equation is $S^6+2S^5+8S^4+12S^3+20S^2+16S+16=0$. Also determine the number of roots lying on right half of S-plane, left half of S-plane and on imaginary axis.
(ii) Explain the procedure for Nyquist Stability Criterion

7. (i) Construct Routh array and determine the stability of the system whose characteristic equation is $S^5+S^4+2S^3+2S^2+3S+5=0$. Comment on the location of the roots of Characteristic equation.
(ii) Explain the rules for construction of the Root Locus of a feedback system.

8. Sketch the Root Locus of the System whose open loop transfer function is $G(S) = K / S(S+1)(S+3)$. Determine the Value of K for Damping Ratio equal to 0.5.

9. Construct the Nyquist plot for a system, whose open loop transfer function is given by $G(S)H(S) = K(1+S)^2 / S^3$. Find the range of K for stability.

10. Draw the Nyquist 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 the closed loop System is Stable.

UNIT V- STATE VARIABLE ANALYSIS

PART A

1. Name the methods of state space representation for phase variables.
2. What is meant by quantization?
3. Write the properties of State transition matrix?
4. Determine the controllability of the system described by the state equation.
5. How the modal matrix is determined?
6. What are the advantages of Sate Space representations?
7. Define State and State Variable.
8. Define State equation.
9. Give the concept of Controllability.
10. What is meant by Sampled –data Control System?
11. What are the advantages of State Space approach?
12. What is Alias in sampling process?
13. What is meant by sampling theorem?
14. Mention the need for State variables.
15. What is Observability?
16. Draw the Nyquist contour for the Pole lie at origin
17. What is type and order of the system?
18. What is Compensation?
19. Define Open loop sampled data systems.
20. Define closed loop sampled data systems.

PART B

1. Determine the state Controllability and Observability of the system described by

$$\bar{x}=\begin{bmatrix}-3 & 1 & 1\\ -1 & 0 & 1\\ 0 & 0 & 1\end{bmatrix}x+\begin{bmatrix}0 & 1\\ 0 & 0\\ 2 & 1\end{bmatrix}u \qquad y=\begin{bmatrix}0 & 0 & 1\\ 1 & 1 & 0\end{bmatrix}x$$

2. i) Mention in detail a state space representation of a continuous time systems.
   ii) Mention in detail a state space representation of a discrete time systems.

3. Consider the system with state equation

$$\begin{pmatrix}\dot{x}_1\\ \dot{x}_2\\ \dot{x}_3\end{pmatrix}=\begin{pmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -6 & -11 & -6\end{pmatrix}\begin{pmatrix}x_1\\ x_2\\ x_3\end{pmatrix}+\begin{pmatrix}0\\ 0\\ 1\end{pmatrix}u(t)$$

   Check the controllability of the system.

4. For a given state variable representation of a second order system given below find the state response for a unit step input and
$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}0 & 1\\ -2 & -3\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}0\\ 2\end{bmatrix}[u]$ $\begin{bmatrix}x_1(0)\\ x_2(0)\end{bmatrix}=\begin{bmatrix}0\\ 1\end{bmatrix}$ by using discrete time approximation

5. A system is represented by State equation $\dot{X}$= AX+BU; Y=CX Where

$A=\begin{bmatrix} 0 & 1 & 0 \\ 0 & -1 & 1 \\ 0 & -1 & -10 \end{bmatrix}$, $B=\begin{bmatrix} 0 \\ 0 \\ 10 \end{bmatrix}$ and $C=[1\ 0\ 0]$ .Determine the Transfer function of the System.

6. A System is characterized by the Transfer function $\frac{Y(S)}{U(S)} = \frac{3}{(s^3+5s^2+11s+6)}$. Identify the first state as output .Determine whether or not the system is completely controllable and observable

7. i) The State model matrices of a system are given below

   $A=\begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & -2 & -3 \end{bmatrix}$ $B=\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$ and $C=[3\quad 4\quad 1]$

   Evaluate the Observability of the System using Gilberts test.

   ii) Find the Controllability of the System described by the following equations

   $X = \begin{bmatrix} -1 & -1 \\ 2 & -1 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u(t)$

8. i) Determine the Transfer matrix from the data given below

   $A=\begin{bmatrix} -3 & 1 \\ 0 & -1 \end{bmatrix}$ $B=\begin{bmatrix} 1 \\ 1 \end{bmatrix}$ $C=[1\quad 1]$ $D=0$

   ii) The Transfer function of a Control System is given by

   $\frac{Y(S)}{U(S)} = \frac{(s+2)}{(s^3+9s^2+26s+24)}$ Check for controllability

9. The State Space representation of a System is given below

   $\begin{pmatrix} \dot{x}_1 \\ \dot{x}_2 \\ \dot{x}_3 \end{pmatrix} = \begin{pmatrix} -2 & 1 & 0 \\ 0 & -3 & 1 \\ -3 & -4 & -5 \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} u$

   $Y = (0\quad 0\quad 1) \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$ obtain the Transfer Function.

10. i) Check the Controllability of the following state space system.

    $\dot{x}_1 = x_2 + u_2$

    $\dot{x}_2 = x_3$

    $\dot{x}_3 = -2x_2 - 3x_3 + u_1 + u_2$

    ii) Obtain the transfer function model for the following state space system.

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