ELECTRICAL AND ELECTRONICS PRINCIPLES

UNIT CODE: 0713 441 15A

TVET CDACC UNIT CODE: ENG/CU/AUT/CC/05/5/MA

Relationship with Occupational Standards

This unit addresses the unit of competency: Apply Electrical and electronics principles.

Unit Duration: 80 Hours

Unit Description

This unit describes the competences required in order to apply electrical and electronics principles. It involves applying basic concepts of electrical quantities, cells and batteries, magnetism and electromagnetism, basic electrical machines and electronics principles.

Summary of Learning Outcomes

S/No.	Learning Outcomes	Duration (Hours)
1.	Apply basic concepts of electrical quantities	10
2.	Apply DC and AC circuits	10
3.	Apply the concept of cells and batteries	10
4.	Apply magnetism and electromagnetism	10
5.	Apply basic electrical machines	20
6.	Apply electronics components	20
	TOTAL	80

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Use the concept of basic Electrical quantities	1.1 Basic SI Units 1.1.1 Overview of SI Units 1.1.1.1 Power (Watts, W) 1.1.1.2 Current (Amperes, A) 1.1.1.3 Resistance (Ohms, Ω) 1.1.1.4 Voltage (Volts, V)	• Portfolio of evidence • Practical test • Third party report • Written tests • Project work

	1.2 Conductors and Insulators 1.2.1 Identification and Characteristics 1.2.1.1 Metals vs. non-metals 1.2.1.2 Applications in electrical circuits 1.3 Electrical Quantities 1.3.1 Charge, Force, Work, and Power 1.3.2 Definitions and units 1.3.3 Calculations involving Electrical quantities 1.4 Ohm's Law 1.4.1 Understanding Ohm's Law 1.4.2 Practical applications and calculations 1.5 Basic Electrical and Electronic Measurements 1.5.1 Measurement Techniques 1.5.2 Use of Multimeters, oscilloscopes, and ammeters	

	1.5.3 Measurement accuracy and calibration	
2. Apply DC and AC circuits	2.1 Introduction to Electrical Circuits 2.1.1 Introduction to electricity: 2.1.2 Voltage, current, and power. 2.1.3 Overview of DC and AC circuits. 2.1.4 Basic circuit elements: Resistors, capacitors, and inductors. 2.2 DC Circuit Analysis 2.2.1 Series and parallel circuits. 2.2.2 Voltage and current division principles. 2.2.3 Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL). 2.2.4 Analysis of complex circuits using KVL and KCL.	• Oral questioning • Portfolio of evidence • Practical test • Third party report • Written tests • Project work

	2.2.5 Hands-on lab: Building and testing DC circuits. 2.3 AC circuits analysis 2.3.1 Introduction to AC: Sinusoidal waveforms, frequency, and period. 2.3.2 RMS values, peak values, and average values. 2.3.3 AC voltage and current sources. 2.3.4 Phasor representation of AC quantities. 2.3.5 Impedance and admittance. 2.3.6 Series and parallel AC circuits. 2.3.7 Resonance in RLC circuits. 2.3.8 Practical analysis of AC circuits using phasors. 2.3.9 Power in AC Circuits 2.3.9.1 Power factor and power factor correction.	

	2.3.9.2 Real, reactive, and apparent power. 2.3.9.3 AC power calculations for single-phase and three-phase circuits. 2.3.9.4 Energy consumption and efficiency. 2.3.9.5 Applications of AC power in household and industrial settings. 2.4 Practical Activity: 2.4.1 Connection in series and Parallel Simulation	
3. Apply the concept of cells and batteries	3.1 Introduction to Cells and Batteries 3.2 Overview of energy storage and electrochemical cells. 3.3 Basic concepts: Voltage, current, capacity, and energy density. 3.4 Internal resistance of cells and electromotive force, e.m.f. 3.5 Electrochemical principles: Redox reactions and electrode potentials.	• Portfolio of evidence • Practical test • Third party report • Written tests • Project work

	3.6 Components of a cell: Anode, cathode, electrolyte, and separator. 3.7 Types of cells: Primary vs. secondary cells (non-rechargeable vs. rechargeable). 3.8 Primary Cells (Non-Rechargeable) 3.8.1 Zinc-Carbon Cells: Construction, chemistry, and applications. 3.8.2 Alkaline Cells: Advantages over zinc-carbon, usage, and performance characteristics. 3.8.3 Comparison of common primary cells (e.g., lithium primary cells). 3.8.4 Performance limitations and efficiency of primary cells. 3.8.5 Environmental impact and disposal considerations for non-rechargeable batteries.	

