Exam Date & Time: 02-May-2024 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

SIXTH SEMESTER B.TECH END SEMESTER EXAMINATIONS, APRIL - MAY 2024

BIOPROCESS CONTROL AND INSTRUMENTATION [BIO 3252]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

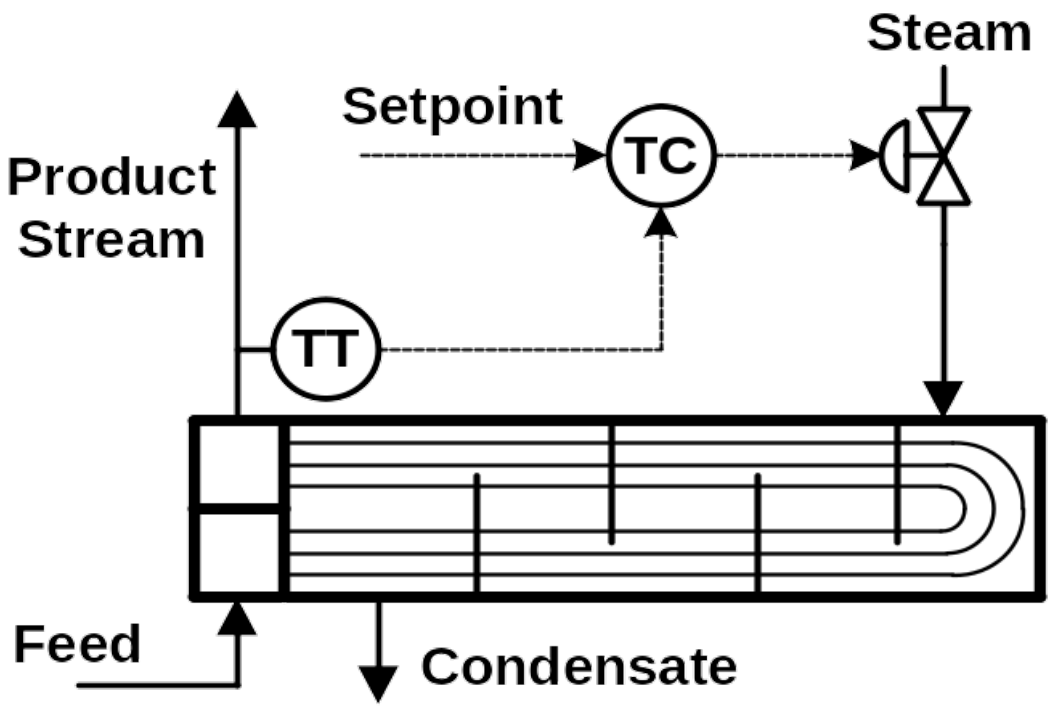
Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) What are the external disturbances in a stirred tank heater and how will you design (all possible ways) a control system to suppress the external disturbances. (4)

A)

B) Briefly explain the response of a stable and unstable process with neat diagram. (3)

C) Identify the Controlled variable, Manipulated variable, Disturbance, Sensor and Actuator in the below heat exchanger.



(3)

2) A completely enclosed stirred tank heating process is used to heat an incoming stream whose flow rate varies. The heating rate from this coil and the volume are both constant.

A) Assumptions:

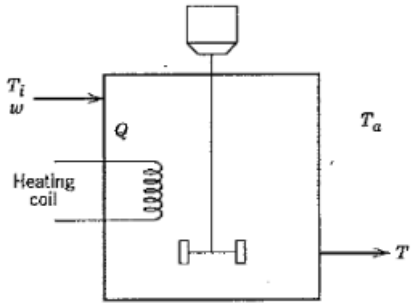
- ρ and Cp are constants.

- U, the overall heat transfer coefficient, is constant.

- As is the surface area for heat losses to ambient.

- Ti > Ta (inlet temperature is higher than ambient temperature)

(4)



(a) Develop a mathematical model (differential and algebraic equations) that describe the exit temperature if heat losses to the ambient occur and if the ambient temperature (T_a) and the incoming stream's temperature (T_i) both can vary.

(b) Discuss qualitatively what you expect to happen as T_i and w increase (or decrease). Justify by reference to your model.

B) If $g(t) = \frac{df(t)}{dt}$ & $F(s) = (2s+1)/(s^2+9s+18)$, find the value g(t=0) using the initial value theorem. (3)

C) A heated process is used to heat the liquid in the tank with first order dynamics, that is, the transfer function relating changes in temperature T to changes in the heater input power level P is

$$\frac{T(s)}{P(s)} = \frac{K}{\tau s + 1}$$

Where K has units [^{o}C/Kw] and τ has units (minutes). The process is at steady state when an engineer changes the power input stepwise from 1 to 1.5 Kw, the following have been observed: (3)

(a) The process temperature initially is 80 ^{o}C.

(b) Four minutes after changing the power input, the temperature is 230 ^{o}C.

(c) Thirty minutes later (steady state) the temperature is 280 ^{o}C.

Determine the values of K and τ in the process transfer function.

