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**PRESIDENCY UNIVERSITY
BENGALURU**

SET A

**SCHOOL OF ENGINEERING
END TERM EXAMINATION - JAN 2024**

Semester : Semester V - 2021
Course Code : ECE3007
Course Name : Control Systems
Program : B.Tech.

Date : 04-JAN-2024
Time : 9:30AM - 12:30 PM
Max Marks : 100
Weightage : 50%

Instructions:

- (i) Read all questions carefully and answer accordingly.
- (ii) Question paper consists of 3 parts.
- (iii) Scientific and non-programmable calculator are permitted.
- (iv) Do not write any information on the question paper other than Roll Number.

PART A

ANSWER ALL THE QUESTIONS

5 X 2M = 10M

1. Standard test signals are used to analyze a particular system by giving these inputs to the systems. In control systems, many standard test signals are used. Define a unit parabolic signal and write its Laplace transform.

(CO2) [Knowledge]

2. A required performance criteria of any control system is 0 steady state error. Suppose you have a unity feedback control system with closed loop transfer function given below

$$\frac{C(s)}{R(s)} = \frac{20}{s-2}$$

Estimate the steady state error when a unit step signal is applied as the input.

(CO2) [Knowledge]

3. Second order systems can be classified based on their damping ratio. Suppose you have a second order system with closed loop transfer function

$$G(s) = \frac{100}{s^2 + 10s + 100}$$

Classify the system based on the damping.

(CO2) [Knowledge]

4. Root locus is the path followed by the closed loop poles of a system as the system parameter is varied from 0 to ∞ . Define the angle and magnitude criterion that is valid for any point on the root locus.

(CO3) [Knowledge]

5. Gain Margin and Phase margin are important terms that ascertain whether a system is stable or not. The gain cross over frequency is the frequency at which gain in dB is _____ and the phase margin is given as $PM = 180^\circ + \dots\dots\dots$

(CO3) [Knowledge]

PART B

ANSWER ALL THE QUESTIONS

5 X 10M = 50M

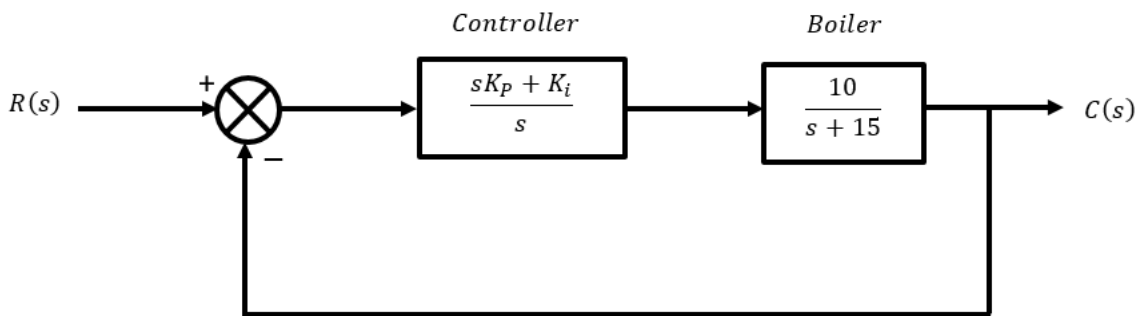
6. Suppose you are a control Engineer in Bosch Ltd. You have a system with the closed loop transfer function given by

$$G(s) = \frac{20}{s^6 + 3s^5 + 4s^4 + 6s^3 + 5s^2 + 3s + 2}$$

You are asked to investigate the stability of the system. Investigate the stability of the system by finding the number of poles on the left half of the s plane, right half of the s plane and on the imaginary axis.

(CO2) [Comprehension]

7. Suppose you are a control engineer in Kochi Refineries Limited. You are working with the temperature control of a boiler.



Your supervisor has asked you to maintain the temperature inside the boiler such that the following specifications are met

Specification 1: The response when a step input is applied, have an overshoot of 5% only.

