



JEPPIAAR
ENGINEERING COLLEGE

JEPPIAAR NAGAR, CHENNAI - 600119

Department of Electronics & Communication Engineering

QUESTION BANK

EC3351- CONTROL SYSTEMS
II Year/ III Semester ECE
Regulation – 2021
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BATCH 2023-2027

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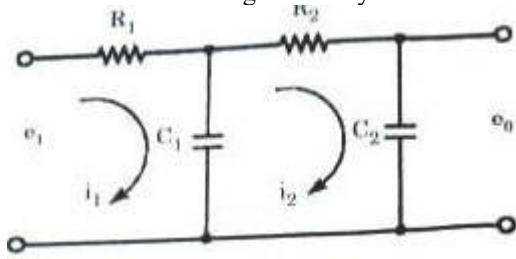
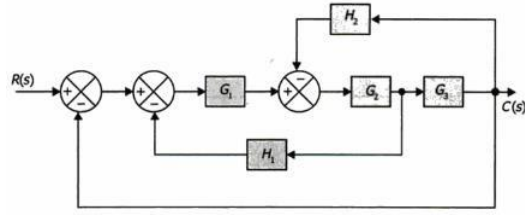
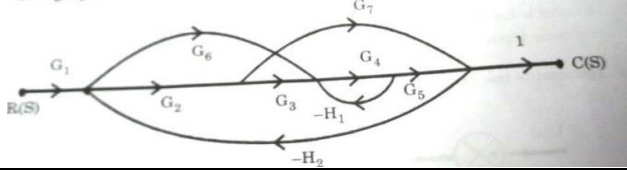
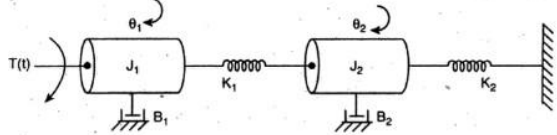
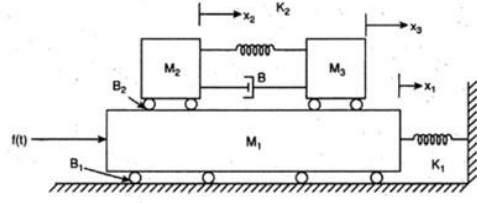
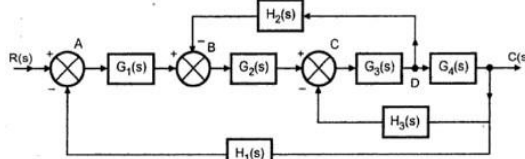
QUESTION BANK

SUBJECT : EC3351– Control Systems Engineering

YEAR /SEM: II /III

UNIT I SYSTEMS COMPONENTS AND THEIR REPRESENTATION				
Control System: Terminology and Basic Structure-Feed forward and Feedback control theory- Electrical and Mechanical Transfer Function Models-Block diagram Models-Signal flow graphs models-DC and AC servo Systems-Synchronous -Multivariable control system				
PART – A				
CO Mapping : C.305.1				
Q.No	Questions	BT Level	Competence	PO
1.	What is called feedback control system? Give an example	BTL-1	Remembering	PO1
2.	Write the analogous electrical elements in torque–voltage analogy for the elements of mechanical rotational system.	BTL-1	Remembering	PO1
	Give the comparison between open loop and closed loop system	BTL-4	Analyzing	PO1
3.	Write Masons Gain formula	BTL-2	Understanding	PO1,PO2,PO3
4.	Define transfer function	BTL-1	Remembering	PO1,PO2
5.	What is control system?	BTL-1	Remembering	PO1
6.	List the basic elements of translational mechanical systems	BTL-1	Remembering	PO1
7.	What are the advantages of the closed loop control system	BTL-3	Applying	PO1
8.	What is block diagram?	BTL-1	Remembering	PO1,PO2
9.	What are the elements of block diagram?	BTL-1	Remembering	PO1,PO2
10.	Give some examples of control system	BTL-3	Applying	PO1
11.	What are the two major types of control system?	BTL-1	Remembering	PO1
12.	Define open loop control system.	BTL-1	Remembering	PO1
13.	Define closed loop control system	BTL-1	Remembering	PO1
14.	Name any two dynamic models used to represent control systems.	BTL-1	Remembering	PO1,PO2,PO3
15.	What are the components of feedback control system?	BTL-1	Remembering	PO1
16.	What are the characteristics of negative feedback?	BTL-4	Analyzing	PO1
17.	What are the basic components of automatic control systems?	BTL-1	Remembering	PO1
18.	Differentiate between positional servomechanism and rate servomechanism	BTL-2	Understanding	PO2
19.	What is an error detector in a control system?	BTL-1	Remembering	PO1
20.	What is a mathematical model?	BTL-1	Remembering	PO1,PO2
21.	Write the transfer function of the system whose block diagram is shown below	BTL-6	Creating	PO1,PO2
22.	What is block diagram?	BTL-1	Remembering	PO1,PO2
23.	What are the elements of block diagram?	BTL-1	Remembering	PO1,PO2
24.	What is the basis for framing the rules of block diagram reduction technique?	BTL-6	Creating	PO1,PO2,PO3
25.	What is a signal flow graph?	BTL-1	Remembering	PO1,PO2
26.	What are the properties of signal flow graphs?	BTL-2	Understanding	PO1
27.	What are Analogue systems?	BTL-1	Remembering	PO1,PO2
28.	Define order of a system.	BTL-1	Remembering	PO!
29.	Define path, Non-touching loop.	BTL-1	Remembering	PO1
30.	What is node?	BTL-1	Remembering	PO1
31.	Define Self loop.	BTL-1	Remembering	PO1
32.	What is sink and source?	BTL-1	Remembering	PO1
33.	Write the analogous electrical elements in force voltage analogy for the elements of mechanical translational system.	BTL-2	Understanding	PO1,PO2
34.	What are the basic elements used for modeling mechanical translational system?	BTL-1	Remembering	PO1,PO2
35.	Write the force balance equation of an ideal mass element	BTL-2	Understanding	PO1,PO2
36.	Write the force balance equation of ideal dashpot element.	BTL-2	Understanding	PO1,PO2
37.	Write the force balance equation of ideal spring element.	BTL-2	Understanding	PO1,PO2
38.	What is servomechanism?	BTL-1	Remembering	PO1

PART – B & C

Q.No	Questions	BT Level	Competence	PO
1.	<p>Write the differential equation governing the electrical system.determine the transfer function .assume the capacitance c_1 and c_2 are not charged initially.</p> 	BTL-4	Analyzing	PO1,PO2,PO3
2.	<p>Simplify the following diagram using block diagram reduction method; Also derive the transfer function of the same using signal flow graph.</p> 	BTL-5	Evaluating	PO1,PO2,PO3
3.	<p>Obtain the closed loop transfer function of the systems , by using Mason's gain formula</p> 	BTL-5	Evaluating	PO1,PO2,PO3
4.	<p>Write the differential equation governing the mechanical rotational system shown in fig below .Draw the Electrical equivalent analogy circuits and derive its transfer function</p> 	BTL-4	Analyzing	PO1,PO2,PO3
5.	<p>Write the differential equations governing the mechanical systems shown in fig and determine the transfer function.</p> 	BTL-4	Analyzing	PO1,PO2,PO3
6.	<p>Reduce the block diagram shown in figure below and determine the transfer function</p> 	BTL-5	Evaluating	PO1,PO2,PO3
7.	<p>Explain the features of closed loop feedback control systems.</p>	BTL-2	Understanding	PO1,PO2
8.	<p>What are the basic elements of mechanical rotational systems? Write its force balance equation</p>	BTL-2	Understanding	PO1,PO2

9.	<p>Obtain the closed loop transfer function of the systems , by using Mason's gain formula.</p>	BTL-5	Evaluating	PO1,PO2,PO3
10.	<p>Write down the differential equation for the given mechanical system as shown in fig.(1) and derive its transfer function and also draw the electrical equivalent analog system</p>	BTL-5	Evaluating	PO1,PO2,PO3
11.	<p>Obtain the differential equation for the mechanical system shown in fig below and obtain the force-voltage analogous and force-current analogous.</p>	BTL-5	Evaluating	PO1,PO2,PO3

UNIT II TIME RESPONSE ANALYSIS				
Transient response-steady state response-Measures of performance of the standard first order and second order system-effect on an additional zero and an additional pole-steady error constant and system- type number-PID control-Analytical design for PD, PI,PID control systems				
PART – A				
CO Mapping : C305.2				
Q.No	Questions	BT Level	Competence	PO
1.	Draw the unit step response curve for the second order system and show the time domain specification	BTL-1	Remembering	PO1
2.	What are the dynamic error coefficients?	BTL-1	Remembering	PO1
3.	Name the test signals used in control system.	BTL-4	Analyzing	PO1
4.	What are generalized error coefficients?	BTL-1	Remembering	PO1,PO2
5.	Define Steady state error.	BTL-2	Understanding	PO1,PO2
6.	Draw the transfer function model for PID control?	BTL-4	Analyzing	PO2
7.	List the time domain specifications	BTL-1	Remembering	PO1
8.	What is the effect of PI controller on the system performance?	BTL-2	Understanding	PO1
9.	How do you find the type of a system?	BTL-2	Understanding	PO1,PO2
10.	What is steady state response?	BTL-1	Remembering	PO1
11.	What is an order of a system	BTL-1	Remembering	PO1
12.	Define Damping ratio.	BTL-1	Remembering	PO1
13.	How a control system is classified depending on the value of damping?	BTL-2	Understanding	PO1,PO2
14.	What are transient and steady state response of a control system?	BTL-4	Analyzing	PO1
15.	Give the steady state errors to a various standard inputs for type 2 system	BTL-4	Analyzing	PO1,PO2