	3.8.6 Hands-on lab: Testing the performance of different primary cells. 3.9 Secondary Cells (Rechargeable) 3.9.1 Lead-Acid Batteries: Chemistry, construction, and applications (e.g., automotive). 3.9.2 Nickel-Cadmium (NiCd) and Nickel-Metal Hydride (NiMH): Differences, pros, and cons. 3.9.3 Charging and discharging cycles of rechargeable cells. 3.9.4 Lithium-Ion Batteries: Working principles, construction, and applications. 3.9.5 Advantages of lithium-ion technology over older battery types.	

	3.9.6 Safety considerations: Overcharging, thermal runaway, and battery management systems. 3.9.7 Emerging Technologies: Solid-state batteries, lithium-sulphur, and other advancements. 3.9.8 Energy density and power density considerations in modern applications. 3.9.9 Batteries maintenance 3.9.10 Hands-on lab: Disassembling and examining a rechargeable battery. 3.10 Battery Performance and Characteristics 3.10.1 Battery capacity: Ampere-hour (Ah) ratings and energy content. 3.10.2 Factors affecting battery life:	

	Temperature, charge/discharge rates, and cycling. 3.10.3 Internal resistance and its effect on performance. 3.10.4 Battery efficiency and energy losses. 3.10.5 State of charge (SOC) and depth of discharge (DOD). 3.10.6 Battery degradation and aging mechanisms. 3.10.7 Measuring battery parameters (voltage, current, capacity). 3.10.8 Testing techniques for battery health and performance. 3.10.9 Hands-on lab: Performance testing of different battery types. 3.11 Applications of Batteries 3.11.1 Batteries in consumer electronics (e.g., smartphones, laptops).	

	3.11.2 Automotive applications: Starting, lighting, and ignition (SLI) batteries. 3.11.3 Electric vehicles (EVs) and hybrid electric vehicles (HEVs): Battery requirements and challenges. 3.11.4 Industrial and grid storage applications. 3.11.5 Renewable energy integration: Solar and wind energy storage solutions. 3.11.6 Specialized applications: Medical devices, aerospace, and military. 3.11.7 Case studies on battery failure and safety incidents. 3.11.8 Discussion on regulations and standards for battery use. 3.12 Environmental Impact and Recycling	

	3.12.1 Environmental impact of battery production and disposal. 3.12.2 Strategies for reducing the ecological footprint of battery technologies. 3.12.3 Recycling processes for different types of batteries. 3.12.4 Government policies and regulations regarding battery disposal. 3.12.5 Advances in battery recycling technologies. 3.13 Hands-on lab: Exploring the recycling process and evaluating eco-friendly battery alternatives.	
4. Apply magnetism and electromagnetism	4.1 Magnetic Circuits and Devices 4.1.1 Introduction to magnetic circuits. 4.1.2 Magnetic flux, magnetic field density, magnetic field strength,	• Oral questioning • Portfolio of evidence • Practical test • Third party report • Written tests • Project work

	Reluctance, magnetomotive force (MMF), and magnetic flux. 4.1.3 Calculations involving magnetic circuits 4.1.4 Analogies between electric and magnetic circuits. 4.1.5 Magnetic materials in electrical devices (soft and hard magnetic materials). 4.2 Electromagnetic Induction 4.2.1 Faraday's Law of electromagnetic induction. 4.2.2 Lenz's Law: Direction of induced EMF. 4.2.3 Practical applications: Electric generators and transformers. 4.2.4 Induced EMF in different configurations (moving conductors, changing magnetic fields). 4.2.5 Self-induction and mutual induction.	