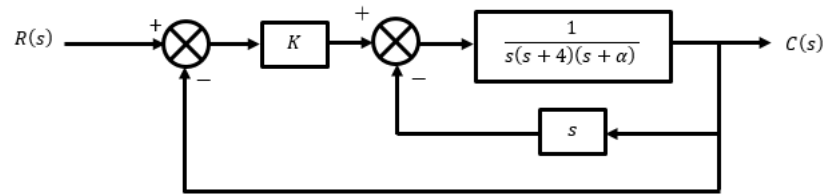
Specification 2: The systems settles to the required temperature in 0.5 s.

You are planning to use a Proportional Integral Controller

Estimate the controller parameters K_p , and K_i which will meet the specifications given by your supervisor. Estimate the steady state error when a unit step input is applied.

(CO2) [Comprehension]

8. Mr. Kiran is analyzing a control system shown below.



He observed that the system is oscillating at a frequency of 3 rad/s. Help him deduce the value of K and α .

Using this value of α , and K as a variable, what is the range of K for which the system is STABLE?

(CO2) [Comprehension]

9. Mr. Vivek designed a filter using operational amplifier which has a transfer function

$$G(s) = \frac{800s}{(s+4)(s+200)}$$

Bode plot can be used to find out the behavior of a certain system for different frequencies. Draw the Bode plot (both Gain plot and Phase plot) and hence state what type of filter (Low Pass, High Pass, Band Pass, Band Stop) is this?

(CO3) [Comprehension]

10. Suppose you are a design engineer at Bharat Electricals Ltd. You are working with the speed control of a DC motor.

The state vector is

$$X = \begin{bmatrix} \theta_m \\ \omega_m \\ i_a \end{bmatrix}$$

θ_m is the angular displacement, ω_m is the velocity and i_a is the armature current.

The input is

$$u = v_a$$

v_a is the armature voltage

Then the state space model can be written as

$$\dot{X} = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ -2 & -4 & -6 \end{bmatrix} X + \begin{bmatrix} 1 \\ 2 \\ 0 \end{bmatrix} u$$

$$Y = [1 \quad 0 \quad 1]X$$

You want to use state feedback to design a controller and an observer for the dc motor to obtain some certain requirements. For this you should know whether the system is controllable and observable. Infer whether the system is controllable and observable using a suitable method.

(CO4) [Comprehension]

PART C

ANSWER ALL THE QUESTIONS

2 X 20M = 40M

11. Mr. Praise is an engineer at Indian Space Research Organization. He is analyzing a system with the following open loop transfer function

$$G(s)H(s) = \frac{K(s + 2)}{(s - 4)(s + 1)}$$

He wants to design a controller for the system to meet some specifications. He is planning to use Root Locus as his design method. Obtain the root locus plot. Draw neatly. The specifications to be met are as below

Specification 1 : System should be STABLE

Specification 2 : System should be underdamped.

Help him by finding the range of K which meets the above specifications. Show that part of the root locus will be a circle.

(CO3) [Application]

12. Dr. Pritam is a scientist in HAL Bengaluru. He is conducting a study on a system. He modelled the system using a differential equation given below

$$3 \frac{d^2 c(t)}{dt^2} - 3c(t) = 6r(t)$$

Here $r(t)$ is the input to the system and $c(t)$ is the corresponding output. He wants to model the system using matrices. Identify the modelling to be used and hence model the system in that form. [6 Marks]

Now he wants to analyze the stability of the system by obtaining the poles of the system by finding the transfer function from this particular model. Deduce the transfer function and write the poles of the system. Is the system STABLE? [6 Marks]

Now he needs to know how the system will behave for a particular initial condition and when no input is applied. Deduce the response of the system to an initial condition of $c(0) = 2$ and $c'(0) = -1$ [8 Marks]

(CO4) [Application]