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Question Bank

Subject Name	:	CONTROL ENGINEERING	**Code**	:	AE1304
Year	:	III	**Semester**	:	V
Degree & Branch	:	B.E. & AERONAUTICAL			

PART A

1. **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.

2. **What are the two major types of control system?**

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

3. **Define open loop control system.**

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

4. **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.

5. **What are the components of feedback control system?**

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

6. **Distinguish between open loop and closed loop system**

Open loop system	Closed loop system
1. Inaccurate	Accurate
2. Simple and economical	Complex and costlier
3. The changes in output due to external disturbance are not corrected	The changes in output due to external disturbances are corrected automatically
4. They are generally stable	Great efforts are needed to design a stable system

7. Why negative feedback is invariably preferred in closed loop system?

The negative feedback results in better stability in steady state and rejects any disturbance signals.

8. Define transfer function.

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

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

Mass, spring and dashpot.

10. What are the basic elements used for modeling mechanical rotational system?

Moment of inertia J, dashpot with rotational frictional coefficient B and torsional spring with stiffness K.

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

$F = M\, d^2x/dt^2$

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

$F = B\, dx/dt$

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

$F = kx$

14. Name two types of electrical analogous for mechanical system.

The two types of analogies for the mechanical system are Force voltage and force current analogy.

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

a. Force-voltage e

b. Velocity v-current i

c. Displacement x-charge q

d. Frictional coefficient B-Resistance R

e. Mass M- Inductance L

f. Stiffness K-Inverse of capacitance 1/C

16. Write the analogous electrical elements in force current analogy for the elements of mechanical translational system.

a. Force-current i

b. Velocity v-voltage v

c. Displacement x-flux φ

d. Frictional coefficient B-conductance 1/R

e. Mass M- capacitance C

f. Stiffness K-Inverse of inductance 1/L

17. 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.

18. 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.

19. 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.

20. What is transmittance?

The transmittance is the gain acquired by the signal when it travels from one node to another node in signal flow graph.

21. What is sink and source?

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

22. Define non touching loop.

The loops are said to be no touching if they do not have common nodes.

23. Write Masons Gain formula.

Masons Gain formula states that the overall gain of the system is

$$T = \frac{1}{\Delta} \sum_{k} P_k \, \Delta_k$$

k- Forward path in the signal flow graph

P_k- Forward path gain of k^{th} forward path

Δ = 1-[sum of individual loop gains] +[sum of gain products of all possible combinations of two non touching loops]-[sum of gain products of all possible combinations of three non touching loops]+…

Δ_k = Δ for that part of the graph which is not touching k^{th} forward path.

24. What is servomechanism?

The servomechanism is a feedback control system, in which the output is mechanical position (or time derivatives of position velocity and acceleration).

25. What is stepper motor?

A stepper motor is a device which transforms electrical pulses into equal increments of rotary shaft motion called steps.

26. What is servomotor?

The motors used in automatic control systems or in servomechanism are called servomotors. They are used to convert electrical signal into angular motion.

27. What is synchro?

A synchro is a device used to convert an angular motion to an electrical signal or vice versa.

28. Name the test signals used in control system

The commonly used test input signals in control system are impulse, step, ramp, acceleration and sinusoidal signals.

29. 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.

30. 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.

31. 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.

32. What is transient response?

The transient response is the response of the system when the system changes from one state to another.

33. What is steady state response?

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

34. What is an order and type number 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.

The type number is the number of poles at the origin.

35. Define damping ratio.

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

36. List the time domain specifications.

The time domain specifications are

i. Delay time

ii. Rise time

iii. Peak time

iv. Peak overshoot

37. Define delay time.

The time taken for response to reach 50% of final value for the very first time is delay time.

38. Define rise time.

The time taken for response to rise from 0% to 100% for the very first time is rise time.

39. Define peak time.

The time taken for the response to reach the peak value for the first time is peak time.

40. Define peak overshoot.

Peak overshoot is defined as the ratio of maximum peak value measured from the Maxmium value to final value.

41. Define settling time.

Settling time is defined as the time taken by the response to reach and stay within specified error.

