Exam Date & Time: 27-May-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

B. Tech in Chemical Engineering
VI Semester External Examination
May/June 2023

PROCESS DYNAMICS AND CONTROL [CHE 3252]

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

Descriptive Questions

Answer all the questions. Section Duration: 180 mins

1) How does the number of degrees of freedom affect number and selection of the control objectives in a process? (2)

A)

B) Find y(t) for the following equation

$$\frac{d^2y}{dt^2} - 10\frac{dy}{dt} + 9y = 5t$$

(4)

$$y(0) = -1; y'(0) = 2$$

C) Explain Zeros and Poles of a transfer function. Mention its significance in control system analysis. (4)

2) A stirred tank heater has an internal cooling coil to remove heat liberated in the reaction. A proportional controller is used to regulate coolant flow rate so as to keep the reactor temperature reasonably constant. The controller has been designed so that the controlled reactor exhibits typical underdamped second order temperature response characteristics when it is disturbed, either by feed flow rate or by coolant temperature changes.

A)

a. The feed flow rate to the reactor changes suddenly from 0.4 to 0.5 kg/s, and the temperature of the reactor contents, initially at 100 °C, changes eventually 102 °C. What is the gain of the transfer function that relates changes in reactor temperature to changes in feed flow rate? (4)

b. The operator notes that the resulting response is slightly oscillatory with maxima estimated to be 102.5 °C and 102 °C occurring at times 1000 and 3060 s after the change is initiated. What is the complete process transfer function?

c. The operator failed to note the rise time. Predict t_r based on the results.

B) Consider the following transfer function:

$$G(s) = \frac{y(s)}{x(s)} = \frac{2}{20s + 4}$$

(4)

a. If input changes by step form of magnitude 10, what is the value of the output y(t)

when $t \rightarrow \infty$?

b. For the same input change as in (a), what is the value of the output when t = 10?

C) Determine decay ratio of the response, if the system has a transfer function of

$$G(s) = \frac{5}{(s^2 + 0.4s + 0.5)}$$ (2)

3) A pneumatic proportional controller is used to control temperature within the range of 50°C to 90°C. The controller is adjusted so that the output pressure goes from 3 psi

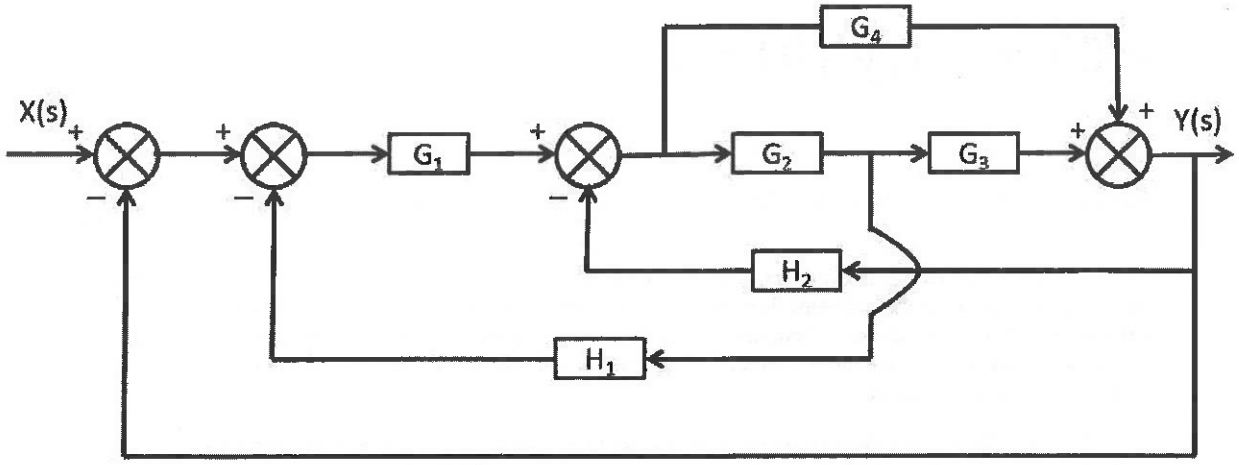
A) (valve fully open) to 15 psi (valve fully closed) as the measured temperature goes for 61°C to 65°C with the set point held constant. Find the gain and proportional band. (2)

B) Validate that by the addition of integral mode in a proportional controller, the offset is completely removed. (4)

C) A closed loop control system has two first order systems in series with time constants of 1 and 2 min and gains of 10 and 5 respectively. Proportional control is used. For a servo problem, determine what value of K_c gives a damping coefficient of 0.5 for closed loop response? (4)

4) Derive the closed loop transfer function for the control system shown in figure. Show the block diagram reduction step by step.

A)



(4)

B) By means of the Routh Hurwitz method, determine the value of K_c for the below mentioned closed loop system transfer functions which leads to stable response.

$$G_p(s) = \frac{2.98(s+2.25)}{(s+1.45)(s+2.85)^2(s+4.35)}$$

$$G_m(s) = G_f(s) = 1$$ (4)

$$G_c(s) = K_c$$

C) What are the steps involved to design a best controller? (2)

5) Sketch Bode plot for the system which has a transfer function

A) $$G(s) = \frac{10}{(s+1)(0.2s+0.5)} e^{-0.1s}$$ (4)

B) For the above-mentioned problem in (5A), from graph determine the following

a) Cross over frequency

b) Gain Margin

c) Phase Margin

d) Stability of the system (2)

C) Briefly discuss about adaptive control and inferential control scheme. (4)

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