**Instructions to candidates:**

1. **All questions are compulsory.**
2. **All questions carry equal marks.**
3. **Figures to right indicates full marks.**

|  |  |  |
| --- | --- | --- |
| **1** |  |  |
| **i** | For a second order underdamped system damping factor and natural frequency . Show these two factors graphically in s-plane | **1** |
| **ii** | Depending upon damping factor classify the control systems   1. Undamped system, 2. Underdamped system, 3. Critically damped system, 4. Overdamped system, | **1** |
| **iii** | The time response of a control system is the sum of the **transient** **response** and the **steady** **state** **response**. | **1** |
| **iv** | The **steady** **state** error is a measure of system accuracy. | **1** |
| **v** | If the characteristic equation of a system is , the system is **overdamped**. | **1** |
|  |  |  |
| **2** | A unity feedback system whose open loop transfer function is given by when subjected to a unit step input gives underdamped response. If peak overshoot is 25% at 3 second. Determine the value of K and T. By what factor K should be multiplied so that peak overshoot amplified from 25% to 75%?  Compare with standard form of the transfer function office second order system | **10** |
|  | and  The peak overshoot is .25 i.e. 25% therefore  Now  By what factor K should be multiplied so that peak overshoot amplified from 25% to 75%?  and  For peak overshoot 0.75 let and K = K1  and  For peak overshoot 0.25 let and K = K2  The peak overshoot is given by  For peak overshoot 0.25 K = K1  For peak overshoot 0.75 K = K2  This indicates that to increase the peak overshoot 25% to 75% K should be increased by 19.65 times. |  |
| **3** | Determine the stability of system using Routh-Hurwitz criteria having characteristic equation Also comment on systems closed loop pole locations. | **5** |

The route table is formed as follows:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 1 | 5 | 8 | 4 |
|  | 3 | 9 | 6 |  |
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|  |  |  |  |  |
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All the elements in the are zeros. So, the Routh’s test fails. The system is unstable. To complete the Routh table, form an auxiliary equation using the coefficients of the row (the row just above the row of zeroes)

Taking the first derivative of auxiliary equation

Replace the row of zeros by the elements of first derivative of the auxiliary equation and process with the formation of Routh table

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 1 | 5 | 8 | 4 |
|  | 3 | 9 | 6 |  |
|  | 2 | 6 | 4 |  |
|  | 2 | 3 | 0 |  |
|  |  |  | 0 |  |
|  |  | 0 |  |  |
|  |  |  |  |  |

Since all the elements in the first column of the Routh array positive, there are no roots of characteristics equation in the right half of the s plane. Still the system is unstable due to existence of the row of zeros, which means that there must be roots on imaginary axis of the s plane. To determine the roots on imaginary axis, solve the auxiliary equation. To determine the other roots divide characteristics equation by auxiliary equation.

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|  |  |
|  |  |
|  |  |
|  | 0 |

Therefore, the two poles are and

Now solve the auxiliary equation for the roots on imaginary axis

There are two pairs of non-repeated roots on the imaginary axis. So, the system oscillates and it is marginally stable (unstable).