TVET CURRICULUM DEVELOPMENT, ASSESSMENT AND CERTIFICATION COUNCIL (TVET CDACC)

Qualification Code	**:**	**071606T4MCT**
Qualification	**:**	**Mechatronic Technician Level 6**
Unit Code	**:**	**ENG/OS/MC/CR/05/6/A**
Unit of Competency	**:**	**Carry out mechatronic programming**

WRITTEN ASSESMENT

INSTRUCTIONS TO ASSESSOR:

1. The candidate has **TWO HOURS** to attempt all the questions.
2. Marks for each section are indicated in the brackets
3. The paper consists of **TWO** sections: **A** and **B.**
4. The candidate is required to attempt **ALL** questions from section **A** and **ANY THREE** questions from section **B.**
5. The candidate is provided with answer booklet for their responses.

NB: ***These only serves as a guide to expected responses.***

SECTION A: SHORT ANSWER QUESTIONS (40 MARKS)

1. List **four** advantages of a PLC over relays. (4 marks)
   - ✓ ***Less expensive for complex processes,***
   - ✓ ***Debugging tools,***
   - ✓ ***Reliable,***
   - ✓ ***Flexible,***
   - ✓ ***Easy to expand, etc.***
2. Explain why ladder logic outputs are coils. (2 marks)
   - ✓ ***The ladder logic outputs were modelled on relay logic diagrams.***
   - ✓ ***The output in a relay ladder diagram is a relay coil that switches a set of output contacts.***
3. Write the equivalent Instruction List program for the Ladder Logic in Figure 1 below. (4 marks)

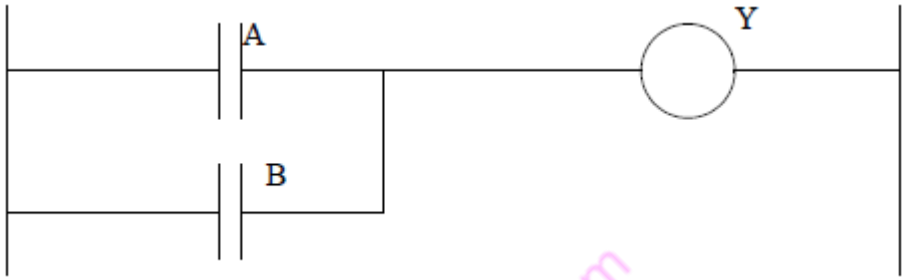


Figure 1

   - ✓ ***LD A***
   - ✓ ***OR B***
   - ✓ ***OUT Y***
   - ✓ ***END***
4. In the Figure 2 below, identify the state of the power for the output on the first rung and on the second rung. (2 marks)

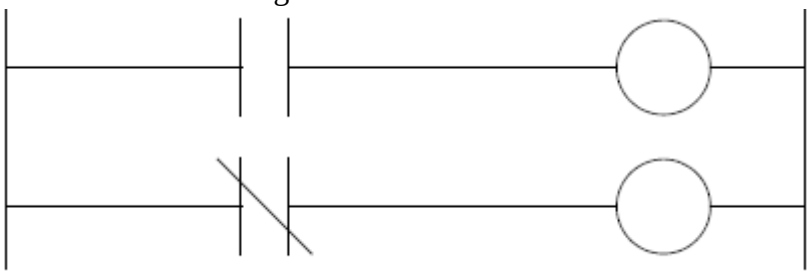


Figure 2

   - ✓ ***1st rung – power OFF***
   - ✓ ***2nd rung – Power ON***
5. State **five** advantages of using structured design and documentation techniques on PLC. (5 marks)
   - ✓ ***More reliable programs***
   - ✓ ***Less debugging time***
   - ✓ ***More routine***
   - ✓ ***Others can pick up where you left off***

