FEDERAL MINISTRY OF EDUCATION

National Technical Certificate (NTC) Curriculum in

ELECTRICAL AND SOLAR PV INSTALLATION AND MAINTENANCE

February, 2025

Innovation Development and Effectiveness in the Acquisition of Skills (IDEAS) Project

Funded by IDEAS project

NATIONAL BOARD FOR TECHNICAL EDUCATION

Plot B, Bida Road, P.M.B. 2239, Kaduna, Nigeria

NATIONAL TECHNICAL CERTIFICATE

CURRICULUM AND MOUDULE SPECIFICATIONS IN

ELECTRICAL AND SOLAR PV INSTALLATION AND MAINTENANCE

2025

GENERAL INFORMATION

AIM

To give training and impact the necessary skills leading to the production of skilled personnel that can fit into the sector as ELECTRICAL AND SOLAR PV INSTALLATION AND MAINTENANCE craftsmen and self-reliant entrepreneurs.

ENTRY QUALIFICATIONS

Craft Programme

Candidates must not be less than 14 years of age and should have successfully completed three years of Junior Secondary education or its equivalent. Special consideration may be given to sponsored candidates with lower academic qualifications who hold trade test certificates and are capable of benefiting from the programme.

Advanced Craft Programme

Candidates should possess the National Technical Certificate or its equivalent and should have had a minimum of two years post qualification cognate industrial experience.

The Curriculum

The Curriculum of each programme is broadly divided into three components:

a. General Education, which accounts for 30% of the total hours required for the programme.

b. Trade Theory, Trade Practice and Related Studies which account for 65% and,

c. Supervised Industrial Training/Work Experience which accounts for about 5% of the total hours required for the programme. This component of the course which may be taken in industry or in the College production unit is compulsory for the full-time students.

Included in the curriculum are the teacher's activity and learning resources required for the guidance of the teacher.

Unit Course/Modules

A course/ module is defined as a body of knowledge and skills capable of being utilized on its own or as a foundation or pre-requisite knowledge for more advanced work in the same or other fields of study. Each trade course/ module when successfully completed can be used for employment purposes.

Behavioural Objectives

These are educational objectives, which identify precisely the type of behaviour a student should exhibit at the end of a course/module or programme. Two types of behavioural objectives have been used in the curriculum. They are:

a. General Objectives
b. Specific Learning Outcomes

General objectives are concise but general statements of the behaviour of the students on completion of a unit of week such as understanding the principles and application of:

a Occupational Health and Safety
b Basic Electricity.
c Maintenance and trouble shooting in Solar PV Systems..

Specific learning outcomes are concise statements of the specific behaviour expressed in units of discrete practical tasks and related knowledge the students should demonstrate as a result of the educational process to ascertain that the general objectives of course/ programme have been achieved. They are more discrete and quantitative expressions of the scope of the tasks contained in a teaching unit.

General Education in Technical Colleges

The General Education component of the curriculum aims at providing the trainee with knowledge in critical subjects like English Language, Mathematics, Economics, Physics, Chemistry, Biology, Entrepreneurial Studies and Mathematics, etc. to enhance the understanding of machines, tools and materials of their trades and their application as a foundation for post-secondary technical education for the above average trainee. Hence, it is hoped that trainees who successfully complete their trade and general education may be able to compete with their secondary school counterparts for direct entry into Universities, Polytechnics or Colleges of Education (Technical) for degree, ND or NCE courses respectively.

For the purpose of certification, only the first three courses in mathematics will be required. The remaining modules are optional and are designed for the above average students.

National Certification

The NTC and ANTC programmes are run by Technical Colleges accredited by N.B.T.E.
NABTEB conducts the final national examination and awards certificates.

Trainees who successfully complete all the courses/ modules specified in the curriculum table and passed the national examinations in the trade will be awarded one of the following certificates:

S/NO	LEVEL	CERTIFICATE
	Technical Programme	
1.	NTC	National Technical Certificate
2.	ANTC	Advanced National Technical Certificate

Guidance Notes for Teacher implementing the Curriculum

The number of hours stated in the curriculum table may be increased or decreased to suit individual institutions' timetable provided the entire course content is properly covered and goals and objectives of each module are achieved at the end of the term.

The maximum duration of any module in the new scheme is 300 hours. This means that for a term of 15 weeks, the course should be offered for 20 hours a week. This can be scheduled in sessions of 4 hours in a day leaving the remaining hours for general education. However, properly organized and if there are adequate resources, most of these courses can be offered in two sessions a day, one in the morning and the other one in the afternoon. In so doing, some of these programmes may be completed in lesser number of years than at present.

The sessions of 4 hours include the trade theory and practice. It is left to the teacher to decide when the class should be held in the workshop or in a lecture room.