3) Consider the second order system where ζ=0.6 and ωn=5 rad/sec. find the rise time , peak time , maximum overshoot , time period and settling time when the system is subjected to a unit-step input? (4)

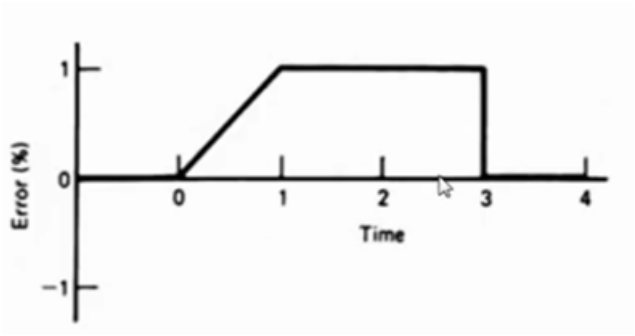
A)

B) Explain the working principle of air to open and air to close valves and write its applications. (3)

C) Figure below shows an error time graph. Sketch the PID controller output with respect to time. Assume **K_p = 10, K_i = 2, K_d = 0.5** and **P_0 = 0**. The controller input- output can be written as

$$u = k_p e + k_i \int e dt + k_d \frac{d}{dt} e + P_0$$

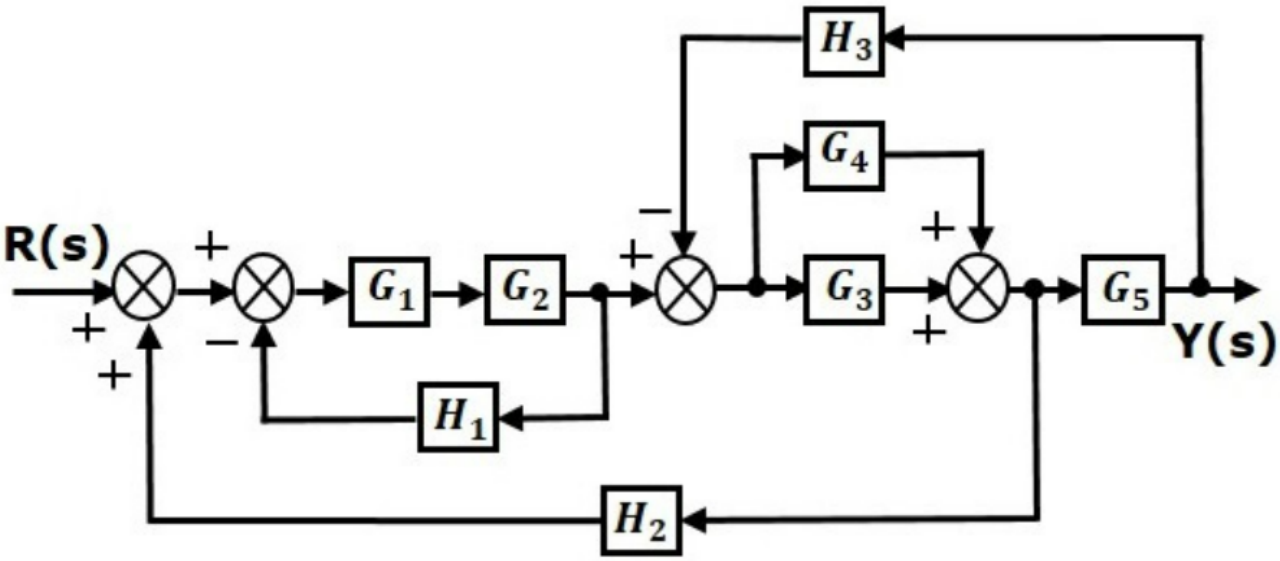
(3)



4) Consider a characteristic equation, $s^4+3s^3+5s^2+6s+k+10=0$. For what values of K, the system is stable. (3)

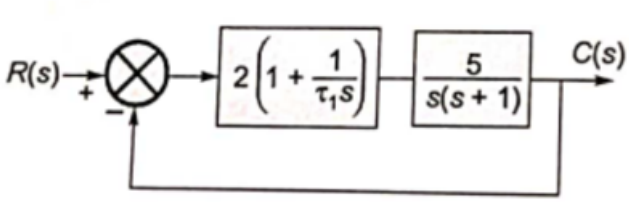
A)

B) Consider the block diagram shown in the following figure. simplify (reduce) this block diagram using the block diagram reduction rules.



(4)

C) The closed loop control system shown in figure has $\tau_I > 0$. Determine the range of τ_I in which the system will remain stable.



(3)

5) Consider a process with the transfer function:

A) $$G_p(s) = \frac{1}{(s^4 + 10s^3 + 36s^2 + 56s + 32)}$$ (4)

If a PI Controller is used to control this process, determine the value of the integral time τ_I and K_c using the Ziegler-Nichols closed loop tuning method.

B) Determine the PID parameters using direct synthesis method, where

$$G_M = \frac{3}{(2s+1)(3s+1)(5s+1)} \quad \text{and} \quad G^{des} = \frac{1}{9s^2+3s+1}$$ (3)

C) Briefly explain the steps involved to find the tuning parameters using Cohen-Coon method. (3)

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