- ✓ ***Reduces confusion***

6. Describe **four** tasks performed by a discrete input module. (4 marks)
   - ✓ ***Sense when a signal is received from a field device.***
   - ✓ ***Convert the input signal to the correct voltage level for the particular PLC.***
   - ✓ ***Isolate the PLC from fluctuations in the input signal's voltage or current.***
   - ✓ ***Send a signal to the processor indicating which sensor originated the signal.***
7. The PLC, like all digital equipment, operates on the binary principle. Explain the binary principle. (3 marks)
   - ✓ ***The term binary principle refers to the idea that many things can be thought of as existing in only one of two states. These states are 1 and 0.***
   - ✓ ***The 1 and 0 can represent ON or OFF, open or closed, true or false, high or low, or any other two conditions.***
   - ✓ ***The key to the speed and accuracy with which binary information can be processed is that there are only two states, each of which is distinctly different.***
8. Outline the sequence of events involved in a PLC scan cycle. (4 marks)
   - ✓ ***Input scan,***
   - ✓ ***Program scan,***
   - ✓ ***Output scan, and***
   - ✓ ***Housekeeping duties***
9. Identify **two** matrix limitations that may apply to certain PLCs. (2 marks)
   - ✓ ***Limitations to the number of series contact instructions that can be included in one rung of a ladder diagram***
   - ✓ ***Limitations to the number of parallel branches.***
10. Briefly describe each of the following PLC modes of operation: (6 marks)
    i. Program
       - ✓ ***The program mode is used to enter a new program, edit or update an existing program, upload files, download files, document (print out) programs, or change any software configuration file in the program.***
       - ✓ ***When the PLC is switched into the program mode, all outputs from the PLC are forced off regardless of their rung logic status, and the ladder I/O scan sequence is halted.***

    ii. Test
       - ✓ ***The test mode is used to operate or monitor the user program without energizing any outputs.***
       - ✓ ***The processor still reads inputs, executes the ladder program, and updates the output status table files, but without energizing the output circuits.***

    iii. Run
       - ✓ ***The run mode is used to execute the user program.***
       - ✓ ***Input devices are monitored and output devices are energized accordingly.***
11. Explain the **two** broad categories of memory space of a typical PLC processor. (4 marks)

- ✓ ***Program files are the part of the processor memory that stores the user ladder logic program. It contains the ladder logic that controls the machine operation.***
- ✓ ***The data files store the information needed to carry out the user program. This includes information such as the status of input and output devices, timer and counter values, data storage, and so on.***

SECTION B: EXTENDED ANSWER QUESTIONS (60 MARKS)

12. Given the components on Figure 3, the following operations are expected;

- When the (Preparation) switch (X001) is turned ON, the (Ready indicator lamp) (Y000) turns ON and latched. When the (Preparation cancel) switch (X003) is turned ON, the (Ready indicator lamp) (Y000) turns OFF and unlatched.
- When the (Fan start/stop) switch is pressed while the (Ready) indicator lamp (Y000) is ON, the electromagnetic contactor for the fan (Y002) is actuated and the fan starts or stops. The wind velocity of the fan can be selected by the selector switch (X005/X006).
    - When X005 is ON: The weak wind output (Y001) is ON.
    - When X006 is ON: The strong wind output (Y003) is ON.
    - The weak and strong output are interlocked