16.	List out the different frequency domain specifications?	BTL-1	Remembering	PO1
17.	How the transient responses of a system with feedback differ to that with feedback?	BTL-4	Analyzing	PO1
18.	Define type of a system.	BTL-1	Remembering	PO1
19.	What are the type 0 and type 1 system?	BTL-1	Remembering	PO1
20.	Define resonant Peak	BTL-1	Remembering	PO1
21.	Define Resonant frequency	BTL-1	Remembering	PO1,PO2
22.	Define Damping ratio	BTL-1	Remembering	PO1,PO2
23.	Define Delay time	BTL-1	Remembering	PO1,PO2
24.	Define Rise time	BTL-1	Remembering	PO1,PO2
25.	Define peak time	BTL-1	Remembering	PO1,PO2
26.	Define peak overshoot	BTL-1	Remembering	PO1,PO2
27.	Define Settling time	BTL-1	Remembering	PO1,PO2
28.	What is step signal	BTL-1	Remembering	PO1,PO2,PO3
29.	What is ramp signal	BTL-1	Remembering	PO1,PO2,PO3
30.	What is a parabolic signal?	BTL-1	Remembering	PO1,PO2,PO3
31.	List the advantages of generalized error coefficients	BTL-1	Remembering	PO1
32.	Mention the characteristics of PI controller.	BTL-2	Understanding	PO1
33.	What is the need for a controller?	BTL-2	Understanding	PO1
34.	What are the different types of controllers?	BTL-2	Understanding	PO1,PO2
35.	What is proportional controller?	BTL-1	Remembering	PO1,PO2
36.	What is PI controller?	BTL-1	Remembering	PO1,PO2
37.	What is PD controller?	BTL-1	Remembering	PO1,PO2
38.	What is the significance of integral controller and derivative controller in a PID controller?	BTL-2	Understanding	PO1,PO2
39.	Why derivative controller is not used in control systems	BTL-4	Analyzing	PO1,PO2
40.	What is the disadvantage in proportional controller?	BTL-2	Understanding	PO1,PO2
41.	What is the effect of PD controller on system performance?	BTL-2	Understanding	PO1,PO2
42.	What is the effect of PI controller on the system performance	BTL-2	Understanding	PO1,PO2

PART – B & C

1.	A unity feedback control system is characterized by the following open loop transfer function $G(S) = \frac{10}{S(S+2)}$ Determine the closed loop transfer function, damping ratio and natural frequency of oscillation. Also evaluate the rise time, peak overshoot, peak time and settling time for a unit step of 12units.	BTL-5	Evaluating	PO1,PO2, PO3,PO4
2.	State and explain the effects of P ,PI and PID controller on the system dynamics.	BTL-1	Remembering	PO1,PO2
3.	A unity feedback control system is characterized by the following open loop transfer function $G(S) = \frac{4S+1}{S(S+6)}$ Determine its transient response for unit step input and sketch the response. Evaluate the maximum overshoot and the corresponding peak time.	BTL-5	Evaluating	PO1,PO2, PO3,PO4
4.	A unity feedback control system is characterized by the following open loop transfer function $G(S) = \frac{K}{S(S+10)}$ Determine the gain K so that the system will have a damping ration of 0.5 for this value of K. Determine settling time ,peak overshoot and peak time for a unit step input.	BTL-5	Evaluating	PO1,PO2, PO3,PO4
5.	Derive the time domain specification of a second order subjected to a step input.	BTL-4	Analyzing	PO1,PO2, PO3,PO4

6.	A unity feedback control system has a is characterized by the following open loop transfer function $G(S) = \frac{KS}{(1+S)^2}$ For the input $r(t) = 1 + 5t$ Find the minimum value of K so that the steady state error is less than 0.1.	BTL-5	Evaluating	PO1,PO2, PO3,PO4
7.	Determine the type and order of the system with following transfer function. 1. $G(S) = \frac{S+4}{(3+S)(S-2)}$ 2. $G(S) = \frac{10}{S^3(S^2+2+1)}$	BTL-4	Analyzing	PO1,PO2, PO3,PO4
8.	For a system whose $G(S) = \frac{10}{S(S+1)(S+2)}$ Find the state steady when it is subjected to input $r(t) = 1 + 2t + 1.5t^2$	BTL-5	Evaluating	PO1,PO2, PO3,PO4
9.	The open loop transfer function of a unity feedback system is given by $G(S) = \frac{K}{S(ST+1)}$ where K&T are positive constants by what factor should be amplifier gain K be reduced to that peak overshoot of unit step response of the system is reduced from 75% to 25%.	BTL-5	Evaluating	PO1,PO2, PO3,PO4
10.	Derive an expression to find steady state error of a closed loop control system	BTL-3	Applying	PO1,PO2, PO3,PO4

UNIT III FREQUENCY RESPONSE AND SYSTEM ANALYSIS

Closed loop frequency response-Performance specification in frequency domain-Frequency response of standard second order system- Bode Plot - Polar Plot- Nyquist plots-Design of compensators using Bode plots-Cascade lead compensation-Cascade lag compensation-Cascade lag-lead compensation

PART – A

CO Mapping : C305.3

Q.No	Questions	BT Level	Competence	PO
1.	Define Gain and Phase margin	BTL-1	Remembering	PO1,PO2
2.	Why compensation is necessary in feedback control system.	BTL-4	Analyzing	PO1,PO2
3.	What are the constant M and N circle?	BTL-1	Remembering	PO1
4.	Why compensation is necessary for feedback control systems?	BTL-2	Understanding	PO1
5.	State the significance of Nichol's plot	BTL-1	Remembering	PO1,PO2
6.	What is phase margin?	BTL-1	Remembering	PO1,PO2
7.	What is series compensation?	BTL-1	Remembering	PO1
8.	What are the frequency domain specifications?	BTL-2	Understanding	PO1,PO2
9.	How phase margin determined from bode's plot?	BTL-4	Analyzing	PO1,PO2
10.	Mention the need for lead compensation and lag compensation.	BTL-4	Analyzing	PO1,PO2
11.	Define Phase cross over?	BTL-1	Remembering	PO1,PO2
12.	Define Gain cross over?	BTL-1	Remembering	PO1,PO2
13.	What is Bode plot?	BTL-1	Remembering	PO1,PO2
14.	What are the main advantages of Bode plot?	BTL-1	Remembering	PO1,PO2
15.	Define Corner frequency?	BTL-1	Remembering	PO1,PO2,PO3
16.	Define Phase lag and phase lead?	BTL-1	Remembering	PO1,PO2,PO3
17.	What are M circles?	BTL-1	Remembering	PO1,PO2,PO3
18.	What is Nichols chart?	BTL-1	Remembering	PO1,PO2,PO3
19.	What are two contours of Nichols chart?	BTL-1	Remembering	PO1,PO2,PO3
20.	How is the Resonant Peak (Mr), resonant frequency (Wr), and band width determined from Nichols chart?	BTL-4	Analyzing	PO1,PO2,PO3
21.	What are the advantages of Nichols chart?	BTL-2	Understanding	PO1,PO2,PO3
22.	What are the three types of compensators?	BTL-2	Understanding	PO1,PO2
23.	When is lag lead compensator is required	BTL-2	Understanding	PO1,PO2
24.	What is a compensator?	BTL-1	Remembering	PO1,PO2
25.	What is compensation and compensators?	BTL-1	Remembering	PO1,PO2
26.	What are the effects of lag-lead compensators?	BTL-2	Understanding	PO1,PO2
27.	List the advantages and disadvantages of phase lag network.	BTL-1	Remembering	PO1,PO2
28.	What are the two types of compensation?	BTL-2	Understanding	PO1,PO2
●29.	What are the uses of lead compensator?	BTL-2	Understanding	PO1,PO2

30.	What is the use of lag compensator?	BTL-1	Remembering	PO1,PO2
31.	What is bandwidth?	BTL-1	Remembering	PO1,PO2,PO3
32.	Define Gain and Phase margin.	BTL-1	Remembering	PO1,PO2,PO3
33.	What is a lag lead compensator?	BTL-1	Remembering	PO1,PO2,PO3
34.	What are the two situations in which compensation is required?	BTL-3	Applying	PO1,PO2
35.	What are the observations that are made from the Bode's plot of the lag compensated system?	BTL-4	Analyzing	PO1,PO2,PO3
36.	What are compensating networks?	BTL-1	Remembering	PO1,PO2,PO3
PART – B & C				
1.	Discuss the procedure for constructing bode magnitude plot and bode phase plot	BTL-1	Remembering	PO1,PO2
2.	A unity feedback system has a open loop transfer function of is $G(S) = \frac{K}{S(2S + 1)}$.design a suitable lag compensator so that phase margin as 40°. and the steady state error for that ramp input is less than or equal to 0.02.	BTL-6	Creating	PO1,PO2, PO3,PO4
3.	A unity fed back control systems $G(S) = \frac{K}{S(S + 4)(S + 10)}$ Draw the bode plot.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
4.	The open loop transfer function of a unity feedback system is $G(S) = \frac{K}{S(S + 1)}$ It is desired to have the velocity error constant $K_v = 20 \text{sec}^{-1}$ and phase margin as 40°. Design a lead compensator to meet the above specification.	BTL-6	Creating	PO1,PO2, PO3,PO4
5.	Analyze on Lead, Lag and Lag-Lead compensators with a neat diagram also explain their importance.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
6.	Plot the polar plot for the following transfer function $G(S) = \frac{15}{(S + 1)(S + 3)(S + 6)}$	BTL-4	Analyzing	PO1,PO2, PO3,PO4
7.	Plot the polar plot for the following transfer function $G(S) = \frac{1}{S(S + 1)^2}$	BTL-4	Analyzing	PO1,PO2, PO3,PO4
8.	A unity feedback control systems $G(S) = \frac{KS^2}{(1 + 0.2S)(1 + 0.02S)}$ Draw the bode plot.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
9.	A unity fed back control systems $G(S) = \frac{20}{S(1 + 3S)(1 + 4S)}$ Draw the bode plot.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
10.	Plot the polar plot for the following transfer function $G(S) = \frac{1}{S^2(S + 1)(1 + 2S)}$	BTL-4	Analyzing	PO1,PO2, PO3,PO4
11.	A unity fed back control systems $G(S) = \frac{5}{S(10 + S)(20 + S)}$ Draw the bode plot.	BTL-4	Analyzing	PO1,PO2, PO3,PO4

UNIT IV CONCEPTS OF STABILITY ANALYSIS

Concept of stability-Bounded - Input Bounded - Output stability-Routh stability criterion-Relative stability-Root locus concept-Guidelines for sketching root locus-Nyquist stability criterion.

