REPUBLIC OF KENYA

COMPETENCY BASED MODULAR CURRICULUM

FOR

INDUSTRIAL CONTROLS AND INSTALLATIONS

KNQF LEVEL 6

(CYCLE 3)

ISCED CODE: 0714 554A

TVET CDACC
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FOREWORD

The provision of quality education and training is fundamental to the Government's overall strategy for social and economic development. Quality education and training contribute to the achievement of Kenya's development blueprint and sustainable development goals.

Reforms in the education sector are necessary to achieve Kenya Vision 2030 and meet the provisions of the Constitution of Kenya 2010. The education sector had to be aligned to the Constitution, and this resulted in the formulation of the Policy Framework for Reforming Education and Training in Kenya (Sessional Paper No. 14 of 2012). A key feature of this policy is the radical change in the design and delivery of TVET training. This policy document requires that training in TVET be competency-based, curriculum development be industry-led, certification be based on demonstration of competence, and the mode of delivery allow for multiple entry and exit in TVET programmes.

These reforms demand that Industry takes a leading role in curriculum development to ensure the curriculum addresses its competence needs. It is against this background that this curriculum has been developed. For trainees to build their skills on foundational hands-on activities of the occupation, units of learning are grouped in modules. This has eliminated duplication of content and streamlined exemptions based on skills acquired as a trainee progresses in the up-skilling process, while at the same time allowing trainees to be employable in the shortest time possible through the acquisition of part qualifications.

It is my conviction that this curriculum will play a great role in developing competent human resources for the Industrial Control and Installation Sector's growth and development.

PRINCIPAL SECRETARY

STATE DEPARTMENT FOR TVET

MINISTRY OF EDUCATION

PREFACE

Kenya Vision 2030 aims to transform Kenya into a newly industrializing middle-income country, providing high-quality life to all its citizens by the year 2030. Kenya intends to create globally competitive and adaptive human resource base to meet the requirements of a rapidly industrializing economy through lifelong education and training. TVET has a responsibility to facilitate the process of inculcating knowledge, skills, and worker behaviour necessary for catapulting the nation to a globally competitive country, hence the paradigm shift to embrace Competency-Based Education and Training (CBET).

CAP 210A and Sessional Paper No. 1 of 2019 on Reforming Education and Training in Kenya for Sustainable Development emphasized the need to reform curriculum development, assessment, and certification. This called for a shift to CBET to address the mismatch between skills acquired through training and skills needed by industry, as well as increase the global competitiveness of the Kenyan labour force.

This curriculum has been developed in adherence to the Kenya National Qualifications Framework and CBETA standards and guidelines. The curriculum is designed and organized into Units of Learning with Learning Outcomes, suggested delivery methods, learning resources, and methods of assessing the trainee's achievement. In addition, the units of learning have been grouped in modules to concretize the skills acquisition process and streamline upskilling.

I am grateful to all expert trainers and everyone who played a role in translating the Occupational Standards into this competency-based modular curriculum.

CHAIRMAN.
TVET CDACC

ACKNOWLEDGMENT

This curriculum has been designed for competency-based training and has independent units of learning that allow the trainee flexibility in entry and exit. In developing the curriculum, significant involvement and support were received from expert trainers, institutions and organizations.

I recognize with appreciation the role of the Industrial Control and Installations National Sector Skills Committee (NSSC) in ensuring that competencies required by the industry are addressed in the curriculum. I also thank all stakeholders in the Industrial Control and Installations sector for their valuable input and everyone who participated in developing this curriculum.

I am convinced that this curriculum will go a long way in ensuring that individuals aspiring to work in the Industrial Control and Installations Sector acquire competencies to perform their work more efficiently and effectively.

COUNCIL SECRETARY/CEO

TVET CDACC

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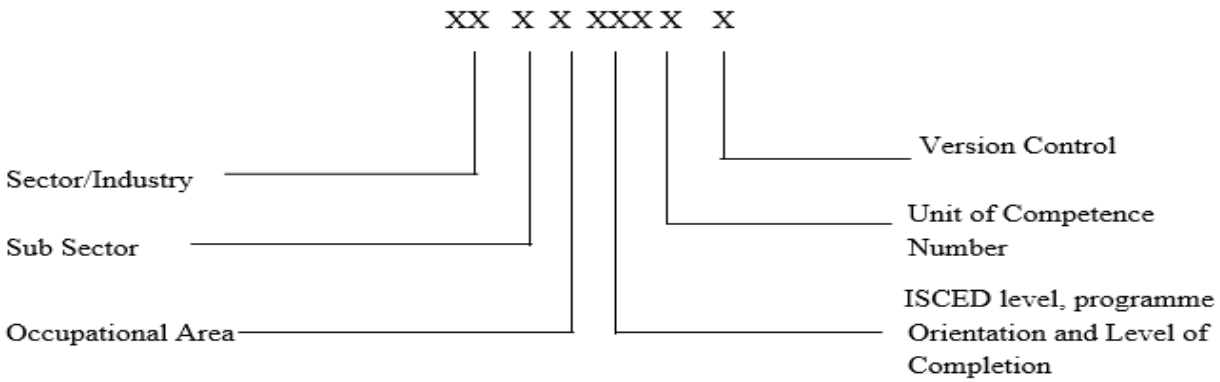

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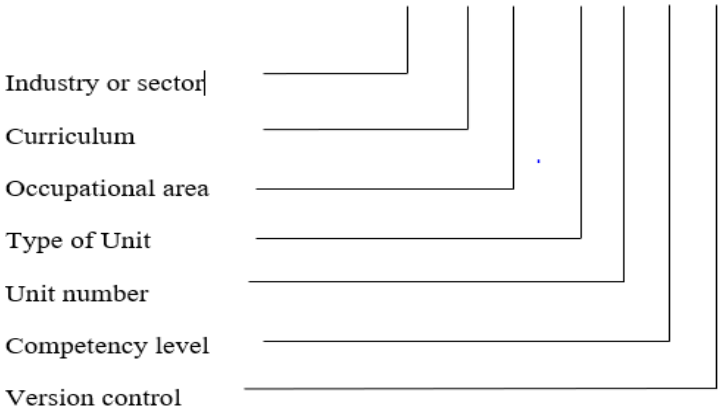
ENG /CU /IC /BC /01 /6 /MA



ABBREVIATIONS AND ACRONYMNS

A	Control version
AIDS	Acquired Immunodeficiency Syndrome
BC	Basic Unit
CAD	Computer Aided Design
CBET	Competency Based Education and Training
CC	Common unit
CDACC	Curriculum Development Assessment Certification Council
CEO	Council Secretary
CR	Core Unit
CU	Curriculum
HIV	Human Immuno-Deficiency Virus
HV	High Voltage
HVAC	Heating Ventilation and Air Conditioning
IEE	Institute of Electrical Engineers
KCSE	Kenya Certificate of Secondary Education
KEBS	Kenya Bureau of Standards
KNQA	Kenya National Qualifications Authority
KNQF	Kenya National Qualification Framework
KPLC	Kenya Power and Lighting Company
LCD	Liquid Crystal Display
NCA	National Construction Authority
NEMA	National Environment Management Authority
OSH	Occupational Safety and Health
OSHA	Occupational Safety and Health Act
PESTEL	Political Environmental Social Technological Economic Legal
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
PPE	Personal Protective Equipment

PV	Photo Voltaic
Q&A	Questions and Answer
SSAC	Sector Skills Advisory Committee
SWOT	Strength Weakness Opportunity Threat
TVET	Technical and Vocational Education and Training
WIBA	Work Injury Benefits Act

COURSE OVERVIEW

Industrial Controls and Installations level 6 qualification consists of competencies that an individual must achieve to Industrial Control and Installation activities. It involves managing Motor Control Systems, Programmable Logic Controllers, SCADA Systems, Instrumentation and Process Control Systems, High Voltage Systems and Analysing Alternative Energy Systems.

Summary of Units of Learning

ISCED Unit Code	TVET CDACC Unit Code	Unit of Learning Title	Duration in Hours	Credit Factor
MODULE I				
0611 551 01A	ENG/CU/IC/BC/01/6/MA	Digital literacy	40	4
0031 551 02A	ENG/CU/IC/BC/02/6/MA	Communication skills	40	4
0713 541 05A	ENG/CU/IC/CC/01/6/MA	Electrical and Electronics Principles	220	22
0713 551 11A	ENG/CU/IC/CR/01/6/MA	Electrical Installation	80	8
		SUB TOTAL	**380**	**38**
MODULE II				
0541 541 06A	ENG/CU/IC/CC/02/6/MA	Engineering Mathematics I	140	14
0713 551 12A	ENG/CU/IC/CR/02/6/MA	Motor Control Systems I	150	15
0417 551 03A	ENG/CU/IC/BC/03/6/MA	Work ethics and Practices	40	4
		SUB TOTAL	**330**	**33**
MODULE III				
0541 541 07A	ENG/CU/IC/CC/03/6/MA	Engineering Mathematics II	140	14
0713 551 13A	ENG/CU/IC/CR/03/6/MA	Motor Control Systems II	140	14
0732 541 08A	ENG/CU/IC/CC/04/6/MA	Technical Drawing	150	15
		SUB TOTAL	**430**	**43**
MODULE IV				
0541 541 09A	ENG/CU/IC/CC/05/6/MA	Engineering Mathematics III	140	14

0715 551 14A	ENG/CU/IC/CR/04/6/MA	Programmable Logic Controllers Systems	240	24
0413 451 04A	ENG/CU/IC/BC/04/6/MA	Entrepreneurial skills	40	4
		SUB TOTAL	**420**	**42**
MODULE V				
0541 541 10A	ENG/CU/IC/CC/06/6/MA	Engineering Mathematics IV	140	14
0713 551 15A	ENG/CU/IC/CR/05/6/MA	High Voltage Systems	180	18
0715 551 16A	ENG/CU/IC/CR/06/6/MA	Supervisory Control and Data Acquisition (SCADA) Systems	140	14
		SUB TOTAL	**460**	**46**
MODULE VI				
0714 551 17A	ENG/CU/IC/CR/07/6/MA	Instrumentation and Process Control Systems	200	20
0713 551 18A	ENG/CU/IC/CR/08/6/MA	Alternative Energy Systems	190	19
		SUB TOTAL	**390**	**39**
		INDUSTRY TRAINING	**480**	**48**
		GRAND TOTAL	**2890**	**289**

Entry Requirements

An individual entering this course should have any of the following minimum requirements:

a) Kenya Certificate of Secondary Education (K.C.S.E) with Grade C- (minus)

Or

b) Certificate in Electrical Engineering (power option) Level 5, Certificate in Instrumentation and Control Engineering Level 5, Certificate in Industrial Automation and Robotics Level 5

c) Equivalent qualifications as determined by TVETA.

Trainer Qualification

Qualifications of a trainer for this course include:

a) Have a minimum of Industrial Control and Installations KNQF Level 7 qualification or its equivalent in a related trade area.

b) License by TVETA; and

c) Registered by Engineers Board of Kenya (E.B.K) or Kenya Engineering Technology Registration (KETRB)

Industry Training

An individual enrolled in this course will be required to undergo Industry training for a minimum period of 480 hours in Industrial Control Installations sector. The industrial training may be taken after completion of all units for those pursuing the full qualification or be distributed equally in each unit for those pursuing part qualification. In the case of dual training model, industrial training shall be as guided by the dual training policy.

Assessment

The course shall be assessed formatively and summatively:

a) During formative assessment all performance criteria shall be assessed based on performance criteria weighting.
b) Number of formative assessments shall minimally be equal to the number of elements in a unit of competency.
c) During summative assessment basic and common units may be integrated in the core units or assessed as discrete units.
d) Theoretical and practical weighting for each unit of learning shall be 40-60 for all units.
e) Formative and summative assessments shall be weighted at 60% and 40% respectively in the overall unit of learning score
f) For a candidate to be declared competent in a unit of competency, the candidate must meet the following conditions:
    i) Obtained at least 40% in theory assessment in formative and summative assessments.
    ii) Obtained at least 60% in practical assessment in formative and summative assessment where applicable.
    iii) Obtained at least 50% in the weighted results between formative assessment and summative assessment where the former constitutes 60% and the latter 40% of the overall score.
g) Assessment performance rating for each unit of competency shall be as follows:

MARKS	COMPETENCE RATING
80 -100	Mastery
65 - 79	Proficiency
50 - 64	Competent
49 and below	Not Yet Competent
Y	Assessment Malpractice/irregularities

h) Assessment for Recognition of Prior Learning (RPL) may lead to award of part and/or full qualification.

Certification

A candidate will be issued with a Certificate of Competency upon demonstration of competence in a core Unit of Competency. To be issued with Kenya National TVET Certificate in Industrial Controls and Installations level 6, the candidate must demonstrate competence in all the Units of Competency as given in the qualification pack. Statement of Attainment certificate may be awarded upon demonstration of competence in certifiable element within a unit.

These certificates will be issued by TVET CDACC

MODULE I

DIGITAL LITERACY

TVET CDACC UNIT CODE: ENG/CU/IC/BC/01/6/MA

ISCED UNIT CODE: 0611 551 01A

Relationship to Occupational Standards

This unit addresses the Unit of Competency: Apply Digital Literacy

Duration of Unit: 40 Hours

Unit Description

This unit covers the competencies required to demonstrate digital literacy. It involves operating computer devices, solving tasks using the Office suite, accessing online/offline data and information, performing online communication and collaboration, applying cybersecurity skills and performing jobs online. It also involves applying job entry techniques.

Summary of Learning Outcomes

By the end of this unit, the learner should be able to:

S/No	Learning Outcomes	Duration (Hours)
1.	Operate computer devices	6
2.	Solve tasks using office suite	14
3.	Manage data and information	6
4	Perform online communication and collaboration	4
5	Apply cybersecurity skills	4
6	Perform online jobs	4
7	Apply job entry techniques	2
	Total	**40**

Learning Outcomes, Content, and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Operate computer devices	1.1 Meaning and importance of digital literacy 1.2 Functions and Uses of Computers 1.3 Classification of computers 1.4 Components of a computer system 1.5 Computer Hardware 1.5.1 The System Unit E.g. Motherboard, CPU, casing 1.5.2 Input Devices e.g. Pointing, keying, scanning, voice/speech recognition, direct data capture devices. 1.5.3 Output Devices e.g. hardcopy output and softcopy output 1.5.4 Storage Devices e.g. main memory e.g. RAM, secondary storage (Solid state devices, Hard Drives, CDs & DVDs, Memory cards, Flash drives 1.5.5 Computer Ports e.g. HDMI, DVI, VGA, USB type C etc. 1.6 Classification of computer software 1.7 Operating system functions 1.8 Procedure for turning/off a computer 1.9 Mouse use techniques 1.10 Keyboard Parts and Use Techniques 1.11 Desktop Customization 1.12 File and Files Management using an operating system 1.13 Computer Internet	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment

Learning Outcome	Content	Suggested Assessment Methods
	Connection Options 1.13.1. Mobile Networks/Data Plans 1.13.2. Wireless Hotspots 1.13.3. Cabled (Ethernet/Fiber) 1.13.4. Dial-Up 1.14 Satellite 1.15 Computer external devices management 1.15.1. Device connections 1.15.2. Device controls (volume controls and display properties)	
2. Solve tasks using office suite	2.1 Meaning and Importance of Word Processing 2.2 Examples of Word Processors 2.3 Working with word documents 2.3.1 Open and close word processor 2.3.2 Create a new document 2.3.3 Save a document 2.3.4 Switch between open documents 2.4 Enhancing productivity 2.4.1 Set basic options/preferences 2.4.2 Help resources 2.4.3 Use magnification/zoom tools 2.4.4 Display, hide built-in tool bar 2.4.5 Using navigation tools 2.5 Typing Text 2.6 Document editing (copy, cut, paste commands, spelling and Grammar check)	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment

Learning Outcome	Content	Suggested Assessment Methods
	2.7 Document formatting 2.7.1 Formatting text 2.7.2 Formatting paragraph 2.7.3 Formatting styles 2.7.4 Alignment 2.7.5 Creating tables 2.7.6 Formatting tables 2.8 Graphical objects 2.8.1 Insert object (picture, drawn object) 2.8.2 Select an object 2.8.3 Edit an object 2.8.4 Format an object 2.9 Document Print setup 2.9.1 Page layout, 2.9.2 Margins set up 2.9.3 Orientation. 2.10 Word Document Printing 2.11 Meaning & Importance of electronic spreadsheets 2.12 Components of Spreadsheets 2.13 Application areas of spreadsheets 2.14 Using spreadsheet application 2.14.1 Parts of Excel screen: ribbon, formula bar, active cell, name box, column letter, row number, Quick Access Toolbar. 2.14.2 Cell Data Types 2.14.3 Block operations 2.14.4 Arithmetic operators (formula bar (-, +, 2.14.5 Cell Referencing 2.15 Data Manipulation 2.15.1 Using Functions	

Learning Outcome	Content	Suggested Assessment Methods
	(Sum, Average, SumIF, Count, Max, Max, IF, Rank, Product, mode etc) 2.15.2 Using Formulae 2.15.3 Sorting data 2.15.4 Filtering data 2.15.5 Visual representation using charts 2.15.6 Worksheet printing 2.16 Electronic Presentations 2.17Meaning and Importance of electronic presentations 2.18Examples of Presentation Software 2.19Using the electronic presentation application 2.19.1 Parts of the PowerPoint screen (slide navigation pane, slide pane, notes, the ribbon, quick access toolbar, and scroll bars). 2.19.2 Open and close presentations 2.19.3 Creating Slides (Insert new slides, duplicate, or reuse slides.) 2.19.4 Text Management (insert, delete, copy, cut and paste, drag and drop, format, and use spell check). 2.19.5 Use magnification/zoom tools 2.19.6 Apply or change a theme. 2.19.7 Save a presentations 2.19.8 Switch between open presentations	

Learning Outcome	Content	Suggested Assessment Methods
	2.20Developing a presentation 2.20.1 Presentation views 2.20.2 Slides 2.20.3 Master slide 2.21Text 2.21.1 Editing text 2.21.2 Formatting 2.21.3 Tables 2.22Charts 2.22.1 Using charts 2.22.2 Organization charts 2.23Graphical objects 2.23.1 Insert, manipulate 2.23.2 Drawings 2.24Prepare outputs 2.24.1 Applying slide effects and transitions 2.25Check and deliver 2.25.1 Spell check a presentation 2.25.2 Slide orientation 2.25.3 Slide shows, navigation 2.26 Print presentations (slides and handouts)	
3. Manage data and information	3.1 Meaning of Data and information 3.2 Importance and Uses of data and information 3.3 Types of internet services 3.3.1 Communication Services 3.3.2 Information Retrieval Services 3.3.3 File Transfer 3.3.4 World Wide Web Services 3.3.5 Web Services 3.3.6 Automatic Network Address Configuration	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment

