



# MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

**FACULTY OF ENGINEERING, SCIENCE AND TECHNOLOGY**

**DEPARTMENT: CHEMICAL AND PROCESSING ENGINEERING**

**MODULE: INSTRUMENTATION, PROCESS DYNAMICS AND CONTROL**

**CODE: CHEP 225**

**SESSIONAL EXAMINATIONS**

**JUNE 2023**

**DURATION: 3 HOURS**

**EXAMINER: ENG. P. SIGAUKE**

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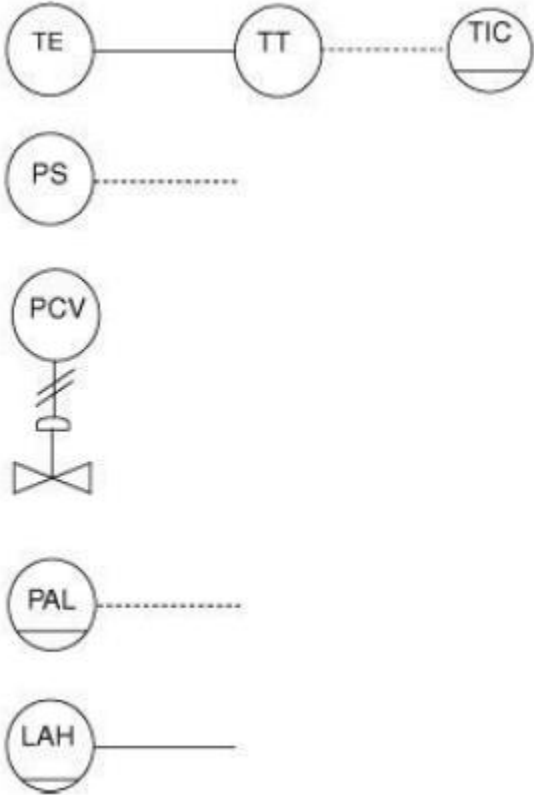
## **INSTRUCTIONS**

- 1. Answer **ALL FOUR** questions*
- 2. Start a new question on a fresh page*
- 3. Total marks 100*

***Additional material(s): Calculator***

### QUESTION 1

a) What do the following symbols (as seen on a P&ID) indicate? [7]



b) As a chemical engineer in charge of a plant, what could be the benefits of process control? Give four (4) reasons and explain each. [8]

c) Draw a P&ID for a cascade control, and give one concrete example. [10]

### QUESTION 2

a) Describe and explain the concept of the feedback and feedforward control systems using fully labeled diagrams? [10]

b) What are the principal types of diagrams used by process engineers to describe the flow of chemicals in a process? [6]

c) A problem has occurred in the measuring element of a level-indicating

controller in a batch reactor. To what principal diagram should you refer to in order to troubleshoot the problem? Explain your answer [4]

d) Which of the principal diagrams is used to do the following:

i) Determine the number of trays in a distillation column [1]

ii) Determine the top and bottom temperatures in a distillation column [1]

iii) Validate the overall material balance for a process [1]

iv) Check the instrumentation for a given piece of equipment in a 'pre-start-up' review [1]

v) Determine the overall material balance for a whole chemical plant [1]

### QUESTION 3

a) During a retrofit of an existing process, a vessel used to supply the feed pump to a batch reactor has been replaced because of excessive corrosion. The vessel is essentially identical to the original one, except it is now grounded differently to reduce corrosion. If the function of the vessel (namely to supply liquid to a pump) has not changed, answer the following questions:

i) Should the new vessel have a new equipment number, or should the old vessel number be used again? Explain your answer. [3]

ii) On which diagram or diagrams (BFD, PFD, or P&D) should the change in the grounding setup be noted? [1]

b) A process that is being considered for construction has been through several technical reviews; block flow, process flow, and piping and instrumentation diagrams are available for the process. Explain the changes that would have to be made to the three principal diagrams if during a final preconstruction review, the following changes were made:

i) the efficiency of a fired heater had been specified incorrectly as 90% instead of 82% [3]

ii) a waste process stream flow rate (sent to a sludge pond) was calculated incorrectly as 92% instead of 82%. [3]

iii) it has been decided to add a second (backup) drive for an existing compressor. The locations of several control valves have changed to allow for better operator access. [3]

c) Draw a section of a P&ID diagram for a vessel receiving a process liquid through an insulated 4''sch 40 pipe. The purpose of the vessel is to store approximately 5 minutes of liquid volume and to provide "capacity" for a feed pump connected to the bottom of the vessel using a 6''sch 40 pipe. The diagram should include the following features:

i) The vessel is numbered V-1402 and the pump(s) are P-1407 A/B.

ii) The discharge side of the pump is made of 4''sch 40 carbon steel pipe and all pipe is insulated.

iii) A control valve is located in the discharge line of the pump, and a double block and bleed arrangement is used.

iv) Both pumps and vessel have isolation (gate) valves.

v) The pumps should be equipped with drain lines that discharge to a chemical sewer.

vi) The vessel equipped with local pressure and temperature indicators

vii) The vessel has a pressure relief valve set to 50 psig that discharge to a flare system [12]

#### QUESTION 4

a) Define

i) mathematical modeling [2]

ii) accuracy [2]

iii) calibrate [2]

iv) set point [2]

v) transducer [2]

b) Often, during the distillation of liquid mixtures, some non-condensable gases are dissolved in the feed to the tower. These non-condensables come out of solution when heated in the tower and may accumulate in the overhead reflux drum. In order for the column to operate satisfactorily, these vapors must be periodically vented to a flare or stack. One method to achieve this venting process is to implement a control scheme in which a process control valve is placed on the vent line from the reflux drum. A pressure signal from the drum is used to trigger the opening or closing of the vent line valve.

i) Sketch the basic control loop needed for this venting process on a process flow diagram representing the top portion of the tower. [8]

ii) Create the sketch as a PI&D to show all the instrumentation needed for this control loop. [7]

**END OF EXAMINATION**