UNIVERSITY OF JOHANNESBURG

PROGRAM	:	NATIONAL DIPLOMA *ENGINEERING : ELECTRICAL*
SUBJECT	:	**Process Instruments 3**
CODE	:	**PRI 3221**
DATE	:	November 2019
DURATION	:	180 minutes
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

ASSESSOR	:	Mr. Johan Venter
MODERATOR	:	Mrs J Buisson-Street
NUMBER OF PAGES	:	4 PAGES (Cover Page Including)

INSTRUCTIONS	:	ONLY ONE POCKET CALCULATOR PER CANDIDATE MAY BE USED.

INSTRUCTIONS TO STUDENTS

PLEASE ANSWER ALL QUESTIONS ON THE PAPER.

QUESTION 1 Programming and Digital Communications Protocols [41 marks]

1.1 Design a PLC program which performs the following functions: (25)

TAKE NOTE OF THE FOLLOWING SEQUENCE OF EVENTS using Visilogic.

The application is a glass bottle counting machine at a bottling plant. The system must pour the precise amount of liquid into the bottle, place a cap on the bottle and only then count the bottle.

Assume all the necessary electronics have been connected and are in full working order.

- The PLC must only be started with the power-up bit (SB2).

- The global system can only be started with the Input 0 bit (I 0 bit).

- The complete system, excluding the PLC, receives power via a contactor and a relay connected to Output 0 bit (O 0 bit). The system can only receive power when SB2 bit and I 0 bit is TRUE.

- Start the bottling sequence by setting the Input 1 bit (I 1 bit). The PLC must provide notice to the rest of the system to start the bottling sequence via Output 1 bit (O 1 bit).

- At any given time, the bottling sequence can be stop by setting I 0 bit low (0 V). All bottling must stop and the system must be halted completely.

- The system must bottle 1 bottle of beverage at a time. This includes the pouring of the beverage, placing the cap on the bottle and registering the count. If any of the bottling process is not complete, the system must be halted by setting the Input 7 bit (I 7 bit). When this happens, O 1 bit must be set low (0 V).

- The volume of beverage left is provided by an analogue value 0 – 10 V via MI 0 element. When the volume is at maximum (1000 litres), the input is 10 V. When the tank is empty, the input is 1 V. The resolution of the input is 12 bits. Save the calibrated value in MI 1 element.
    - Separately, for this linearization block, state the following values
        - X1, X2, Y1, Y2, X and Y

- The pouring sequence can only be started when the bottle passes a sensor connected to Input 2 bit (I 2 bit). Output 2 bit (O 2 bit) is set which starts the timer. Timer 0 must then run for 3 seconds. This is a DELAY type timer. When the timer is finished, set Input 3 bit (I 3 bit) and set O 2 bit low (i.e. reset O 2).

- Negate movement on the conveyor belt.

- Only I 3 has been set, set Output 3 bit (O 3 bit) to start the sequence of placing the cap on. Upon successful placement of the cap, set Input 4 bit (I 4 bit).

- Then the conveyor belt must move the bottle past a counting sensor (no need to program anything regarding the conveyor belt movement). Once the bottle moves past the counting sensor, set Input 5 bit (I 5 bit) high momentarily, i.e. for a brief period, and then set it back to 0 V (low). When this happens, the MI 2 element (number of bottles) must be increased by 1. Assume the value of MI 2 at start-up is 0. Also assume MB 0, MB 1 and MB 2 ars cleared (low).

- When the count reaches 100, set Memory bit 0 (MB 0).

- When the count reaches 200, set Memory bit 1 (MB 1). MB 0 must be cleared.

- When the count reaches 500, set Memory bit 2 (MB 2). MB 0 and MB 1 must be cleared.

The only blocks that can be used is the ***Direct Contact***, ***Inverted Contact***, ***Direct Coil***, ***Compare***, ***Linearization*** and ***Store***. No other blocks may be used. Examples of the blocks are given below:

IN	X1		
	Y1		
	X2		
	Y2		
	X		
OUT	Y		

1.2.1 Draw the linearization graph (Similar to the Unitronics PLC) indicating the volume (in liters) on the vertical axis and the sensor input (in voltage) on the horizontal axis. Clearly indicate the values of the 2 calibration points. Also clearly indicate the points where the different output bits are set. ***SHOW ALL STEPS*** (6)

1.2.2 Calculate the SPAN of the sensor. (3)

1.2.3 What is the ZERO-OFFSET value? (2)

1.2.4 Calculate the gain of the sensor system (The slope of the graph). (5)

QUESTION 2 Process Control [8 marks]

2.1 Discuss three (3) advantages of Cascade Control. (3)

2.2 What is Split-Range Control? (2)

2.3 Briefly describe three (3) limitations of Feedback Control. (3)

QUESTION 3 Control Methods [28 marks]

3.1 Describe three (3) advantages of the 4-20 mA Analogue Communication Protocol? (3)

3.2 Design a circuit to illustrate Integral control using a comparator. (5)

3.3 Explain, with the use of a sketch, what feedback control is. (4)

3.4 Briefly discuss three advantages of the 4-20 mA communication protocol. (3)

3.5 Draw the Loop network topology. (3)

3.6 List three (3) of the six (6) Network Controlling Devices. (3)

3.7 With the use of graphs only, explain how noise can be perfectly cancelled out? (3)

3.8 List 4 of the 6 PROFIsafe safety monitoring features. (4)

QUESTION 4 Furnaces, Boilers and Distillation [14 marks]

4.1 Draw and label a graph showing the phases of water with temperature increases. There are four (4) phases. (4)

4.2 List the six (6) boiler losses. (6)

4.3 The setpoint for pressure is a compromise between two extremes. Discuss them. (4)

QUESTION 5 Analytical instruments [9 marks]

5.1 Define **Electrical conductivity**. (2)

5.2 There are six (6) factors which may affect measurement in an Electrode Type Conductivity meter. Discuss four (4) of them. (4)

5.3 What does **pH**-measuring device actually measure? (3)

[100]