N.B.: 1. Question No. 1 is Compulsory.
   2. Attempt any three from the remaining questions.
   3. Assume suitable data wherever necessary.
   4. Figure to right indicate full marks.

1. Attempt any four questions:-

   a) Explain Adaptive control system.
   b) Explain lead and lag compensator.
   c) Explain Controllability and Observability with its necessity condition for stability.
   d) Determine whether the following systems are stable, marginally stable, and unstable
      (i) -2,0; (ii) -2+j, -2-j; (iii) -2+j4, -2-j4, -2; (iv) \( x(t) = \cos \omega t \); (v) \( x(t) = e^t \sin 4t \).
   e) Examine the stability of \( s^5 + 2s^4 + 2s^3 + 4s^2 + 4s + 8 = 0 \) using Routh's method.

2. a) Obtain the overall transfer function from block diagram.

   ![Block Diagram]

   b) Sketch the complete root locus for the system

   \[
   G(s)H(s) = \frac{K(s+1)(s+2)}{(s+0.1)(s-1)}, \quad \text{where} \ K > 0. 
   \]

3. a) Obtain the state variable model of the parallel RLC network.

   ![RLC Network]

   b) Explain P, PI and PID controller.

TURN OVER
4. a) The state equation of a linear time-invariant system is given below:

\[
\begin{bmatrix}
\dot{x}_1 \\
\dot{x}_2
\end{bmatrix} = \begin{bmatrix}
-2 & 0 \\
1 & -1
\end{bmatrix} \begin{bmatrix}
x_1 \\
x_2
\end{bmatrix} + \begin{bmatrix}
0 \\
1
\end{bmatrix} u
\]

Where \( u > 0 \).

Determine the following:
(i) The state transition matrix.
(ii) Controllability of the system.

b) Sketch the bode plot for the open loop transfer function given by:

\[
G(s) = \frac{[288 \ (s+4)]}{[s(s+1) \ (s^2 + 4.8s + 144)]} \ \text{and} \ \ H(s) = 1.
\]

5. a) Derive the expressions of Peak Overshoot when step input applied to the system.

b) Sketch the polar plot of \( G(s) = 12 / [s(s+1)] \).

c) For \( G(s)H(s) = 1+4s / [s^3 \ (1+s)(1+2s)] \), draw the Nyquist plot and examine the stability of the system.

6. Attempt any two-

a) Write a short note on Robust control system.

b) Construct the signal flow graphs for the following set of equations:

\[
\begin{align*}
Y_2 &= G_1 Y_1 - G_2 Y_4 \\
Y_3 &= G_3 Y_2 + G_4 Y_3 \\
Y_4 &= G_5 Y_1 + G_6 Y_3
\end{align*}
\]

where \( Y_4 \) is the output.

Using Mason’s gain formula find the transfer function of the system.

c) Explain the Correlations between time and frequency domain specifications of the system.