42. What is the need for a controller?

The controller is provided to modify the error signal for better control action.

43. What are the different types of controllers?

a. Proportional controller

b. PI controller

c. PD controller

d. PID controller

44. What is proportional controller?

It is a device that produces a control signal which is proportional to the input error signal.

45. What is PI controller?

It is a 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.

46. What is PD controller?

PD controller is a proportional plus derivative controller which produces an output signal consisting of two times -one proportional to error signal and other proportional to the derivative of the signal.

47. 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.

48. 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.

49. What is the disadvantage in proportional controller?

The disadvantage in proportional controller is that it produces a constant steady state error.

50. 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.

51. Why derivative controller is not used in control system?

The derivative controller produces a control action based on rare of change of error signal and it does not produce corrective measures for any constant error. Hence derivative controller is not used in control system

52. 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.

53. What is steady state error?

The steady state error is the value of error signal e (t) when t tends to infinity.

54. What are static error constants?

The Kp, Kv, and Ka are called static error constants.

55. What is the drawback of static coefficients?

The main drawback of static coefficient is that it does not show the variation of error with time and input should be standard input.

56. What are the three constants associated with a steady state error?

Positional error constant

Velocity error constant

Acceleration error constant

57. What are the main advantages of generalized error co-efficient?

Steady state is function of time.

Steady state can be determined from any type of input

58. What is frequency response?

The response of the system at the steady state when the input to the system is a sinusoidal signal is called as the frequency response.

50. List out the different frequency domain specifications?

The frequency domain specifications are

i) Resonant peak. ii) Resonant frequency.

51. Define –resonant peak (μ_r)?

The maximum value of the magnitude of closed loop transfer function is called resonant peak.

52. Define resonant frequency (f_r)?

The frequency at which resonant peak occurs is called resonant frequency.

53. 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.

54. Define cut-off rate?

The slope of the log-magnitude curve near the cut-off is called cut-off rate. The cut-off rate indicates the ability to distinguish the signal from noise.

55. Define gain margin?

The gain margin, k_g is defined as the reciprocal of the magnitude of the open loop transfer function at phase cross over frequency.

Gain margin $k_g = 1 / | G(j\omega_{pc}) |$.

56. Define phase cross over.

The frequency at which, the phase of open loop transfer function crosses -180° is called phase cross over frequency ω_{pc}.

57. What is phase margin?

The phase marginγ is the amount of phase lag at the gain cross over frequency required to bring system to the verge of instability.

58. 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.

59. 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 ω. The other is a plot of the phase angle of a sinusoidal function versus logω.

60. What are the main advantages of Bode plot?

The main advantages are:

a. Multiplication of magnitude can be in to addition.

b. A simple method for sketching an approximate log curve is available.

c. It is based on asymptotic approximation. Such approximation is sufficient if rough information on the frequency response characteristic is needed.

d. The phase angle curves can be easily drawn if a template for the phase angle curve of $1+ j\omega$ is available.

61. Define corner frequency?

The frequency at which the two asymptotic meet in a magnitude plot is called corner frequency.

62. Define phase lag and phase lead.

A negative phase angle is called phase lag.

A positive phase angle is called phase lead.

63. What are M circles?

The magnitude of closed loop transfer function with unit feed back can be shown to be for every value if M. These circles are called M circles.

64. What are N circles?

If the phase of closed loop transfer function with unity feedback is α, then tan α will be in the form of circles for every value of α; these circles are called N circles.

65. What is Nichols chart?

The chart consisting if M & N loci in the log magnitude versus phase Diagram is called Nichols chart.

66. 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.

67. How the resonant peak (M_r), resonant frequency (w_r), and band width are determined from Nichols chart?

The resonant peak is given by the value of μ. Contour which is tangent to G ($j\omega$) locus.

The resonant frequency is given by the frequency of G($j\omega$) at the tangent point.

The bandwidth is given by frequency corresponding to the intersection point of G($j\omega$) and –3dB M-contour.

68. What are the advantages of Nichols chart?

The advantages are:

a. It is used to find the closed loop frequency response from open loop frequency response.

b. Frequency domain specifications can be determined from Nichols chart.

c. The gain of the system can be adjusted to satisfy the given specification.