PART – A

CO Mapping : C305.4

Q.No	Questions	BT Level	Competence	PO
1.	What will be the Stability of the system when the roots of characteristic equation are lying on imaginary axis?	BTL-2	Understanding	PO1,PO2
2.	How the stability of the linear control systems analyzed by using Nyquist stability criterion.	BTL-2	Understanding	PO1,PO2
3.	State Nyquist stability criterion.	BTL-1	Remembering	PO1,PO2
4.	What are the advantages of Routh Hurwitz stability criterion	BTL-1	Remembering	PO1,PO2,PO3
5.	Define BIBO stability	BTL-1	Remembering	PO1,PO2,PO3
6.	What is a dominant pole?	BTL-1	Remembering	PO1,PO2,PO3
7.	Write the necessary and sufficient condition for the stability in Routh Stability criterion.	BTL-2	Understanding	PO1,PO2
8.	How will you find root locus on real axis?	BTL-2	Understanding	PO1,PO2,PO3
9.	Define sensitivity of a control system.	BTL-1	Remembering	PO1,PO2,PO3
10.	Define stability of the system	BTL-1	Remembering	PO1
11.	What are M circles?	BTL-1	Remembering	PO1,PO2
12.	What is Nichols chart?	BTL-1	Remembering	PO1,PO2,PO3
13.	What are two contours of Nichols chart?	BTL-1	Remembering	PO1,PO2,PO3
14.	How is the Resonant Peak (M_r), resonant frequency (ω_r), and band Width determined from Nichols chart?	BTL-4	Analyzing	PO1,PO2,PO3
15.	What are the advantages of Nichols chart?	BTL-1	Remembering	PO1,PO2,PO3
16.	What is Nyquist contour?	BTL-1	Remembering	PO1,PO2,PO3
17.	What is meant by relative stability?	BTL-1	Remembering	PO1,PO2,PO3
18.	What are the two segments of Nyquist contour?	BTL-2	Understanding	PO1,PO2,PO3
19.	What is root locus?	BTL-1	Remembering	PO1,PO2,PO3
20.	What are the main significances of root locus?	BTL-2	Understanding	PO1,PO2,PO3
21.	What are the effects of adding a zero to a system?	BTL-2	Understanding	PO1,PO2,PO3
22.	What are N circles?	BTL-1	Remembering	PO1,PO2,PO3
23.	What is the necessary condition for stability?	BTL-2	Understanding	PO1,PO2,PO3
24.	What is limitedly stable system?	BTL-1	Remembering	PO1,PO2
25.	Define parameter variations.	BTL-1	Remembering	PO1,PO2
26.	How the roots of characteristic equation are related to stability?	BTL-2	Understanding	PO1,PO2,PO3
27.	What is the relation between stability and coefficient of characteristic polynomial?	BTL-4	Analyzing	PO1
28.	What will be the Stability of the system when the roots of characteristic equation are lying on right half of the S-plane?	BTL-2	Understanding	PO1,PO2
29.	The addition of a pole will make a system more stable. Justify your answer.	BTL-5	Evaluating	PO1,PO2
30.	What is centroid? How the centroid is calculated?	BTL-1	Remembering	PO1,PO2
31.	Give the effect of addition of poles on the root locus.	BTL-2	Understanding	PO1,PO2
32.	State the advantages of root locus method.	BTL-1	Remembering	PO1,PO2,PO4
33.	Define gain margin in Nyquist plot.	BTL-1	Remembering	PO1,PO2,PO3

PART – B & C

1.	<p>Determine the range of k for stability for the system.</p>	BTL-4	Analyzing	PO1,PO2, PO3,PO4
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2.	Sketch the root locus for the system whose loop transfer function $G(S) = \frac{K}{S(S+1)(S+2)}$. $H(s) = 1$. determine the value of k such that damping ratio of a pair of dominant complex-conjugate closed loop poles is 0.5.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
3.	Using Nyquist stability criterion, find the relative stability of the system whose open loop transfer function is $G(S)H(S) = \frac{K(1+S)}{(S+4)(S+2)S^2}$.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
4.	Sketch the root locus for $G(S) = \frac{K(S^2 - 4S + 20)}{(S+2)(S+4)}$ Find the gain, K at the point where the locus crosses the imaginary axis.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
5.	Draw the Nyquist plot for the system whose open loop transfer function is $G(S) = \frac{K(1+05S)(1+S)}{(10S+1)(S-1)}$ Determine the range of K for which closed loop system is stable.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
6.	Define Stability. With an example explain the steps to be followed for Routh - Hurwitz criterion.	BTL-3	Applying	PO1,PO2, PO3,PO4
7.	Determine the range of K for stability of unity feedback system using Routh stability criterion whose transfer function $\frac{C(S)}{R(S)} = \frac{K}{S(S^2 + S + 1)(S + 2) + K}$	BTL-4	Analyzing	PO1,PO2, PO3,PO4
8.	Explain briefly about the steps to be followed to construct a root locus plot of a given transfer function.	BTL-6	Creating	PO1,PO2, PO3,PO4
9.	Construct R-H criterion and determine the stability of a system representing the characteristics equation $S^5 + S^4 + 2S^3 + 2S^2 + 3S + 5 = 0$.Comment on location of the roots of the characteristics equation.	BTL-3	Applying	PO1,PO2, PO3,PO4
10.	Construct R-H criterion and determine the stability of a system representing the characteristics equation $S^6 + 2S^5 + 8S^4 + 12S^3 + 20S^2 + 16S + 16 = 0$.Comment on location of the roots of the characteristics equation.	BTL-3	Applying	PO1,PO2, PO3,PO4
11.	A unity feedback control system has an open loop transfer function $G(S) = \frac{K}{S(S^2 + 4S + 13)}$ Sketch the root locus.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
12.	Describe the Nyquist contour and its various segments.	BTL-6	Creating	PO1,PO2, PO3,PO4

UNIT V CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS				
State variable representation-Conversion of state variable models to transfer functions-Conversion of transfer functions to state variable models-Solution of state equations-Concepts of Controllability and Observability-Stability of linear systems-Equivalence between transfer function and state variable representations-State variable analysis of digital control system-Digital control design using state feedback.				
PART – A				
CO Mapping : C305.5				
Q.No	Questions	BT Level	Competence	PO
1.	How do you define state and state variables?	BTL-1	Remembering	PO1,PO2
2.	What is meant by sampling theorem?	BTL-1	Remembering	PO1,PO2
3.	Define state model of nth order system?	BTL-1	Remembering	PO1,PO2
4.	What are the uses of sampled-data control systems?	BTL-3	Applying	PO1,PO2
5.	List the main properties of state transition matrix.	BTL-2	Understanding	PO1,PO2
6.	What is zero-order hold?	BTL-1	Remembering	PO1
7.	What is state vector?	BTL-1	Remembering	PO1,PO2
8.	What is state space?	BTL-1	Remembering	PO1,PO2
9.	List the methods used to test the stability of discrete time system.	BTL-1	Remembering	PO1,PO2
10.	Draw the Sampler and Hold circuit.	BTL-4	Analyzing	PO1,PO2
11.	When a system is said to be controllable.	BTL-2	Understanding	PO1,PO2
12.	Define sampled data system.	BTL-1	Remembering	PO1
13.	What are sampling and sampler?	BTL-1	Remembering	PO1
14.	What is periodic sampling?	BTL-1	Remembering	PO1
15.	What is first order hold?	BTL-1	Remembering	PO1
16.	What is acquisition time?	BTL-1	Remembering	PO1
17.	Define aperture time.	BTL-1	Remembering	PO1
18.	What is settling time?	BTL-1	Remembering	PO1,PO2
19.	When a system is referred as sampled data control system.	BTL-2	Understanding	PO1,PO2
20.	When a ZOH is used	BTL-2	Understanding	PO1
21.	What is state variable?	BTL-1	Remembering	PO1,PO2
22.	When a system is said to be observable.	BTL-2	Understanding	PO1,PO2
23.	Give the state equation for observability.	BTL-2	Understanding	PO1,PO2
24.	What is state transition matrix?	BTL-1	Remembering	PO1,PO2
25.	Mention the need for state variables	BTL-2	Understanding	PO1,PO2
26.	What is meant by quantization?	BTL-1	Remembering	PO1
27.	What is meant by sampled data controlled system?	BTL-1	Remembering	PO1
28.	What are the advantages of state space representation?	BTL-2	Understanding	PO1
29.	Define state equation?	BTL-1	Remembering	PO1,PO2
30.	Give the concept of controllability.	BTL-3	Applying	PO1,PO2
31.	What are sampler and hold circuits?	BTL-1	Remembering	PO1
PART – B & C				
1.	Obtain a state space equation and output equation for the system defined by $\frac{Y(S)}{U(S)} = \frac{2S^3 + S^2 + S + 2}{S^3 + 4S^2 + 5S + 2}$	BTL-5	Evaluating	PO1,PO2, PO3,PO4
2.	What are Sampled Data control systems? With an aid of a block diagram show basic elements of a sampled data control systems and give functioning of these elements.	BTL-2	Understanding	PO1,PO2, PO3,PO4

3.	<p>The state space representation of a system is given below</p> $\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ -2 & -3 & 0 \\ 0 & 2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix} u$ <p style="text-align: right;">and</p> $y = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ <p>Check for controllability and observability.</p>	BTL-5	Evaluating	PO1,PO2, PO3,PO4
4.	<p>A system is characterized by transfer function</p> $\frac{Y(s)}{U(s)} = \frac{2}{s^3 + 6s^2 + 11s + 6}$ <p>find the state and output equation in matrix form and also test the controllability and observability of the system</p>	BTL-5	Evaluating	PO1,PO2, PO3,PO4
5.	<p>for a system represented by the state equation $\dot{X}(t)=AX(t)$. the response is</p> $X(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix} \text{ when } X(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$ <p>and $X(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix}$ When $X(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$. Determine the system matrix A and state transition matrix.</p>	BTL-5	Evaluating	PO1,PO2, PO3,PO4
6.	Write Detailed notes on Sampler and Hold Circuits.	BTL-2	Understanding	PO1,PO2, PO3,PO4
7.	A discrete time system is described by the difference equation $y(k+2)+5y(k+1)+6y(k)=u(k)$. $Y(0)=y(1)=0$. and $T=1$ sec. determine (i) state model in canonical form. (ii) State transition matrix.	BTL-5	Evaluating	PO1,PO2, PO3,PO4
8.	Draw the State model of a linear single input Single output and obtain its corresponding Equations.	BTL-4	Analyzing	PO1,PO2, PO3,PO4
9.	<p>The state space representation of a system is given below</p> $\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u$ <p style="text-align: right;">and</p> $y = \begin{bmatrix} 10 & 5 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ <p>Check for controllability and observability</p>	BTL-5	Evaluating	PO1,PO2, PO3,PO4
10.	Consider the following systems with a differential equations given by $\ddot{y} + 6\dot{y} + 11y = 6U$ Obtain the state model in diagonal canonical form	BTL-4	Analyzing	PO1,PO2, PO3,PO4

UNIT I SYSTEMS COMPONENTS AND THEIR REPRESENTATION

Control System: Terminology and Basic Structure-Feed forward and Feedback control theory- Electrical and Mechanical Transfer Function Models-Block diagram Models-Signal flow graphs models-DC and AC servo Systems-Synchronous -Multivariable control system

PART – A

1. What is called feedback control system? Give an example

A system in which the value of some output quantity is controlled by feeding back the value of the controlled quantity and using it to manipulate an input quantity so as to bring the value of the controlled quantity closer to a desired value. Also known as closed-loop control system.

