UNIVERSITY OF JOHANNESBURG

PROGRAM	NATIONAL DIPLOMA *CHEMICAL ENGINEERING*
SUBJECT	**PROCESS CONTROL**
CODE	**ICP3111**
DATE	SUMMER EXAMINATION 23 NOVEMBER 2019
DURATION	(SESSION 1) 8:30 - 11:30
TOTAL MARKS	100
FULL MARKS	100

EXAMINER	MR G PAHLA
MODERATOR	DR C BHONDAYI
NUMBER OF PAGES	07

REQUIREMENTS : Use of scientific (non-programmable) calculator is permitted (only one per candidate); graph paper

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HINTS AND INSTRUCTIONS TO CANDIDATE(S):

- Purpose of assessment is to determine not only if you can write down an answer, but also to assess whether you understand the concepts, principles and expressions involved. Set out solutions in a logical and concise manner with justification for the steps followed.
- **ATTEMPT ALL QUESTIONS**. Please answer each question to the best of your ability.
- Write your details (module name and code, ID number,student number etc.)on script(s).
- Number each question clearly; questions may be answered in any order.
- Make sure that you read each question carefully before attempting to answer the question.
- Show all steps (and units) in calculations; this is a 'closed book' test.
- Ensure your responses are legible, clear and include relevant units (where appropriate).

Question 1 **[Total 20 Marks]**

Process control systems

Consider a hot/cold water mixer shown in figure 1.1 below. The design intent is to maintain the temperature of the mixed warm water $\mathbf{T_O}$ at some output temperature set point $\mathbf{T_{O,SP}}$. The disturbances that can bring instability to the system are;

The flow of cold water $\mathbf{F_C}$ and the temperature of the cold water $\mathbf{T_C}$ which are determined by upstream processes. The flow of hot water $\mathbf{F_H}$, can be changed by a control valve.

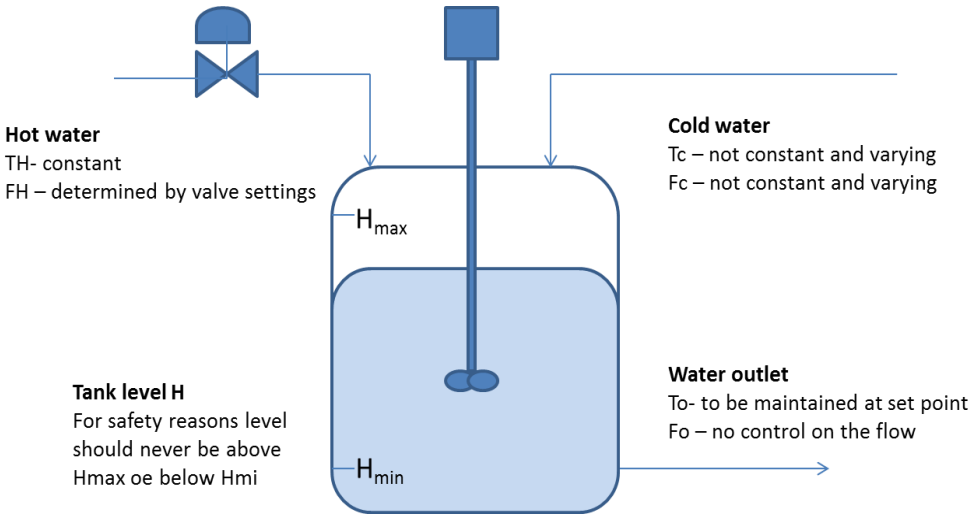


Figure 1.1: Schematic of a tank mixer process flow diagram

1.1. Do not *consider level control*. Show how you can control the tank mixer system using Feedback control.

Follow the steps below.