INTEGRATED APPROACH IN THE TEACHING OF TRADE

Theory, Trade Science and Trade Calculation

The traditional approach of teaching trade science and trade calculation as separate and distinct subjects in Technical College programmes is not relevant to the new programme as it will amount to a duplication of the teaching of mathematics and physical science subjects in the course. The basic concepts and principles in mathematics and physical science are the same as in the trade calculation and trade science. In the new scheme therefore, qualified persons in these fields will teach mathematics and physical science and the instructors will apply the principles and concepts in solving trade science and calculation problems in the trade theory classes. To this end, efforts have been made to ensure that mathematics and science modules required to be able to solve technical problems were taken as pre-requisite

Evaluation of Programme/Module

For the programme to achieve its objectives, any course started at the beginning of a term must terminate at the end of the term.

Instructors should therefore device methods of accurately assessing the trainees to enable them give the student's final grades at the end of the term. A national examination will be taken by all students who have successfully completed their modules. The final award will be based on the aggregate of the scores attained in the course work and the national examination.

PROGRAMME: ELECTRICAL AND SOLAR PV INSTALLATION AND MAINTENANCE

GOAL: Upon completing this course, learners will be able to design, install, maintain, and troubleshoot electrical and solar systems, ensuring efficient, safe, and sustainable energy solutions

CURRICULUM TABLE AND COURSE HOURS/WEEK
PROGRAMME: NATIONAL TECHNICAL CERTIFICATE

Module Code	**MODULE**	**YEAR I**						**YEAR 2**						**YEAR 3**						**TOTAL HOURS**
		Term 1		Term 2		Term 3		Term 1		Term 2		Term3		Term 1		Term 2		Term 3		
		T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	
CAM 12 - 15	Mathematics	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-	216
CEN 11 - 17	English	2	-	2	-	2	-	3	-	3	-	3	-	3	-	3	-	3	-	288
CPH 10 - 12	Physics	2	-	2	-	2	-	2	1	2	1	2	1	2	1	2	1	2	1	288
CCH 10 - 12	Chemistry	2	-	2	-	2	1	2	1	2	1	2	1	2	1	2	1	2	1	288
CEC 11 - 13	Economics	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-	2	-	216
CBM 11	Entrepreneurship	-	-	-	-	-	-	2	-	2	-	2	-	-	-	-	-	-	-	72
ICT 11 - 15	Computer Studies	-	-	-	-	-	-	1	2	1	2	1	2	1	2	1	2	-	-	180
CTD 113 – 13	Drawings	-	3	-	3	-	3	-	3	-	3	-	2	-	2	-	2	-	2	288

CME11	General Metal Work I	3	4					-	-	-	-	-	-	-	-	-	-	-	-	84
CES1:11	Occupational Health and safety	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72
CES1:12	Basic Electricity	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	84
CES1:13	Introduction to Renewable Energy	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	72
CES1:21	Domestic Electrical Installation	-	-	-	-	-	-	10	13	-	-	-	-	-	-	-	-	-	-	276
CES1:22	Electrical / Electronic Drawing	-	-	-	-	-	-	-	-	3	5	-	-	-	-	-	-	-	-	96
CES1:31	Introduction to Solar P V System	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	-	72
CES1:32	Components and Electrical connections in Solar PV installation	-	-	-	-	3	5	-	-	-	-	-	-	-	-	-	-	-	-	96
CES1:33	Solid State Devices and Circuit	-	-	-	-	8	12-	-	-	-	-	-	-	-	-	-	-	-	-	240
CES2:21	Installation of solar pv system	-	-	-	-	-	-	3	5	-	-	-	-	-	-	-	-	-	-	96
CES2-11	Battery Charging and Maintenance	-	-	-	-	-	-	1	2	3	2	1	4	-	-	-	-	-	-	156
CES2-12	Solar PV System Size and Site Evaluation	-	-	-	-	-	-	3	5	-	-	-	-	-	-	-	-	-	-	96
CES2:22	Maintenance and Troubleshooting of Solar PV System	-	-	-	-	-	-	-	-	2	4	-	-	-	-	-	-	-	---	72

CES2:23	Solar Thermal Technology	-	-	-	-	-	-	-	-	3	5	-	-	-	-	-	-	-	-	96
CES3:11	Winding	-	-	-	-	-	-	--	-	-	-	-	-	6	12	-	--	-	-	216
CES3:12	Cable Jointing	-	-	-	-	-	-	-	-	-	-	-	-	9	9	-	-	-	--	**216**

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ELECTRICAL AND SOLAR INSTALLATION & MAINTENANCE		
Course: Occupational Health and Safety	**Course Code: CES1-11**	**Total Hours: 72HRS**
Year: 1 Term: 1	**Pre-requisite:**	**Practical:**
Goal: This module is designed to equip the trainee with safety measures and work ethics		
General Objectives: On completion of this module, the trainee should be able to: 1. Understand Safety Measures 2. Understand the hazards that occur during installations 3. Know the importance of first aid box		