2. Write the analogous electrical elements in force voltage analogy for the elements of mechanical translational system.

S.No.	Items	Mechanical System		Electrical System	
		Translational System	Rotational System	Loop System (Force-Voltage)	Nodal System (Force-Current)
1.	Independent Variable	Force F	Torque T	Voltage E	Current I
2.	Dependent Variable	Linear velocity v	Angular velocity ω	Current I	Voltage E
3.	Dissipative Component	Linear dash-pot where $F=Bv$	Rotational dash-pot B where $T = B\omega$	Resistance where $E=RI$	Conductance G where $I=GE$
4.	Power Dissipation	F^2/B	T^2/B	E^2/R	I^2/G
5.	Storing Element	Mass M where $F = M \frac{dv}{dt}$	Inertia J where $T = J \frac{d\omega}{dt}$	Inductance L where $E = L \frac{di}{dt}$	Capacitance C where $I = C \frac{dE}{dt}$
6.	Storing Element	Spring K where $F = K \int v dt$	Spring K Where $T = K \int \omega dt$	Capacitance where $E = \frac{1}{C} \int i dt$	Inductance L where $I = \frac{1}{L} \int E dt$
7.	Physical Laws	D' Alembert's Principle $\Sigma F = 0$	D' Alembert's Principle $\Sigma T = 0$	Kirchhoff's voltage Law $\Sigma E = 0$	Kirchhoff's current Law $\Sigma i = 0$
8.	Changing the level of the independent variable	Lever $\frac{F_1}{F_2} = \frac{l_2}{l_1}$	Gear $\frac{T_1}{T_2} = \frac{n_1}{n_2}$	Voltage transformer $\frac{E_1}{E_2} = \frac{N_1}{N_2}$	Current transformer $\frac{I_1}{I_2} = \frac{N_2}{N_1}$

2. Write Masons Gain formula.

The overall system transfer function $C(S)/R(S)$ is referred as Mason's gain formula. It is given by Overall T.F = $\frac{\sum (TK\Delta_k)}{\Delta}$, Where K = Number of forward paths, TK = Gain of k^{th} forward path, Δ = system determinant to be calculated as: $\Delta = 1 - (\sum \text{all individual feedback loop gains (including self loops)}) + (\sum \text{Gain} \times \text{gain product of all possible combinations of two non-touching loops}) - (\sum \text{Gain} \times \text{Gain} \times \text{Gain product of all possible combinations of two non-touching loops}) + \dots$ Δ_k = value of above Δ for all loop gains and associated products which are touching to the k^{th} forward path.

3. Define transfer function.

The T.F of a system is defined as the ratio of the Laplace transform of output to Laplace transform of input with zero initial conditions.

4. What is control system?

A System consists of a number of components connected together to perform a specific function. In a system when the output quantity is controlled by varying the input quantity then the system is called control system.

5. List the basic elements of translational mechanical systems.

There are three fundamental physical elements that make up translating mechanical system: inertia elements, springs and friction elements.

6. What are the advantages of the closed loop control system?

Advantages:

Accuracy: They are more accurate than open loop system due to their complex construction. They are equally accurate and are not disturbed in the presence of non-linearity. **Noise reduction ability:** Since they are composed of a feedback mechanism, so they clear out the errors between input and output signals, and hence remain unaffected to the external noise sources.

7. What is block diagram?

A block diagram of a system is a pictorial representation of the functions performed by each component of the system and shows the flow of signals. The basic elements of block diagram are block, branch point and summing point.

8. What are the elements of block diagram?

The elements of block diagram are

- Block
- Summing point
- Branch point

9. Give some examples of control system.

The examples of control systems are

- Temperature control system
- Traffic control system
- Numerical control system
- Position control system

10. What are the two major types of control system?

The two major types of control system are open loop and closed loop.

11. Define open loop control system.

The control system in which the output quantity has no effect upon the input quantity are called open loop control system. This means that the output is not feedback to the input for correction.

12. Define closed loop control system.

The control system in which the output has an effect upon the input quantity so as to maintain the desired output value is called closed loop control system.

13. Name any two dynamic models used to represent control systems.

- i) Force voltage analogy
- ii) Force current analogy

14. What are the components of feedback control system?

The components of feedback control system are plant, feedback path elements, error detector and controller

15. What are the characteristics of negative feedback?

tracking steady state value.

Accuracy in

- Rejection of disturbance signal.
- Low sensitivity to parameter variation.

16. What are the basic components of automatic control systems?

The basic components of an automatic control system are the following.

- Error detector
- Amplifier and controller
- Actuator
- Plant
- Sensor

17. Differentiate between positional servomechanism and rate servomechanism.

Rate servomechanism depends upon rate of change of the controlled quantity and could be measured by frequency signal or voltage magnitude. Positional servomechanism depends upon the position of output from reference input.

18. What is an error detector in a control system?

It is an element

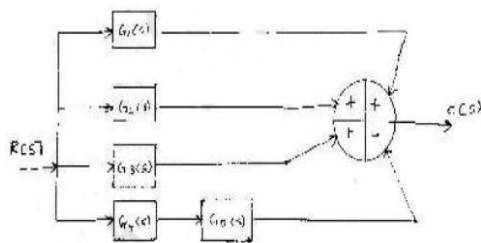
which sums or compares the signal obtained from feedback elements with the reference input signal.

19. What is a mathematical model?

A mathematical model consists of a collection of equations describing the behavior of the system. There are two types of mathematical modeling

- (i) Input / output representations describing the relation between inputs and outputs of a system
- (ii) State model describing the relation between the input states and output states of a system

20. Write the transfer function of the system whose block diagram is shown below



Transfer function = $C(s)/R(s) = G1(s) + G2(s) + G3(s) - G4(s)G5(s)$

21. What is block diagram?

A block diagram of a system is a pictorial representation of the functions performed by each component of the system and shows the flow of signals. The basic elements of block diagram are block, branch point and summing point.

22. What are the elements of block diagram?

The elements of block diagram are

- Block
- Summing point
- Branch point

23. What is the basis for framing the rules of block diagram reduction technique?

The rules for block diagram reduction technique are framed such that any modification made on the diagram does not alter

the input output relation.

24. What is a signal flow graph?

A signal flow graph is a diagram that represents a set of simultaneous algebraic equations. By taking L.T the time domain differential equations governing a control system can be transferred to a set of algebraic equations in s-domain

25. What are the properties of signal flow graphs?

It is applicable to linear systems.

- Signal flow graph can represent a block diagram, but the reverse is not true.
- The algebraic sum of all the signals entering the node gives the value of a variable on each node which leaves it.
- The signal flow graph of a system is not unique.

26. What are Analogue systems?

Systems whose differential equation is of identical form are called analogous system.

27. Define order of a system.

The highest power of the complex variables 'S' in the denominator of transfer function is called as the order of a system.

28. Define path, Non-touching loop.

Path: It is the journey from one node to any other node in the direction of branch arrow

Non-touching loop: Loops are said to be non-touching if they do not possess any common node.

29. What is node?

Node is a system variable which is equal to sum of all incoming signals.

30. Define Self loop.

Self-loop: A path starting from one node and terminates at same node without crossing any other node even once.

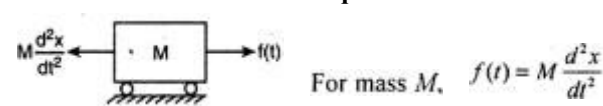
31. What is sink and source?

Source is the input node in the signal flow graph and it has only outgoing branches. Sink is an output node in the signal flow graph and it has only incoming branches.

33. What are the basic elements used for modeling mechanical translational system?

Mass, spring and dashpot.

34. Write the force balance equation of an ideal mass element



35. Write the force balance equation of ideal dashpot element.



36. Write the force balance equation of ideal spring element.

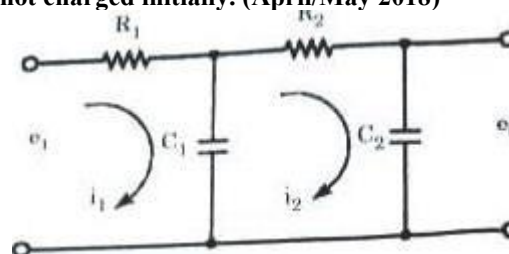


37. What is servomechanism?

Servomechanism is a feedback control system in which the output is Mechanical position (or time derivatives of position velocity and acceleration).

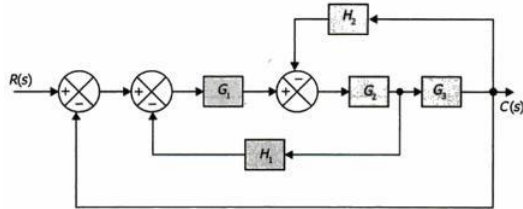
PART – B & C

1. Write the differential equation governing the electrical system. determine the transfer function .assume the capacitance c_1 and c_2 are not charged initially. (April/May 2018)



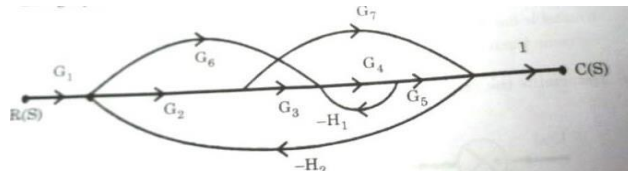
Ref: Control Systems Engineering By Nagoorkani 2nd edition, Pg.No: 1.23

2. Simplify the following diagram using block diagram reduction method; Also derive the transfer function of the same using signal flow graph. (April/May 2017) (April/May 2018)



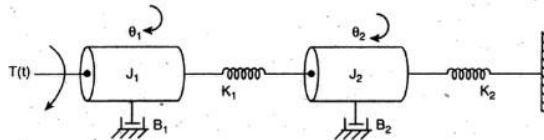
Ref: Control Systems Engineering By S. K. Bhattacharya, Pg.No: 55

3. Obtain the closed loop transfer function of the systems, by using Mason's gain formula.



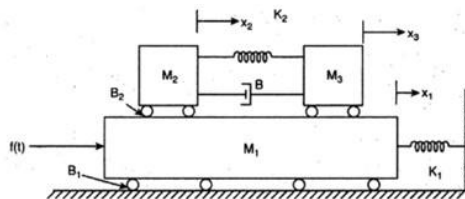
Ref: Control Systems Engineering By Nagoorkani, Pg.No: 117

4. Write the differential equation governing the mechanical rotational system shown in fig below .Draw the Electrical equivalent analogy circuits and derive its transfer function



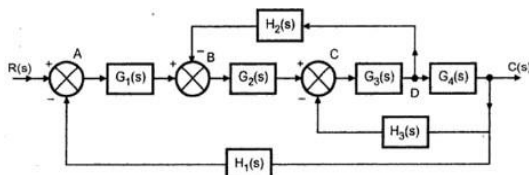
Ref: Control Systems Engineering By Dr.S.Palani, Pg.No: 2.42

5. Write the differential equations governing the mechanical systems shown in fig and determine the transfer function.



Ref: Control Systems Engineering By Dr.S.Palani, Pg.No: 2.43

6. Reduce the block diagram shown in figure below and determine the transfer function.



Ref: Control Systems Engineering By Bakshi, Pg.No: 5.72

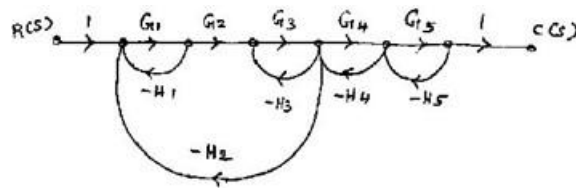
7. Explain the features of closed loop feedback control systems. .

