NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING

INSTRUMENTATION AND PROCESS DYNAMICS AND CONTROL

ECE 2207

Special Final Examination Paper

July 2024

This examination paper consists of 3 pages

Time Allowed: 3 hours

Total Marks: 100

INSTRUCTIONS

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

MARK ALLOCATION

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

QUESTION 1

A. Explain any four metrological characteristics of measuring instruments. **[8]**

B. With the aid of a labeled diagram explain precision and accuracy when analyzing control measurements. **[6]**

C. A thermocouple produces an e.m.f in ***mV*** according to the temperature difference between the sensor tip, T_1 and the gauge head, T_2 such that:

$$e = \propto (T_1 - T_2) + \beta(T_1^2 - T_2^2), \alpha = 3.5\,x10^{-2}, \beta = 8.2\,x10^{-6}$$

The gauge head is at 20°C. The mV output is 10 ***mV***; calculate the temperature at the sensor. **[11]**

QUESTION 2

A. Mention four (4) essential elements of the level process control shown in Fig Q2A and draw a block diagram showing them and also explain how the level is being controlled. **[12]**

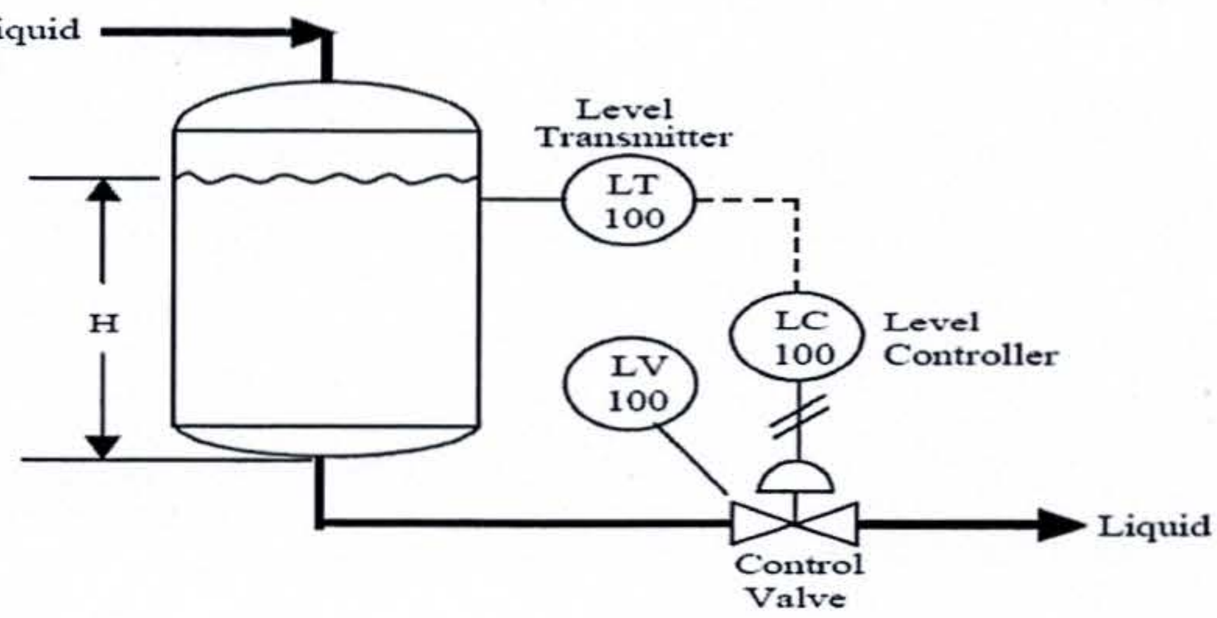

Fig Q2A Tank with level control

B. A nozzle is fitted in a horizontal pipe of diameter 15 cm, carrying a gas of density 1.05 kg/m^3, for the purpose of flow measurement. The differential pressure head indicated by a U-tube manometer containing oil of specific gravity of 0.75 is 18 cm. If the coefficient of discharge and diameter of the nozzle are 0.95 and 5 cm, respectively, determine the flow of the gas through the nozzle flow meter and draw the sketch of the system and label it.

[13]

$$Q = C_d \frac{A_1 A_2}{\sqrt{A_1{}^2 - A_2{}^2}} \sqrt{2g\Delta h}$$

QUESTION 3

A. With the aid of a diagram explain settling time, maximum error, offset error and error area. **[12]**

B. Explain with the aid of a diagram a SISO and a MIMO system in control of Chemical Processes. **[13]**

QUESTION 4

A. A stirred tank heating system is used to preheat a reactant containing a suspended solid catalyst at a constant flow rate of 1000 kg/h. The volume of the tank is 2 m^3 and the density and specific heat of the suspended mixture are 900 kg/m^3 and 1 cal/g°C, respectively. The process is initially operating with inlet and outlet temperatures of 100 and 130°C. What is the heater input (Q) at the initial steady state and the values of $\boldsymbol{K}$ and τ? **[11]**

B. A stirred- tank blending process with a constant liquid holdup of 2.5 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 $F_2 = 500$ 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? **[3]**

ii. Suppose that F_1 changes suddenly from 800 kg/min to 700 kg/min and remains at the new value. Determine an expression for x(t) and plot. **[11]**

QUESTION 5

A. Explain five advantages of using a cascade control in chemical plant processes. **[10]**

B. Calculate and analyze the degree of freedom for the following blending model for the special condition where volume, V is constant:

$$\frac{d(V\rho x)}{dt} = \omega_1 x_1 + \omega_2 x_2 - \omega x$$

Identify the different parameters and variables involved in the blending process. **[15]**

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