Learning Outcome	Content	Suggested Assessment Methods
	3.3.7 News Group 3.3.8 Ecommerce 3.4 Types of Internet Access Applications 3.5 Web browsing concepts 3.5.1 Key concepts 3.5.2 Security and safety 3.6 Web browsing 3.6.1 Using the web browser 3.6.2 Tools and settings 3.6.3 Clearing Cache and cookies 3.6.4 URIs 3.6.5 Bookmarks 3.6.6 Web outputs 3.7 Web based information 3.7.1 Search 3.7.2 Critical evaluation of information 3.7.3 Copyright, data protection 3.8 Downloads Management 3.9 Performing Digital Data Backup (Online and Offline) 3.10 Emerging issues in internet	
4. Perform online communication and collaboration	4.1.Netiquette principles 4.2.Communication concepts 4.2.1 Online communities 4.2.2 Communication tools 4.2.3 Email concepts 4.3.Using email 4.3.1 Sending email 4.3.2 Receiving email 4.3.3 Tools and settings 4.3.4 Organizing email 4.4.Digital content copyright and	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment •

Learning Outcome	Content	Suggested Assessment Methods
	licenses 4.5.Online collaboration tools 4.5.1 Online Storage (Google Drive) 4.5.2 Online productivity applications (Google Docs & Forms) 4.5.3 Online meetings (Google Meet/Zoom) 4.5.4 Online learning environments 4.5.5 Online calendars (Google Calendars) 4.5.6 Social networks (Facebook/Twitter - Settings & Privacy) 4.6.Preparation for online collaboration 4.6.1 Common setup features 4.6.2 Setup 4.7.Mobile collaboration 4.7.1 Key concepts 4.7.2 Using mobile devices 4.7.3 Applications 4.7.4 Synchronization	
5. Apply cybersecurity skills	5.1 Data protection and privacy 5.1.1 Confidentiality of data/information 5.1.2 Integrity of data/information 5.1.3 Availability of data/information 5.2 Internet security threats 5.2.1 Malware attacks 5.2.2 Social engineering attacks 5.2.3 Distributed denial of service (DDoS) 5.2.4 Man-in-the-middle attack (MitM) 5.2.5 Password attacks	• Observation • Portfolio of Evidence • Project • Written assessment • Practical assessment • Oral assessment

Learning Outcome	Content	Suggested Assessment Methods
	5.2.6 IoT Attacks 5.2.7 Phishing Attacks 5.2.8 Ransomware 5.3 Computer threats and crimes 5.4 Cybersecurity control measures 5.4.1 Physical Controls 5.4.2 Technical/Logical Controls (Passwords, PINs, Biometrics) 5.4.3 Operational Controls 5.5 Laws governing protection of ICT in Kenya 5.5.1 The Computer Misuse and Cybercrimes Act No. 5 of 2018 5.5.2 The Data Protection Act No. 24 Of 2019	
6. Perform online jobs	6.1 Introduction to online working 6.2 Types of online Jobs 6.3 Online job platforms 6.3.1 Remotask 6.3.2 Data annotation tech 6.3.3 Cloud worker 6.3.4 Upwork 6.3.5 Oneforma 6.3.6 Appen 6.4 Online account and profile management 6.5 Identifying online jobs/job bidding 6.6 Online digital identity 6.7 Executing online tasks 6.8 Management of online payment accounts.	• Observation • Oral assessment • Portfolio of evidence • Third party report • Written assessment
7. Apply job entry techniques	7.1 Types of job opportunities 7.1.1 Self-employment 7.1.2 Service provision	• Observation • Oral assessment

Learning Outcome	Content	Suggested Assessment Methods
	7.1.3 product development 7.1.4 salaried employment 7.2 Sources of job opportunities 7.3 Resume/ curriculum vitae 7.3.1 What is a CV 7.3.2 How long should a CV be 7.3.3 What to include in a AC 7.3.4 Format of CV 7.3.5 How to write a good CV 7.3.6 Don'ts of writing a CV 7.4 Job application letter 7.4.1 What to include 7.4.2 Addressing a cover letter 7.4.3 Signing off a cover letter 7.5 Portfolio of Evidence 7.5.1 Academic credentials 7.5.2 Letters of commendations 7.5.3 Certification of participations 7.5.4 Awards and decorations 7.6 Interview skills 7.6.1 Listening skills 7.6.2 Grooming 7.6.3 Language command 7.6.4 Articulation of issues 7.6.5 Body language 7.6.6 Time management 7.6.7 Honesty 7.7 Generally knowledgeable in current affairs and technical area	• Portfolio of evidence • Written assessment

Suggested Methods Instruction

- Practical

- Projects
- Demonstrations
- Group discussions
- Direct instruction

Recommended Resources for 25 Trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
1)	Power point presentations	For trainer's use	1	1:25
2)	Sample CVs	For trainee's use	5	1:5
3)	Sample job applications	For trainee's use	5	1:5
B	**Learning Facilities & infrastructure**			
4)	Lecture/theory room		1	1:25
5)	Computers with OS (Windows/Linux/Mac), Microsoft Office, Google Workspace, Antivirus	For trainee's use	25	1:1
6)	Internet connection	For trainees and trainer's use	1 connection	1:25
7)	Whiteboard	For trainer's use	1	1:25
8)	Smartboard/Smart TV (Where applicable)	For trainer's use	1	1:25
C	**Consumable materials**			
9)	Printing papers	For trainer and trainee use	Varies	Varies
10)	Assorted whiteboard markers	For trainer's use	Varies	Varies
D	**Tools and Equipment**			
11)	Printers	For trainer's use	2	1:12
12)	External storage media	For trainer and trainee use	Varies	1:1 or 1:5 depending on need
13)	Projector	For trainer's use	1	1:25

COMMUNICATION SKILLS

TVET CDACC UNIT CODE: ENG/CU/IC/BC/02/6/MA

ISCED UNIT CODE: 0031 551 02A

Relationship to Occupational Standards
This unit addresses the Unit of Competency: Apply Communication Skills

Duration of Unit: 40 hours

Unit Description

This unit encompasses the skills necessary for effective communication. It includes the utilization of various communication methods, such as written, non-verbal, oral, and group communication techniques.

Summary of Learning Outcomes

By the end of this unit, the learner should be able to:

S/No	Learning Outcomes	Duration (Hours)
1.	Apply communication channels.	10
2.	Apply written communication skills.	12
3.	Apply non-verbal skills.	4
4.	Apply oral communication skills.	4
5	Apply group communication skills.	10
Total		**40**

Learning Outcomes, Content, and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Apply communication channels	1.1.Communication process 1.2.Principles of effective communication	• Practical assessment • Observation

	1.3. Channels/medium/modes of communication 1.4. Factors to consider when selecting a channel of communication 1.5. Barriers to effective communication 1.6. Flow/patterns of communication 1.7. Sources of information 1.8. Organizational policies	• Portfolio of Evidence • Oral questions • Written assessment • Third party report
2. Apply written communication skills	2.1 Types of written communication 2.2 Elements of communication 2.3 Organization requirements for written communication	• Practical assessment • Observation • Portfolio of Evidence • Oral questions • Written assessment • Third party report
3. Apply non-verbal communication skills	3.1 Utilize body language and Gestures 3.2 Apply body posture 3.3 Apply workplace dressing code	• Practical assessment • Observation • Portfolio of Evidence • Oral questions • Written assessment • Third party report
4. Apply oral communication skills	4.1 Types of oral communication pathways 4.2 Effective questioning techniques	• Practical assessment • Observation • Portfolio of Evidence

	4.3 Workplace etiquette 4.4 Active listening	• Oral questions • Written assessment • Third party report
5. Apply group discussion skills	1.1 Establishing rapport 1.2 Facilitating resolution of issues 1.3 Developing action plans 1.4 Group organization techniques 1.5 Turn-taking techniques 1.6 Conflict resolution techniques 1.7 Team-work	• Practical assessment • Observation • Portfolio of Evidence • Oral questions • Written assessment • Third party report

Suggested Methods of Instruction

- Discussion
- Roleplaying
- Simulation
- Direct instruction
- Demonstration
- Field trips

Recommended Resources for 25 trainees

S/no.	Category/item	Description/specification	Quantity	Recommended ratio(item: trainee)
A.	**Learning materials**			
1.	Case studies	Published case studies	5	1:5
2.	Business plan templates	Standard business plan templates	5	1:5

3.	Video clips	Digital types	25	1:25
4.	Newspapers and Handouts	Well reputed news papers	5	1:5
5.	Business Journals	Well reputed journals	5	1:5
B.	**Learning facilities and infrastructure**			
1.	Lecture/theory room	$72m^2$	1	1:25
2.	Whiteboard	4 feet by 8 feet	1	1:25
3.	Projector	LCD High resolution	1	1:25
4.	Computers	RAM: 8GB	25	1:25
5.	Printers	Ink Jet	2	1:13
6.	Smart TV	LCD	1	1:25
7.	Internet connection	Adequate speed		1:25
C.	**Consumable materials**			
1.	Stationary materials	Pens, pencils, papers	Enough for 25	1:25
2.	Assorted whiteboard markers	Non-permanent	Enough for 25	1:25

ELECTRICAL AND ELECTRONICS PRINCIPLES

TVET CDACC UNIT CODE: ENG/CU/IC/CC/01/6/MA

ISCED UNIT CODE: 0713 541 05A

UNIT DURATION: 220 HOURS

Relationship to occupational standards

This unit addresses the unit of competency: apply electrical and electronics principles.

Unit description

This unit describes the competences required in order to apply electrical and electronics principles. It involves: applying safety requirements for electricity, basic electrical quantities and principles, D.C and A.C circuits in electrical installation, magnetism and electromagnetism, single and three phase power supply, sensors and transducers principles, principles of analogue electronics, and design electronic circuits

Summary of learning outcomes

By the end of the unit of learning, the trainee will be able to:

S/No.	Learning outcomes	Duration (Hrs)
1	Apply safety requirements for electricity	10
2	Apply basic electrical quantities and principles	20
3	Apply D.C and A.C circuits in electrical installation	20
4	Apply magnetism and electromagnetism	30
5	Perform single and three phase power supply	30
6	Apply sensors and transducers principles	20
7	Apply principles of analogue electronics	30
8	Apply principles of digital electronics	20

9	Design electronic circuits	20
TOTAL		**220**

Learning outcomes, content and suggested assessment methods

Learning outcome	**Content**	**Suggested assessment methods**
1. Apply safety requirements for electricity	1.1 Personal protective equipment (PPE) 1.1.1 Types of PPE 1.1.1.1 Head protection, insulating gloves, eye protection 1.1.1.2 Usage guidelines and importance 1.2 Control of electrical hazards 1.2.1 Identification of Hazards 1.2.1.1 Shocks, explosions, electrocution, burns, fires, electric arcs 1.2.1.2 Risk assessment and management 1.3 Electric Hazard Prevention 1.3.1 Preventative measures	• Project • Practical • Written tests • Oral Questioning • Portfolio of evidence

	1.3.1.1 Lockout/tagout (LOTO) procedures 1.3.1.2 Safe work practices	
2. Apply basic electrical quantities and principles	2.1 Basic SI units 2.1.1 Overview of SI Units 2.1.1.1 Power (Watts, W) 2.1.1.2 Current (Amperes, A) 2.1.1.3 Resistance (Ohms, Ω) 2.1.1.4 Voltage (Volts, V) 2.2 Conductors and insulators 2.2.1 Identification and characteristics 2.2.1.1 Metals vs. non-metals 2.2.1.2 Applications in electrical circuits 2.3 Electrical quantities 2.3.1 Charge, force, work, and power 2.3.2 Definitions and units 2.3.3 Calculations involving Electrical quantities 2.4 Ohm's law 2.4.1 Understanding ohm's law	• Project • Practical • Written tests • Oral Questioning • Portfolio of evidence

	2.4.2 Practical applications and calculations 2.5 Basic electrical and electronic measurements 2.5.1 Measurement Techniques 2.5.2 Use of multimeters, oscilloscopes, and ammeters 2.5.3 Measurement accuracy and calibration	
3. Apply DC and AC circuits in electrical installation	3.1 Introduction to electrical circuits 3.1.1 Introduction to electricity: 3.1.2 Voltage, current, and power. 3.1.3 Overview of DC and AC circuits. 3.1.4 Basic circuit elements: resistors, capacitors, and inductors. 3.2 DC Circuit Analysis 3.2.1 Series and parallel circuits.	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	3.2.2 Voltage and current division principles. 3.2.3 Kirchhoff's Vvltage law (KVL) and Kirchhoff's current law (KCL). 3.2.4 Analysis of complex circuits using KVL and KCL. 3.2.5 Introduction to circuit simulation software (e.g., SPICE). 3.2.6 Practical applications of DC circuit analysis. 3.2.7 Circuit design and testing using breadboards. 3.2.8 Hands-on lab: Building and testing DC circuits. 3.3 AC circuits analysis 3.3.1 Introduction to AC: Sinusoidal waveforms,	

	frequency, and period. 3.3.2 RMS values, peak values, and average values. 3.3.3 AC voltage and current sources. 3.3.4 Phasor representation of AC quantities. 3.3.5 Impedance and admittance. 3.3.6 Series and parallel AC circuits. 3.3.7 Resonance in RLC circuits. 3.3.8 Practical analysis of AC circuits using phasors. 3.3.9 Power in AC Circuits 3.3.9.1 Power factor and power factor correction. 3.3.9.2 Real, reactive, and apparent power. 3.3.9.3 AC power calculations for	

	single-phase and three-phase circuits. 3.3.9.4 Energy consumption and efficiency. 3.3.9.5 Applications of AC power in household and industrial settings. 3.4 Practical activity: 3.4.1 Connection in series and Parallel 3.4.2 Simulation	
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, Reluctance, magnetomotive force (MMF), and magnetic flux. 4.1.3 Calculations involving magnetic circuits 4.1.4 Analogies between electric and magnetic circuits.	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	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. Perform single and three phase power supply principles	5.1 Overview of electrical power systems 5.1.1 Definition and importance of power supply systems 5.1.2 Types of power systems: Single-phase vs. three-phase 5.1.3 Basic electrical concepts 5.1.3.1 Voltage, current, power, and frequency 5.1.3.2 Phase relationships and power factor 5.2 Single-phase power supply 5.2.1 Characteristics of single-phase systems 5.2.1.1 Voltage and current waveforms 5.2.1.2 Applications and limitations of single-phase power 5.2.2 Circuit design and Implementation	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	5.2.2.1 Basic circuit configurations: series and parallel 5.2.2.2 Wiring techniques and component selection 5.2.3 Measurement Techniques 5.2.3.1 Measuring voltage, current, and power in single-phase circuits 5.2.3.2 Tools and instruments for measurements 5.3 Three-phase power supply 5.3.1 Fundamentals of three-phase systems 5.3.1.1 Characteristics of three-phase power: Star (Y) and Delta (Δ) configurations 5.3.1.2 Advantages of three-phase systems over single-phase	

	5.3.2 Circuit design and implementation 5.3.2.1 Wiring and connection techniques for three-phase systems 5.3.2.2 Component selection and configuration 5.3.3 Measurement techniques 5.3.3.1 Measuring line and phase voltages, currents, and power in three-phase circuits 5.3.3.2 Use of power analyzers and other measurement tools 5.4 Power calculations and analysis 5.4.1 Power calculations 5.4.1.1 Active, reactive, and apparent	

	power calculations 5.4.1.2 Understanding the power triangle in both single and three-phase systems 5.4.2 Power factor correction 5.4.2.1 Importance of power factor in electrical systems 5.4.2.2 Techniques for improving power factor in both types of systems 5.5 Troubleshooting and maintenance 5.5.1 Common issues in power supply systems 5.5.1.1 Identifying and diagnosing faults in single and three-phase systems 5.5.1.2 Troubleshooting techniques and best practices	

6. Apply sensors and transducers principles	1.1 Introduction to sensors and transducers 1.1.1 Definitions and Concepts 1.1.2 Differences between sensors and transducers 1.1.2.1 Overview of their roles in measurement and control systems 1.2 Basic principles of operation 1.2.1 How sensors and transducers convert physical phenomena into electrical signals 1.2.2 Common physical quantities measured (e.g., temperature, pressure, moisture, position, oxygen, light) 1.3 Types of sensors 1.3.1 Temperature sensors 1.3.2 Thermocouples, thermistors, and infrared sensors 1.3.3 Principles of operations	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	1.3.4 Applications and selection criteria 1.4 **Pressure sensors** 1.4.1 Strain gauge, piezoelectric, and capacitive pressure sensors 1.4.2 Principles of operations 1.4.3 Measurement techniques and applications 1.5 **Proximity and displacement sensors** 1.5.1 Inductive, capacitive, and photoelectric sensors 1.5.2 Principles of operations 1.5.3 Use cases and installation considerations 1.6 Other **sensor types** 1.6.1 Humidity, moisture, oxygen, flow, level, and gas sensors 1.6.2 Overview of their principles and applications	

	1.7 Types of transducers 1.7.1 Definition **and Functionality** 1.7.1.1 Types of transducers (active vs. passive) 1.7.1.2 Examples and applications 1.8 Electrical **transducers** 1.8.1 Strain gauges, load cells, and piezoelectric transducers 1.8.2 Principles of operation and usage 1.9 Mechanical **transducers** 1.9.1 Overview of mechanical types and their applications 1.9.2 Integration into automated systems 1.10 Hands-on experiments on testing sensors and actuators.	
7. Apply principles of analogue electronics	7.1 Introduction to electronic components 7.1.1 Overview of electronics: What are	• Project • Practical • Written tests • Oral questioning • Portfolio of evidence

	electronic components? 7.1.2 Classification of components: passive, active, and electromechanical. 7.1.3 Introduction to circuit symbols and schematic diagrams. 7.1.4 Basic electrical quantities and units (voltage, current, resistance). 7.1.5 Understanding datasheets and component specifications. 7.1.6 Overview of testing and measurement tools (multimeters, oscilloscopes). 7.2 Passive Components 7.2.1 Resistors: types, color codes, power ratings, and applications. 7.2.2 Capacitors: types (ceramic, electrolytic, film), capacitance	

	value, and working voltage. 7.2.3 Charging and discharging of capacitors in DC circuits. 7.2.4 Applications of capacitors in filtering, timing, and energy storage. 7.2.5 Inductors: types, inductance value, and applications. 7.2.6 Inductor behavior in DC and AC circuits. 7.2.7 Introduction to filters: RC, RL, and RLC circuits. 7.3 Semiconductor devices 7.3.1 Diodes: Introduction to PN junctions, characteristics, and types (LEDs, zener diodes, Schottky diodes). 7.3.2 Applications of diodes in rectification, voltage	

	regulation, and signal clipping. 7.3.3 Transistors: types (BJT and MOSFET), characteristics, and configurations. 7.3.4 Basic transistor circuits: Switches and amplifiers. 7.3.5 Hands-on lab: Building and testing simple diode and transistor circuits. 7.3.6 Special semiconductor devices: thyristors, TRIACs, and optoelectronic devices. 7.3.7 Characteristics and applications in switching and control. 7.4 Integrated Circuits (ICs) 7.4.1 Overview of integrated circuits: Analog vs. digital ICs.	