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 74

8. What are the basic elements of mechanical rotational systems? Write its force balance equation.

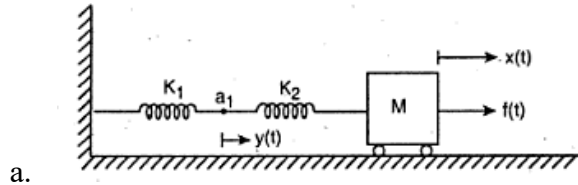
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9. Obtain the closed loop transfer function of the systems, by using Mason's gain formula.



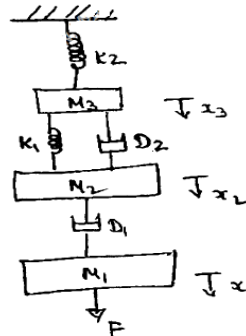
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10. Write down the differential equation for the given mechanical system as shown in fig.(1) and derive its transfer function and also draw the electrical equivalent analogous system



Ref: Control Systems Engineering By Nagoorkani, Pg.No: 85

11. Obtain the differential equation for the mechanical system shown in fig below and obtain the force-voltage analogous and force-current analogous.



Ref: Control Systems Engineering By Nagoorkani, Pg.No: 86

UNIT II TIME RESPONSE ANALYSIS

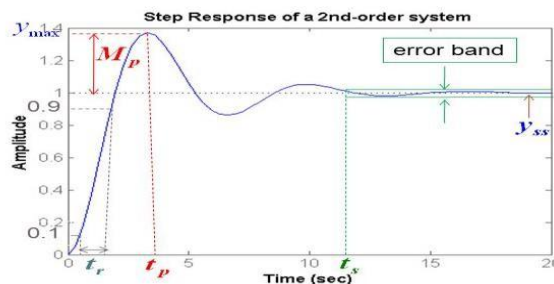
Transient response-steady state response-Measures of performance of the standard first order and second order system-effect on an additional zero and an additional pole-steady error constant and system- type number-PID control-Analytical design for PD, PI,PID control systems

PART - A

1.Draw the unit step response curve for the second order system and show the time domain specification

Time-domain Specifications

1. Steady-state value: y_{ss}
2. Maximum overshoot: $\text{Percent overshoot} = \frac{\Delta M_p}{y_{ss}} \times 100\%$
 $\Delta M_p = y_{\max} - y_{ss}$
3. Peak time: t_p
4. Rise time: t_r
5. Settling time: t_s



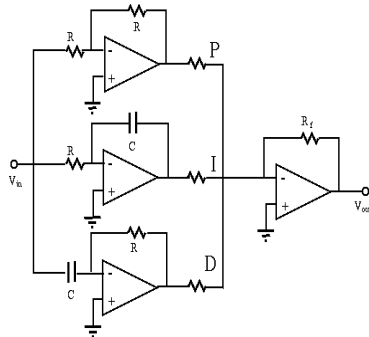
2. What are generalized error coefficients or dynamic error coefficients?

They are the coefficients of generalized series. The generalized error series is given by $e(t) = C_0r(t) + C_1dr(t)/dt + (C_2 / 2!) dr^2(t)/dt^2 + \dots + (C_n / n!) dr^n(t)/dt^n \dots$. The coefficients $C_0, C_1, C_2, \dots, C_n$ are called generalized error coefficients or dynamic error coefficients.

3. Define Steady state error.

The steady state error is defined as the value of error as time tends to infinity. The steady state error is a measure of system accuracy. These error arise from the nature of inputs, type of system and from non linearity of system component.

4. Draw the transfer function model for PID control?



5. List the time domain specifications

The time domain specifications

- Delay time
- Rise time
- Peak time
- Peak overshoot

6. What is the effect of PI controller on the system performance?

The PI controller increases the order of the system by one, which results in reducing the steady state error. But the system becomes less stable than the original system.

7. How do you find the type of a system?

Type of a system is given by number of poles of loop transfer function lying at origin of S-Plane.

8. What is steady state response?

The steady state response is the response of the system when it approaches infinity.

9. What is an order of a system.

The order of a system is the order of the differential equation governing the system. The order of the system can be obtained from the transfer function of the given system.

10. Define Damping ratio.

Damping ratio is defined as the ratio of actual damping to critical damping.

11. How a control system is classified depending on the value of damping?

- Critically damped system
- Over damped system
- Naturally damped system
- Under damped system

12. What are transient and steady state response of a control system?

The transient response is the response of a system as a function of time. Whenever there is an input change, the system cannot respond immediately. It requires sometime. This time gap is referred as transient response. The steady state response is the response of the system when it approaches infinity.

13. Give the steady state errors to a various standard inputs for type 2 system

a) Reference input is step $e_{ss} = \frac{A}{1 + K_p}$

b) Reference input is ramp $e_{ss} = \frac{A}{K_v}$

c) Reference input is parabolic $e_{ss} = A/K_p$

14. List out the different frequency domain specifications?

The frequency domain specification are

- Resonant peak.
- Resonant frequency.
- Bandwidth
- Cut-off rate
- Gain margin
- Phase margin

<p>15. How the transient responses of a system with feedback differ to that with feedback The transient response is the response of a system as a function of time. Whenever there is an input change, the system cannot respond immediately. It requires some time. This time gap is referred to as transient response. A feedback control system has the inherent capability that its parameters can be adjusted to alter both its transient and steady state behavior.</p>
<p>16. Define type of a system. The number of poles of the loop transfer function lying at the origin decides the type number of the system.</p>
<p>17. What are the type 0 and type 1 system Type 0 System are systems whose no. of poles at the origin $(N)=0$. Type 1 System are systems whose no. of poles at the origin $(N)=1$.</p>
<p>18. Define resonant Peak The maximum value of the magnitude of closed loop transfer function is called resonant peak</p>
<p>19. Define Resonant frequency The frequency at which resonant peak occurs is called resonant frequency.</p>
<p>20. Define Damping ratio Damping ratio is defined as the ratio of actual damping to critical damping.</p>
<p>21. Define Delay time The time taken for response to reach 50% of final value for the very first time is delay time.</p>
<p>22. Define Rise time(May/June 2014) The time taken for response to rise from 0% to 100% for the very first time is rise time.</p>
<p>23. Define peak time(Nov/Dec 2012) The time taken for the response to reach the peak value for the first time is peak time. With reference to time response of a control system, define peak time The time taken for the response to reach the peak value for the first time is peak time.</p>
<p>24. Define peak overshoot Peak overshoot is defined as the ratio of maximum peak value measured from the Maximum value to final value.</p>
<p>25. Define Settling time Settling time is defined as the time taken by the response to reach and stay within specified Error.</p>
<p>26. What is step signal The step signal is a signal whose value changes from zero to A at $t=0$ and remains constant at A for $t>0$.</p>
<p>27. What is ramp signal The ramp signal is a signal whose value increases linearly with time from an initial value of zero at $t=0$. The ramp signal resembles a constant velocity.</p>
<p>28. What is a parabolic signal? The parabolic signal is a signal whose value varies as a square of time from an initial value of zero at $t=0$. This parabolic signal represents constant acceleration input to the signal.</p>
<p>29. List the advantages of generalized error coefficients</p> <ul style="list-style-type: none"> ➤ It provided variation of error as a function of time. ➤ For any input other than standard input, error can be obtained.
<p>30. Mention the characteristics of PI controller</p> <ul style="list-style-type: none"> ➤ It increases order of the system ➤ It increases type of the system ➤ Design of K_i must be proper to maintain stability of system. So it makes system relatively less stable. ➤ Steady state error reduces tremendously for same type of inputs.
<p>31. What is the need for a controller? The controller is provided to modify the error signal for better control action</p>
<p>32. What are the different types of controllers?</p> <ul style="list-style-type: none"> ➤ Proportional controller ➤ PI controller ➤ PD controller ➤ PID controller
<p>33. What is proportional controller? It is device that produces a control signal which is proportional to the input error-signal.</p>
<p>34. What is PI controller? It is device that produces a control signal consisting of two terms one proportional to error signal and the other proportional to the integral of error signal.</p>
<p>35. What is PD controller? PD controller is a proportional plus derivative controller which produces an output signal consisting of two terms -one proportional to error signal and other proportional to the derivative of the signal.</p>
<p>36. What is the significance of integral controller and derivative controller in a PID controller? The proportional controller stabilizes the gain but produces a steady state error. The integral control reduces or eliminates the steady state error.</p>
<p>37. Why derivative controller is not used in control systems The derivative controller produces a control action based on the rate of change of error signal and it does not produce corrective measures for any constant error. It amplifies noise signals and may cause a saturation effect on the actuator.</p>
<p>38. What is the disadvantage in proportional controller? The disadvantage in proportional controller is that it produces a constant steady state error.</p>

39. What is the effect of PD controller on system performance?

The effect of PD controller is to increase the damping ratio of the system and so the peak overshoot is reduced.

40. What is the effect of PI controller on the system performance

The PI controller increases the order of the system by one, which results in reducing the steady state error. But the system becomes less stable than the original system.