69. What is Nyquist contour?

The contour that encloses entire right half of S plane is called Nyquist contour.

70. State Nyquist stability criterion.

If the Nyquist plot of the open loop transfer function G(s) corresponding to the Nyquist contour 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.

71. What are the two segments of Nyquist contour?

a. A finite line segment C1 along the imaginary axis.

b. An arc C2 of infinite radius.

72. What are the effects of adding a zero to a system?

Adding a zero to a system results in pronounced early peak to system response thereby the peak overshoot increases appreciably.

73. State magnitude criterion.

The magnitude criterion states that $s=s_a$ will be a point on root locus if for that value of s, $| D(s) | = |G(s)H(s) | =1$

74. State angle criterion.

The Angle criterion states that $s=s_a$ will be a point on root locus for that value of s,, $\angle D(s) = \angle G(s)H(s)$ =odd multiple of 180°

75. Define BIBO stability.

A linear relaxed system is said to have BIBIO stability if every bounded input results in a bounded output.

76. What is the necessary condition for stability?

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

77. What is the necessary and sufficient condition for stability?

The necessary and sufficient condition for stability is that all of the elements in the first column of the Routh array should be positive.

78. What is quadrant symmetry?

The symmetry of roots with respect to both real and imaginary axis called quadrant symmetry.

79. 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.

80. Define relative stability

Relative stability is the degree of closeness of the system, it and indication of strength or degree of stability.

81. What are root loci?

The path taken by the roots of the open loop transfer function when the loop gain is varied from 0 to α are called root loci.

82. What is a dominant pole?

The poles lying close / on the imaginary axis are dominant poles.

83. What are the main significances of root locus?

a. The main root locus technique is used for stability analysis.

b. Using root locus technique the range of values of K, for as table system can be determined

84. What are the two types of compensation?

a. Cascade or series compensation

b. Feedback compensation or parallel compensation

85. What are the three types of compensators?

a. Lag compensator

b. Lead compensator

c. Lag-Lead compensator

86. What are the uses of lead compensator?

a. Speeds up the transient response

b. Increases the margin of stability of a system

c. Increases the system error constant to a limited extent.

87. What is the use of lag compensator?

Improve the steady state behavior of a system, while nearly preserving its transient response.

88. When is lag lead compensator required?

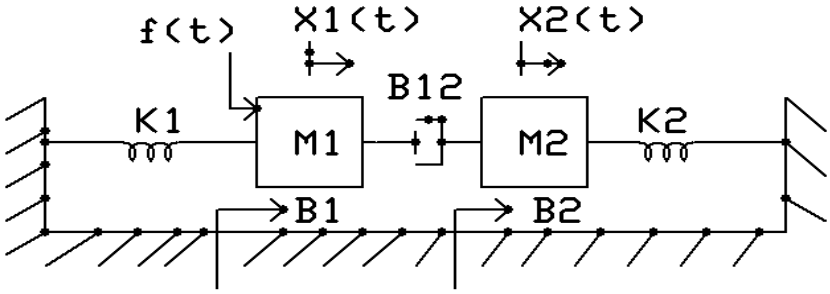
The lag lead compensator is required when both the transient and steady state response of a system has to be improved.

89. What is a compensator?

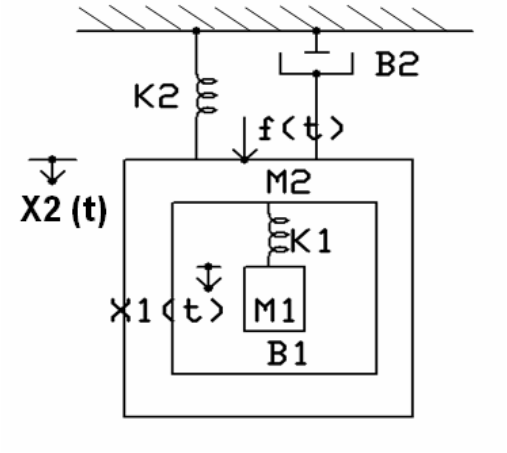
A device inserted into the system for the purpose of satisfying the specifications is called as a compensator.