General Objective:1.0: Understand Safety Measures

Week	Specific Learning Outcomes	Teacher's Activities	Resources	Specific Learning Objectives	Teacher's Activities	Learning Resources
WK 1	1.1 Define safety	Explain safety	Textbooks Internet	Explain safety	Guide learners to identify safety measures	Videos Projectors Safety manual
	1.2 Explain the steps in safety measures	Describe the steps in safety measures	E-learning	Identify safety measures	Guide learners to identify safety measures	Charts
	1.3 Define Personal Protective Equipment	Explain personal protective equipment	Textbooks Internet	Demonstrate how to use PPEs	Guide learners on how to use PPEs	PPEs Pictures Videos
	1.4 Explain the following PPEs; i. Helmet ii. Gloves iii. Goggle iv. Marks v. Ear cover vi. Safety boot vii. Overall	Discuss the following PPEs; i. Helmet ii. Gloves iii. Goggle iv. Marks v. Ear cover vi. Safety boot vii. Overall	PPEs Pictures Videos Projector Safety manual Chart	Identify PPEs and their uses	Guide learners to identify PPEs and their uses	Live PPEs
	1.5 Explain appropriate steps for the selection of PPE in particular	Describe appropriate steps for the selection of PPE in particular circumstances	PPEs Pictures Videos Projector	Demonstrate the appropriate steps involved in selection of PPEs	Guide learners on the appropriate steps involved in selection of PPEs	Live PPEs

	circumstances		Safety manual Chart	for particular circumstances		

General Objective:2.0: Understand the hazards that occur during installation work

Week	Specific Learning Outcomes	Teacher's Activities	Learning Resources	Specific Learning Objectives	Teacher's Activities	Learning Resources
WK 2	2.1 Define hazard	Explain hazard	Textbooks Internet	Identify hazards in the work place	Guide learner to identify hazards in the work place	Safety manual
	2.2 Explain the various types of hazard and safety measures in work place	Describe the various types of hazard and safety measures in work place	Textbooks Pictures Videos	Demonstrate the safety measures on various types of hazards	Guide learner on the safety measure on various types of hazards	Videos Projectors Charts First aid box
	2.3 Define i. Accident ii. Physical accident iii. Non-physical	Explain i.Accident ii. Physical accident iii. Non-physical	Textbooks Pictures Videos	Identify types of accidents	Guide learners to identify types of accidents	Charts Pictures Videos
	2.4 Explain causes of accidents	Discuss causes of accidents during installation and		Identify causes of accidents during	Guide learners to	Charts Pictures Videos

	during installation and maintenance	maintenance		installation	identify causes of accidents during installation and list various ways to prevent accidents occurrences	
	2.5 Explain possible ways to prevent or avoid accident occurrence	Describe possible ways to prevent or avoid accident occurrence	Textbooks Pictures Videos	Identify possible ways to prevent accident occurrence	Guide learners to identify possible ways to prevent accident occurrence	Charts Pictures Videos
	General Objective:3.0: Know the importance of First Aid Box					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
WK 3	3.1 Explain the first aid box	Describe the first aid box	Textbooks Internet	Identify the first aid box	Guide learners to identify the first aid box	Projector First aid box
	3.2 Explain the contents of first aid box and their	Describe the contents of first aid box	Textbooks	Enumerate contents of first aid box	List the contexts of first aid box and	Videos Various contexts

	uses		Pictures Videos		their uses	
	3.3 Explain treatment procedure of the following; i. Cut ii. Burn iii. Electrical shock	Describe treatment procedure of the following; Cut, Burn and Electrical shock	Textbooks Pictures Videos	Carryout treatment techniques of the possible accident that may occur such as cut, burn, electrical shock, etc.	Show learners how to treat accidents using the contexts of first aid box	Projector First aid box Charts Videos

EVALUATION GUIDE FOR MODULE CESI 11 - OCCUPATIONAL HEALTH AND SAFETY

The student will be assessed on the basis of demonstrating an understanding of occupational health and safety theory
Students will be graded on the following Criteria:

a. Project (Process and Product) assessments.
b. Assignments and Tests
c. Terminal Examinations.

The laboratory reports should also be assessed and graded.