PART – B & C

1. A unity feedback control system is characterized by the following open loop transfer function $G(S) = \frac{10}{S(S+2)}$. Determine the closed loop transfer function, damping ratio and natural frequency of oscillation. Also evaluate the rise time, peak overshoot, peak time and settling time for a unit step of 12 units

Ref: Control Systems Engineering By Nagoorkani, 2nd edition Pg.No: 3.35

2. State and explain the effects of P, PI and PID controller on the system dynamics.

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 310

3. A unity feedback control system is characterized by the following open loop transfer function $G(S) = \frac{4S+1}{S(S+6)}$. Determine its transient response for unit step input and sketch the response. Evaluate the maximum overshoot and the corresponding peak time.

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 28

4. A unity feedback control system is characterized by the following open loop transfer function $G(S) = \frac{K}{S(S+10)}$. Determine the gain K so that the system will have a damping ratio of 0.5 for this value of K. Determine settling time, peak overshoot and peak time for a unit step input.

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 289

5. Derive the time domain specification of a second order subjected to a step input

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 121

6. A unity feedback control system has a is characterized by the following open loop transfer function $G(S) = \frac{KS}{(1+S)^2}$. For the input $r(t) = 1 + 5t$ Find the minimum value of K so that the steady state error is less than 0.1

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 314

7. Determine the type and order of the system with following transfer function

$$1. G(S) = \frac{10}{(3+S)(S-2)} \quad 2. G(S) = \frac{10}{S^3(S^2+2+1)}$$

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 313

8. For a system whose $G(S) = \frac{10}{S(S+1)(S+2)}$ Find the state steady when it is subjected to input

$$r(t) = 1 + 2t + 1.5t^2$$

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 314

9. The open loop transfer function of a unity feedback system is given by $G(S) = \frac{K}{S(ST+1)}$ where K&T are

positive constants by what factor should be amplifier gain K be reduced to that peak overshoot of unit step response of the system is reduced from 75% to 25%..

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 316

10. Derive an expression to find steady state error of a closed loop control system

Ref: Control Systems Engineering By Nagoorkani, Pg.No: 210

UNIT III	FREQUENCY RESPONSE AND SYSTEM ANALYSIS
Closed loop frequency response-Performance specification in frequency domain-Frequency response of standard second order system- Bode Plot - Polar Plot- Nyquist plots-Design of compensators using Bode plots-Cascade lead compensation-Cascade lag compensation-Cascade lag-lead compensation	
PART – A	
<p>1. Why compensation is necessary for feedback control systems? In order to obtain the desired performance of the system, we use compensating networks. Compensating networks are applied to the system in the form of feed forward path gain adjustment. Compensate a unstable system to make it stable. A compensating network is used to minimize overshoot.</p>	
<p>2. Define Gain and Phase margin The gain margin is defined as the reciprocal of the magnitude of open - loop transfer function at phase cross over frequency. The phase margin is the amount of phase lag at the gain cross over frequency required to bring system to the verge of instability.</p>	
<p>3. What are the constant M and N circle? The magnitude, M of the closed loop transfer function section with unity feedback will be in the form of circles in complex plane for each constant value of M. The families of these circles are called M circles. Let $N = \tan \alpha$ where α is the phase of closed loop transfer function with unity feedback. For each constant of N, a circle can be drawn in the complex plane the family of these circles are called N circles.</p>	
<p>4. State the significance of Nichol's plot</p> <ul style="list-style-type: none"> ➤ The Nichols plot is a plot used in signal processing and control ➤ Gain and phase margin can be determined easily and also graphically 	
<p>5. What is phase margin? The phase margin is the amount of phase lag at the gain cross over frequency required to bring system to the verge of instability.</p>	
<p>5. What is series compensation Series compensation is defined as insertion of reactive power elements (capacitor) into transmission lines and provides the following benefits: Reduces line voltage drops. Limits load-dependent voltage drops. Influences load flow in parallel transmission lines.</p>	
<p>7. What are the frequency domain specifications? The frequency domain specifications are Resonant peak, Resonant frequency, Bandwidth, Cut-off rate, Gain margin, Phase margin</p>	
<p>8. How phase margin determined from bode's plot? The phase margin is the amount of phase lag at the gain cross over frequency required to bring system to the verge of instability. It is given by $180^\circ + \phi_{gc}$, where ϕ_{gc} is the phase of $G(j\omega)$ at the gain cross over frequency.</p>	
<p>9. Mention the need for lead compensation and lag compensation Lead compensation essentially yields an appreciable improvement in transient response and a small improvement in steady state accuracy. Lead compensation essentially yields an appreciable improvement in steady state accuracy at the expense of increase of transient response time.</p>	
<p>10. Define Phase cross over? The frequency at which, the phase of open loop transfer functions is called phase cross over frequency ω_{pc}.</p>	
<p>11. Define Gain cross over? The gain cross over frequency ω_{gc} is the frequency at which the magnitude of the open loop transfer function is unity.</p>	
<p>12. What is Bode plot? The Bode plot is the frequency response plot of the transfer function of a system. A Bode plot consists of two graphs. One is the plot of magnitude of sinusoidal transfer function versus $\log \omega$. The other is a plot of the phase angle of a sinusoidal function versus $\log \omega$.</p>	
<p>13. What are the main advantages of Bode plot? The main advantages are:</p> <ul style="list-style-type: none"> ➤ Multiplication of magnitude can be in to addition. ➤ A simple method for sketching an approximate log curve is available. ➤ It is based on asymptotic approximation. Such approximation is sufficient if rough information on the frequency response characteristic is needed. ➤ The phase angle curves can be easily drawn if a template for the phase angle curve of $1 + j\omega$ is available. 	
<p>14. Define Corner frequency? The frequency at which the two asymptotic meet in a magnitude plot is called corner frequency.</p>	
<p>15. Define Phase lag and phase lead? A negative phase angle is called phase lag. A positive phase angle is called phase lead</p>	
<p>16. What are M circles? The magnitude of closed loop transfer function with unit feed back can be shown to be in the every value of M. These circles are called M circles.</p>	
<p>17. What is Nichols chart? The chart consisting if M & N loci in the log magnitude versus phase diagram is called Nichols chart.</p>	

<p>18. What are two contours of Nichols chart? Nichols chart of M and N contours, superimposed on ordinary graph. The M contours are the magnitude of closed loop system in decibels and the N contours are the phase angle locus of closed loop system.</p>
<p>19. How is the Resonant Peak (M_r), resonant frequency (ω_r), and band width determined from Nichols chart? The resonant peak is given by the value of M contour which is tangent to $G(j\omega)$ locus. The resonant frequency is given by the frequency of $G(j\omega)$ at the tangency point. The bandwidth is given by frequency corresponding to the intersection point of $G(j\omega)$ and 3dBM-contour.</p>
<p>20. What are the advantages of Nichols chart?(April/May 2015) The advantages are:</p> <ul style="list-style-type: none"> ➤ It is used to find the closed loop frequency response from open loop frequency response. ➤ Frequency domain specifications can be determined from Nichols chart. ➤ The gain of the system can be adjusted to satisfy the given specification.
<p>21. What are the three types of compensators?</p> <ul style="list-style-type: none"> ➤ Lag compensator ➤ Lead compensator ➤ Lag-Lead compensator
<p>22. When is lag lead compensator is required The lag lead compensator is required when both the transient and steady state response of a system has to be improved</p>
<p>23. What is a compensator? A device inserted into the system for the purpose of satisfying the specifications is called as a compensator.</p>
<p>24. What is compensation and compensators?(May/June 2007) The compensation is the design procedure in which the system behavior is altered to meet the desired specification, by introducing additional device called compensator.</p>
<p>25. What are the effects of lag-lead compensators?(May/June 2007)</p> <ul style="list-style-type: none"> ➤ Increases bandwidth and speeds up response ➤ Decreases maximum overshoot ➤ Increases low frequency gain and improves steady state accuracy of the system
<p>26. List the advantages and disadvantages of phase lag network.(April/May 2015) The Phase lag compensator helps to improve the steady-state error of the system. The poles of the lag compensator should be very close together to help prevent the poles of the system from shifting right, and therefore reducing system stability.</p>
<p>27. What are the two types of compensation? The Phase lag compensator helps to improve the steady-state error of the system. The poles of the lag compensator should be very close together to help prevent the poles of the system from shifting right, and therefore reducing system stability.</p>
<p>28. What are the uses of lead compensator?</p> <ul style="list-style-type: none"> ➤ Speeds up the transient response ➤ Increases the margin of stability of a system ➤ Increases the system error constant to a limited extent.
<p>29. What is the use of lag compensator? Improve the steady state behavior of a system, while nearly preserving its transient response.</p>
<p>30. What is bandwidth? The bandwidth is the range of frequencies for which the system gain is more than 3 dB. The bandwidth is a measure of the ability of a feedback system to reproduce the input signal, noise rejection characteristics and rise time.</p>
<p>31. Define Gain and Phase margin.(Nov/Dec 2014) The gain margin is defined as the reciprocal of the magnitude of open - loop transfer function at phase cross over frequency. The phase margin is the amount of phase lag at the gain cross over frequency required to bring system to the verge of instability.</p>
<p>32. What is a lag lead compensator? When both the transient and steady state response require improvement lag lead compensator is required. This is basically a lag lead compensator connected in series.</p>
<p>33. What are the two situations in which compensation is required? There are two situations in which compensation is required: The system is absolutely unstable and the compensation is required to stabilize it as well as to achieve a specified performance. The system is stable but the compensation is required to obtain the desired performance.</p>
<p>34. What are the observations that are made from the Bode's plot of the lag compensated system? The cross over frequency is reduced. The high frequency end of the lag-magnitude plot has been raised up by a dB gain of $20 \log(1/a)$.</p>
<p>35. What are compensating networks? The compensator is a physical device. It may be an electrical network, mechanical unit pneumatic, hydraulic or combinations of various types. The commonly used electrical compensating networks are Lead network or Lead compensator Lag network or Lag compensator Lag-Lead network or Lag-Lead compensator.</p>