Part B

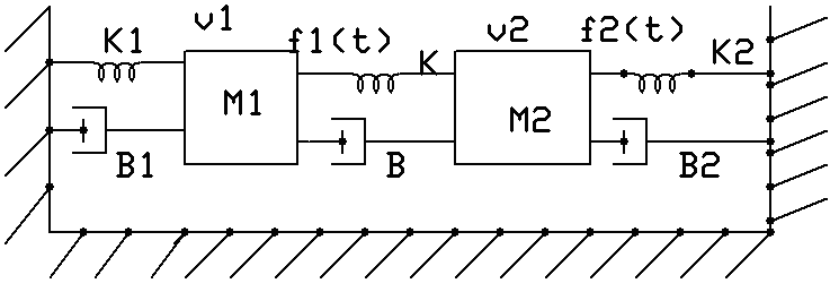
1. Determine the transfer function X1(S) / F(S) and X2(S) / F(S) of the mechanical system shown in figure.



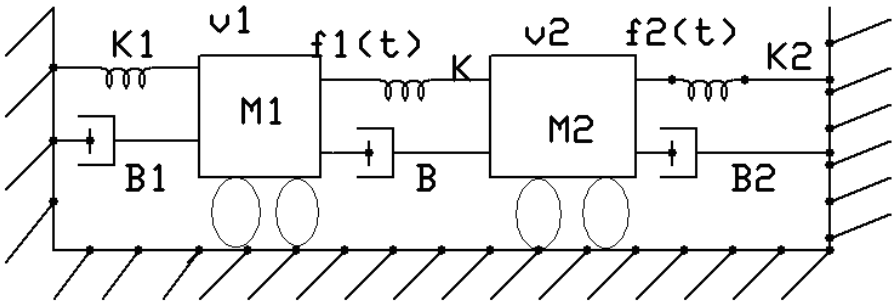
2. Write the governing differential equations of the mechanical system shown in figure.



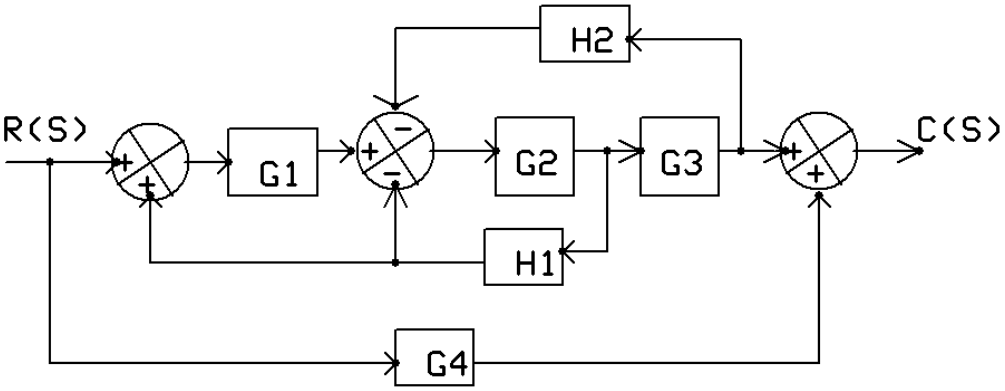
3. Write the governing differential equations of the mechanical system shown in figure.



4. Write the governing differential equations of the mechanical system shown in figure.



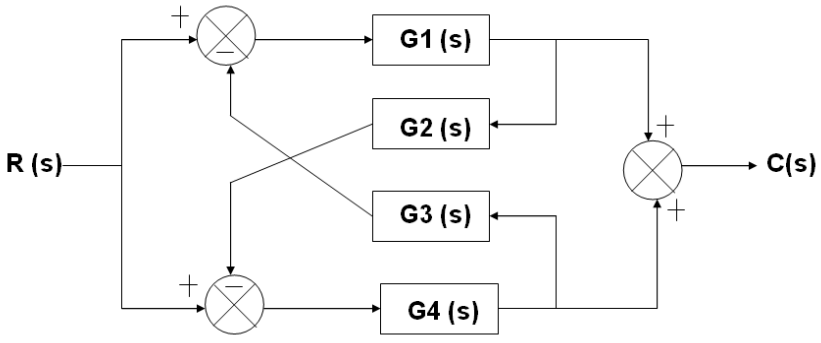
5. Obtain the closed loop transfer function C(S) / R(S) of the system whose block diagram is shown in figure. Use Block diagram reduction technique and verify the transfer function with signal flow graph technique.