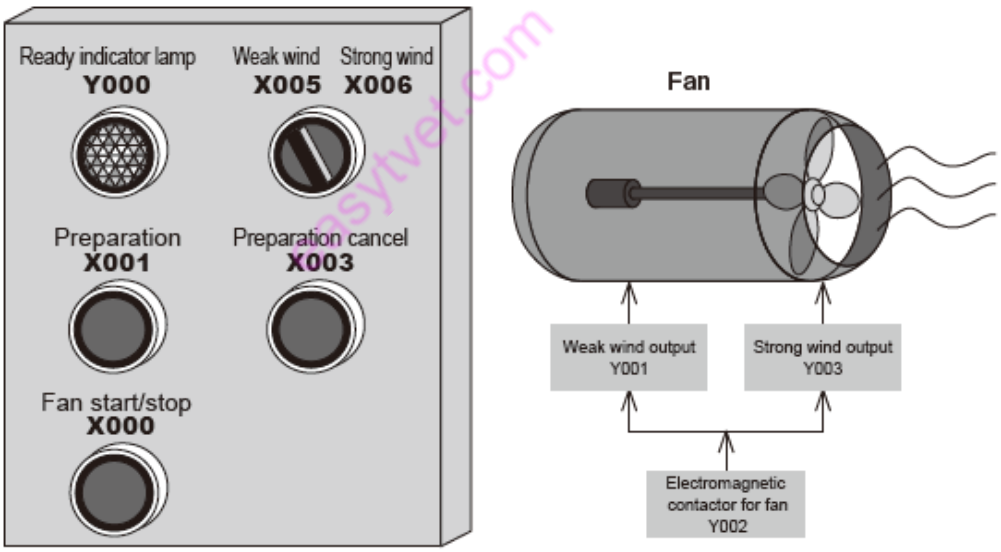


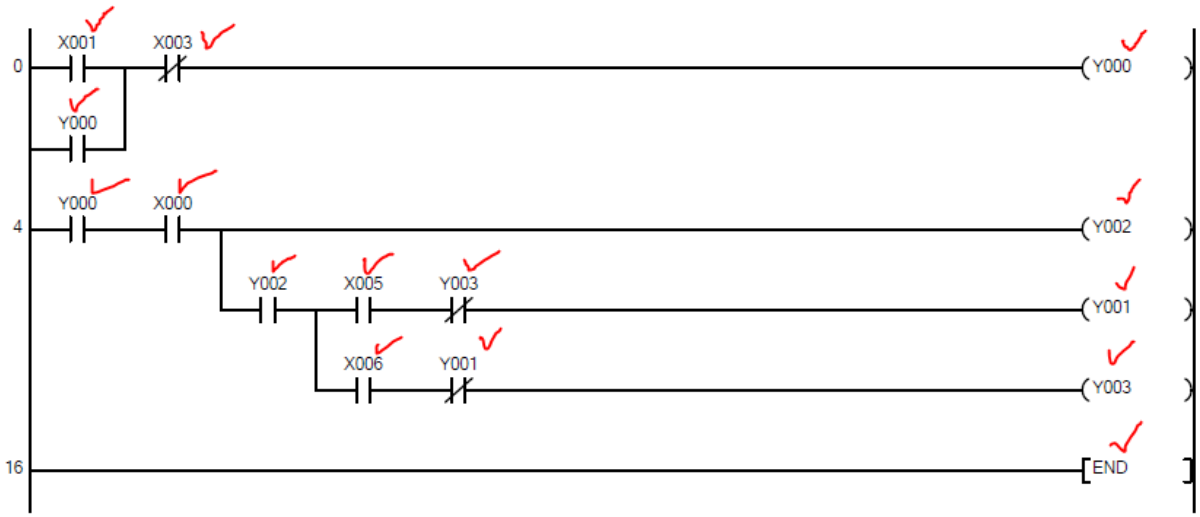
Figure 3

i. Prepare an input correspondence table. (5 marks)

Input	
✓ *X000*	*(Fan start/stop) switch*
✓ *X001*	*(Preparation) switch*
✓ *X003*	*(Preparation cancel) switch*
✓ *X005*	*(Weak wind) selection*
✓ *X006*	*(Strong wind) selection*