	7.4.2 Operational amplifiers (Op-Amps): Characteristics and basic configurations. 7.4.3 Applications of Op-Amps in signal processing. 7.4.4 Timers and oscillators: 555 timer IC and its applications. 7.4.5 Voltage regulators: Linear and switching regulators. 7.4.6 Introduction to data converters (ADC and DAC). 7.5 Electromechanical and Specialized components 7.5.1 Relays: types, operation, and applications in switching. 7.5.2 Switches and connectors: types and usage in electronic circuits.	

	7.5.3 Transformers: basic operation, step-up/step-down functions, and isolation. 7.5.4 Displays: LED, LCD, and seven-segment displays. 7.5.5 Circuit design and practical applications 7.5.6 Basic circuit design principles: bread boarding, PCB layout, and soldering. 7.5.7 Introduction to circuit simulation tools (e.g., Multisim, LTSpice). 7.5.8 Testing and troubleshooting techniques. 7.5.9 Real-world applications of electronic components. 7.5.10 Building practical projects: Power supplies, audio amplifiers, and sensor-based circuits.	

	7.5.11 Hands-on lab: Final project assembly and testing.	
8. Apply principles of digital electronics	8.1 Basics of digital electronics 8.1.1 Introduction to digital electronics, importance, and applications 8.1.2 Introduction to binary, decimal, hexadecimal, and octal number systems 8.2 Number systems and conversions 8.2.1 Converting between binary, decimal, hexadecimal, and octal systems 8.2.2 Application of number systems in digital electronics 8.3 Digital logic gates 8.3.1 Boolean algebra 8.3.2 Types and functions of logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR)	• Project • Practical • Written tests • Oral Questioning • Portfolio of evidence

	8.3.3 Reading and interpreting logic gate symbols and truth tables 8.3.4 Construction of digital circuits using logic gates 8.4 Digital circuit construction 8.4.1 Building basic digital circuits with logic gates 8.4.2 Testing and verifying functionality according to design requirements 8.4.3 Practical exercises: simple logic gate projects	
9. Design electronic circuits	1.1 Drawing electronic circuit schematics 1.1.1 Introduction to circuit schematic symbols and layout 1.1.2 Software tools for drawing schematic diagrams	• Project • Practical • Written tests • Oral Questioning • Portfolio of evidence

	1.1.3 Practical exercises: creating schematic diagrams 1.2 Identification and selection of circuit components 1.2.1 Identifying components and understanding their roles in circuits 1.2.2 Selection of components based on design specifications and functionality 1.3 Simulation of electronic circuits 1.3.1 Introduction to circuit simulation software 1.3.2 Simulation electronic circuits for testing and troubleshooting 1.3.3 Evaluation of simulation results and identifying design adjustments 1.4 Soldering and circuit assembly 1.4.1 Techniques in soldering and	

	desoldering components 1.4.2 Assembly of circuits as per design specifications 1.4.3 Quality checks and safety protocols in circuit assembly 1.5 Testing and troubleshooting 1.5.1 Testing circuit functionality and performance 1.5.2 Identification and rectification of faults in assembled circuits 1.5.3 Practical exercises: testing and troubleshooting projects	

Suggested Methods of Instruction

- Group discussions
- Demonstration by trainer
- Exercises by trainee

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 electronics principles.	5 pcs	1:5
2	Charts	Visual aids covering electrical theories and safety protocols	10 pcs	1:3
3	PowerPoint Presentations	For trainer's use, covering course content and practical applications	adequate	
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	25 pcs	1:1
4	Sensors	Assorted types	adequate	

5	Signal generators	For generating AC signals	5pcs	1:5
6	Transducers	Assorted	adequate	
7	Electronic components	Resistors, transistors, capacitors, relays, transformers. Integrated IC, OPAM.	assorted	
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	1:7
3	Pliers	For gripping and bending wires	3 pcs	1:9
4	Stripping Knives	For stripping insulation from wires	4 pcs	1:7
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
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	1:3
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

ELECTRICAL INSTALLATION

TVET CDACC UNIT CODE: ENG/CU/IC/CR/01/6/MA

ISCED UNIT CODE: 0713 551 11A

Relationship to Occupational Standards

This unit addresses the unit of competency: Perform Electrical Installation

Duration of Unit: 80 Hours

Unit Description

This unit specifies the competencies required for performing electrical installation. It involves preparing a list of tools equipment and materials, performing piping, and laying of cables, installing of electrical components, terminating of electrical installation, inspecting and testing the installation and documenting an electrical installation.

Summary of Learning Outcomes

By the end of this unit, the learner should be able to:

S/NO	LEARNING OUTCOMES	DURATION(HOURS)
1.	Prepare list of tools, equipment, and materials	10
2.	Perform piping and laying of cables	20
3.	Install electrical components	18
4.	Terminate electrical installation	12
5.	Inspect and test installation	10
6.	Document an Electrical installation	10
	TOTAL HOURS	**80**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Prepare a list of tools, equipment and materials	1.1 Health and safety procedures 1.1.1 PPEs 1.1.2 Safety, Rules and, regulations 1.1.3 Hazards 1.1 Electrical installation tools and materials 1.2.1 Cutting tools 1.2.2 Measuring tools 1.2.3 Measuring equipment 1.2.4 Cables and conductors 1.2.5 Crimping tools 1.2.6 Conduits 1.2.7 Trunking 1.2.8 Consumables 1.2 Types, application, care, maintenance and storage of: 1.2.1 Tools 1.2.1.1 Cable strippers 1.2.1.2 Pliers 1.2.1.3 Screw drivers 1.2.1.4 Hammers 1.2.1.5 Chisels 1.2.1.6 Allen keys 1.2.1.7 Electrician knives 1.2.1.8 Crimping tools 1.2.1.9 Bending springs	• Oral questioning • Written tests • Observation • Practical

Learning Outcome	Content	Suggested Assessment Methods
	1.2.1.10 Steel tapes 1.2.1.11 Draw wires 1.2.1.12 Hack saws 1.2.1.13 Drills 1.2.2 Equipment 1.2.2.1 Stock and die 1.2.2.2 Vice 1.2.3 Materials 1.2.3.1 Cables 1.2.3.2 Fittings 1.2.3.3 Accessories 1.3 Assemble electrical installation tools, equipment and materials	
2. Perform piping and laying of cables	2.1 Meaning of terms 2.2 Procedures for piping 2.3 Cables and cable joints 2.4 Wiring systems and accessories 2.4.1 Types and applications 2.4.1.1 Conduits 2.4.1.2 Cable trays 2.4.1.3 Cable ducts 2.4.1.4 Trunking 2.4.2 Preparation of wiring systems 2.4.2.1 Marking out 2.4.2.2 Cutting 2.4.2.3 Bending	• Written tests • Observation • Oral questioning • Practical test

Learning Outcome	Content	Suggested Assessment Methods
	2.4.2.4 Threading 2.4.2.5 Chiseling 2.4.2.6 Trenching 2.5 Draw –in/Lay of cables routes 2.5.1 Cable Identification 2.6 IEE regulations	
3 Install electrical components	3.1 Meaning of terms 3.2 Electrical symbols and abbreviations 3.3 Meaning of electrical drawings 3.4 Drawing of electrical diagrams 3.4.1 block 3.4.2 schematic 3.4.3 circuit 3.4.4 line 3.4.5 wiring 3.5 Electrical components 3.5.1 Junction boxes 3.5.2 Ceiling rose 3.5.3 Switches 3.5.4 Socket outlets 3.5.5 Bulb holders 3.5.6 IEE regulations	• Written tests • Oral questioning • Practical tests • Observation

Learning Outcome	Content	Suggested Assessment Methods
4 Terminate electrical installation	4.1 Meaning of Terms 4.2 Importance of termination 4.3 Cable labelling 4.4 Cable lugging 4.5 Tools used in cable termination e.g. 4.5.1 Crimping tool 4.5.2 Strip Knife 4.6 IEE regulations 4.7 Disposal of waste materials	• Written tests • Oral questioning • Practical tests • Observation
5 Inspect and test installation	5.1 Types of tests on an electrical installation system 5.2 IEE regulations in regard to electrical installation testing and inspection 5.3 Electrical testing instruments	• Written tests • Oral questioning • Practical tests • Observation
6 Document an Electrical installation	6.1 Report preparation 6.2 Sharing of the installation report 6.3 Report filing	• Written tests • Oral questioning • Practical tests • Observation

Suggested Methods of Instruction

- Demonstration by trainer
- Practice by the trainee
- Field trips
- On-job-training
- Discussions

Recommended Resources for 25 trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
1.	Textbooks	1. B. Scaddan Electrical installation work 2. J. Hyde Electrical Installation Principles and Practices 3. Electrical Theory for the Electrician" by Mike Holt 4. Electrical installation work by Brian Scaddan	5 pcs	1:5
2.	Installation manuals	IEEE regulation BS3939 NEMA regulations OSHA	5 pcs	1:5
3.	Charts	Single line diagram Circuit diagrams Colour codes	1 pcs for each	1:25
4.	Power point presentations	For trainer's use	1	1:25
B	**Learning Facilities & infrastructure**			
1.	Lecture/theory room	$60m^2$	1	1:25
2.	Workshop	$150m^2$	1	1:25

3.	Site			
C	**Consumable materials**			
1.	Electrical wires	1.5mm^2(red, black green)	5 rolls	1:5
		2.5mm^2(red, black green)	5 rolls	1:5
		4.0 mm^2(red, black green)	3 rolls	1:10
		6.0 mm^2(red, black green)	2 rolls	1:12
		10 mm^2(red, black green)	2 rolls	1:12
2.	Insulation tapes		25 pcs	1:1
3.	Accessories	Switches, sockets, Junction boxes, Consumer units, Lamp holders, Patrice boxes, Circuit breakers, energy meter, cut out, cooker unit, instant water heater switch,	25 pcs	1:1
4.	Conduits and trunkings	PVC conduits, Steel conduits, Mini trunking	25 pcs	1:1
	Tools and Equipment			
1.	Hacksaws		25 pcs	1:1
2.	Striping knives		25 pcs	1:1
3.	Side cutters		25 pcs	1:1
4.	Pliers		25 pcs	1:1
5.	Tape measure		25 pcs	1:1

6.	Try Square		25 pcs	1:1
7.	Spirit level		25 pcs	1:1
8.	Assorted Screw driver		25 pcs	1:1
9.	Assorted hammers		25 pcs	1:1
10.	PPEs		25 pcs	1:1
11.	Multimeters		5 pcs	1:5
12.	Clamp meters		5 pcs	1:5
13.	Earth resistance meter		5 pcs	1:5
14.	Stocks & Dies		5 pcs	1:5
15.	Vices		5 pcs	1:5
16.	Pipe bending Machine		5 pcs	1:5
17.	Bending spring		5 pcs	1:5
18.	Drilling machines		5 pcs	1:5
19.	Work stations		25	1:1
20.	Installation boards		13 pcs	1:2

MODULE II

ENGINEERING MATHEMATICS I

TVET CDACC UNIT CODE: ENG/CU/IC/CC/02/6/MA

ISCED UNIT CODE: 0541 541 06A

Relationship to Occupational Standards

This unit addresses the unit of competency: Apply Engineering Mathematics I

Duration of Unit: 140 hours

Unit Description

This unit describes the competencies required by an Industrial Control Installation technician to apply a wide range of Engineering mathematics in their work. This includes applying algebraic functions, trigonometry and hyperbolic functions, complex numbers, coordinate geometry and binomial expansion

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Apply Algebra	34
2.	Apply Trigonometry and hyperbolic functions	44
3.	Apply complex numbers	24
4.	Apply Coordinate Geometry	24
5.	Carry out Binomial Expansion	14
TOTAL		**140**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods

1. Apply Algebra	1.1 Base and Index 1.2 Law of indices 1.3 Indicial equations 1.4 Laws of logarithm 1.5 Logarithmic equations 1.6 Conversion of bases 1.7 Use of calculator 1.8 Reduction of equations 1.9 Solution of equations reduced to quadratic form 1.10 Solutions of simultaneous linear equations in three unknowns 1.11 Solutions of problems involving AP and GP	1. Assignments 2. Supervised exercises 3. Oral assessment 4. Written assessment 5. Observation 6. Portfolio of Evidence
2. Apply Trigonometry and hyperbolic functions	2.1 Half -angle formula 2.2 Factor formula 2.3 Trigonometric functions 2.4 Parametric equations 2.5 Relative and absolute measures 2.6 Measures calculation 2.7 Meaning of hyperbolic equations 2.8 Properties of hyperbolic functions 2.9 Evaluations of hyperbolic functions Hyperbolic identities 2.10 Osborne's Rule 2.11 Ashx+bshx=C equation 2.12 One-to-one relationship in functions 2.13 Inverse functions for one-to-one relationship 2.14 Inverse functions for trigonometric functions 2.15 Graph of inverse functions 2.16 Inverse hyperbolic functions	1. Assignments 2. Supervised exercises 3. Oral assessment 4. Written assessment 5. Observation 6. Portfolio of Evidence

3. Apply complex numbers	3.1 Meaning of complex numbers 3.2 Stating complex numbers in numbers in terms of conjugate argument and 3.3 Modulus 3.4 Representation of complex numbers on the Argand diagram 3.5 Arithmetic operation of complex numbers 3.6 Application of De Moivre's theorem 3.7 Application of complex numbers to engineering	1. Assignments 2. Supervised exercises 3. Oral assessment 4. Written assessment 5. Observation 6. Portfolio of Evidence
4. Apply Coordinate Geometry	4.1 Polar equations 4.2 Cartesian equation 4.3 Graphs of polar equations 4.4 Normal and tangents 4.5 Definition of a point 4.6 Locus of a point in relation to a circle 4.7 Loci of points for given mechanism	1. Assignments 2. Supervised exercises 3. Oral assessment 4. Written assessment 5. Observation 6. Portfolio of Evidence
5. Carry out Binomial Expansion	5.1 Binomial theorem in determination of Roots of numbers 5.2 Estimation of errors of small changes using binomial theorem. 5.3 Binomial Expansion in 5.4 deriving power series	1. Assignments 2. Supervised exercises 3. Oral assessment 4. Written assessment 5. Observation 6. Portfolio of Evidence

Suggested Methods of Instruction

- Group discussions
- Demonstration by trainer
- Exercises by trainee

Recommended Resources for 30 Trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
1.	Textbooks	Engineering Mathematics by John bird 8th edition	6 pcs	1:5
2.		Engineering Mathematics by A.K stround 8th edition	6 pcs	1:5
3.		SMP	30	1:1
B	**Learning Facilities & infrastructure**			
1	Lecture/theory room	50 m^2	1	1:30
C	**Consumable materials**			
1.	Charts	Manila papers		
2.	marker pens	Erasable		
D	**Tools and Equipment**			
1.	Calculators	Scientific	30 pcs	1:1

ELECTRICAL MOTOR CONTROL SYSTEMS I

TVET CDACC UNIT CODE: ENG/CU/IC/CR/02/6/MA

ISCED UNIT CODE: 0713 551 12A

Relationship to Occupational Standards:

This unit addresses the unit title: Manage Electrical Motor Control Systems I

Duration of Unit: 150 hours

UNIT DESCRIPTION

This unit describes the competences required in order to Manage Electrical Motor Control Systems I. It involves applying workshop safety, using workshop tools, instruments and equipment, preparing workshop tools and instruments for an electrical installation practical, storing electrical tools and materials after practical, troubleshooting and repairing/ replacing workshop tools and equipment and safely install motor control equipment using best practices.