	4.2.6 Transformers: Working principles, construction, and applications. 4.2.7 Step up and step-down transformers 4.2.8 Power losses in transformers. 4.2.9 Calculations involving transformers 4.2.10 Energy stored in magnetic fields.	
5. Apply basic electrical machines	5.1 DC Machines 5.1.1 DC machine construction and types (motors and generators). 5.1.2 Working principle of DC generators and back EMF. 5.1.3 Types of DC generators: Series, shunt, and compound. 5.1.4 Working principle of DC motors. 5.1.5 Types of DC motors: Series, shunt, and compound.	• Portfolio of evidence • Practical test • Third party report • Written tests • Project work

	5.1.6 Speed-torque characteristics of DC motors. 5.1.7 Performance analysis and efficiency of DC machines. 5.1.8 Starting methods for DC motors. 5.1.9 Hands-on lab: Testing and operating a DC motor/generator. 5.2 Induction Motors (AC Machines) 5.2.1 Introduction to induction motors: Construction and working principles. 5.2.2 Types of induction motors: Squirrel cage and wound rotor. 5.2.3 Rotating magnetic fields and slip in induction motors. 5.2.4 Equivalent circuit model of an induction motor. 5.2.5 Torque-speed characteristics.	

	5.2.6 Methods of starting and speed control. 5.2.7 Performance analysis of induction motors. 5.2.8 Losses and efficiency considerations. 5.3 Hands-on lab: Testing and operating an induction motor.	
6. Apply electronics components	6.1 Introduction to Electronic Components 6.1.1 Overview of electronics: What are electronic components? 6.1.2 Classification of components: Passive, active, and electromechanical. 6.1.3 Introduction to circuit symbols and schematic diagrams. 6.1.4 Basic electrical quantities and units (voltage, current, resistance). 6.1.5 Understanding datasheets and component specifications.	• Portfolio of evidence • Practical test • Third party report • Written tests • Project work

	6.1.6 Overview of testing and measurement tools (multimeters, oscilloscopes). 6.2 Passive Components 6.2.1 Resistors: Types, color codes, power ratings, and applications. 6.2.2 Capacitors: Types (ceramic, electrolytic, film), capacitance value, and working voltage. 6.2.3 Charging and discharging of capacitors in DC circuits. 6.2.4 Applications of capacitors in filtering, timing, and energy storage. 6.2.5 Inductors: Types, inductance value, and applications. 6.2.6 Inductor behavior in DC and AC circuits. 6.2.7 Introduction to filters: RC, RL, and RLC circuits. 6.3 Semiconductor Devices 6.3.1 Diodes: Introduction to PN junctions, characteristics, and	

	types (LEDs, Zener diodes, Schottky diodes). 6.3.2 Applications of diodes in rectification, voltage regulation, and signal clipping. 6.3.3 Transistors: Types (BJT and MOSFET), characteristics, and configurations. 6.3.4 Basic transistor circuits: Switches and amplifiers. 6.3.5 Hands-on lab: Building and testing simple diode and transistor circuits. 6.3.6 Special semiconductor devices: Thyristors, TRIACs, and optoelectronic devices. 6.3.7 Characteristics and applications in switching and control. 6.4 Integrated Circuits (ICs) 6.4.1 Overview of integrated circuits: Analog vs. digital ICs. 6.4.2 Operational amplifiers (Op-Amps): Characteristics and basic configurations.	

	6.4.3 Applications of Op-Amps in signal processing. 6.4.4 Timers and oscillators: 555 timer IC and its applications. 6.4.5 Voltage regulators: Linear and switching regulators. 6.4.6 Introduction to data converters (ADC and DAC). 6.4.7 Digital ICs: Logic gates and flip-flops. 6.4.8 Applications of digital ICs in basic logic circuits. 6.4.9 Hands-on lab: Building circuits using Op-Amps, timers, and logic gates. 6.5 Electromechanical and Specialized Components 6.5.1 Relays: Types, operation, and applications in switching. 6.5.2 Switches and connectors: Types and usage in electronic circuits. 6.5.3 Transformers: Basic operation, step-	

	up/step-down functions, and isolation. 6.5.4 Displays: LED, LCD, and seven-segment displays. 6.5.5 Circuit Design and Practical Applications 6.5.6 Basic circuit design principles: Bread boarding, PCB layout, and soldering. 6.5.7 Introduction to circuit simulation tools (e.g., Multisim, LTSpice). 6.5.8 Testing and troubleshooting techniques. 6.5.9 Real-world applications of electronic components. 6.5.10 Building practical projects: Power supplies, audio amplifiers, and sensor-based circuits. 6.5.11 Hands-on lab: Final project assembly and testing.	

