NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

PROCESS DYNAMICS, MODELING AND CONTROL

TCE 5102

Special Final Examination Paper

July 2024

This examination paper consists of 3 pages

Time Allowed: 3 hours

Total Marks: 100

INSTRUCTIONS

1. Answer any 4 questions
2. Each question carries 25 marks
3. Graph paper is supplied
4. Use of calculators is permissible

MARKS ALLOCATION

QUESTION	MARKS
1.	**25**
2.	**25**
3.	**25**
4.	**25**
5.	**25**
TOTAL ATTAINABLE MARKS	**100**

QUESTION 1

A. Explain the five (5) most quoted simple performance criteria characterizing closed loop of a response system. **[10]**

B. With the aid of fully labeled sketch diagrams explain the effects of gain ($\mathbf{K_c}$) and reset time ($\boldsymbol{\tau_I}$) parameters for a **PI** controlled process. **[15]**

QUESTION 2

A. Explain two important aspects of why Frequency Response Analysis is a useful 'Tool' for designing Feedback Controllers. **[6]**

B. Determine the range of 'k' over which the following system is asymptotically stable:

$$\mathbf{s^3 + 5s^2 + (k - 6)s + k = 0} \qquad \textbf{[19]}$$

QUESTION 3

The open loop transfer function of a control system is given as:

$$G(s) = \frac{300(s + 100)}{s(s + 10)(s + 40)}$$

i. Determine an expression for the phase angle of ***G(jw)*** in terms of the angles of its basic factors. Calculate its value at a frequency of 28.3 rad/s. **[15]**

ii. Determine the expression for the magnitude of ***G(jw)*** in terms of the magnitudes of its basic factors. Find its value in dB at a frequency of 28.3 rad/s. **[10]**

QUESTION 4

A. With aid of sketch diagrams, explain the importance of gain and phase margins. **[17]**

B. Explain two important advantages of the Bode Stability Criterion to the Routh Stability Criterion. **[8]**

QUESTION 5

A stirred- tank blending process with a constant liquid holdup of 3.0 m^3 is used to blend the streams whose densities are both approximately 1 200 kg/m^3. The density does not change during mixing.

i. Assume that the process has been operating for a long period of time with flow rates of $F_1 = 800$ kg/min and $F_2 = 400$ kg/min, and feed compositions (mass fractions) of $x_1 = 0.4$ and $x_2 = 0.75$. What is the steady – state value of x? **[4]**

ii. Suppose that F_1 changes suddenly from 800 kg/min to 700 kg/min and remains at the new value. Determine an expression of response for x(t) and plot it. **[21]**

END OF EXAMINATION QUESTION PAPER