PART – B & C	
1.	Discuss the procedure for constructing bode magnitude plot and bode phase plot Ref :Control systems Engineering by Nagoorkani ,2 nd edition ,Pg.No:4.18
2.	A unity feedback system has an open loop transfer function of $G(S) = \frac{K}{S(2S + 1)}$. design a suitable lag compensator so that phase margin as 40° and the steady state error for that ramp input is less than or equal to 0.02. (April/May 2018) Ref :Control systems Engineering by Nagoorkani ,2 nd edition ,Pg.No:6.35
3.	A unity feedback control systems $G(S) = \frac{K}{S(S + 4)(S + 10)}$ Draw the bode plot. Ref :Control systems Engineering by Nagoorkani ,Pg.No:370
4.	The open loop transfer function of a unity feedback system is $G(S) = \frac{K}{S(S + 1)}$ It is desired to have the velocity error constant $K_v = 20 \text{ sec}^{-1}$ and phase margin as 40° Design a lead compensator to meet the above specification Ref :Control systems Engineering by Nagoorkani ,Pg.No:378
5.	Analyze on Lead, Lag and Lag-Lead compensators with a neat diagram also explain their importance. Ref :Control systems Engineering by Nagoorkani ,Pg.No:410
6.	Plot the polar plot for the following transfer function $G(S) = \frac{15}{(S + 1)(S + 3)(S + 6)}$ Ref :Control systems Engineering by Nagoorkani ,Pg.No:350
7.	Plot the polar plot for the following transfer function $G(S) = \frac{1}{S(S + 1)^2}$ Ref :Control systems Engineering by Nagoorkani ,Pg.No:353
8.	A unity feedback control systems $G(S) = \frac{KS^2}{(1 + 0.2S)(1 + 0.02S)}$ Draw the bode plot. Ref :Control systems Engineering by Nagoorkani ,Pg.No:375
9.	A unity feedback control systems $G(S) = \frac{20}{S(1 + 3S)(1 + 4S)}$ Draw the bode plot. Ref :Control systems Engineering by Nagoorkani ,Pg.No:376
10.	Plot the polar plot for the following transfer function $G(S) = \frac{1}{S^2(S + 1)(1 + 2S)}$ Ref :Control systems Engineering by Nagoorkani ,Pg.No:353
11.	A unity feedback control systems $G(S) = \frac{5}{S(10 + S)(20 + S)}$ Draw the bode plot. Ref :Control systems Engineering by Nagoorkani ,Pg.No:375

UNIT IV CONCEPTS OF STABILITY ANALYSIS	
Concept of stability-Bounded - Input Bounded - Output stability-Routh stability criterion-Relative stability-Root locus concept-Guidelines for sketching root locus-Nyquist stability criterion.	
PART – A	
1. What will be the Stability of the system when the roots of characteristic equation are lying on imaginary axis?	If the roots of characteristic equation lie on imaginary axis, then the Stability of the system is oscillatory.
2. State Nyquist stability criterion	If the Nyquist plot of the open loop transfer function G(s) corresponding to the Nyquist control in the S-plane encircles the critical point $-1+j0$ in the counter clockwise direction as many times as the number of right half S-plane poles of G(s), the closed loop system is stable.
3. What are the advantages of Routh Hurwitz stability criterion	

<ul style="list-style-type: none"> ➤ Stability can be judged without solving the characteristic equation. ➤ Less calculation time. ➤ The number of roots in RHP can be found in the case of the unstable condition. ➤ The range of value of K for system stability can be calculated. ➤ Intersection point with the $j\omega$-axis can be calculated. ➤ The frequency of oscillation at steady-state is calculated.
<p>4. Define BIBO stability A linear relaxed system is said to have BIBO stability if every bounded (finite) input results in a bounded (finite) output.</p>
<p>5. What is a dominant pole? The dominant pole is an air of complex conjugate pair which decides the transient response of the system.</p>
<p>6. Write the necessary and sufficient condition for the stability in Routh Stability criterion The necessary and sufficient condition for stability is that all of the elements in the first column of the Routh array should be positive.</p>
<p>7. How will you find root locus on real axis On the real axis, for $K > 0$, the root locus exist to the left of an odd number of real axis, fi- nite open-loop poles and/or finite open loop zeros.</p>
<p>8. Define sensitivity of a control system. An effect in the system performance due to parameter variations can be studied mathematically defining the tern sensitivity of a control system. The change in particular variable due to parameter can be expressed in terms of sensitivity.</p>
<p>9 .Define stability of the system A linear time- invariant system is stable if the following two notions of system stability are satisfied. When the system is by a bounded input, the output is bounded. 2. In the absence of the input, the output tends towards zero irrespective of initial conditions</p>
<p>10.What are M circles? The magnitude of closed loop transfer function with unit feedback can be shown to be in the for every value if M. These circles are called M circles</p>
<p>11.What is Nichols chart? The chart consisting if M & N loci in the log magnitude versus phase diagram is called Nichols chart.</p>
<p>12.What are two contours of Nichols chart? Nichols chart of M and N contours, superimposed on ordinary graph. The M contours are the magnitude of closed loop system in decibels and the N contours are the phase angle locus of closed loop system.</p>
<p>13. How is the Resonant Peak (M_r), resonant frequency (ω_r), and band Width determined from Nichols chart?</p> <ul style="list-style-type: none"> ➤ The resonant peak is given by the value of i.contour which is tangent to $G(j\omega)$ locus. ➤ The resonant frequency is given by the frequency of $G(j\omega)$ at the tangency point. ➤ The bandwidth is given by frequency corresponding to the intersection point of $G(j\omega)$ and -3dB M-contour.
<p>14. What are the advantages of Nichols chart?(April/May 2010) The advantages are:</p> <ul style="list-style-type: none"> ➤ It is used to find the closed loop frequency response from open loop frequency response. ➤ Frequency domain specifications can be determined from Nichols chart. ➤ The gain of the system can be adjusted to satisfy the given specification
<p>15.What is Nyquist contour? The contour that encloses entire right half of S plane is called nyquist contour.</p>
<p>16.What is meant by relative stability Relative stability is the degree of closeness of the system, itis an indication of strength or degree of stability</p>
<p>17.What are the two segments of Nyquist contour? i)An finite line segment C1 along the imaginary axis. ii) An arc C2 of infinite radius.</p>
<p>18.What is root locus? The path taken by the roots of the open loop transfer function when the loop gain is varied from 0 to infinity_ are called root loci.</p>
<p>19. What are the main significances of root locus?</p> <ul style="list-style-type: none"> ➤ The main root locus technique is used for stability analysis. ➤ Using root locus technique the range of values of K, for as table system can be determined
<p>20.What are the effects of adding a zero to a system? Adding a zero to a system increases peak overshoot appreciably.</p>
<p>21.What are N circles? If the phase of closed loop transfer function with unity feedback N is then $\tan \alpha$ will be in the form of circles for every value of N. These circles are called N circles.</p>

22.What is the necessary condition for stability

The necessary condition for stability is that all the coefficients of the characteristic polynomial be positive.

23.What is limitedly stable system?

For a bounded input signal if the output has constant amplitude oscillations then the system may be stable or unstable under some limited constraints such a system is called limitedly stable system.

24.Define parameter variations.

The parameters of any control system cannot be constant through its entire life. There are always changes in the parameters due to environmental changes and other disturbances. These changes are called parameter variations.

25.How the roots of characteristic equation are related to stability?

If the roots of characteristic equation has positive real part then the impulse response of the system is not bounded (the impulse response will be finite as t tends to infinity.) hence the system will be unstable. If the roots have negative real parts then impulse response is bounded. (The impulse response becomes zero as t tends to infinity). Hence the system will be stable.

26.What is the relation between stability and coefficient of characteristic polynomial?

If the coefficients of characteristic polynomial are negative or zero, then some of the roots lie on the right half of the S-plane. Hence the system is unstable. If the coefficients k of characteristic polynomial are positive and if no coefficient is zero, then there is a possibility of the system to be stable, provided all the roots are lying on left half of S-plane.

27.What will be the Stability of the system when the roots of characteristic equation are lying on right half of the S-plane?

When the roots are lying on the real axis, i.e on the right half of the S-plane, the response is exponentially increasing. When the roots are complex conjugate and lying on the right half of the S-plane, the response is oscillatory with exponentially increasing amplitude.

28.The addition of a pole will make a system more stable. Justify your answer.

This is false statement. When the pole is added to the system, it drives the root locus towards imaginary axis, they become dominant and hence relative stability of the system decrease. It makes the system more oscillatory. So addition of pole makes the system unstable and not stable.

29.What is centroid? How the centroid is calculated?

The meeting point of asymptotes with real axis is called centroid. The centroid is given by Centroid (G) = sum of real parts of poles - sum of real parts of zeros

30. Give the effect of addition of poles on the root locus.

- Root locus shift towards imaginary
- System stability relatively decrease
- System becomes more oscillatory in nature.
- Range of operating value of K for system stability decreases.

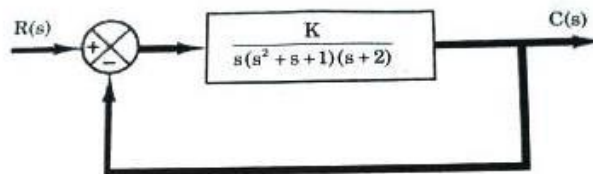
31. State the advantages of root locus method.

- Root locus analysis helps in deciding the stability of the control systems with time delay.
- Information about settling time of the system also can be determined from the root locus.

32.Define gain margin in Nyquist plot.

Gain margin is the amount of gain in decibels (db) that is allowed to be increased in the log before the closed loop system reaches stability

PART – B & C

1. Deterr

Ref: Control Systems Engineering By Nagoorkani, 2nd edition, Pg.No: 5.23

2. Sketch the root locus for the system whose loop transfer function $G(S) = \frac{K}{S(S+1)(S+2)}$.H(s)

=1.determine the value of k such that damping ratio of a pair of dominant complex-conjugate closed loop poles is 0.5.

