TEVETA
Technical Education, Vocational and Entrepreneurship Training Authority

DIPLOMA IN BIOMEDICAL ENGINEERING

LEVEL 6 YEAR III EXAMINATIONS

FINAL INTERGRATED SUMMATIVE EXAMINATIONS

SITTING: JULY /AUGUST 2026

SUBJECT: INDUSTRIAL MOTOR CONTROL

TIME: THREE (3) HOURS **TOTAL MARKS: 100**

PASS MARK: 50

INSTRUCTIONS TO CANDIDATE

1. Write your Examination number and National Registration Card (NRC) number on the answer booklet provided. Ensure you append your signature in the space provided on the answer booklet.
2. Write the ANSWER SCRIPT SERIAL NUMBER on the examination register and on the entry slip.
3. This paper has TWO (2) Sections.
   - Answer ALL questions in section A.
   - Answer FIVE (5) questions in Section B. Question one (1) is compulsory then answer any four (4) questions from the remaining six (6) questions.
4. Diagrams may be used where necessary to clarify your answer.
5. Cell phones and programmable calculators are not allowed in the examination room

DO NOT TURN THIS PAPER UNTIL YOU ARE TOLD TO DO SO

SECTION A: MULTIPLE CHOICE QUESTIONS **TOTAL MARKS: 20**
ANSWER ALL QUESTIONS BY CHOOSING THE BEST OPTION

1. What does the acronym PLC stand for?
   A. Programmable Line Computer
   B. Pneumatic Logic Controller
   C. Programmable Logic Controller
   D. Process Loop Control

2. Which component of a PLC system is responsible for executing the control program logic and managing memory?
   A. Input Module
   B. Central Processing Unit (CPU)
   C. Power Supply
   D. Output Module

3. Which programming language defined by IEC 61131-3 closely resembles traditional electromechanical relay ladder diagrams?
   A. Structured Text (ST)
   B. Sequential Function Chart (SFC)
   C. Instruction List (IL)
   D. Ladder Diagram (LD)

4. What are the three basic, sequential steps executed during a standard PLC scan cycle?
   A. Boot, Run, Fault check
   B. Read Inputs, Execute Program, Write Outputs
   C. Compile code, Download code, Test memory
   D. Sinking, Sourcing, Isolating

5. In PLC hardware configuration, a "sinking" input module requires that the external input field device:
   A. Supply or "source" the current to the module's input terminal
   B. Connect directly to an alternating current (AC) ground line
   C. Act as a variable resistor
   D. Absorb current out of the module

6. Which type of PLC instruction is logically true when the corresponding memory bit or physical input terminal is de-energized (0)?
   A. Examine if Closed (XIC / Normally Open symbol)
   B. Examine if Open (XIO / Normally Closed symbol)
   C. Output Energize (OTE / Coil symbol)
   D. Output Latch (OTL)

7. What happens to a standard PLC timer (TON - Timer On Delay) if the rung conditions feeding it lose continuity before the preset time accumulates completely? The timer ...
   A. pauses and holds its accumulated value
   B. faults the PLC CPU
   C. resets its accumulated value back to zero
   D. immediately sets its Done bit (DN) to true

8. Which device is considered a typical analog input for a PLC?
   A. Start pushbutton
   B. Temperature transmitter (4-20mA signal)
   C. Magnetic limit switch
   D. Red indicator lamp

9. What type of PLC output device is best suited for switching high-frequency, low-power direct current (DC) loads silently and with minimal wear?
   A. Electromechanical relay output
   B. Transistor output
   C. Triac output
   D. Isolated mechanical dry contact

10. What is the function of optical isolation (optocouplers) within PLC input and output modules? To...
   A. allow operators to see the inner circuit boards
   B. electrically isolate internal microprocessor logic from high-voltage field spikes
   C. convert analogue values into binary representation
   D. speed up the CPU clock rate

11. What is the very first safety protocol that must be performed before opening a power enclosure to repair a faulted motor circuit?
   A. Recalibrate the overload relay settings
   B. Check the circuit for continuity
   C. Implement Lockout/Tagout (LOTO) procedures to isolate energy sources
   D. Clean dust away from the transformer

12. While troubleshooting a dead control circuit, you measure line voltage across the primary side of the control transformer, but 0V across the secondary side. What is the most likely cause? The ...
   A. start pushbutton contact is welded shut
   B. control transformer has a blown primary or secondary fuse, or an open internal winding
   C. motor is running overloaded
   D. short circuit in the output indicating light

13. When using a digital multimeter to check for an open contact in a live, energized series control rung, a reading equal to full control voltage across a specific switch indicates that the switch is:
    A. Closed and working correctly
    B. Open
    C. Defective and shorted out internally
    D. Properly grounded