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Apply workshop safety procedures.	30
2.	Use workshop tools, instruments, and equipment correctly.	24
3.	Prepare workshop tools, instruments, and workspace for electrical installation practical.	12
4.	Store electrical tools and materials appropriately after practical.	18
5.	Troubleshoot and repair workshop tools and equipment.	24
6.	Safely install motor control equipment	42
TOTAL		**150**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods

1. Apply workshop safety	1.1 Meaning of PPE 1.1.1 Standard operating procedure in PPE 1.2 Workshop rules 1.3 Electrical hazards e.g. 1.3.1 Electric shock. 1.4 Fire 1.4.1 Classes of fire 1.4.2 Causes of fire 1.4.3 Various methods of fire extinguishing 1.5 First Aid	• Oral questioning • Written tests • Practical tests
2. Use of workshop tools, instruments and equipment	• Meaning of workshop tools, instruments and equipment • Uses of workshop tools, Instruments and equipment • Classification of workshop tools and equipment • Care and Maintenance of workshop tools and Instruments	• Oral questioning • Practical tests • Written tests
3. Prepare workshop tools and instruments for an electrical installation practical	3.1 Tools and instruments for an Electrical practical 1.1.1 Preparation of a list of tools and instruments for an Electrical practical. 1.1.2 Issuing and confirmation of tools and instruments before and after practical 3.2 Testing of practical tools and Instruments	• Observation • Oral questioning • Practical tests • Written tests
4. Store electrical tools and materials after practical	4.1 Classification of workshop tools and instruments. 4.2 Storage of workshop Tools and equipment 4.3 Waste disposal	• Observation • Oral questioning • Practical tests • Written tests
5. Troubleshoot and repair/replace	5.1 Meaning of troubleshooting 5.2 Common faults in Electrical equipment	• Observation • Oral questioning • Practical tests

workshop tools and equipment	5.3 Fault diagnosis procedure 5.4 Repair/Replace of components in Electrical equipment	• Written tests
6. Install motor control equipment	6.1 Electrical drawings are interpreted in accordance with electrical and electronics regulations. 6.1.1 Single Line Diagrams 6.1.2 Wiring Diagrams 6.1.3 Layout Diagram 6.1.4 Schematic Diagrams 6.2 Components are identified and selected for installation in accordance with the drawing. 6.2.1 Selection criteria 6.2.1.1 Component Voltage rating 6.2.1.2 Current rating 6.2.1.3 Short circuit rating 6.2.1.4 Size 6.2.1.5 Terminals 6.3 Tools are selected for installation as per the circuit components and parts. 6.3.1 Selection criteria 6.3.1.1 Component specific requirements 6.3.1.2 Safety compliance 6.3.1.3 Tool quality 6.3.1.4 Task specific 6.4 Motor control system is installed as per the design. 6.4.1 Motor Control 6.4.1.1 Manual Starters 6.4.1.2 Direct-on-line starters 6.4.1.3 Star-Delta Starters 6.4.1.4 Variable Frequency Drive 6.4.1.5 Servo Drives 6.4.1.6 Stepper Motor Control	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests • Observation

	6.5 Electrical control circuit is energized and tested in accordance with the intended design drawings. 1.5.1 Pre-Energization checks 1.5.2 Safety Preparation 1.5.3 Power Up Control Circuit 1.5.4 Validate Logic Operation 1.5.5 Post Energization Test	

Recommended Resources for 30 Trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
1.	Textbooks	V.K Mehta Principles of Electrical Machines B. Scaddan Electrical installation work J. Hyde Electrical installation Principles and Practices	5 pcs	1:5
2.	Installation manuals	Electrical machine manuals	5 pcs	1:5
3.	Charts	Single line diagram Motor starting circuits Circuit diagrams Colour codes	1 pcs for each	1:30
4.	Power point presentations	For trainer's use	1	1:30

B	**Learning Facilities & infrastructure**			
6.	Lecture/theory room	60m^2	1	1:30
7.	Workshop	150m^2	1	1:30
8.	Site			
C	**Consumable materials**			
9.	Electrical wires	1.5mm^2(red, black green)	5 rolls	1:5
		2.5mm^2(red, black green)	5 rolls	1:5
		4.0 mm^2(red, black green)	3 rolls	1:10
		6.0 mm^2(red, black green)	2 rolls	1:12
		10 mm^2(red, black green)	2 rolls	1:12
10.	Insulation tapes		30 pcs	1:1
11.	Accessories	Push buttons, relays, Timers, contactors, Thermo overloads, DIN rail, Circuit breakers, TPN	30 pcs	1:1
12.	Pipes and trunkings	PVC conduits, Steel conduits, Mini trunking	30 pcs	1:1
D	**Tools and Equipment**			
13.	3-Phase motors		5 pcs	1:5
14.	Synchronous Motors		5 pcs	1:5
15.	Single Phase motors		5 pcs	1:5
16.	Electric Generator		5 pcs	1:5
17.	DC motors		5 pcs	1:5

18.	Hacksaws		30 pcs	1:1
19.	Striping knives		30 pcs	1:1
20.	Side cutters		30 pcs	1:1
21.	Pliers		30 pcs	1:1
22.	Tape measure		30 pcs	1:1
23.	Try Square		30 pcs	1:1
24.	Spirit level		30 pcs	1:1
25.	Assorted Screw driver		30 pcs	1:1
26.	Assorted hammers		30 pcs	1:1
27.	Crimping tools		5 pcs	1:5
28.	PPEs		30 pcs	1:1
29.	Multimeters		5 pcs	1:5
30.	Clamp meters		5 pcs	1:5
31.	Earth resistance meter		5 pcs	1:5
32.	Stocks & Dies		5 pcs	1:5
33.	Vices		5 pcs	1:5
34.	Oscilloscope		5 pcs	1:5
35.	Pipe bending Machine		5 pcs	1:5
36.	Bending spring		5 pcs	1:5
37.	Drilling machines		5 pcs	1:5
38.	Work stations		30	1:1
39.	Installation boards		13 pcs	1:2

WORK ETHICS AND PRACTICES

TVET CDACC UNIT CODE: ENG/CU/IC/BC/03/6/MA

ISCED UNIT CODE: 0417 551 03A

Relationship to Occupational Standards
This unit addresses the Unit of Competency: Apply work ethics and practices.

Duration of Unit: 40 hours

Unit Description

This unit covers competencies required to demonstrate employability skills. It involves the ability to: conduct self-management, promote ethical work practices and values, promote teamwork, manage workplace conflicts, maintain professional and personal development, apply problem-solving, and promote customer care.

Summary of Learning Outcomes

By the end of this unit, the learner should be able to:

S/No	Learning Outcomes	Duration (Hours)
1.	Apply self-management skills	10
2.	Promote ethical work practices and values	4
3.	Promote team work	10
4	Maintain professional and personal development	10
5	Apply problem solving skills	4
6	Promote customer care	2
	Total	**40**

Learning Outcomes, Content, and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Apply self-management skills	1.1 Self-awareness 1.2 Formulating personal vision, mission, and goals	• Observation • Portfolio of evidence • Project

Learning Outcome	Content	Suggested Assessment Methods
	1.3 Healthy lifestyle practices 1.4 Strategies for overcoming work challenges 1.5 Emotional intelligence 1.6 Coping with Work Stress. 1.7 Assertiveness versus aggressiveness and passiveness 1.8 Developing and maintaining high self-esteem 1.9 Developing and maintaining positive self-image 1.10 Time management 1.11 Setting performance targets 1.12 Monitoring and evaluating performance targets	• Practical • Written assessment • Oral assessment
2. Promote ethical work practices and values	2.1 Integrity 2.2 Core Values, ethics and beliefs 2.3 Patriotism 2.4 Professionalism 2.5 Organizational codes of conduct 2.6 Industry policies and procedures	• Portfolio of evidence • Project • Practical • Observation • Written assessment • Oral assessment
3. Promote teamwork	3.1 Types of teams 3.2 Team building 3.3 Individual responsibilities in a team 3.4 Determination of team roles and objectives 3.5 Team parameters and relationships 3.6 Benefits of teamwork 3.7 Qualities of a team player 3.7.1 Leading a team	• Observation • Written assessment • Oral assessment • Portfolio of evidence • Project • Practical

Learning Outcome	Content	Suggested Assessment Methods
	3.7.2 Team performance and evaluation 3.7.3 Conflicts and conflict resolution 3.7.4 Gender and diversity mainstreaming 3.7.5 Developing Healthy workplace relationships 3.7.6 Adaptability and flexibility 3.7.7 Coaching and mentoring skills	
4. Maintain Professional and Personal Development	4.1.Personal vs professional development and growth 4.2.Avenues for professional growth 4.3.Recognizing career advancement 4.4.Training and career opportunities 4.5.Assessing training needs 4.6.Mobilizing training resources 4.7.Licenses and certifications for professional growth and development 4.8.Pursuing personal and organizational goals 4.9.Managing work priorities and commitments 4.10. Dynamism and on-the-job learning	● Project ● Practical ● Observation ● Written assessment ● Oral assessment ● Portfolio of evidence
5. Apply problem-solving skills	5.1 Causes of problems 5.2 Methods of solving problems 5.3 Problem-solving process 5.4 Decision making	● Observation ● Project ● Portfolio of evidence ● Practical ● Written assessment

Learning Outcome	Content	Suggested Assessment Methods
	5.5 Creative thinking and critical thinking process in development of innovative and practical solutions	• Oral assessment
6. Promote customer care	6.1 Identifying customer needs 6.2 Qualities of good customer service 6.3 Customer feedback methods 6.4 Resolving customer concerns 6.5 Customer outreach programs 6.6 Customer retention	• Observation • Project • Practical • Portfolio of evidence • Written assessment • Oral assessment

Suggested Methods of Instruction

- Practical
- Projects
- Demonstrations
- Group discussions
- Direct instruction

Recommended Resources for 25 Trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
1)	Power point presentations	For trainer's use	1	1:25
2)	Charts	For trainees and Trainer's use	6-10	1:5 pr 1:10
3)	Video clips	For trainees and Trainer's use	Varies	Varies
4)	Audio tapes	For trainees and Trainer's use	Varies	Varies
B	**Learning Facilities & infrastructure**			

5)	Lecture/theory room	For Trainer/trainee's use	1	1:25
6)	Computers	For trainee's use	25	1:1
7)	Radio sets	For trainee's use	3-5	1:5 or 1:10
8)	TV sets	For trainee's use	3-5	1:5 or 1:10
C	**Consumable materials**			
9)	Stationery	For trainees and trainer's use	Varies	Varies
D	**Tools and Equipment**			
10)	LCD projectors	For trainer's use	1	1:25

MODULE III

ENGINEERING MATHEMATICS II

TVET CDACC UNIT CODE: ENG/CU/IC/CC/03/6/MA

ISCED UNIT CODE: 0541 541 07A

Relationship to Occupational Standards

This unit addresses the unit of competency: Apply Engineering Mathematics II

Duration of Unit: 140 hours

Unit Description

This unit describes the competencies required by an Industrial Control Installation technician to apply a wide range of Engineering mathematics in their work. This includes,applying Statistics, Vector theory, Matrix and Probability.

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Apply Statistics	30
2.	Apply Vector theory	45
3.	Apply Matrix	30
4.	Apply concept of probability for work	35
TOTAL		**140**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Apply Statistics	1.1 Classification of data 1.1.1 Grouped data 1.1.2 Ungrouped data 1.2 Data collection 1.2.1 Importance of sampling 1.2.2 Errors in sampling 1.2.3 Types of sampling and their limitations 1.3 Tabulation of data	• Assignments • Oral questioning • Supervised exercises • Written tests • Simulation • Data modelling

		1.3.1 Class intervals 1.3.2 Class boundaries 1.3.3 Frequency tables 1.3.4 Cumulative frequency 1.4 Diagrammatic and graphical presentation of data e.g. 1.4.1 Histograms 1.4.2 Frequency polygons 1.4.3 Bar charts 1.4.4 Pie charts 1.4.5 Curves 1.5 Measures of central tendency (mean, mode and median) 1.6 Measures of dispersion 1.6.1 Variance and standard deviation	
2	Apply Vector theory	2.1 Definition of dot and cross product of vectors 2.2 Solution of problems involving dot and cross production of cross 2.3 Definition of operators 2.4 Definition of vector field 2.5 Solutions of problems involving vector fields 2.6 Definition of Gradient, Divergence and curl 2.7 Solutions of involving Gradient, Divergence and curl 2.8 Application of vectors 2.9 Green's, Gauss's and Stoke's theorem and their application	• Assignments • Oral questioning • Supervised exercises • Written tests
3	Apply Matrix methods	3.1 Matrix operation 3.2 Determinant of 3x3 matrix 3.3 Inverse of 3x3 matrix 3.4 Solutions of linear simultaneous equations in three unknowns	• Assignments • Oral questioning • Supervised exercises • Written tests

		3.5 Calculations of Eigen values and Eigen vectors 3.6 Application of matrices	
4	Apply concepts of probability in work	4.1 Probability 4.1.1 Laws of probability 4.2 Expectation variance and S.D. 4.3 Types of distributions 4.4 Mean, variance and S.D of probability distributions 4.5 Types of probability events 4.5.1 Dependent 4.5.2 Independent 4.5.3 Mutually exclusive 4.6 Counting techniques 4.6.1 Permutation 4.6.2 Combination 4.6.3 Tree diagrams 4.6.4 Venn diagrams 4.7 Application of probability distributions	• Assignments • Oral questioning • Supervised exercises • Written tests

Suggested Methods of Instruction

- Group discussions
- Demonstration by trainer
- Exercises by trainee

Recommended Resources for 30 Trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
4.	Textbooks	Engineering Mathematics by John bird 8th edition	6 pcs	1:5

5.		Engineering Mathematics by A.K stround 8th edition	6 pcs	1:5
6.		SMP	30	1:1
B	**Learning Facilities & infrastructure**			
2	Lecture/theory room	50 m^2	1	1:30
C	**Consumable materials**			
3.	Charts	Manila papers		
4.	marker pens	Erasable		
D	**Tools and Equipment**			
2.	Calculators	Scientific	30 pcs	1:1

ELECTRICAL MOTOR CONTROL SYSTEMS II

TVET CDACC UNIT CODE: ENG/CU/IC/CR/03/6/MA

ISCED UNIT CODE: 0713 551 13A

Relationship to Occupational Standards:

This unit addresses the unit title: Manage Electrical Motor Control Systems II

Duration of Unit: 140 hours

UNIT DESCRIPTION

This unit describes the competences required in order to Manage Electrical Motor Control Systems II. It involves Designing and developing motor control systems, Troubleshooting and repairing electrical motor control systems, maintaining motor control system and Preparing motor control technical reports and workplace records

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Design and develop motor control systems	37
2.	Troubleshoot and repair electrical motor control systems	37
3.	Maintain motor control systems	30
4.	Prepare motor control technical reports and workplace records	36
TOTAL		**140**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Design and develop motor control systems	1.1 Electrical drawing is prepared in accordance with electrical and electronics' regulations. 1.1.1 Electrical standard symbols	• Practical • Portfolio of evidence • Third party report • Oral questioning

	1.1.2 Component codes 1.1.3 CAD tools 1.1.4 Component Labelling 1.2 Components values and ratings are calculated and determined in accordance with standard electrical design principles. 1.2.1 Motor load current 1.2.2 Conductor size 1.2.3 Protection Device rating 1.2.4 Capacitor values 1.2.5 Contactor rating 1.3 Motor control prototype is built as per the drawing in accordance with electrical and electronic regulations 1.3.1 Preparation 1.3.2 Assembly 1.3.3 Wiring 1.3.4 Compliance checks 1.3.5 Initial Test 1.4 Motor control prototype is simulated and operational response and behavior analyzed and compared with set objectives. 1.4.1 Preparation 1.4.1.1 Technical drawings 1.4.1.2 Test environment 1.4.1.3 Test instruments 1.4.2 Pre simulation checks 1.4.3 Simulation setup 1.4.4 Simulation run 1.4.5 Simulation records 1.5 Motor control prototype test data is developed and documented in	• Written tests

		accordance with workplace procedures. 1.5.1 Test Data 1.5.2 Electrical measurements 1.5.2.1 Current 1.5.2.2 Voltage 1.5.3 Timing measurements 1.5.3.1 Start/Stop response time 1.5.3.2 Timer relay delay 1.5.4 Protection Test 1.5.4.1 Overload trip current setting 1.5.4.2 Short circuit protection	
2	Troubleshoot and repair electrical motor control systems	2.1 Motor control diagnostic/troubleshooting tools are selected in accordance with task requirements. 2.1.1 Diagnostic/Troubleshooting tools 2.1.1.1 Electrical measuring tools 2.1.1.2 Signal and Control testing tools 2.1.1.3 Mechanical and Thermal Diagnostic tools 2.1.1.4 Specialized equipment 2.1.2 Section criteria 2.1.2.1 Identification of problem 2.1.2.2 Review of schematic 2.1.2.3 Choice of tool 2.1.2.4 Tool Calibration 2.2 Motor control faulty components are identified, replaced or repaired in	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	accordance with manufacturers' specifications. 2.2.1 Identification of Faulty Components 2.2.1.1 Review Test 2.2.1.2 Visual Inspection 2.2.1.3 Electrical tests 2.2.1.4 Manufacturer datasheet 2.2.2 Replacement/Repair 2.2.3 Test after repair 2.2.3.1 Continuity test 2.2.3.2 Insulation Test 2.2.3.3 Functional Test 2.3 Motor control system functional test(s) are carried out on motor controls. 2.3.1 Power-on Test 2.3.1.1 Start/Stop Control 2.3.1.2 Direction Control 2.3.1.3 Protection Control 2.3.1.4 Sequence/Timer Functions 2.3.1.5 Indicator lamps signal 2.4 Motor control Job rectification card(s) are filled out.	
3 Maintain motor control systems	3.1 Maintenance schedule is prepared according to workplace procedures. 3.1.1 Equipment Inventory 3.1.2 Maintenance Tasks 3.1.3 Frequency 3.1.4 Responsible party 3.1.5 Tools/Equipment 3.1.6 Safety 3.2 Maintain motor control maintenance procedure manuals are acquired and materials/tools/equipment list prepared	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	and selected in accordance with task requirements. 3.2.1 Acquiring Maintenance Manuals 3.2.1.1 Workplace Archives 3.2.1.2 Manufacturer/ Component supplier 3.2.1.3 On line Database 3.3 Motor control system is inspected, serviced, and routine functional tests carried out in accordance with maintenance procedure manuals 3.1.1 Inspection 3.1.1.1 Contactor/ Relays 3.1.1.2 Wiring and Cables 3.1.1.3 Motor Control panel 3.1.1.4 Safety Devices 3.1.2 Servicing 3.1.2.1 Lubrication 3.1.2.2 Cleaning 3.1.2.3 Torque checks 3.4 Functional anomalies are identified, isolated and tagged as per the installation and tag out procedure(s). 3.4.1 Anomalies 3.4.1.1 Overheating 3.4.1.2 Intermittent Operation 3.4.1.3 Excessive Vibration 3.4.2 Isolation Procedures 3.4.2.1 De-Energize 3.4.2.2 Verification of zero energy 3.4.2.3 LOTO	

		3.5 Motor control system maintenance job cards are filled out in accordance with the workplace procedures.	
4	Prepare motor control technical reports and workplace records	4.1 Motor control design, installation procedures, trouble-shooting methods and maintenance data/information are gathered and formulated in the required sequence and format. 4.1.1 Documented Information 4.1.1.1 Design specifications 4.1.1.2 Installation Procedures 4.1.1.3 Troubleshooting guides 4.1.1.4 Maintenance record 4.1.2 Documentation format 4.1.2.1 Checklists 4.1.2.2 Flowcharts 4.1.2.3 Technical Reports 4.2 Motor control report structure, presentation style and format is determined according to standard operating procedures 4.2.1 Title page 4.2.2 Executive summary 4.2.3 Introduction 4.2.4 Methodology 4.2.5 Findings 4.2.6 Recommendations 4.2.7 Appendices 4.3 Motor control technical report is developed and shared in accordance with standard guidelines and procedures. 1.3.1 Email	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	1.3.2 Cloud Storage 1.3.3 Printed copies 1.3.4 Team message Apps 4.4 Workplace records are maintained in accordance with standard operating procedures 4.5 Workplace records, catalogues and other required business documents are created and maintained as per industry-accepted procedures. 4.1.1 Technical Records 4.1.1.1 High-voltage system installation logs. 4.1.1.2 Maintenance and repair records. 4.1.1.3 Test and inspection reports. 4.1.1.4 Equipment calibration records. 4.1.2 Catalogues 4.1.2.1 Manufacturer equipment catalogues and datasheets. 4.1.2.2 Spare parts lists and inventory records. 4.1.3 Business Documents 4.1.3.1 Purchase orders for HV parts and equipment. 4.1.3.2 Quotations and supplier contracts. 4.1.3.3 Job cards and rectification forms. 4.1.3.4 Training attendance records for HV safety	