Ref: Control Systems Engineering By Nagoorkani, 2nd edition, Pg.No: 5.75

<p>3. Using Nyquist stability criterion, find the relative stability of the system whose open loop transfer function is $G(S)H(S) = \frac{K(1+S)}{(S+4)(S+2)S^2}$.</p> <p>Ref: Control Systems Engineering By Nagoorkani, 2nd edition, Pg.No: 5.54</p>
<p>4. Sketch the root locus for $G(S) = \frac{K(S^2 - 4S + 20)}{(S+2)(S+4)}$. Find the gain, K at the point where the locus crosses the imaginary axis</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No: 316</p>
<p>5. Draw the Nyquist plot for the system whose open loop transfer function is $G(S) = \frac{K(1+0.5S)}{(10S+1)(S-1)}$</p> <p>Determine the range of K for which closed loop system is stable.</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No: 378</p>
<p>6. Define Stability. With an example explain the steps to be followed for Routh - Hurwitz criterion. Ref: Control Systems Engineering By Nagoorkani, Pg.No:318</p>
<p>7. Determine the range of K for stability of unity feedback system using Routh stability criterion whose transfer function $\frac{C(S)}{R(S)} = \frac{K}{S(S^2 + S + 1)(S + 2) + K}$</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:435</p>
<p>8. Explain briefly about the steps to be followed to construct a root locus plot of a given transfer function. Ref: Control Systems Engineering By Nagoorkani, Pg.No:302</p>
<p>9. Construct R-H criterion and determine the stability of a system representing the characteristics equation $S^5 + S^4 + 2S^3 + 2S^2 + 3S + 5 = 0$. Comment on location of the roots of the characteristics equation</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:302</p>
<p>10. Construct R-H criterion and determine the stability of a system representing the characteristics equation $S^6 + 2S^5 + 8S^4 + 12S^3 + 20S^2 + 16S + 16 = 0$. Comment on location of the roots of the characteristics equation</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:425</p>
<p>11. A unity feedback control system has an open loop transfer function $G(S) = \frac{K}{S(S^2 + 4S + 13)}$. Sketch the root locus.</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:316</p>
<p>12. Describe the Nyquist contour and its various segments</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:421</p>

<p>UNIT V CONTROL SYSTEM ANALYSIS USING STATE VARIABLE METHODS</p> <p>State variable representation-Conversion of state variable models to transfer functions-Conversion of transfer functions to state variable models-Solution of state equations-Concepts of Controllability and Observability-Stability of linear systems-Equivalence between transfer function and state variable representations-State variable analysis of digital control system-Digital control design using state feedback.</p>
<p>PART – A</p>
<p>1..Define state and state variables?</p> <p>STATE: The state of a system is the set of quantities that, once determined at a point in time, the future output of the system is completely independent of the past inputs of the system.</p> <p>STATE VARIABLE: It is one of the set of variables that are used to describe the mathematical "state" of a dynamical system. Intuitively, the state of a system describes enough about the system to determine its future behavior in the absence of any external forces affecting the system</p>
<p>2.What is meant by sampling theorem?</p> <p>The theorem that a signal that varies continuously with time is completely determined by its value at an infinite sequence of equally spaced times if the frequency of these sampling times is greater than twice the highest frequency component of the signal. Also known as Shannon's sampling Theorem.</p>

3. What is state vector?

The state vector $x(t)$ is the vector sum of all the state variables.

4. What are the uses of sampled-data control systems

For using digital computer as part of the control loop.

For time sharing of control components. Whenever a transmission channel forms part of the of the control loop.

5. Define state model of nth order system?

It is a representation of the dynamics of an Nth order system as a first order differential equation in an N-vector, which is called the state. It Convert the Nth order differential equation that governs the dynamics into N first-order differential equations

6. List the main properties of state transition matrix.

1.	$\Phi(t_2, t_1)\Phi(t_1, t_0) = \Phi(t_2, t_0)$
2.	$\Phi^{-1}(t, \tau) = \Phi(\tau, t)$
3.	$\Phi^{-1}(t, \tau)\Phi(t, \tau) = I$
4.	$\frac{d\Phi(t, t_0)}{dt} = \mathbf{A}(t)\Phi(t, t_0)$

7. What is zero-order hold

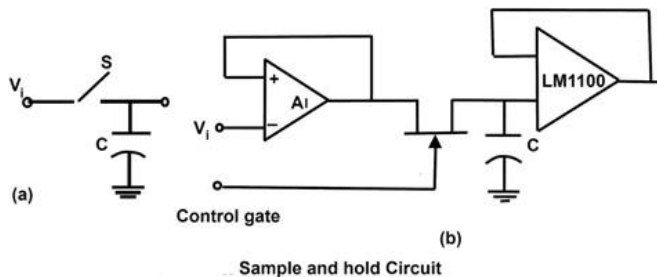
It is a hold circuit. The output of the hold circuit is analog signal whose magnitude equal to latest sampled value till next sample occurs

8. What is state space?

The space whose coordinate axes are nothing but the 'n' state variables with time as the implicit variable is called state space.

9. List the methods used to test the stability of discrete time system.

- Jury's stability test.
- Bilinear transformation.
- Root locus technique.

10. Draw the Sampler and Hold circuit**11. When a system is said to be controllable**

A system is said to be completely state controllable if it is possible to transfer the system state from any initial state $x(t_0)$ to any desired state $x(t)$ in specified finite time by a control vector $u(t)$.

12. Define sampled data system.

In a control system, if the signals in any part/point of the system is discrete (digital or sampled) then the entire system is said to be sampled data system.

13. What are sampling and sampler?

Sampling of a signal is a process by which analog signals are sampled at predetermined intervals to convert into discrete time signals. The device used to perform sampling is called sampler.

14. What is periodic sampling?

Sampling of a signal at uniform equal intervals is called periodic sampling. The uniform interval T is called period

15. What is first order hold?

The output of the first order hold is constructed from latest two samples (current and previous samples). The slope of the output signal is determined by this current and previous sample.

16. What is acquisition time?

Time taken by an analog to digital converter to sample the signal, to quantize it and to code it is known as acquisition time.

17. Define aperture time.

It is the duration of sampling of analog signal.

<p>18. What is settling time? Time taken by a digital to analog converter to convert the given digital signal into analog signal magnitude and be remain within the tolerance is called settling time.</p>
<p>19. When a system is referred as sampled data control system. The overall system is hybrid in which the signal is in sampled form in the digital controller and in continuous form in the rest of the system. A system of this kind is referred to as a sampled-data control system.</p>
<p>20. When a ZOH is used. Zero-order hold is used in conjunction with a high sampling rate to provide satisfactory performance.</p>
<p>21. What is state variable? The state of a dynamical system is a minimal set of variables known as state variable such that the knowledge of these variables at $t = t_0$ together with the knowledge of the inputs for $t > t_0$, completely determines the behavior of the system for $t > t_0$</p>
<p>22. When $Q_c = [B : AB : \dots : A^{n-1}B]$ a system is said to be observable. A system is said to be completely state observable, if every state $x(t_0)$ can be completely identified by measurements of the outputs $y(t)$ over a finite time interval.</p>
<p>23. $Q_o = [C^T : A^T C^T : \dots : (A^T)^{n-1} C^T]$ Give the state equation for observability.</p>
<p>24. What is state transition matrix? The transition in state is carried out by the matrix exponential. Because of this property, is known as state transition matrix and is denoted by (t).</p>
<p>25. Mention the need for state variables. A state variable is one of the set of variables that are used to describe the mathematical "state" of a dynamical system. Intuitively, the state of a system describes enough about the system to determine its future behavior in the absence of any external forces affecting the system.</p>
<p>26. What is meant by quantization? Quantization, in mathematics and digital signal processing, is the process of mapping a large set of input values to a (countable) smaller set. Rounding and truncation are typical examples of quantization processes. Quantization is involved to some degree in nearly all digital signal processing, as the process of representing a signal in digital form ordinarily involves rounding.</p>
<p>27. What is meant by sampled data controlled system A sampled-data system is a control system in which a continuous-time plant is controlled with a digital device. Under periodic sampling, the sampled-data system is time-varying but also periodic; thus, it may be modeled by a simplified discrete-time system obtained by discretizing the plant</p>
<p>28. What are the advantages of state space representation</p> <ul style="list-style-type: none"> ➤ It can be applied to non linear system. ➤ It can be applied to tile invariant systems. ➤ It can be applied to multiple input multiple output systems. ➤ Its gives idea about the internal state of the system.
<p>29. Define state equation?(Nov/Dec 2013) It is defined as an equation that is used for determining state of a system.</p>
<p>30. Give the concept of controllability. Controllability is an important property of a control system and the controllability property plays a crucial role in many control problems. Controllability denotes the ability to move a system around in its entire configuration space using only certain admissible manipulations. State controllability condition implies that it is possible by admissible inputs to steer the states from any initial value to any final value within some finite time window. A continuous time-invariant linear state-space model is controllable if and only if $\text{rank} [B \ AB \ A^2B \ \dots \ A^{n-1}B] = n$, Where rank is the number of linearly independent rows in a matrix.</p>
<p>31. What are sampler and hold circuits A sample and hold circuit is an analog device that samples the voltage of a continuously varying analog signal and holds its value at a constant level for a specified minimum period of time.</p>
<p>PART – B & C</p>

<p>1. Obtain a state space equation and output equation for the system defined by</p> $\frac{Y(S)}{U(S)} = \frac{2S^3 + S^2 + S + 2}{S^3 + 4S^2 + 5S + 2} \text{ (APL/MAY 2018)}$ <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:623</p>
<p>2. What are Sampled Data control systems? With an aid of a block diagram show basic elements of a sampled data control systems and give functioning of these elements.</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:514</p>
<p>3. The state space representation of a system is given below.</p> <p>a. $\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 \\ -2 & -3 & 0 \\ 0 & 2 & -3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix} u \text{ and } y = \begin{bmatrix} 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$</p> <p>b. Check for controllability and observability.</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:619</p>
<p>4. What are Sampled Data control systems? With an aid of a block diagram show basic elements of a sampled data control systems and give functioning of these elements.</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:620</p>
<p>5. A system is characterized by transfer function $\frac{Y(s)}{U(s)} = \frac{2}{s^3 + 6s^2 + 11s + 6}$ find the state and output equation in matrix form and also test the controllability and observability of the system</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:623</p>
<p>6. for a system represented by the state equation $\dot{X}(t) = AX(t)$. the response is</p> $X(t) = \begin{bmatrix} e^{-2t} \\ -2e^{-2t} \end{bmatrix} \text{ when } X(0) = \begin{bmatrix} 1 \\ -2 \end{bmatrix}$ $\text{and } X(t) = \begin{bmatrix} e^{-t} \\ -e^{-t} \end{bmatrix} \text{ When } X(0) = \begin{bmatrix} 1 \\ -1 \end{bmatrix}.$ <p>Determine the system matrix A and state transition matrix.</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:623</p>
<p>7. Write Detailed notes on Sampler and Hold Circuits</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:514</p>
<p>8. A discrete time system is described by the difference equation $y(k+2) + 5y(k+1) + 6y(k) = u(k)$. $Y(0) = y(1) = 0$. and $T = 1$ sec. determine (i) state model in canonical form. (ii) State transition matrix.</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:514</p>
<p>9. Draw the State model of a linear single input Single output and obtain its corresponding Equations.</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:502</p>
<p>10. The state space representation of a system is given below.</p> $\begin{bmatrix} \dot{X}_1 \\ \dot{X}_2 \\ \dot{X}_3 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} + \begin{bmatrix} 1 \\ 0 \\ 1 \end{bmatrix} u \text{ and } y = \begin{bmatrix} 10 & 5 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$ <p>Check for controllability and observability</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:619</p>
<p>11. Consider the following systems with a differential equations given by $\ddot{y} + 6\dot{y} + 11y = 6U$ Obtain the state model in diagonal canonical form</p> <p>Ref: Control Systems Engineering By Nagoorkani, Pg.No:633</p>