Register No.: ..... Name: .....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

FIFTH SEMESTER B.TECH DEGREE EXAMINATION (S), FEBRUARY 2024
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code : 20CHT307

Course Name: Instrumentation and Process Control

Max. Marks : 100 **Duration: 3 Hours**

Normal/ semi log graph sheets shall be provided

PART A

(Answer all questions. Each question carries 3 marks)

1. Distinguish between sensors and transducers with suitable example.
2. Explain the principle of a thermocouple and list out the different types of thermocouples.
3. Applying the final value theorem solve:
$$f(s) = \frac{(s+4)}{s(s+1)(s+2)(s+3)}$$
4. Graph the following equation:
$$f(t) = u(t) - 2u(t-1) + u(t-3)$$
5. Give any one application of the following controllers:
   i) Proportional Controller
   ii) PI Controller
   iii) PID controller
6. Explain the working principle of a control valve with a neat sketch.
7. Sketch the block diagram of a typical feedback control system and label the block components.
8. Differentiate servo and regulator problem.
9. Give the expressions for Amplitude ratio and Phase lag.
10. Explain the terms gain margin and phase margin.

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) What do mean by static characteristics of an instrument. Define any six static characteristics of a measuring instrument. (10)
    b) Explain the working of optical pyrometers for temperature measurement. (4)

OR

12. a) Explain the working and principle of hot ionization gauge used for pressure measurement with a neat, labelled figure. Why does the lower and upper limits of pressure measurement in hot ionization gauge lead to erroneous reading? (10)

b) Differentiate resistance thermometers and thermocouples. (4)

MODULE II

13. a) Solve the following:

$$2y'' + 3y' - 2y = te^{-2t}$$

for the condition: (8)

$$y\,(0) = 0 \; and \; y'(0) = -2$$

b) Find the inverse transform f(t),

$$F(s) = \frac{(s+7)}{s^2 - 3s - 10}$$ (6)

OR

14. a) If a forcing function f(t) has the Laplace transform as given below, and graph the function.

$$f(s) = \frac{1}{s} + \frac{e^{-s} - e^{-2s}}{s^2} - \frac{e^{-3s}}{s}$$ (4)

b) Derive an expression for G(s) of a mercury in glass thermometer to obtain the equation for step response. (10)

MODULE III

15. a) A step change of magnitude 3 is introduced into a transfer function

$$\frac{Y(s)}{X(s)} = \frac{10}{2s^2 + 0.3s + 0.5}$$ (6)

Determine overshoot and frequency of oscillation.

b) Derive an expression for G(s) of a non-interacting two tank system in terms of $\frac{H_2(s)}{Q(s)}$. Obtain the equation for the step response. (8)

OR

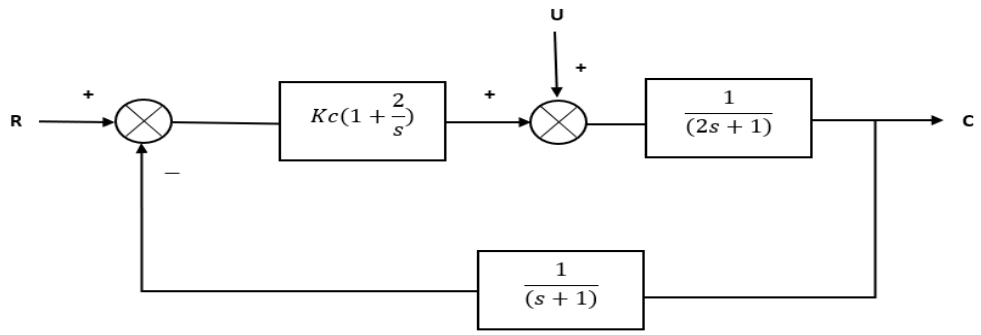
16. a) Derive an expression for G(s) for a step response of a manometer. (10)

b) List out the different types of controllers with its corresponding transfer function. (4)

MODULE IV

17. a) What do you understand by stability of a system and describe the Routh Stability method and its limitations? (6)

b) Write the characteristic equation for the control system shown below and determine the ultimate value of Kc, above which the system is unstable. (8)

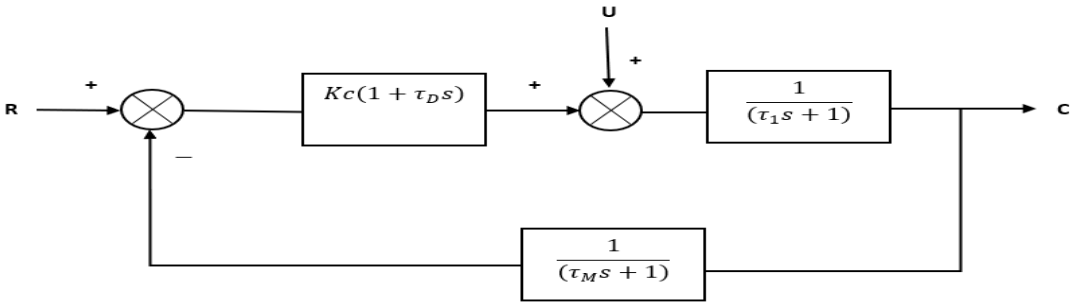


OR

18. a) Plot the root locus diagram for the open-loop transfer function G(s)

$$G(s) = \frac{K}{(s+1)(s+2)(s+3)} \quad (10)$$

b) A PD controller is used in a control system having first-order process and a measurement lag as shown in figure below.



(4)

Find expressions for "ζ" and "τ" for the closed-loop response.

MODULE V

19. Sketch the Bode plot for the following transfer function.

$$F(s) = \frac{K(0.2s+1)}{(0.05s+1)(0.5s+1)^2} \quad (14)$$

From the bode stability criterion, determine the value of K for stability.

OR

20. a) Explain the procedure to compute phase margin and gain margin from Bode plot. (6)

b) Using Ziegler-Nichols tuning rules, determine the settings of PID controllers for a process whose open loop transfer function is given by (8)

$$G(s) = \frac{2e^{-s}}{(10s+1)(5s+1)}$$

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