14. What type of electrical fault is characterized by a sudden, massive spike in current that immediately trips the magnetic element of a circuit breaker?
    A. Overload fault
    B. Open circuit fault
    C. Short circuit or ground fault
    D. Under-voltage condition

15. What is a common physical symptom that an electromechanical contactor's mechanical spring mechanism is failing or its core faces have dirt build-up?
    A. The control transformer starts leaking fluid
    B. The contactor emits a loud, audible chattering or buzzing noise
    C. The indicator lamps switch color from green to red
    D. The PLC stops scanning its logic program

16. Which diagnostic tool is specifically designed to safely test the insulation resistance of motor windings to identify degradation or grounding?
    A. Clamp-on ammeter
    B. Megohmmeter (Megger)
    C. Oscilloscope
    D. Phase rotation meter

17. If a three-phase motor is "single-phasing," what exactly does this mean?
    A. The motor is being controlled by a single PLC output
    B. One of the three power lines has opened, causing the motor to run on only two phases
    C. The motor has reached maximum synchronous speed
    D. The motor is running in the forward direction only

18. While diagnosing a PLC-controlled system, you notice the physical input status LED lights up when a proximity sensor trips, but the PLC logic does not register the input as true. Where should your troubleshooting focus?
    A. Replace the field sensor immediately
    B. Check the PLC program logic addressing or check for a forced bit in the memory allocation
    C. Verify the main three-phase power fuses
    D. Adjust the control transformer output tap

19. What is the purpose of checking contacts for pitting, discoloration, or erosion during routine preventive maintenance? To ..
    A. determine if the wire insulation material is correct
    B. identify high-resistance points that can cause intermittent operation or component failure
    C. check if the programming needs to be rewritten
    D. measure the frequency of the power supply

20. When replacing a failed electromechanical control relay, which set of specifications must match the original equipment to ensure safe and correct operation?
    A. Physical colour of the housing and length of terminal screws
    B. Coil voltage/type, contact current rating, and contact arrangement (NO/NC configuration)
    C. Brand of the mounting DIN rail only
    D. The horsepower rating of the largest upstream circuit breaker

SECTION B **TOTAL MARKS 80**

THERE ARE SEVEN (7) QUESTIONS IN THIS SECTION, ANSWER FIVE (5) QUESTIONS. QUESTION ONE (1) IS COMPULSORY.

QUESTION 1 (COMPULSORY)

a) State the **four (4)** functions of industrial motor control. [4 marks]
b) Explain five (5) functions of motor control [5 marks]
c) Indicate **five (5)** components used in industrial motor control. [5 marks]
d) Differentiate between an overload relay and a circuit breaker in relation to their functions. [6 marks]

[TOTAL MARKS 20]

QUESTION 2

a) Define an overload current. [2 marks]
b) Explain the construction on the following devices:
   i) Time delay on energizing (TDOE) . [4 marks]
   ii) Time delay on de-energizing (TDOD) [4 marks]
c) Draw a well labelled power circuit used in DOL starting of a single-phase motor. [5 marks]

[TOTAL MARKS 15]

QUESTION 3

a) Indicate **five (5)** advantages of a hard-wired system. [5 marks]
b) State **five (5)** disadvantages of a hard wired system. [5 marks]
c) Describe **five (5)** languages used in Programmable Logic Controllers (PLCs). [5 marks]

[TOTAL MARKS 15]

QUESTION 4

a) State **three (3)** control systems used in industrial motor control. [3 marks]
b) Draw the following for an auto transformer starter:
   i) Power circuit. [5 marks]
   ii) Control circuit. [7 marks]

[TOTAL MARKS 15]

QUESTION 5

a) Compare the DOL and the Y-Δ motor starting methods. [9 marks]
b) state the key control circuit components required in the following motor starting methods:
   i) DOL starting [3 marks]
   ii) Y-Δ starting [3 marks]

[TOTAL MARKS 15]

QUESTION 6

a) State **five (5)** key steps followed in the maintenance process of electrical and electronic circuits. [5 marks]

b) What are the **four (4)** types of circuit diagrams used in industrial motor control? [4 marks]

c) Explain the difference between a power circuit and control circuit in motor control [6 marks]

[TOTAL MARKS 15]

QUESTION 7

a) Outline **five (5)** advantages of Programmable Logic Controller (PLC). [5 marks]

b) Construct a ladder diagram from the mnemonic PLC program below. [10 marks]

0001	LD	X1
0002	AND	X2
0003	AND NOT	X3
0004	OUT	Y1
0005	LD	X4
0006	OR NOT	X6
0007	OUT	Y2
0008	LD	X7
0009	AND	X8
0010	OUT	Y3

[TOTAL MARKS 15]