Recommended resources for 25 Trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
5.	Textbooks	V.K Mehta Principles of Electrical Machines B. Scaddan Electrical installation work J. Hyde Electrical installation Principles and Practices	5 pcs	1:5
6.	Installation manuals	Electrical machine manuals	5 pcs	1:5
7.	Charts	Single line diagram Motor starting circuits Circuit diagrams Colour codes	1 pcs for each	1:25
8.	Power point presentations	For trainer's use	1	1:25
B	**Learning Facilities & infrastructure**			
40.	Lecture/theory room	$60m^2$	1	1:25
41.	Workshop	$150m^2$	1	1:25
42.	Site			
C	**Consumable materials**			
43.	Electrical wires	$1.5mm^2$(red, black green)	5 rolls	1:5
		$2.5mm^2$(red, black green)	5 rolls	1:5
		4.0 mm^2(red, black green)	3 rolls	1:10

		6.0 mm^2(red, black green)	2 rolls	1:12
		10 mm^2(red, black green)	2 rolls	1:12
44.	Insulation tapes		25 pcs	1:1
45.	Accessories	Push buttons, relays, Timers, contactors, Thermo overloads, DIN rail, Circuit breakers, TPN	25 pcs	1:1
46.	Pipes and trunkings	PVC conduits, Steel conduits, Mini trunking	25 pcs	1:1
D	**Tools and Equipment**			
47.	3-Phase motors		5 pcs	1:5
48.	Synchronous Motors		5 pcs	1:5
49.	Single Phase motors		5 pcs	1:5
50.	Electric Generator		5 pcs	1:5
51.	DC motors		5 pcs	1:5
52.	Hacksaws		25 pcs	1:1
53.	Striping knives		25 pcs	1:1
54.	Side cutters		25 pcs	1:1
55.	Pliers		25 pcs	1:1
56.	Tape measure		25 pcs	1:1
57.	Try Square		25 pcs	1:1
58.	Spirit level		25 pcs	1:1
59.	Assorted Screw driver		25 pcs	1:1
60.	Assorted hammers		25 pcs	1:1
61.	Crimping tools		5 pcs	1:5

62.	PPEs		25 pcs	1:1
63.	Multimeters		5 pcs	1:5
64.	Clamp meters		5 pcs	1:5
65.	Earth resistance meter		5 pcs	1:5
66.	Stocks & Dies		5 pcs	1:5
67.	Vices		5 pcs	1:5
68.	Oscilloscope		5 pcs	1:5
69.	Pipe bending Machine		5 pcs	1:5
70.	Bending spring		5 pcs	1:5
71.	Drilling machines		5 pcs	1:5
72.	Work stations		25	1:1
73.	Installation boards		13 pcs	1:2

TECHNICAL DRAWING

TVET CDACC UNIT CODE: ENG/CU/IC/CC/04/6/MA

ISCED UNIT CODE: 0732 541 08A

Relationship to Occupational Standards
This unit addresses the unit of competency: Prepare and Interpret Technical Drawings

Duration of Unit: 150 hours

UNIT DESCRIPTION
This unit covers the competencies required to prepare and interpret technical drawings. It involves selecting, using and maintaining drawing equipment and materials, producing plain geometry drawings, solid geometry drawings, pictorial and orthographic drawings and applying Computer Aided Design (CAD) packages.

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Use and maintain drawing equipment and materials	22
2.	Produce plane geometry drawings	26
3.	Produce solid geometry drawings	13
4.	Produce orthographic drawings and pictorial drawings	44
5.	Produce electrical drawings	13
6.	Apply CAD packages	32
TOTAL		**150**

Learning Outcomes, Content and Suggested Assessment Methods:

Learning Outcome	Content	Suggested Assessment Methods
1. Use and maintain drawing equipment and materials	1.1 Identification and care of drawing equipment 1.2 Identification and care of drawing materials	• Observation • Oral questioning • Written tests • Portfolio of evidence

Learning Outcome	Content	Suggested Assessment Methods
	1.3 Reference to manufacturer's instructions and work place procedures on use and maintenance of drawing equipment and materials 1.4 Reference to relevant environmental legislations 1.5 Use of Personal Protective Equipment (PPEs)	
2. Produce plane geometry drawings	2.1 Types of lines in drawings 2.2 Construction of geometric forms e.g. squares, circles 2.3 Construction of different angles 2.4 Measurement of different angles 2.5 Bisection of different angles and lines 2.6 Standard drawing conventions	• Practical • Demonstration • Projects • Written tests • Oral test
3. Produce solid geometry drawings	3.1 Interpretation of sketches and drawings of patterns e.g. cylinders, prisms and pyramids 3.2 Sectioning of solids e.g. prisms, cones 3.3 Development and interpenetrations of solids e.g. cylinder to cylinder and cylinder to triangular, prism	• Practical • Demonstration • Projects • Written tests • Oral test
4. Produce orthographic drawings and pictorial drawings	4.1 Meaning of pictorial and orthographic drawings 4.2 Meaning of sectioning 4.3 Meaning of symbols and abbreviations 4.4 Drawing and interpretation of orthographic elevations 4.5 Dimensioning of orthographic elevations 4.6 Sectioning of views 4.7 Assembly drawing	• Practical • Demonstration • Projects • Written tests • Oral test

Learning Outcome	Content	Suggested Assessment Methods
	4.8 Meaning of pictorial drawings 4.9 Drawing objects in isometric view 4.10 Drawing objects in oblique view	
5. Produce electrical drawings	5.1 Electrical symbols and abbreviations 5.2 Meaning of electrical drawings 5.3 Drawing of electrical diagrams e.g. block, schematic, circuit, line and wiring	• Practical • Demonstration • Projects • Written tests • Oral test
6. Apply CAD packages	6.1 Identification of CAD packages e.g. AutoCAD, circuit maker 6.2 Use of CAD packages in drawing of: 6.3 Plane geometry 6.4 Solid 6.5 Orthographic 6.6 Pictorial 6.7 Electrical e.g. block, schematic, circuit, line and wiring	• Practical • Demonstration • Projects • Written tests • Oral test

Suggested Methods of Instruction

- Projects
- Demonstration by trainer
- Practice by the trainee
- Discussions

Recommended Resources for 30 trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)

A	**Learning Materials**			
1.	Textbooks	K.Morling Geometric and Engineering drawing	6 pcs	1:5
2.	Drawing instruments	T-squares, set squares, drawing sets, Masking tapes	30	1:1
3.	Power point presentations	For trainer's use	1	1:30
B	**Learning Facilities & infrastructure**			
4.	Lecture/theory room	$50m^2$	1	1:30
5.	Drawing tables		30	1:1

MODULE IV

ENGINEERING MATHEMATICS III

TVET CDACC UNIT CODE: ENG/CU/IC/CC/05/6/MA

ISCED UNIT CODE: 0541 541 09A

Relationship to Occupational Standards

This unit addresses the unit of competency: Apply Engineering Mathematics III

Duration of Unit: 140 hours

Unit Description

This unit describes the competencies required by an Industrial Control and Installation technician to apply a wide range of Engineering mathematics in their work. This includes Calculus, ordinary differential equations, Laplace transforms and commercial calculations.

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Apply Calculus	47
2.	Solve Ordinary differential equations	30
3.	Apply Laplace transforms	30
4.	Perform commercial calculations	38
TOTAL		**140**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods

1. Apply Calculus	1.1 Meaning of derivatives of a function 1.2 Differentiation from first principle i.e sin x, cos x, x^n and ln x 1.3 Tables of some common derivatives 1.4 Rules of differentiation i.e. product, chain, quotient, sum, implicit 1.5 Rate of change and small change 1.6 Derivative of inverse functions 1.7 Stationery points of functions of two variables 1.8 Meaning of integration 1.9 Indefinite and definite integral 1.10 Methods of integration, application of integration i.e., Integration by parts, Substitution, polynomials, inverse functions 1.11 Integrals of hyperbolic and inverse functions	• Written tests • Oral questioning • Assignments • Supervised exercises
2. Solve Ordinary differential equations	2.1 Types of first order differential equations 2.1.1 Linear Differential Equations 2.1.2 Homogeneous Equations 2.1.3 Exact Equations 2.1.4 Separable Equations 2.1.5 Integrating Factor 2.2 Formation of first order differential equation 2.3 Solution of first order differential equations 2.4 Application of first order differential equations	• Written tests • Oral questioning • Assignments • Supervised exercises

	2.5 Formation of second order differential equations for various systems 2.6 Solution of second order differential equations 2.7 Application of second order differential equations	
3. Apply Laplace transforms	3.1 Meaning of Laplace transforms 3.2 Deriving Laplace transforms from first principles 3.3 State properties of Laplace transform 3.4 Determination of inverse LT of simple transforms and partial fractions 3.5 Solution of differential equation by LT 3.6 Solution of simultaneous differential equation by given initial conditions	• Written tests • Oral questioning • Assignments • Supervised exercises
4. Perform commercial calculations	4.1 Product pricing 4.2 Average sales determination 4.3 Stock turnover 4.4 Calculation of incomes 4.5 Profit and loss calculations 4.6 Salaries 4.6.1 Gross 4.6.2 Net 4.7 Wages 4.7.1 Time rate 4.7.2 Flat rate 4.7.3 Overtime 4.7.4 Piece rate 4.7.5 Commission 4.7.6 Percentage 4.7.7 Bonus 4.8 Conversion of one currency to another 4.9 Exchange rates calculation	• Oral questioning • Written tests • Assignments • Supervised exercises

	4.9.1 Devaluation 4.9.2 Revaluation	

Suggested Methods of Instruction

- Group discussions
- Demonstration by trainer
- Exercises by trainee

List of Recommended Resources for 30 trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
1.	Textbooks	Engineering Mathematics by K.A. Stroud Advanced Engineering Mathematics by Erwin Kreyszig	6 pcs 6 pcs	1:5 1:5
B	**Learning Facilities & infrastructure**			
2.	Lecture/theory room	$60m^2$	1	1:30
3.	Computer	Operating System: 64-bit Windows 11 or 10 version 1809 or above Processor: 2.5 GHz (3+ GHz recommended), Memory: 8 GB (32GB recommended) Disk space: 10 GB	30 pcs	1:1

		Display: 1920 x 1080 resolution Display Card: 2 GB GPU (8 GB recommended) and DirectX 11 compliant (DirectX 12 recommended)		
4.	Projector		1	1:30
5.	Interactive screen	Specifications: 77-inch interactive whiteboard with touch and pen functionality.	1	1:30
C	**Software**			
6.	MATLAB	License: Educational licenses available. Features: Matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, interfacing with programs in other languages.	Installed in 30 computers	1:1
7.	GeoGebra	License: Free educational software. Interactive geometry, algebra, statistics, and calculus applications	Installed in 30 computers	1:1
D	**Consumables**			

8.	Pens, pencils, rulers and paper	Whiteboard markers, 2H pencils, plastic rulers, A2 white papers	Enough	

PLC SYSTEM INSTALLATION AND MAINTANANCE

TVET CDACC UNIT CODE: ENG/CU/IC/CR/04/6/MA

ISCED UNIT CODE: 0715 551 14A

Relationship to occupational standards

This unit addresses the unit of competency: install and maintain plc systems.

Duration of unit: 240 hours.

Unit description

This unit describes the competences required required by an industrial mechatronic technician in order to install and maintain plc systems. It involves mounting PLC hardware, interfacing PLC I/O modules, programming PLC, and maintaining PLC systems

Summary of learning outcomes

By the end of unit of learning, the trainee will be able to;

S/No.	Learning outcomes	Duration (Hrs)
1	Mount PLC hardware	60
2	Interface PLC with I/O modules	60
3	Program PLC	60
4	Maintain PLC Systems	60
	TOTAL	**240**

Learning outcomes, content and suggested assessment methods

Learning Outcome	Content	Suggested assessment methods
1. Mount PLC hardware	1.1 Health and safety; 1.1.1 Operator safety 1.1.2 PPEs 1.1.3 Work permits	• Practical assessment • Oral presentations • Observations

Learning Outcome	Content	Suggested assessment methods
	1.1.4 Waste management 1.1.5 Electrical wiring colour coding 1.1.6 Danger warning signage 1.1.7 Barricades 1.1.8 High voltage signage 1.1.9 Health policy 1.2 Selection of tools and equipment in PLC hardware mounting, 1.2.1 Clamp-meter 1.2.2 Multi-meter 1.2.3 Ethernet crimping tools 1.2.4 Set of screwdrivers 1.2.5 Set of wrenches 1.2.6 Set of Pliers 1.3 Preparation of PLC installation cabinet 1.4 Installation of PLC hardware in the cabinet 1.4.1 Power supply 1.4.2 Input module 1.4.3 Output module 1.4.4 Processor (CPU) 1.4.5 Rack or mounting assembly 1.4.6 Indicator lights 1.5 PLC wiring 1.5.1 Interpretation of PLC hardware component manuals	• Trainee report • Supervisor's report • Online assignments • Case studies • Trainer report • Written assessments • Portfolio assessment

Learning Outcome	Content	Suggested assessment methods
	1.5.2 Interpretation of PLC software manuals 1.5.3 Interpretation of I/O modules installation manuals 1.5.4 Interpretation of installation drawings 1.5.5 Interpretation of electrical wiring drawings 1.5.6 Electrical wiring standards, codes and procedures 1.6 Practice: Cabinet preparation and hardware installation	
2 Interface PLC with I/O modules	2.1 PLC network working cables 2.1.1 Ethernet cable 2.1.2 USB Cable 2.1.3 Serial Cable 2.1.4 Profinet cables 2.1.5 Profibus cables 2.1.6 Coaxial cables 2.2 Fiber optic cables PLC cable layout and cable management 2.3 Network cables termination 2.4 Network cables testing 2.4.1 Professional testers 2.4.2 Continuity testers 2.4.3 LAN cable tester 2.4.4 Phone line tester	• Practical assessment • Oral presentation • Observations • Trainee assessment • Supervisor's report • Online assignments

Learning Outcome	Content	Suggested assessment methods
	2.5 PLC device communication protocols and channels 2.6 PLC memory addressing 2.7 Human machine interface 2.8 Configuration of network ports 2.8.1 Ethernet ports 2.8.2 USB ports 2.8.3 HDMI ports 2.8.4 Mac serial ports 2.9 Practice: Network cable termination	
3 Program PLC	3.1 Installation of PLC programming software 3.1.1 RS Logix 3.1.2 Logosoft 3.1.3 Gx works 3.1.4 Step 5- Micro wins 3.1.5 Step 7- Simatic Manager 3.1.6 TIA portal 3.2 Configuration of PLC software and hardware 3.3 Flow diagrams 3.3.1 Cross functional flow diagrams 3.3.2 Swim lane flow diagrams 3.4 PLC programming languages 3.4.1 ladder logic 3.4.2 functional block diagrams	• Practical assessment • Oral presentations • Observations • Trainee report • Supervisor's report • Online assignments • Case studies • Trainer report • Written assessments • Portfolio assessment

Learning Outcome	Content	Suggested assessment methods
	3.4.3 Structured Text 3.4.4 Sequential Flow Charts 3.4.5 Instruction Lists 3.5 Creation of PLC, I/O schedules 3.6 PLC programming 3.6.1 PLC program structure 3.6.2 PLC rungs 3.7 Simulation of PLC program 3.8 Troubleshoot PLC program faults 3.8.1 I/O module failure 3.8.2 Power supply failure 3.8.3 Corrupted memory 3.8.4 Failed voltage supply 3.9 Reconfiguration of PLC programming software 3.10 PLC operation modes 3.11 Establishment of PLC communication 3.12 Clearance of PLC memory 3.13 Downloading of PLC program to PLC hardware 3.14 Practice: Developing and debugging PLC programs	
4 Maintain PLC systems	4.1 Environmental and safety standards 4.2 PLC program back-up 4.2.1 Extraction of PLC program 4.2.2 Recovery of PLC program	• Practical assessment • Oral presentations • Observations • Trainee report

Learning Outcome	Content	Suggested assessment methods
	4.3 PLC system tag out/Lock out and routine checks 4.4 PLC network data communication 4.5 Verification of I/O modules for normal operations 4.6 Verification of PLC's CPU optimum performance 4.7 Verification of sensors for normal performance 4.8 PLC system configuration 4.9 PLC modules 4.9.1 Power supply module (PS) 4.9.2 CPU 4.9.3 Interface module (IM) 4.9.4 Signal modules (SM) 4.9.5 Function module (FM) 4.9.6 Communication processor (CP) 4.10 Identification of PLC wires and cables 4.10.1 Terminal cables 4.10.2 Tag cables 4.11 Interpretation of schematic diagrams and maintenance manuals 4.12 Visual checks on PLC attachments 4.13 Cleaning of PLC systems and peripheral devices 4.14 Restoration of PLC program	• Supervisor's report • Online assignments • Case studies • Trainer report • Written assessments • Portfolio assessment

Learning Outcome	Content	Suggested assessment methods
	4.15 Format PLC system software 4.16 Maintenance of logging activities in maintenance management systems 4.17 Maintenance documentation 4.17.1 CPU module specification sheet 4.17.2 I/O terminal block specification sheet 4.17.3 Output specification sheet 4.17.4 DeviceNET link specification sheet 4.17.5 Flow diagrams 4.17.6 I/O schedule 4.17.7 PLC program 4.18 Practice: Prepare maintenance documentation report	

Suggested delivery methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Tools**			
1.	Ethernet crimping tool	For crimping jacks	5 pcs	1:5
2.	Set of screwdrivers	Flat and star-assorted sizes. For fastening screws	2 set each	-
3.	Set of wrenches	For tightening bolts and nuts in various sizes	5 pcs	1:5
4.	Clamp meter	For measuring current without connection to a circuit in series	5 pcs	1:5
5.	Continuity testers	For cable continuity testing	5 pcs	1:5
6.	LAN cable tester	For testing ethernet cables	5 pcs	1:5
7.	Phone line tester	For line fault diagnosis	5 pcs	1:5
B	**Materials and supplies**			
1.	Whiteboard markers	For writing on whiteboards during instruction	Adequate	
2.	PCB boards	For circuit assembly and testing	10 pcs	2:5
3.	Bolts, Nuts, and Washers	For securing components	Adequate	
4.	Fasteners	Used in assembly tasks	5 pcs	1:5

5.	Breadboards	For prototype circuit assembly	10 pcs	2:5
6.	Trunking	For organizing and protecting cables	Sufficient	
7.	DIN rail	For mounting components	Adequate	
8.	Sensors	Assorted-For PLC inputs	Adequate	
9.	PLC cables and wires	For PLC wiring	Adequate	
10.	Racks	For mounting PLC modules	Adequate	
c	**Equipment**			
1.	Projectors	For visual presentations	1	1:25
2.	Actuators	For demonstrating movement control	5 pcs	1:5
3.	PLC Modules	For programmable logic control setups	5 pcs	1:5
4.	HMI	For Human Machine Interface	5 pcs	1:5
5.	Power supplies	For powering PLC systems	5 pcs	1:5
6.	RCD	For electrical shock prevention	5 pcs	1:5
7.	Contactors	For PLC outputs	5 pcs	1:5
D	**Reference materials**			
1.	PLC maintenance manuals/handbooks	Manuals for reference on PLC maintenance	Adequate	
2.	Health and safety manuals	For workplace safety instructions	Adequate	

3.	PLC operation manuals	Comprehensive guides on PLC systems	Adequate	
4.	Relevant PLC textbooks	For refencing	Adequate	
5.	Relevant journals and websites	For refencing	Sufficient	N/A
E	**Software**			
1.	PLC software	For programming PLC	1 license (distributable)	N/A
	Trainee requirements			
1.	Computing Devices	Desktops, laptops, or tablets for individual use	25 pcs	1:1
2.	Personal PROTECTIVE EQUIPMENT (PPEs):	Overalls /dust coats, safety shoes, ear muffs, safety goggles, nose masks, helmets, welding ray protection shields	25 sets	1:1

ENTREPRENEURIAL SKILLS

TVET CDACC UNIT CODE: ENG/CU/IC/BC/04/6/MA

ISCED UNIT CODE: 0413 551 04A

Relationship to occupational standards
This unit addresses the unit of competency: Apply Entrepreneurial skills.