- Define the control objective. **[2]**
- Identify the disturbances. **[2]**
- Select Measured variables. **[2]**
- Select manipulated variables. **[2]**
- Designing a controller, redraw the diagram showing the control configuration.**[12]**

Question 2 **[Total 25 Marks]**

2.1. Draw a logic circuit for the following

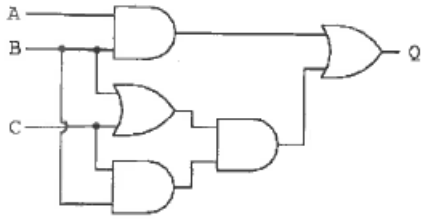
(a) $F= (A+B).C$ **[3]**

(b) $F= A+B.\overline{C+D}$ **[3]**

(c) $F= A.B +\overline{A.C}$ **[4]**

(d) $F=\overline{(A+B)}.(C+D).\overline{C}$ **[5]**

2.2. Find the behaviour expression or alarm setting output for the following circuit (Neatly copy the circuit and label each signal stream and show the final expression Q. **[5]**



Question 3 **[Total 20 Marks]**

A control with an equal percentage inherent characteric has a maximum Cv of 1300 and a rengeability of 40.

3.1. Calculate the % changes in the flow for every 10% change in valve. **[5]**

3.2. Calculate the values of Cv corresponding to valve travel from 10% to 40% by step of 10% draw a table containing these values. **[10]**

Question 4 **[Total 20 Marks]**

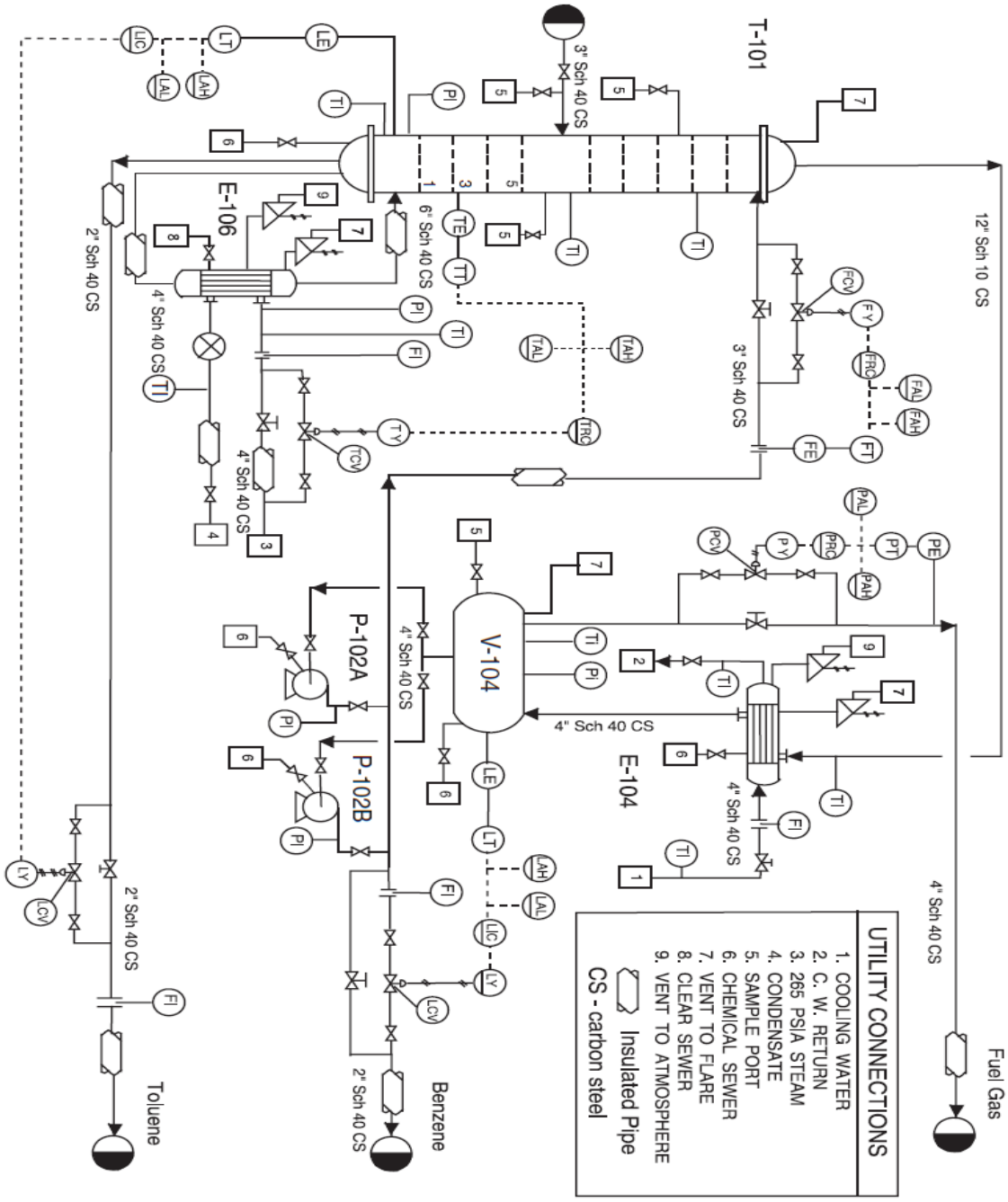
Refer to the P&ID below and answer the following questions:

4.1. List all major process equipment by their labels in the P&ID; **[10]**

4.2. List and describe all temperature control loops in the P&ID, i.e. state which equipment or line is controlled and what line is manipulated; **[3]**

4.3. List and describe all pressure control loops in the P&ID, i.e. state which equipment or line is controlled and what line is manipulated; **[3]**

4.4. List and describe all flow control loops in the P&ID, i.e. state which equipment or line is controlled and what line is manipulated. **[4]**



Question 5 **[Total 15 Marks]**

5.1. State what process variable each of the below measures:

a) Bourdon tube. **[2]**

b) Orifice tube. **[2]**

c) Vortex meter. **[2]**

5.2. A level measurement system operates with a capacitance based detector. Explain the operating principle and state the advantages and disadvantages of using a capacitance based detector.

Total Marks: 100

Appendix A :Traditional digital logic gate symbols, Boolean functions and truth table

<table>
<tr><th>Type</th><th>Distinctive shape</th><th>Boolean algebra between A & B</th><th>Meaning</th><th>Truth table</th></tr>
<tr><td><u>AND</u></td><td>  </td><td>$A \cdot B$</td><td>Output is true if and only if (<u>iff</u>) both A and B are true</td><td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A AND B</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
<tr><td><u>OR</u></td><td>  </td><td>$A + B$</td><td>True iff A is true, or B is true, or both.</td><td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A OR B</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
<tr><td><u>NOT</u></td><td>  </td><td>$\overline{A}$</td><td>True iff A is false.</td><td>
<table>
<tr><th>INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>NOT A</td></tr>
<tr><td>0</td><td>1</td></tr>
<tr><td>1</td><td>0</td></tr>
</table>
</td></tr>
<tr><td><u>NAND</u></td><td>  </td><td>$\overline{A \cdot B}$</td><td>A and B are not both true.</td><td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A NAND B</td></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
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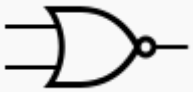
<tr>
<td><u>NOR</u></td>
<td>  </td>
<td>$\overline{A + B}$</td>
<td>True iff neither A nor B.</td>
<td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A NOR B</td></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
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</td>
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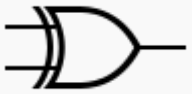
<tr>
<td><u>XOR</u></td>
<td>  </td>
<td>$A \oplus B$</td>
<td>True iff A is not equal to B.</td>
<td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A XOR B</td></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>1</td></tr>
<tr><td>1</td><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>0</td></tr>
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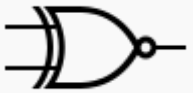
<td><u>XNOR</u></td>
<td>  </td>
<td>$\overline{A \oplus B}$</td>
<td>True iff A is equal to B.</td>
<td>
<table>
<tr><th colspan="2">INPUT</th><th>OUTPUT</th></tr>
<tr><td>A</td><td>B</td><td>A XNOR B</td></tr>
<tr><td>0</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
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