6. Derive the transfer function of
   i. Armature controlled d.c. motor
   ii. Field control d.c. motor with necessary block diagram

7. Explain the rules for block diagram reduction.

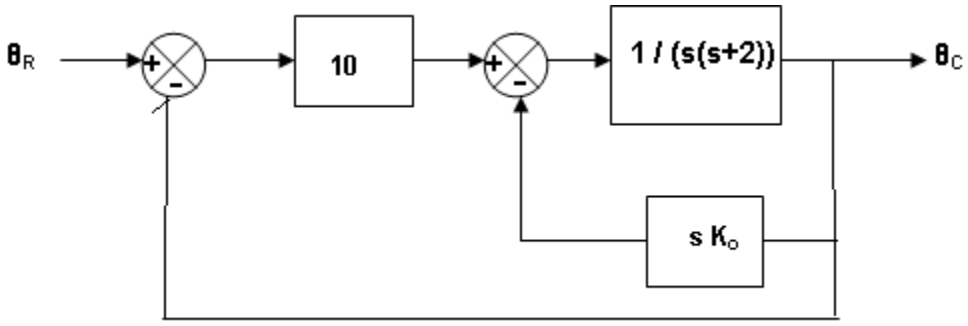
8. Determine the transfer function of the system shown in the following figure.



9. Measurements are conducted on a servomechanism show the system response to be $C(t) = 1 + 0.2\ e^{-60t} - 1.2\ e^{-10t}$ when subjected to unit step input.
   i. Obtain the expression for the closed loop transfer function.
   ii. Determine the undamped natural frequency and damping ratio of the system.

10. Obtain the unit impulse response and unit step response of a unity feedback system whose open loop transfer function is $G(s) = (2s + 1) / s^2$.

11. Determine the damping factor and natural frequency of the system when $K_0 = 0$. What is the steady state error resulting from unit ramp input? Determine the derivative feedback constant K_0 which will increase the damping factor of the system to 0.6. What is the steady state error to unit ramp input with this setting?



12. Derive an expression for the time response of an under damped II order system subjected to unit step input. Plot the response and mark the time domain specifications in it. Define rise time, peak time, peak overshoot and settling time.

13. Enumerate the advantages of generalized error co-efficients and determine the generalized error co-efficients and steady state error for a system whose open loop transfer function is $G(s) = 1 / (s\ (s + 1)\ (s + 10))$ and the feedback transfer function is $H(s) = (s + 2)$ with input $r(t) = 6 + t + t^2$.

14. The open loop transfer function of a unity feedback system is given by $G(s) = 20 / (s^2 + 5s + 6)$. Determine the damping ratio, maximum overshoot, rise time and peak time. Derive the used formula.

15. Determine the time response specifications and expression for output of the system described by he differential equation $d^2y / dt^2 + 5\ dy / dt + 16\ y = 19x$ for unit step input (y – output and x-input).

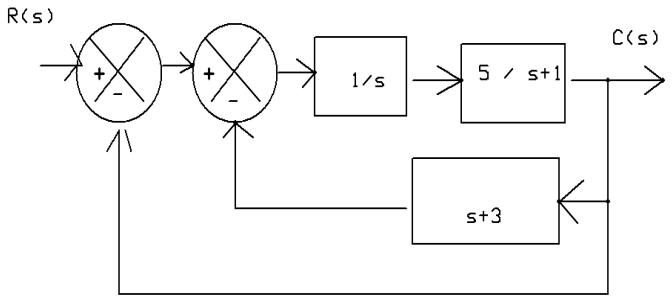
16. A unity feedback heat treatment system has $G(s) = 10000 / [(1 + s)\ (1+ 0.5\ s)\ (1+ 0.02\ s)]$.The output set point is 500^0C.What is the steady state temperature?