Duration of unit: 40 hours

Unit Description:

This unit covers the competencies required to demonstrate an understanding of entrepreneurship. It involves demonstrating an understanding of financial literacy, applying entrepreneurial concepts, identifying entrepreneurship opportunities, applying business legal aspects, and developing business innovative strategies and business plans.

Summary of Learning Outcomes

By the end of this unit, the learner should be able to:

S/No	Learning Outcomes	Duration (Hours)
1.	Apply financial literacy skills	6
2.	Apply the entrepreneurial concept	4
3.	Identify entrepreneurship opportunities	6
4	Apply business legal aspects	6
5	Innovate business strategies	6
6	Develop a business plan	12
	Total	**40**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Apply Financial Literacy	1.1.Personal finance management 1.2.Balancing between needs and wants 1.3. Budget Preparation	• Practical • Portfolio of evidence • Project • Observation

Learning Outcome	Content	Suggested Assessment Methods
	1.4.Saving management 1.5. Factors to consider when deciding where to save 1.6.Debt management 1.7.Factors to consider before taking a loan 1.8.Investment decisions 1.9.Types of investments 1.10. Factors to consider when investing money 1.11. Insurance services 1.12. insurance products available in the market 1.13. Insurable risks	• Written assessment • Oral assessment • Third party reports • Interviews
2.Apply Entrepreneurial Concept	2.1 Difference between Entrepreneurs and Business persons 2.2 Types of entrepreneurs 2.3 Ways of becoming an entrepreneur 2.4 Characteristics of Entrepreneurs 2.5 salaried employment and self-employment 2.6 Requirements for entry into self-employment 2.7 Roles of an Entrepreneur in an enterprise 2.8 Contributions of Entrepreneurship	• Observation • Project • Written assessment • Oral assessment • Third party report
3.Identify Entrepreneurship Opportunities	3.1 Sources of business ideas 3.2 Factors to consider when evaluating business opportunity 3.3 Business life cycle	• Observation • Project • Written assessment • Oral assessment • Third party report
4.Apply Business Legal	4.1 Forms of business	• Observation

Learning Outcome	Content	Suggested Assessment Methods
Aspects	ownership 4.2 Business registration and licensing processing 4.3 Types of contracts and agreements 4.4 Employment laws 4.5 Taxation laws	• Project • Written assessment • Oral assessment • Third party report
5.Innovate Business Strategies	5.1 Creativity in business 5.2 Innovative business strategies 5.3 Entrepreneurial Linkages 5.4 ICT in business growth and development	• Observation • Project • Written assessment • Oral assessment • Third party report
6.Develop Business Plan	6.1 Business description 6.2 Marketing plan 6.3 Organizational/Management 6.4 plan 6.5 Production/operation plan 6.6 Financial plan 6.7 Executive summary 6.8 Business plan presentation 6.9 Business idea incubation	• Observation • Written assessment • Project • Oral assessment • Third party report

Suggested Methods of Instruction

- Direct instruction with active learning strategies
- Project (Business plan)
- Case studies
- Field trips
- Group Discussions
- Demonstration
- Question and answer
- Problem solving
- Experiential
- Team training
- Guest speakers

Recommended Resources for 25 trainees

S/no.	Category/item	Description/specification	Quantity	Recommended ratio(item: trainee)
A.	**Learning materials**			
1.	Report writing templates	Digital report template	5	1:5
2.	Flashcards	Educational flash cards	5	1:5
3.	Flip charts	Educational flip charts	5	1:5
B.	**Learning facilities and infrastructure**			
1.	Lecture/theory room	$72m^2$	1	1:25
2.	Whiteboard	4 feet by 8 feet	1	1:25
3.	Projector	LCD High resolution	1	1:25
4.	Computers	RAM: 8GB	25	1:25
5.	Printers	Ink Jet	2	1:13
C.	**Consumable materials**			
1.	Printing Papers	A4	Enough for 25	1:25
2.	Assorted whiteboard markers	Non-permanent	Enough for 25	1:25
D.	**Tools and equipment**			
1.	Mobile phones	Functioning smart phone	Enough for 25	1:25

MODULE V

ENGINEERING MATHEMATICS IV

TVET CDACC UNIT CODE: ENG/CU/IC/CC/06/6/MA

ISCED UNIT CODE: 0541 541 10A

Relationship to Occupational Standards

This unit addresses the unit of competency: Apply Engineering Mathematics IV

Duration of Unit: 140 hours

Unit Description

This unit describes the competencies required by an Industrial Control and Installation to apply a wide range of Engineering mathematics in their work. This includes Laplace transforms, power series, Fourier Series, Numerical methods and estimations and measurements in solving problems.

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Apply Power Series	33
2.	Apply Fourier Series	33
3.	Apply Numerical methods	33
4.	Perform Estimations, Measurements and calculations of quantities	41
TOTAL		**140**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods
1. Apply Power Series	1.1 Meaning of the term power series 1.2 Taylor's theorem 1.3 Deduction of Maclaurin's theorem to obtain power series	• Written tests • Oral questioning • Assignments • Supervised exercises

	1.4 Application of Taylor's theorem and Maclaurin's theorems in numerical work	
2. Apply Fourier Series	2.1 Determination of the Fourier series as a periodic function of the period 2π and extend to π 2.2 Determination of Fourier series of non-periodic functions over a given range 2.3 Determination of Fourier series for even and odd functions and the half-range series for a given function 2.4 Determination of Fourier series over any range	• Assignments • Oral questioning • Supervised exercises • Written tests
3. Apply Numerical methods	3.1 Meaning of interpolation and extrapolation 3.2 Application of interpolation 3.3 Application of interactive methods to solve equations 3.4 Application of interactive methods to areas and volumes	• Assignments • Oral questioning • Supervised exercises • Written tests
4. Perform estimations, measurements and calculations of quantities	4.1 Units of measurements and their symbols 4.2 Conversion of units of measurement 4.3 Calculation of length, width, height, perimeter, area and angles of figures 4.4 Measuring tools and equipment 4.5 Measurements and estimations of quantities e.g., Areas and volumes using Pappus theorem	• Assignments • Oral questioning • Practical tests • Observation • Supervised exercises • Written tests

Suggested Methods of Instruction

- Group discussions
- Demonstration by trainer

- Exercises by trainee

List of Recommended Resources for 30 trainees

S/No.	Category/Item	Description/ Specifications	Quantity	Recommended Ratio (Item: Trainee)
A	**Learning Materials**			
1.	Textbooks	Engineering Mathematics by K.A. Stroud Advanced Engineering Mathematics by Erwin Kreyszig	6 pcs 6 pcs	1:5 1:5
B	**Learning Facilities & infrastructure**			
2.	Lecture/theory room	$60m^2$	1	1:30
3.	Computer	Operating System: 64-bit Windows 11 or 10 version 1809 or above Processor: 2.5 GHz (3+ GHz recommended), Memory: 8 GB (32GB recommended) Disk space: 10 GB Display: 1920 x 1080 resolution Display Card: 2 GB GPU (8 GB recommended) and DirectX 11 compliant	30 pcs	1:1

		(DirectX 12 recommended)		
4.	Projector		1	1:30
5.	Interactive screen	Specifications: 77-inch interactive whiteboard with touch and pen functionality.	1	1:30
C	**Software**			
6.	MATLAB	License: Educational licenses available. Features: Matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, interfacing with programs in other languages.	Installed in 30 computers	1:1
7.	GeoGebra	License: Free educational software. Interactive geometry, algebra, statistics, and calculus applications	Installed in 30 computers	1:1
D	**Consumables**			
8.	Pens, pencils, rulers and paper	Whiteboard markers, 2H pencils, plastic rulers, A2 white papers	Enough	

HIGH VOLTAGE SYSTEMS

TVET CDACC UNIT CODE: ENG/CU/IC/CR/05/6/MA

ISCED UNIT CODE: 0713 551 15A

Relationship to Occupational Standards:

This unit addresses the unit title: Manage High Voltage Systems

Duration of Unit: 180 hours

UNIT DESCRIPTION

This unit describes the competences required in order to Manage High Voltage Systems. It involves Determining high voltage systems location, ordering high voltage system components and Preparing High Voltage System Work plan, Installing High Voltage-associated equipment, using best practices, Troubleshooting and Repairing High Voltage Systems, Maintaining High Voltage Systems Maintaining and Preparing High Voltage Systems workplace records and Technical Reports

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Determine high voltage systems location	17
2.	Order high voltage system components and Prepare High Voltage System Work plan	17
3.	Install High Voltage-associated equipment, using best practices	52
4.	Troubleshoot and Repair High Voltage Systems	46
5.	Maintain High Voltage Systems	19
6.	Maintain and Prepare High Voltage Systems workplace records and Technical Reports	29
TOTAL		**180**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods

1. Determine high voltage systems location	1.1 High Voltage systems locations are selected in accordance with accepted IEEE standards. 1.1.1 Proximity to load centers 1.1.2 Environmental conditions 1.1.3 Soil and geological conditions 1.1.4 Safety and accessibility 1.1.5 Regulatory Compliance 1.1.6 Future Expansion 1.2 High voltage locations' earth is measured for resistivity and conductance. 1.2.1 Site assessment 1.2.2 Measurement methods 1.2.2.1 Weener 4-point Methods 1.2.2.2 Fall of potential Test 1.2.3 Equipment Preparation 1.2.4 Resistivity formula 1.3 High voltage locations are selected based on exposure to weather and climatic conditions. High voltage locations 1.3.1 Outdoor substations 1.3.2 Power Plants 1.3.3 Transmission lines/ Overhead lines 1.3.4 Underground cable routes routes	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests
2. Order high voltage system components and Prepare High Voltage System Work plan	2.1 High voltage components are selected based on electrical capacity, i.e. 2.1.1 ampacity, 2.1.2 insulation and 2.1.3 environmental conditions. 2.2 High voltage Work plans are developed congruent with the intended systems needs 2.2.1 Electrical load	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	requirements 2.2.2 Safety and Compliance needs 2.2.3 Reliability 2.2.4 Site specific needs i.e resistance, space 2.2.5 Future expansion 2.2.6 Cost 2.3 High voltage components are selected based on 2.3.1. consideration to cost, 2.3.2. longevity, 2.3.3. quality and availability.	
3. Install High Voltage-associated equipment, using best practices.	3.1 High voltage drawings are interpreted in accordance with electrical and electronics regulation. 3.1.1 High Voltage Drawings 3.1.2 Single Line Diagrams SLDs 3.1.3 Three line Diagrams 3.1.4 Substation Layout Diagrams 3.1.5 Protection and Control schematics 3.1.6 Cable routes and Trench layouts 3.1.7 Electrical and Electronics Regulations 3.1.8 IEEE 315 Standard for graphic symbols in electrical diagrams 3.2 High voltage tools are selected for installation as per the circuit components and parts. 3.2.1 Insulated screwdrivers (VDE-rated) 3.2.2 Insulated pliers/wrenches (1,000V+ rated)	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	3.2.3 Cable cutters (ASTM F1505 compliant) 3.2.4 High Voltage Detectors (e.g., proximity testers) 3.2.5 Phasing Sticks (for synchronizing circuits) 3.2.6 Megohmmeters (Meggers) (5kV–15kV range for insulation testing) 3.2.7 Partial Discharge (PD) Detectors 3.3 High Voltage systems are installed adhering to best safety practices. High Voltage Systems 3.4.3 Power Transmission systems 3.4.4 Substations systems 3.4.5 Steel mill arc furnaces 3.4.6 Large motor drives-compressors 3.4.7 HVDC systems 3.4 High voltage connections (i.e. splices, terminations) are installed correctly in accordance with IEEE standards and work place regulations. High voltage connectors 3.4.1 Heat- shrink terminators 3.4.2 Cold- shrink terminator 3.4.3 Ceramic terminators 3.4.4 Taped splices 3.4.5 Molded splices 3.4.6 Gas insulated Splices 3.4.7 Bolted Clamps IEEE Standards 3.4.8 IEEE 48 Cable termination 3.4.9 IEEE 404 Cable jointing 3.5 High voltage Switch gear is	

	installed correctly in accordance with IEEE standards and work place regulations. High Voltage switch gear 3.5.1 Air Insulated switch gear AIS 3.5.2 Gas Insulated switch gear GIS 3.5.3 Hybrid switch gear 3.5.4 Metal Clad switch gear IEEE Standards 3.5.5 IEEE C37.122 – GIS 3.5.6 IEEE 3007.2 – Bolted connections 3.6 Adherence to safety for the various voltages associated with HV systems: 125VDC, 240 VAC 1 Φ, 415 3 Φ AC, 660 3 Φ AC and above is demonstrated in accordance with IEEE regulations. IEEE regulations 3.6.1 IEEE 1584 – Insulated tools, LOTO 3.6.2 IEEE 3007.2- GFCI protection, Insulation 3.6.3 IEEE 1584 – Arc suits, Current limiting fuses 3.6.4 IEEE 80 – Hot sticks, SF6 Insulation 3.7 High voltage circuit is energized and tested in accordance with the design. 3.7.1 Pre energization checks; - Visual Inspection, Safety clearances 3.7.2 Insulation resistance 3.7.3 Contact resistance 3.7.4 High voltage Withstand 3.7.5 Phasing verification 3.7.6 Post energization tests;- voltage stability, harmonic distortion	

	3.8 High voltage lock-out/Tag-out procedures properly demonstrated in accordance with accepted safety regulations 3.8.1 Pre- LOTO preparations 3.8.1.1 Identifying energy sources 3.8.1.2 Notify affected personnel 3.8.1.3 Review schematics 3.8.2 Equipment shutdown 3.8.3 Lock-out/Tag out Application 3.8.4 Verification of Isolation 3.8.5 Safety during work 3.8.6 Restoring power 3.8.7 Safety regulations 3.8.7.1 OSHA 1910.147 General LOTO requirements 3.8.7.2 IEEE 3007.2 3.9 High voltage measuring devices for the presence of energy sources, i.e. electrical, pneumatic, springs, hydraulics, and heat and stored energy (capacitors & batteries) are properly used. 3.9.1 HV Multimeter 3.9.2 Digital Clamp meters 3.9.3 Phase Rotation meters 3.9.4 Capacitance meters	
4. Troubleshoot and Repair High Voltage Systems	4.1 Faults in High Voltage systems are accurately identified and located in accordance with task requirements. 4.1.1 Types of Faults 4.1.1.1 Insulation failure 4.1.1.2 Open Circuit 4.1.1.3 Arcing Fault 4.1.1.4 Ground Fault 4.1.1.5 Short Circuit 4.1.2 Fault Location 4.1.2.1 Visual Inspection 4.1.2.2 Electrical Tests	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	4.1.2.3 Arc reflection method 4.1.2.4 Surge pulse tests 4.2 High Voltage systems' circuit faults are analyzed. 4.2.1 Protective Relay Logs 4.2.2 Event Logs 4.2.3 Symmetrical components analysis 4.2.4 Sequence network diagrams analysis 4.3 Repair strategies and solutions are identified. 4.3.1 Component replacement 4.3.2 Refurbishment 4.3.3 Preventive maintenance 4.3.4 System reconfiguration 4.4 Faults in HV systems are predicted and located. 4.1.1 Visual inspection 4.1.2 Thermal imaging 4.1.3 Electrical Testing 4.5 Faulty HV equipment is located, replaced and/or repaired using manufacturers' specifications/catalogs and manuals. 4.1.4 Equipment model number 4.1.5 Technical specifications 4.1.6 Replacement part numbers 4.1.7 Recommended handling procedures 4.6 Parts and equipment due to faults in HV systems are replaced as per manufacture specifications. 4.6.1 Correct part selection 4.6.2 Documentation reference 4.6.3 Replacement procedures 4.7 Basic repairs on HV systems are conducted applying knowledge of proper design principles to read	

	and interpret relevant technical documents. 4.7.1 Design Principles 4.7.1.1 Electrical load capacity 4.7.1.2 Insulation 4.7.1.3 Fault current limits 4.7.1.4 Safety clearances 4.7.2 Technical documents 4.7.2.1 Single-line diagrams 4.7.2.2 Schematic diagrams 4.7.2.3 Manufacturer's manuals 4.7.2.4 Installation drawings 4.7.2.5 Maintenance procedures 4.8 HV systems Job rectification card(s) are filled out. 4.8.1 Job Reference Number 4.8.2 System/Equipment Identification 4.8.3 Fault Description 4.8.4 Cause of Fault 4.8.5 Repair Actions Taken 4.8.6 Parts Replaced 4.8.7 Test Results 4.8.8 Personnel Details 4.8.9 Date and Time of Completion. 4.8.10 Safety Verification	
5. Maintain High Voltage Systems	5.1 High voltage equipment is maintained in good working order using manufacturers' specifications/catalogs and manuals. 5.1.1 Preventive maintenance 5.1.2 Predictive maintenance 5.1.3 Corrective maintenance 5.2 Maintenance on HV equipment is conducted applying knowledge of proper design principles to read and interpret relevant technical	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	documents. 4.2.1 Checking and adjusting protective device settings 4.2.2 Replacing HV terminations or bushings 4.2.3 Cleaning insulators 4.2.4 Servicing HV switchgear mechanisms 4.2.5 Verifying Earthing system continuity and resistance 4.2.6 Updating or annotating diagrams after maintenance changes. 5.3 Performance tests on HV systems are carried out as per industry-accepted practices. 5.3.1 Dielectric withstand test 5.3.2 Contact resistance test 5.3.3 Circuit breaker timing test 5.3.4 Transformer test 5.3.5 Insulation test	
6. Maintain and Prepare High Voltage Systems workplace records and Technical Reports	6.1 Protective relay data sheet are correctly filled out. 6.1.1 Relay Identification 6.1.2 Electrical Ratings 6.1.3 Protection Functions 6.1.4 Settings 6.1.5 Test Results 6.1.6 Environmental/Condition Notes 6.1.7 Technician Details 6.2 Proper design principles to identify symbols, characters etc. in schematics, One-Line drawings, and technical documentation are applied. 6.2.1 Correctly read and interpret the symbols,	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	letters, numbers, and notations used in: 6.2.1.1 Schematics (detailed wiring diagrams) 6.2.1.2 One-line diagrams (single-line representation of the system) 6.2.1.3 Technical documentation (manuals, catalogs, specifications) 6.2.2 Apply design principles (voltage levels, equipment ratings, phasing, grounding schemes) 6.3 Power Distribution and One-line diagrams are produced. 6.4.2 Identifying main components 6.4.3 Using correct standards 6.4.4 Using correct tools 6.4.5 Verification 6.4 High Voltage installation, repair, and maintenance records for systems are documented according to workplace procedure and manufacturer specifications. 6.4.6 Documented information 6.4.6.1 System Identification 6.4.6.2 Work details 6.4.6.3 Technical Data 6.4.6.4 Personnel Information 6.4.6.5 Reference documents: - drawings, manuals 6.5 Workplace records, catalogues and other required business documents are created and maintained. 1.5.6 Technical Records	

	1.5.6.1 High-voltage system installation logs. 1.5.6.2 Maintenance and repair records. 1.5.6.3 Test and inspection reports. 1.5.6.4 Equipment calibration records. 1.5.7 Catalogues 1.5.7.1 Manufacturer equipment catalogues and datasheets. 1.5.7.2 Spare parts lists and inventory records. 1.5.8 Business Documents 1.5.8.1 Purchase orders for HV parts and equipment. 1.5.8.2 Quotations and supplier contracts. 1.5.8.3 Job cards and rectification forms. 1.5.8.4 Training attendance records for HV safety.	