Suggested Methods of Instruction

- Demonstration by trainer

- Practice by the trainee
- Field trips
- Discussions

Recommended Resources for 25 trainees

S/No.	Category/Item	Description/Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
1	Textbooks	Comprehensive texts on electrical and control principle.	5 pcs	1:5
2	Charts	Visual aids covering electrical theories and safety protocols	10 pcs	1:2.5
3	PowerPoint Presentations	For trainer's use, covering course content and practical applications	1	1:25
B	**Learning Facilities & Infrastructure**			
1	Lecture/Theory Room	Equipped with projectors and seating for 25 trainees, ~60 sqm	1	1:25
2	Workshop	Hands-on training area with workbenches, tools, and safety equipment, ~80 sqm	1	1:25
3	Computer Laboratory	Equipped with testing setups for electrical experiments, ~50 sqm. Equipped with computers installed with Circuit simulation software.	25	1:1
C	**Consumable Materials**			

1	Electrical Wires	Assorted sizes and color-coded (e.g., 1.5mm², 2.5mm², 4mm²)	5 rolls	1:5
2	Insulation Tapes	For securing connections and insulation, assorted colors	25 pcs	1:1
3	Breadboard	For prototyping and testing circuits	5 pcs	1:5
4	Sensors	Assorted types (temperature, pressure, proximity)	10 pcs	1:2.5
5	Signal generators	For generating AC signals	5pcs	1:5
6	Transducers	Assorted	10 pcs	1:3
7	Electronic components	Resistors, transistors, capacitors, relays, transformers. Integrated IC, OPAM.	100pcs	4:25
D	**Tools and Equipment**			
1	Screwdrivers	Assorted sets for various applications	2 sets	1:12.5
2	Side Cutters	For cutting wires and cables	4 pcs	1:6.25
3	Pliers	For gripping and bending wires	3 pcs	1:8.33
4	Stripping Knives	For stripping insulation from wires	4 pcs	1:6.25
5	Computers	Equipped with electrical and electronics simulation software	5 pcs	1:5
6	Multimeters	For measuring voltage, current, and resistance	5 pcs	1:5
7	Clamp Meters	For measuring current flow in circuits	5 pcs	1:5
8	Oscilloscope	For observing waveforms and signals	1	1:25

9	Voltmeter	For measuring voltage	1	1:25
10	Ammeter	For measuring current	1	1:25
11	Signal Generator	For generating electrical signals for testing	1	1:25
12	Soldering gun	For soldering	10	1:3
13	Soldering wire	For making joints in electrical circuits	10	1:3
14	PLC	For program practice	5	1:5
15	Cells and batteries	For learning	5	1:5
E	**PPE (Personal Protective Equipment)**			
1	PPE Sets	Includes helmets, gloves, safety goggles, shoes, and harnesses	25 sets	1:1
2	Safety Signs and Barriers	For simulating safety zones and hazards	10 sets	1:2.5
3	Earthing Test Kits	For ground testing and demonstrating earthing procedures	5 pcs	1:5
4	Electrical Test Benches	For hands-on testing of functionality and circuit design	5 pcs	1:5
F	**Reference Materials**			
1	Industrial Automation Manuals	Covering principles and practices in automation	25 pcs	1:1
2	Electrical Standards	Reference on industry standards (e.g., IEEE Guidelines)	5 pcs	1:5
3	Technical Handbooks	On motors, drives, and wiring systems	25 pcs	1:1

4	Training Presentations/Slides	Digital format for shared access among trainees	1	1:25
5	Multimedia Learning Modules	Digital licenses for videos and tutorials	25 pcs	1:1
6	Practical Assessment Guides	Worksheets for practical assessments	25 pcs	1:1