17. A unity feedback system is characterized by the open loop transfer function $G(s) = 1 / (s\ (1 + 0.5\ s)\ (1 + 0.2s))$. Determine the steady state errors for unit step, unit ramp, and unit acceleration inputs.

18. Derive the unit step, ramp and impulse response of a first order system and draw the curves.

19. Evaluate the static error co-efficients for a unity feedback system having a forward path transfer function $G(s) = 50 / (s\ (s + 10))$.

20. For the system shown in fig. What is the steady state error for unit step input?



21. A second order mechanical system is represented y the transfer function θ(s) / I((s) = 1 / Js^2 + fs + k. A step input of 10 N-m is applied to the system.

22. The open loop transfer function of a unity feedback system is given by G(s) = 10 (s + 3) / (s (s + 2) (s^2 + 4s + 100)). Draw the Bode plot and hence find the gain margin and phase margin.

23. Draw the Bode plot for the function G(s) = K s^2 / [(1 + 0.2 s) (1 + 0.02s)]. Determine the value of K for a gain cross over frequency of 20 rad/sec.

24. The open loop transfer function of a unity feedback system is G(s) = 100 (1 + 0.2 s) / s (1+0.1 s). Draw the Bode plot and hence find the gain margin and phase margin.

25. Draw the Bode plot of the system whose open loop transfer function is G(s) H(s) = K / (s (1 + s) (1 + 0.1 s) (1 + 0.02 s)). Determine the value of K for the gain margin of 10 dB.

26. Sketch the Bode plot for a unity feedback system characterised by G(s) H(s) = (K (1 + 0.2 s) (1 + 0.025 s)) / (s^2 (1 + 0.01 s) (1 + 0.005 s)).

27. Sketch the root locus for the open loop transfer function of unity feedback system is given by $G(s) = \frac{K}{s(s+3)(s^2+2s+2)}$.

28. Determine the range of K for stability of unity feedback system whose open loop transfer function is $G(s) = \frac{K}{s(s+1)(s+2)}$.

29. Sketch the root locus for the open loop transfer function of unity feedback system given by $G(s) = \frac{K}{s(s+2)(s+4)}$.

30. Construct the root locus for a system with G(s) = [K (s + 9)] / [s (s^2 + 4s + 11)] and H(s) = 1. Locate the closed loop poles so that the dominant closed loop poles have a damping ratio of 0.5. Determine the corresponding value of gain K.

31. Sketch the Nyquist plot for a feedback system with the open loop transfer function G(s) H(s) = [K (s + 3) (s + 5)] / [(s - 2) (s - 4)]. Determine the range of K for which the system is stable.

32. Design a phase lead compensator for a system with open loop transfer function G(s) H(s) = K / (s (s + 2)) so that the velocity error constant is 20 sec^{-1}, phase margin is at least 50^0 and gain margin is at least 10 dB.

33. The open loop transfer function of a unity feedback system is given by $G(s) = K / [(s + 2) (s + 4) (s^2 + 6s + 25)]$. By applying Routh criterion, discuss the stability of the closed loop system as a function of K. Determine K which will cause sustained oscillations in the system. What are the corresponding oscillation frequencies?

34. Construct the root locus for the function $G(s) H(s) = [K (s + 2)] / (s + 2)^2$ and discuss about the stability of the system.

35. Sketch the Nyquist plot for a system with the open loop transfer function $G(s) H(s) = [K (1 + 0.4 s) (s + 1)] / [(1 + 8s) (s - 1)]$. Determine the range of K for which the system is stable.

36. Design a phase lag compensator so that the system $G(s) H(s) = 100 / [s (s + 1)]$ will have phase margin of 15^0.

37. For a system with characteristic equation $s^4 + 22 s^3 + 10 s^2 + s + K = 0$, discuss on the stability of the system as a function of K. Obtain the marginal value of K for stability, and the frequency of oscillations at that value of K.