Suggested Methods of Instruction

- Classroom Lecture and demonstration
- Practical demonstration of tasks by Instructor and/or Shop Technician
- Practice by trainees.
- Brainstorming in groups to solve wiring and circuit faults
- Ongoing observations and comments and corrections by trainers.

Recommended Resources for 25 trainees

Item Name	**Description / Specifications**	**Quantity**	**Recommended Ratio**

High Voltage Insulation Resistance Tester (Megger)	Digital insulation resistance tester, test voltage range 500V to 5kV, CAT IV safety rating	5	1 per group
High Voltage Multimeter (CAT IV)	True RMS, up to 1000V AC/DC, safety rated for HV work	5	1 per group
Earth Resistance Tester	3-point and 4-point testing, 0.01 Ω resolution, suitable for soil resistivity tests	2	1 per 2–3 groups
High Voltage Test Gloves	Class 2 or higher (17kV rated), leather protectors included	25 pairs	1 pair per trainee
Arc Flash PPE Kit	Includes arc-rated hood, face shield, balaclava, coat, and gloves; ATPV ≥ 40 cal/cm²	5	1 per group
Lock-Out/Tag-Out (LOTO) Kits	Electrical LOTO kit with padlocks, hasps, and tags	5	1 per group
High Voltage Phase Rotation Tester	Suitable for up to 1000V AC, three-phase systems	3	1 per 2 groups
High Voltage Proximity Detector	Non-contact, range 240V to 69Kv	3	1 per 2 groups
Switchgear Training Panel	Simulated HV switchgear setup with protective relays and circuit breakers for practice	5	1 per group
High Voltage Cable Termination Kit	Includes cold-shrink/heat-shrink terminations, connectors, and jointing tools	5	1 per group
Protective Relay Test Set	Digital relay tester, 3-phase voltage/current injection capability	2	1 per 2–3 groups
Digital Clamp Meter (CAT IV)	Measures AC/DC current up to 1000A, voltage up to 1000V	5	1 per group
Thermal Imaging Camera	Infrared camera for hot-spot detection in HV equipment	2	1 per 2–3 groups

High Voltage Schematic Diagrams & Manuals	Printed and laminated one-line diagrams, IEEE standards reference	5 sets	1 set per group
Hydraulic/Pneumatic Tool Kit for HV Work	Includes crimpers, cutters, and compression tools rated for HV cables	5	1 per group
Capacitor Discharge Stick	Discharges stored energy in capacitors safely, up to 25kV	3	1 per 2 groups
First Aid & CPR Kit (Electrical Burns Focus)	Equipped for HV shock and burn incidents	5	1 per group
Power Quality Analyzer	3-phase analyzer for harmonics, voltage sags/swells	2	1 per 2–3 groups
Arc Flash Boundary Markers & Barriers	Portable insulated safety barriers with warning signage	5 sets	1 per group
Portable Lighting & Inspection Mirror Kit	Explosion-proof LED lights and telescopic inspection mirrors	5	1 per group

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEMS INSTALLATION AND MAINTANANCE

TVET CDACC UNIT CODE: ENG/CU/IC/CR/06/6/MA

ISCED UNIT CODE: 0715 551 16A

Relationship to occupational standards

This unit addresses the unit of competency: Maintain SCADA systems.

Duration of unit: 140 hours.

Unit description

This unit covers the competencies required by an industrial mechatronic technician to maintain SCADA systems. It enables the learner to: prepare SCADA system installation site, mount SCADA system components, program SCADA system and maintain SCADA system.

Summary of learning outcomes

By the end of unit of learning, the trainee will be able to;

S/No.	Learning outcomes	Duration (Hrs)
1	Prepare SCADA system installation site	50
2	Mount SCADA system components	50
3	Program SCADA system	50
4	Maintain SCADA system	50
	TOTAL	**200**

Learning outcomes, content and suggested assessment methods

Learning outcome	Content	Suggested assessment methods
1. Prepare SCADA system installation site	1.1 Observe occupational health and safety 1.2 Types and usage of PPE 1.3 Industrial safety signs 1.4 SCADA installation tools and equipment	• Observation • Oral assessment • Portfolio of evidence

Learning outcome	Content	Suggested assessment methods
	1.5 SCADA system parts and accessories 1.6 Installation management 1.6.1 Initiation 1.6.2 Planning 1.6.3 Execution 1.6.4 Work distribution 1.7 Project: Prepare site preparation plan	• Interviews • Third party report • Written assessment • Practical assessment • Projects
2. Mount SCADA system components	2.1 Health and safety 2.1.1 PPEs 2.1.2 Work permits 2.1.3 Waste management 2.1.4 Electrical wiring colour coding 2.1.5 Danger warning signage 2.1.6 Barricades 2.1.7 High voltage signage 2.2 Selection of tools and equipment in SCADA hardware mounting 2.3 Preparation of SCADA installation cabinet 2.4 SCADA components 2.4.1 Data input devices such as sensors 2.4.2 Data processing devices, such as a PLC or RTU	• Observation • Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	2.4.3 Data output devices such as an HMI or monitor, relays 2.4.4 Communication devices 2.5 SCADA system wiring 2.5.1 Industrial communication networks 2.5.2 Industrial automation control mechanisms 2.5.3 Transmission media 2.5.3.1 Wireless: radio waves 2.5.3.2 Wired: twisted pair, coaxial cable or fiber optics 2.6 Network troubleshooting 2.7 SCADA hierarchical levels 2.7.1 Field level 2.7.2 PLCs and RTU Level 2.7.3 Communications Level 2.7.4 HMI Level 2.8 Functional classification of industrial communication networks 2.8.1 Serial Communication 2.8.2 HART (Highway Addressable Remote Transducer) 2.8.3 DeviceNet 2.8.4 Modbus	

Learning outcome	Content	Suggested assessment methods
	2.8.5 Profibus 2.8.6 Foundation Fieldbus 2.9 SCADA Wiring regulations 2.10 Project: Mount and wire a SCADA system	
3. Program SCADA system	3.1 SCADA programming software 3.1.1 WinTr 3.1.2 Siemens 3.1.3 MC Works64 3.1.4 Easy SCADA 3.2 Installation of SCADA program on SCADA system 3.3 SCADA program simulation 3.4 Downloading SCADA program 3.5 Testing SCADA program 3.6 Troubleshooting and restoration of SCADA program 3.7 Project: write and download a SCADA Program	• Observation • Oral assessment • Portfolio of evidence • Interviews • Third party report • Written assessment • Practical assessment • Projects
4. Maintain SCADA system	4.1 SCADA system 4.1.1 SCADA software 4.1.2 Firewalls 4.1.3 Security updates 4.1.4 Firmware updates 4.1.5 PLCs 4.2 Backup SCADA program	• Observation • Oral assessment • Portfolio of evidence • Interviews • Third party report

Learning outcome	Content	Suggested assessment methods
	4.2.1 Establishment of SCADA system 4.2.2 Extraction of SCADA program 4.2.3 Recovery of SCADA program 4.2.4 Troubleshooting and restoration of SCADA program 4.3 SCADA system tagging 4.4 Diagnosis of SCADA system faults 4.4.1 Interconnections of SCADA system 4.4.2 Online diagnostics of SCADA system 4.4.3 Identification of network faults 4.5 Replacement of faulty SCADA parts 4.5.1 Preparation of requisition forms as per operational regulation 4.5.2 Removal of faulty parts from system 4.5.3 Replacement of faulty parts with new parts 4.5.4 Test replaced parts as per maintenance manual 4.6 Routine maintenance	• Written assessment • Practical assessment • Projects

Learning outcome	Content	Suggested assessment methods
	4.6.1 Inspection of remote terminal unit condition 4.6.2 Inspection of network utilities condition 4.6.3 Servicing of sensors 4.6.4 SCADA system updating 4.7 Maintenance records documentation 4.7.1 Filling work orders as per workplace standards 4.7.2 Filling maintenance check sheets 4.7.3 Generation of maintenance reports 4.8 Project: Diagnose and replace SCADA faulty part.	

Suggested delivery methods

- Group discussions
- Demonstration by trainer
- Online videos
- Power point presentation

Recommended resources for 25 trainees

S/No.	Category/item	Description/specifications	Quantity	Recommended ratio (item: trainee)
A	**Tools**			
1.	Multipurpose network cable tester	For testing cables	10 pcs	2:5
2.	Ethernet crimping tool	For crimping jacks	25 pcs	1:1
3.	Soldering gun	For soldering components	25 pcs	1:1
4.	Breadboard	For experimenting electronic components	25 pcs	1:1
5.	Variable power supplies	For powering up circuits	5 pcs	1:5
6.	Oscilloscope	For waves analysis	5 pcs	1:5
7.	Greasing guns/pumps	For greasing joints and bearings	5 pcs	1:5
8.	Assorted screw drivers	Flat and star-assorted sizes. For fastening screws	adequate	
9.	Pliers	For gripping	25 pcs	1:1
10.	Bearing extraction tools	For removing bearings	5 pcs	1:5
11.	Spanners	Assorted sizes for fastening nuts.	adequate	
12.	Allen keys,	Assorted sizes for hexagonal bolts and nuts	adequate	
13.	Multi-meters	For measuring electrical quantities.	5 pcs	1:5

14.	Pipe wrenches	For tightening bolts and nuts in various sizes	5 pcs	1:5
15.	Tape measures	For linear measurements	10 pcs	2:5
16.	portable drilling machines	For drilling holes	10 pcs	2:5
17.	Square	For right angle measurement	25 pcs	1:1
18.	Scribers	For marking out	10 pcs	2:5
19.	Centre punches	For holes piloting	10 pcs	2:5
20.	Files	For filing materials	25 pcs	1:1
21.	Taps and dies	For creating threads	5 pcs	1:5
22.	Vernier calipers	For internal and external measurement	10 pcs	2:5
23.	Micrometer screw gauge	For internal and external measurement	10 pcs	2:5
24.	Assorted gauges	Measuring different objects with different dimensions	10 pcs	2:5
25.	Signal generator	For generating repeating and non-repeating waveforms	5 pcs	1:5
26.	Continuity testers	For cable continuity testing	5 pcs	1:5
27.	Phone line tester	For line fault diagnosis	5 pcs	1:5
28.	SCADA cables and wires	For SCADA networking	sufficient	
B	**Materials and supplies**			

29.	Whiteboard Markers	For writing on whiteboards during instruction	adequate	
30.	PCB boards	For circuit assembly and testing	10 pcs	2:5
31.	Bolts, nuts, and washers	For securing components	adequate	
32.	Fasteners	Used in fastening	5 pcs	1:5
33.	Breadboards	For prototype circuit assembly	10 pcs	2:5
34.	Trunking	For cable management	adequate	
C	**Equipment**			
35.	Projectors	For visual presentations	1	1:25
36.	Actuators	For demonstrating movement control	10 pcs	2:5
37.	PLC modules	For programmable logic control setups	10 pcs	2:5
38.	HMI	For human machine interface	10 pcs	2:5
39.	RTUs	For connecting hardware to a SCADA system	10 pcs	2:5
D	**Reference materials**			
40.	SCADA maintenance manuals/handbooks	Manuals for reference on SCADA maintenance	adequate	
41.	Health and safety manuals	For workplace safety instructions	adequate	
42.	SCADA operation manuals	Comprehensive guides on SCADA systems	adequate	

43.	Periphery equipment maintenance manuals	Comprehensive guides on periphery systems	adequate	
44.	Relevant SCADA textbooks	For referencing	adequate	
45.	Relevant journals and websites	For referencing	adequate	
E	**Software**			
46.	SCADA software	For programming SCADA	1 license (distributable)	
47.	PLC software	For programming PLC	1 license (distributable)	
F	**Trainee Requirements**			
48.	Computing devices	Desktops, laptops, or tablets for individual use	25 pcs	1:1
49.	Personal protective equipment (PPEs):	Overalls /dust coats, safety shoes, ear muffs, safety goggles, nose masks, helmets, welding ray protection shields	25 sets	1:1

MODULE VI

INSTRUMENTATION AND PROCESS CONTROL SYSTEMS & PID

TVET CDACC UNIT CODE: ENG/CU/IC/CR/07/6/MA

ISCED UNIT CODE: 0714 551 17A

Relationship to Occupational Standards:

This unit addresses the unit title: Manage Process Control and Instrumentation Systems and PID

Duration of Unit: 200 hours

UNIT DESCRIPTION

This unit describes the competences required in order to Manage Process Control and Instrumentation Systems and PID. It involves Installing process control and Instrumentation associated equipment, safely install Process Control and Instrumentation-associated equipment, using best practices, Troubleshoot and Repair of Instrumentation, Process Control and PID Controllers, Maintain and service Instrumentation and Process Control Systems, Prepare PID control and Instrumentation system technical reports and work place records.

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Install process control and Instrumentation associated equipment	40
2.	Safely install Process Control and Instrumentation-associated equipment, using best practices	44
3.	Troubleshoot and Repair of Instrumentation, Process Control and PID Controllers	40
4.	Maintain and service Instrumentation and Process Control Systems	42
5.	Prepare PID control and Instrumentation system Technical reports and work place records	34
TOTAL		**200**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods

1. Install process control and Instrumentation associated equipment	1.1 Piping and Instrumentation Diagrams (P&ID) are interpreted in accordance with International Electrotechnical Commission (IEC) standards. 1.1.1 Purpose of P&ID 1.1.2 Interpreting tag names 1.1.3 Loop reference 1.1.4 Applying IEC Conventions 1.2 Materials, components, tools and equipment are identified and selected for installation in accordance Piping and Instrumentation Diagrams 1.2.1 Materials and components 1.2.1.1 Pipes and Pipe fittings 1.2.1.2 Instrumentation devices 1.2.1.3 Mounting Accessories 1.2.1.4 Electrical components 1.2.2 Tools and Equipment 1.2.2.1 Hand tools 1.2.2.2 Power tools 1.2.2.3 Special tools 1.2.2.4 Safety Equipment 1.3 Process control and instrumentation equipment are mounted as per the P&ID. 1.3.1 Preparation of mounting locations 1.3.2 Installing Equipment 1.3.3 Verification against P&ID 1.4 Process control and instrumentation system is energized, and tested in accordance with the student's and/or instructor's design/drawing. 1.4.1 Pre energization checks 1.4.2 Energization procedure 1.4.3 Testing process	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	1.4.4 Documentation of results 1.4.5 Post energization checks	
2. Configure and Calibrate Instrumentation sensors and PID controllers	2.1 Measurement standards/reference materials and associated equipment for configuration and calibration are identified according the work plan. 2.1.1 Review work plan 2.1.2 Identifying measurement standards 2.1.3 Select associated equipment 2.2 Calibration platform/condition is set according to the manufacture specifications 2.2.1 Choice of work environment: - Temperature, humidity 2.2.2 Calibration preparation 2.2.3 Equipment setup 2.2.4 Safety measures 2.3 Calibration methods/ procedures for the sensors and PID controllers are determined and executed according to manufacture specifications 2.3.1. Calibration Methods for Sensors 2.3.1.1 Pressure Sensors/Transmitters 2.3.1.1.1 Deadweight Tester Calibration 2.3.1.1.2 Pressure Calibrator Comparison 2.3.1.1.3 Zero/Span Adjustment 2.3.1.2 Temperature Sensors (RTDs, Thermocouples) 2.3.1.2.1 Dry Block Calibration 2.3.1.2.2 Liquid Bath Calibration	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	2.3.1.2.3 Ice Point/Boiling Point Method 2.3.1.3 Flow Sensors 2.3.1.3.1 Master Meter Method 2.3.1.3.2 Gravimetric Method. 2.3.1.4 Level Sensors 2.3.1.4.1 Simulated Process Calibration 2.3.2. Calibration Methods for PID Controllers 2.3.2.1 Simulation Calibration 2.3.2.2 Loop testing 2.3.2.3 Auto Tuning 2.3.2.4 Manual Tuning 2.4 Configuration and calibration data are recorded/ developed and documented according to workplace procedures. 2.4.1 Documented Information 2.4.1.1 Instrument Identification 2.4.1.2 Pre Calibration data 2.4.1.3 References standards used 2.4.1.4 Calibration results 2.4.1.5 Configuration results 2.4.1.6 Post calibration verification	
3. Troubleshoot and Repair of Instrumentation, Process Control and PID Controllers	3.1 Instrumentation and PID diagnostic/troubleshooting tools are selected in accordance with task requirements. 3.1.1 Multimeter 3.1.2 Clamp meter 3.1.3 Loop Calibrator 3.1.4 Signal generators 3.1.5 Oscilloscope 3.2 Process control and PID controller faulty components are identified, replaced or repaired in accordance with manufacturers' specifications/catalogue. 3.2.1 Identification of faulty components 3.2.1.1 Visual inspection	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	3.2.1.2 Test instruments 3.2.1.3 Process monitoring 3.2.2 Component replacement 3.2.3 Component repair 3.2.4 Post replacement/repair test 3.3 Analog and digital wiring systems are re-terminated in accordance with manufacturers' specifications/catalogue 3.3.1 Identification of wiring faults 3.3.2 Referencing manuals/drawings 3.3.3 Termination process 3.3.4 Testing 3.4 Instrumentation sensors and PID repaired/replaced components are inspected. 3.4.1 Inspection checklist 3.4.1.1 Physical condition 3.4.1.2 Wiring connections 3.4.1.3 Correct labelling 3.4.1.4 Component compatibility 3.5 Instrumentation and process sensors and equipment are re-calibrated according to manufacturers' specifications/catalogs 3.5.1 Re- calibration procedures 3.5.1.1 Review manufacturer documentation 3.5.1.2 Recalibration standards 3.5.1.3 Verification 3.5.1.4 Documentation 3.6 Voltage, current, signal and Functional test(s) are carried out on Instrumentation sensors and PID controllers 3.6.1 Types of tests 3.6.1.1 Voltage test	

