



**NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**FACULTY OF ENGINEERING**

**DEPARTMENT OF CHEMICAL ENGINEERING**

**PROCESS DYNAMICS, MODELING AND CONTROL 1B**

**ECE/TCE 5202**

**Final Examination Paper**

**March 2025**

This examination paper consists of 3 pages

**Time Allowed: 3 hours**

**Total Marks: 100**

**INSTRUCTIONS**

1. Answer **any four** questions
2. Each question carries 25 marks
3. Use of calculators is permissible

**MARK ALLOCATION**

QUESTION	MARKS
1.	25
2.	25
3.	25
4.	25
5.	25
<b>TOTAL ATTAINABLE MARKS</b>	<b>100</b>

### QUESTION 1

- A. Explain any four (4) causes of dead – time or time delay on chemical processes. [8]
- B. For the system whose transfer function is given by:

$$g(s) = \frac{(-3s + 1)}{(2s + 1)(5s + 1)} \text{ --- 1}$$

and whose step response is given by:

$$y(t) = \left( 1 + \frac{5}{3} e^{-t/2} - \frac{8}{3} e^{-t/5} \right) \text{ --- 2}$$

Show from this step-response expression that this is an inverse responding system and find the time at which the response experiences "turn around." [17]

### QUESTION 2

- A. Explain briefly why singular value analysis (SVA) is important as an analytical tool in control system problems. [12]
- B. With the aid of a diagram explain how a ratio control system works in controlling chemical processes. [13]

### QUESTION 3

- A. What is an Adaptive Control System? With the aid of a well labeled Adaptive Control Structure, explain how it works? [19]
- B. Explain three functions of an Adaptive Control System. [6]

#### QUESTION 4

- A. A process control system in a fertilizer manufacturing company has the following transfer function matrix:

$$G_p = \begin{bmatrix} \frac{5e^{-3s}}{4s+1} & \frac{2e^{-4s}}{8s+1} \\ \frac{3e^{-3s}}{12s+1} & \frac{6e^{-3s}}{10s+1} \end{bmatrix}$$

Find expressions for the ideal decouplers and indicate how they can be simplified based on practical considerations. [15]

- B. Explain the purpose of a decoupling control system. [5]
- C. Differentiate between a SISO and MIMO systems. [5]

#### QUESTION 5

The input-output relationship of the boiler process control system at Delta Beverages Ltd with two controlled outputs and two manipulated inputs are given by the following transfer functions:

$$\bar{y}_1 = \frac{1}{0.1s+1} \bar{m}_1 + \frac{5}{s+1} \bar{m}_2 \quad \dots 1$$

$$\bar{y}_2 = \frac{1}{0.5s+1} \bar{m}_1 + \frac{2}{0.4s+1} \bar{m}_2 \quad \dots 2$$

Form two loops by coupling  $m_1$  with  $y_1$  and  $m_2$  with  $y_2$ . The closed-loop input-output relationships are:

$$H_{11} = \frac{1}{0.1s+1}; H_{12} = \frac{5}{s+1}; H_{21} = \frac{1}{0.5s+1}; H_{22} = \frac{2}{0.4s+1}$$

Let the two controllers be simple proportional controllers with  $G_{c1} = K_{c1}$  and  $G_{c2} = K_{c2}$ . Analyze the stability of the closed-loop response by:

- i. Tuning each controller separately [10]
- ii. Tuning with both loops closed. [15]

**END OF EXAMINATION QUESTION PAPER!!!!!!!**