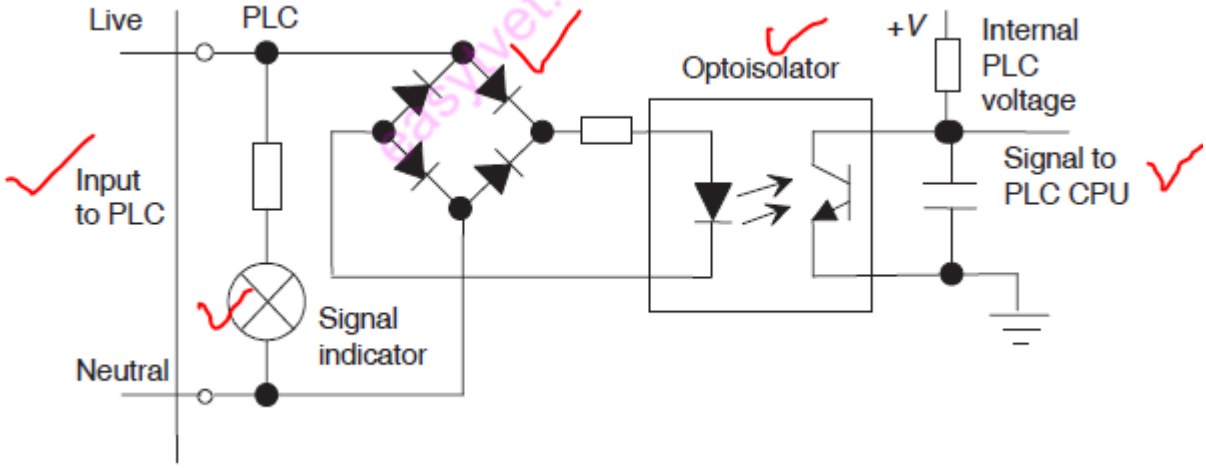
ii. Write a ladder diagram program to accomplish the operations stated.

(15 marks)



13.

i. With the aid of a well labeled diagram, explain the circuitry of an AC input to PLC. (10 marks)



- ✓ ***With the AC input unit, a rectifier bridge network is used to rectify the AC***
- ✓ ***the resulting DC signal can provide the signal for use by the optoisolator***
- ✓ ***to give the input signals to the CPU of the PLC.***
- ✓ ***Individual status lights are provided for each input***
- ✓ ***to indicate when the input device is providing a signal.***

ii. Documentation is the main guide used by everyday users, including for troubleshooting and fault finding with PLCs. Illustrate **five** items that should be included in documentation for a PLC installation. (10 marks)

- ✓ ***A description of the plant***
- ✓ ***Specification of the control requirements***
- ✓ ***Details of the programmable logic controller***
- ✓ ***Electrical installation diagrams***
- ✓ ***Lists of all input and output connections***
- ✓ ***Application program with full commentary on what it is achieving***
- ✓ ***Software backups***
- ✓ ***Operating manual, including details of all start up and shut down procedures and alarms***

14.

i. A manager of a certain company is of the idea of programming newly obtained PLCs internally in the company. He however has no any basic knowledge on any technique to use and therefore called upon you to advice. Base your explanation on the standard International Electrotechnical Commission (IEC) 61131 techniques. (10 marks)

- ✓ ***Ladder Diagram (LD) – a symbolic depiction of instructions arranged in rungs similar to ladder formatted schematic diagrams.***
- ✓ ***Function Block Diagram (FBD) – a graphical depiction of process flow using simple and complex interconnecting blocks.***
- ✓ ***Sequential Function Chart (SFC) – a graphical depiction of interconnecting steps, actions, and transitions.***
- ✓ ***Instruction List (IL) – a low-level, text-based language that uses mnemonic instructions.***
- ✓ ***Structured Text (ST) – a high-level, text-based language such as BASIC, C, or PASCAL specifically developed for industrial control applications.***