	3.6.1.2 Current test 3.6.1.3 Signal test 3.6.1.4 Function tests 3.7 Instrumentation and PID controller Job rectification card(s) are filled out. 3.7.1 Job card details 3.7.1.1 Job Information 3.7.1.2 Equipment details 3.7.1.3 Fault Details 3.7.1.4 Fault Description 3.7.1.5 Corrective action taken 3.7.1.6 Post repair test results 3.7.1.7 Recommendations	
4. Maintain and service Instrumentation and Process Control Systems	4.1 Process and Instrumentation system maintenance procedure manuals are acquired 4.1.1 Manual acquired from 4.1.1.1 Manufacturer/ Supplier 4.1.1.2 From procurement department 4.1.1.3 Installation contractor 4.1.1.4 Online libraries and portals 4.1.1.5 Internal workplace knowledge base 4.2 Materials/tools/equipment list prepared and selected in accordance with task requirements. 4.2.1 Task Requirements 4.2.2 Material list 4.2.3 Tools List 4.2.4 Equipment list 4.3 Instrumentation system and PID are inspected, serviced, and routine functional tests carried out in accordance with maintenance procedure manuals. 4.3.1 Visual checks 4.3.2 Tag identification 4.3.3 Name plate interpretations 4.3.4 Cleaning	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	4.3.5 Lubricating 4.3.6 Replacements 4.4 Sensor and PID functional anomalies are identified, isolated and tagged as per the installation and tag out procedure(s). 4.4.1 Identification of anomalies 4.4.1.1 Observation of readings/outputs 4.4.1.2 Test comparison 4.4.1.3 Symptoms 4.4.2 Isolation of Device 4.4.2.1 LOTO 4.4.2.2 Bypass 4.4.3 Device tagging 4.5 Instrumentation system and PID maintenance job cards are filled out in accordance with the workplace procedures. 4.5.1 Job Card details 4.5.1.1 Job information 4.5.1.2 Equipment details 4.5.1.3 Type of maintenance 4.5.1.4 Work description 4.5.1.5 Test Results	
5. Prepare PID control and Instrumentation system Technical reports and work place records	5.1 PID controllers and sensors installation procedures, troubleshooting methods and maintenance data/information are gathered and formulated in the required sequence and format. 5.1.1 Standard Operating Procedures documents 5.1.2 Troubleshooting flow chart 5.1.3 Task checklists 5.1.4 Maintenance schedule tables 5.2 Process control report structure, presentation style and format are determined according to standard operating procedures and in	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	accordance with industry-accepted specifications. 5.2.1 Title page 5.2.2 Executive summary 5.2.3 Introduction/Background 5.2.4 Scope of work 5.2.5 Methodology/Procedure 5.2.6 Findings/Observations 5.2.7 Results and Analysis 5.2.8 Conclusions 5.2.9 Recommendations 5.2.10 Appendices 5.3 Instrumentation system and PID Controller Technical report*(s)* are prepared and shared in accordance with standard operating procedures. 5.4 Workplace records, catalogues for PID and Instrumentation sensors and other required business documents in are created and maintained accordance with industry-accepted specifications. 5.1.1 Workplace Records 5.1.1.1 Maintenance logs 5.1.1.2 Calibration certificates 5.1.1.3 Repair history sheets 5.1.1.4 Test results and inspection reports 5.1.1.5 Job cards & rectification cards 5.1.2 Catalogues 5.1.2.1 Manufacturer product catalogues for PID controllers and sensors 5.1.2.2 Technical datasheets (range, accuracy, compatibility) 5.1.2.3 Approved parts and spare lists 5.1.3 Business Documents 5.1.3.1 Purchase requisitions and invoices	

	5.1.3.2 Supplier contact lists 5.1.3.3 Warranty and service agreements 5.1.3.4 Compliance certificates	

Suggested Methods of Instruction

- Classroom Lecture and demonstration
- Practical demonstration of tasks by Instructor and/or Shop Technician
- Practice by trainees.
- Brainstorming in groups to solve wiring and circuit faults
- Ongoing observations and comments and corrections by trainers.

Recommended Resources for 25 trainees

Item Name	Description/Specifications	Quantity	Ratio per Group (6 Trainees)
PID Controllers	Industrial-grade (e.g., Siemens, Allen-Bradley)	5 units	1 unit per group
Temperature Sensors	RTD (Pt100) or thermocouple (Type K/J)	10 units	2 units per group
Pressure Sensors	0-10 bar range, 4-20mA output	10 units	2 units per group
Flow Sensors	Turbine or ultrasonic type, 4-20mA output	5 units	1 unit per group
Proximity Sensors	Inductive/capacitive, NPN/PNP output	10 units	2 units per group
Limit Switches	Mechanical/reed switches	10 units	2 units per group
Calibration Equipment	Pressure calibrators, signal generators	5 sets	1 set per group
P&ID Software	AutoCAD, SmartPlant, or equivalent	5 licenses	1 license per group
Oscilloscopes	Digital, 50MHz bandwidth	5 units	1 unit per group
Signal Analyzers	For 4-20mA/0-10V signal testing	5 units	1 unit per group
Multimeters	Digital, with mA measurement	10 units	2 units per group

Wiring & Terminal Kits	DIN rails, terminal blocks, shielded cables	As needed	Shared among groups
PPE Kits	Safety gloves, goggles, ESD jackets	25 sets	1 set per trainee
Technical Manuals	IEC standards, manufacturer catalogs	5 copies	1 copy per group
Process Control Trainer Kits	Modular setups with pumps, valves, and tanks for hands-on practice	5 setups	1 setup per group

ALTERNATIVE ENERGY SYSTEMS

TVET CDACC UNIT CODE: ENG/CU/IC/CR/08/6/MA

ISCED UNIT CODE: 0713 551 18A

Relationship to Occupational Standards:

This unit addresses the unit title: Analyze Alternative Energy Systems

Duration of Unit: 190 hours

UNIT DESCRIPTION

This unit describes the competences required in order to Analyze Alternative Energy Systems. It involves Identifying and compare alternative energy systems, determine alternative energy system locations, determine alternative energy equipment, Install alternative energy electrical systems. Troubleshoot and repair alternative energy electrical systems, maintain alternative energy electrical systems, Prepare and Maintain Alternative Energy Electrical systems workplace records and technical reports

Summary of Learning Outcomes

By the end of this unit of learning the trainee will be able to:

S/NO	Learning Outcome	Duration (Hours)
1.	Identify and compare alternative energy systems.	22
2.	Determine alternative energy system locations.	22
3.	Determine alternative energy equipment.	22
4.	Install alternative energy electrical systems.	42
5.	Troubleshoot and repair alternative energy electrical systems.	34
6.	Maintain alternative energy electrical systems.	24
7.	Prepare and Maintain Alternative Energy Electrical systems workplace records and technical reports	24
TOTAL		**190**

Learning Outcomes, Content and Suggested Assessment Methods

Learning Outcome	Content	Suggested Assessment Methods

1. Identify and compare alternative energy systems.	1.1 Alternative energy systems are analyzed with respect to parameters 1.1.1 ampacity, 1.1.2 voltage, 1.1.3 location, 1.1.4 kwh capacity, 1.1.5 ROI (return on investment) and 1.1.6 sustainability. 1.2 Alternative energy systems, 1.2.1 Wind, 1.2.2 Geothermal, 1.2.3 Solar PV, 1.2.4 wave and tidal, 1.2.5 Biogas	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests
2. Determine alternative energy system locations.	2.1 Alternative energy locations are assessed for A/E system viability. 2.1.1 Factors to consider 2..1.1.1 Land Requirement 2..1.1.2 Climate impact 2..1.1.3 Grid Proximity 2..1.1.4 ROI period 2.2 Climatic conditions, 2.2.1 Solar PV 2.2.1.1 Solar Irradiance 2.2.1.2 Temperature 2.2.1.3 Cloud cover 2.2.1.4 Dust 2.2.1.5 Shading 2.2.2 Wind Power 2.2.2.1 Wind Speed 2.2.2.2 Turbulence 2.2.2.3 Seasonal Variability 2.2.2.4 Extreme events 2.2.3 Geothermal 2.2.3.1 Thermal Gradient 2.2.3.2 Ground water 2.2.3.3 Seismic activities	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	2.2.3.4 Surface Land Use 2.2.4 Biogas 2.2.4.1 Temperature 2.2.4.2 Feedstock availability 2.2.4.3 Humidity	
3. Determine alternative energy equipment.	3.1 Alternative energy Equipment selection 3.1.1 Solar PV 3.1.1.1 Panel Efficiency 3.1.1.2 Inverter compatibility 3.1.1.3 Battery life cycle 3.1.2 Wind 3.1.2.1 Turbine cut –in-speed 3.1.2.2 Tower height 3.1.3 Geothermal 3.1.3.1 Head pump COP 3.1.3.2 HDPE pipe durability 3.1.4 Biogas 3.1.4.1 Digester volume 3.1.4.2 CHP Efficiency. 3.2 Sizing electrical Equipment for alternative energy systems. 3.2.1 Sizing Criteria 3.2.1.1 Daily Energy Load requirement 3.2.1.2 Ampacity 3.2.1.3 Voltage drop 3.2.1.4 DC Input voltage (Inverter) 3.2.1.5 AC Output voltage (Inverter) 3.2.1.6 Depth of discharge 3.2.1.7 Discharge rate	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	3.2.1.8 Over current protection 3.2.1.9 Inverter/ Charge controller size 3.2.1.10 Environmental factors	
4. Install alternative energy electrical systems.	4.1 Installation of alternative energy systems 4.1.2 Procedure 4.1.2.1 Pre installation safety Planning 4.1.2.2 Risk assessment 4.1.2.3 Equipment Inspection 4.1.2.4 Installation stage 4.1.2.5 Conduit/Piping work 4.1.2.6 Wiring 4.1.2.7 Mounting Accessories 4.2 Electrical connections for alternative energy systems 4.2.1 Butt Splices 4.2.2 Crimp 4.2.3 Lugs 4.2.4 DIN Rails 4.2.5 Plug and Socket 4.2.6 Bus bar connections 4.2.7 Soldered joints 4.2.8 Brazing 4.2.9 MC4 connectors 4.3 Safety for the various voltages associated with Alternative Energy systems 4.3.1 125 VDC 4.3.1.1 Insulated tools 4.3.1.2 Discharge capacitors 4.3.1.3 Class OO Gloves 4.3.2 240V AC 4.3.2.1 De-energize and LOTO 4.3.2.2 GFCI Protection 4.3.3 415 VAC 4.3.3.1 Arc Flash protection 4.3.3.2 CAT IV meters	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	4.3.4 660VAC 4.3.4.1 Hot stick 4.3.4.2 Ground Mats 4.3.4.3 Restricted access 4.4 Proper use of PPEs. 4.4.1 Face protection 4.4.2 Respiratory protection 4.4.3 Hand Protection 4.4.4 Ear protection 4.4.5 Foot protection 4.5 Lock-out/Tag-out procedures 4.5.1 Personnel Notification 4.5.2 Identification of all energy sources 4.5.3 Equipment de-energization 4.5.4 Isolation/Disconnect points 4.5.5 Application of Locks/Tags 4.5.6 Verification of zero energy 4.6 Measuring devices are used to detect the presence of energy sources, 4.6.1 Multimeter 4.6.2 Non-contact voltage tester 4.6.3 Clamp meter 4.6.4 Pressure gauge 4.6.5 Bleed valve 4.6.6 Thermal camera 4.6.7 Battery SOC meter	
5 Troubleshoot and repair alternative energy electrical systems.	5.1 Identifying Faults in A/E electrical systems 5.1.1 Visual Inspection 5.1.2 Electrical Testing 5.1.3 Troubleshooting flow charts 5.2 Repair strategies and solutions	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	5.2.1 Cleaning solar panels 5.2.2 Replace damaged cells 5.2.3 Reset inverter 5.2.4 Ensure proper ventilation 5.2.5 Equalize charge 5.2.6 Replace defective batteries 5.2.7 Verify wind speed sensor 5.2.8 Check bearings 5.2.9 Test stator/rotor 5.2.10 Check electrical connections 5.3 Recommendations to mitigate further faults 5.3.1 Scheduled inspections 5.3.2 Performance tracking 5.3.3 Preventive replacements 5.3.4 Proper sizing 5.3.5 Redundancy 5.4 Performance test(s) on repaired and/or replaced equipment in A/E systems 5.4.1 Solar 5.4.1.1 IV curve tracing 5.4.1.2 Insulation resistance 5.4.1.3 Open Circuit Voltage 5.4.1.4 Inverter functionality test 5.4.2 Wind 5.4.2.1 Cut in/Cut out speed 5.4.2.2 Power curve test 5.4.2.3 Vibration analysis 5.4.2.4 Generator output 5.4.3 Geothermal systems	

	5.4.3.1 Flow rate 5.4.3.2 Pressure test 5.4.3.3 Heat Pump COP 5.4.3.4 Thermal gradient	
6 Maintain alternative energy electrical systems.	6.1 Standard procedures to maintain A/E electrical equipment 6.1.1 Solar 6.1.1.1 Panel wiring 6.1.1.2 Cracked panels 6.1.1.3 Shading 6.1.1.4 Test MC4 connectors 6.1.1.5 Open Circuit Voltage/ Short circuit current 6.1.2 Wind 6.1.2.1 Blade imbalance 6.1.2.2 Gear box 6.1.2.3 Bearings 6.1.2.4 Generator windings 6.1.3 Battery systems 6.1.3.1 Capacity degradation 6.1.3.2 Electrolyte balance 6.2 Proper design principles to read and interpret relevant technical documents to conduct maintenance on HV 6.4.7 System schematics 6.4.8 Wiring diagrams 6.4.9 Symbols and notations in A/E systems 6.4.10 System segmentation 6.4.11 Safety 6.3 Periodic test(s) on maintained A/E systems 6.3.1 Solar 6.3.1.1 IV curve tracing 6.3.1.2 Insulation resistance 6.3.1.3 Earthing 6.3.2 Wind Power 6.3.2.1 Vibration analysis 6.3.2.2 Power curve validation 6.3.2.3 Generator winding test 6.3.3 Battery systems	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

		6.3.3.1 Capacity test 6.3.3.2 Internal resistance test 6.3.3.3 Cell voltage balancing	
7	Prepare and Maintain Alternative Energy Electrical systems workplace records and technical reports	7.1 Alternative Energy electrical systems parts and components' data sheets documentation and archiving 1.1.1 Digital Archiving 1.1.2 Physical copies 1.1.3 Compliance labels/ Barcode/QR coding 7.2 Alternative Energy drawings, technical reports, schematics, 'log book' entries/records repair and maintenance records are created, distributed, organized and archived as per industry standards. 1.2.1 Document types and standards 1.2.1.1 As- Built drawing ISO 19650 1.2.1.2 Technical reports IEEE1526, IEC 62548 1.2.1.3 Schematics IEC 60617 1.2.1.4 Logbook Entries ISO 55001 1.2.1.5 Maintenance records IEC 60300 1.2.2 Distribution and Access control 1.2.2.1 Read only access 1.2.2.2 Password-protected access 1.2.2.3 General access 1.2.2.4 Biometrics authorization 7.3 Alternative Energy associated drawings are developed in accordance with industry standard 7.3.1 Drawing Standards	• Practical • Portfolio of evidence • Third party report • Oral questioning • Written tests

	7.3.1.1 Drawing accuracy and clarity IEC 60617 7.3.1.2 Revision Control as per Organization SOP 7.3.1.3 Compliance checks IEEE1547, IEC 62109	

Suggested Methods of Instruction

- Classroom Lecture and demonstration
- Classroom computers for learners with Internet access
- Classroom computers with Office Suite
- Practical demonstration of tasks by Instructor and/or Shop Technician
- Practice by trainees.
- Brainstorming in groups to solve wiring and circuit faults
- Ongoing observations and comments and corrections by trainers

Recommended Resources for 25 trainees

Item Name	Description/Specifications	Quantity	Ratio per Group (6 Trainees)
Solar PV Panels	Monocrystalline or polycrystalline, 100W-300W capacity	10 panels	2 panels per group
Charge Controllers	PWM or MPPT type, 12V/24V, 20A-40A	5 units	1 unit per group
Deep Cycle Batteries	12V or 24V, 100Ah-200Ah capacity	5 units	1 unit per group
Inverters	Pure sine wave, 500W-1000W, 12V/24V input	5 units	1 unit per group
Multimeters	Digital, with DC voltage/current measurement	10 units	2 units per group
Clamp Meters	AC/DC current measurement	5 units	1 unit per group
Solar Irradiance Meters	Measures solar radiation (W/m^2)	5 units	1 unit per group
Insulation Testers	500V-1000V range for cable testing	5 units	1 unit per group

PPE Kits	Gloves, goggles, insulated tools, helmets, safety harnesses	25 sets	1 set per trainee
Lock-out/Tag-out Kits	Locks, tags, and warning signs	5 sets	1 set per group
Wiring & Connectors	MC4 connectors, cables (4mm²-6mm²), junction boxes	As needed	Shared among groups
Solar PV Installation Stand	Mock roof or ground-mounted structure for training	5 setups	1 setup per group
Technical Manuals	Manufacturer guides, electrical standards (e.g., NEC, IEC)	5 copies	1 copy per group
Simulation Software	PV system design software (e.g., PVsyst, Helioscope)	5 licenses	1 license per group