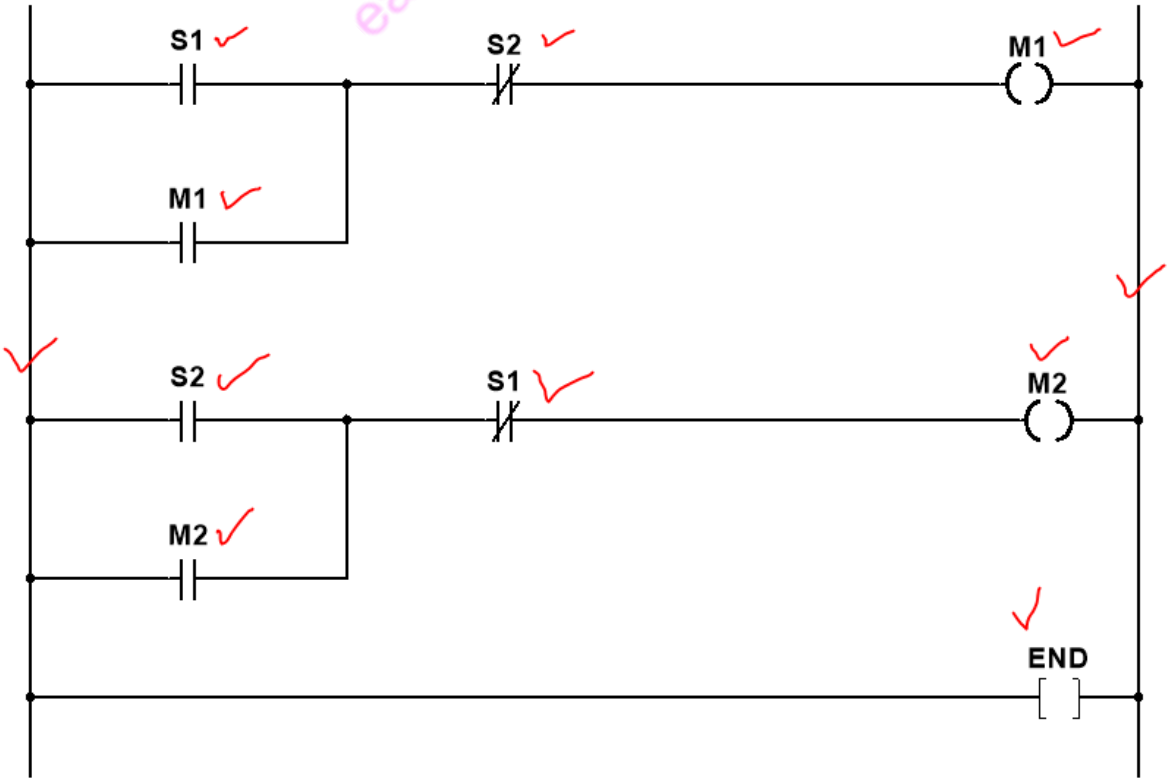
ii. A very commonly used method of programming PLCs is based on the use of ladder diagrams. Discuss **five** conventions adopted in drawing ladder diagrams. (10 marks)

- ✓ ***The vertical lines of the diagram represent the power rails between which circuits are connected. The power flow is taken to be from the left-hand vertical across a rung.***
- ✓ ***Each rung on the ladder defines one operation in the control process.***

- ✓ ***A ladder diagram is read from left to right and from top to bottom.***
- ✓ ***Each rung must start with an input or inputs and must end with at least one output.***
- ✓ ***Electrical devices are shown in their normal condition. Thus, a switch that is normally open until some object closes it is shown as open on the ladder diagram. A switch that is normally closed is shown closed.***
- ✓ ***A particular device can appear in more than one rung of a ladder. For example, we might have a relay that switches on one or more devices. The same letters and/or numbers are used to label the device in each situation.***
- ✓ ***The inputs and outputs are all identified by their addresses; the notation used depends on the PLC manufacturer. This is the address of the input or output in the memory of the PLC***

15. A motor is controlled to run in forward and reverse direction by two buttons S1 and S2 respectively. The motor should run on respective direction even when the switch is released. Also, the motor should not run when both buttons are pressed.

    i. Draw the ladder diagram for this control. (11 marks)



ii. Write the equivalent instruction list program for the ladder diagram. (9 marks)

- ✓ ***LD S1***
- ✓ ***OR M1***
- ✓ ***ANI S2***
- ✓ ***OUT M1***
- ✓ ***LD S2***
- ✓ ***OR M2***
- ✓ ***ANI S1***
- ✓ ***OUT M2***
- ✓ ***END***