Assessment:

Type of Assessment	Purpose and Nature of Assessment	Weighting (%)
Skill (Psychomotor and Affective) Assessment	Project Process and product	30%
Assignment/Test	Cognitive	10%
Terminal Examination	Cognitive/Psychomotor/Affective	60%
	Total	100%

Recommended Textbooks & References: Recommended textbooks and references for Occupational Health and Safety:

Textbooks

1. Fundamentals of Industrial Hygiene by Barbara Plog and Patricia Quinlan (5th Ed., 2001) - a comprehensive guide to industrial hygiene principles and practices.[1]
2. Proctor and Hughes' Chemical Hazards in the Workplace by Gloria J. Hathaway, Nick H. Proctor, and James P. Hughes (4th Ed., 1996) - a definitive guide to chemical hazards in the workplace.
3. Occupational Medicine by Carl Zenz, O. Bruce Dickerson, and Edward P. Horvath (3rd Ed., 1994) - a comprehensive guide to occupational medicine principles and practices.

Reference Guides

4. OHSA Reference Guide (3rd Ed.) - a valuable tool for Joint Health and Safety Committees and Health and Safety Representatives in Ontario, Canada.[2]
5. OHS Act and Regulations Pocket Book (Green Book) - a handy and portable guide to the Ontario Occupational Health and Safety Act and Regulations.
6. Patty's Industrial Hygiene (5th Ed.) - a comprehensive guide to industrial hygiene principles and practices.

Online Resources

7. Occupational Safety and Health Administration (OSHA) - a reliable source of information on occupational health and safety regulations, guidelines, and best practices.

ROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ELECTRICAL AND SOLAR PV INSTALLATION AND MAINTENANCE				
MODULE: BASIC ELECTRICITY			**COURSE CODE: CES1-12**	**CONTACT HOURS:**
YEAR: 1	**TERM:** 1	**PRE: REQUISITE:**	**Theoretical:** 36 Hours **Practical:** 48 Hours	
GOAL: This module is designed to introduce the trainee to basic electricity as it relates to electrical and solar installation				

General Objectives: On completion of this module, the trainee should be able to:

1. Understand the structure of matter and its relevance to electricity/Solar PV
2. Understand the chemical sources of electromotive force.
3. Understand the construction and functions of resistors, inductors and capacitors in a simple circuit
4. Know the values of the resistor, capacitors and inductors
5. Know Ohm's Law and apply it to calculate resistance, voltage and current.
6. Understand the Difference between AC and DC quantities.
7. Analyse, connect and carry out simple calculations on simple electrical circuit.
8. Interpret basic electrical/Solar pv signs and symbols.
9. Understand the Operations, Uses and Limitations of Measuring Instruments

ROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE: BASIC ELECTRICITY				**COURSE CODE: CES1-12**		**CONTACT HOURS:**
YEAR: 1	**TERM:** 1	**PRE: REQUISITE:**	**Theoretical:** 36 Hours **Practical:** 48 Hours			
Goal: This module is designed to introduce the trainee to basic electricity as it relates to electrical and solar installation						
Theoretical Content				**Practical Content**		
GENERAL OBJECTIVE 1.0: Understand the Structure of Matter and its relevance to Electricity/Solar P V.						**Year 1, Term 1**
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1-2	1.1 Define the following terms: a. Molecule b. Electron c. Atom d. Electric charge e. Electric Current f. Electric Voltage g. Quantity of electricity 1.2 Explain the differences between positive and negative charges. 1.3 Explain the flow of electricity	Explain atom, electron, proton , molecule, electric charge, electric current. • Describe the differences between positive and negative charges • Describe how electricity flows	Textbooks Internet	• Identify electrical insulators • Identify electrical conductors	Show Students conductors and insulators.	Charts Pictures Videos Discrete components

GENERAL OBJECTIVE 2.0: Understand the Chemical Source of Electromotive Force. Year 1, Term 1						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
3-4	2.1 Define the following terms: a. Electric power b. Energy 2.2 Explain the difference between e.m.f and potential difference (p.d) 2.3 Explain how to identify the following: a. Primary Cells b. Secondary Cells 2.4 Explain how to use instruments and visual observation to test battery 2.5 Show cells in: a. Series b. Parallel c. Series –Parallel 2.6 Explain the effects of internal resistance on battery voltage output. 2.7 State advantages of cells in series or parallel connections. e.g. voltage in series and in parallel	Explain the following terms: electric power and energy • Distinguish between e.m.f and potential difference (p.d) • Explain how to identify the following: a. Primary Cells b. Secondary Cells • Describe how to use instruments and visual observation to test battery • Draw cells connected in series, parallel and series - Parallel. Describe the effects of internal resistance on battery voltage output. • List the advantages of cells in series or	Textbooks Internet Textbooks • Textbooks • Charts Board Marker Textbooks Textbook Internet Books Internet Books Internet	Describe the following terms: electric power and energy. Demonstrate voltage or emf measurement in a battery and in a circuit Identify Primary and Secondary cells • Identify parts of a primary cell • Identify parts of a secondary cell • Test for the condition of a cell or battery Connect cells in: a. Series b. Parallel c. Series –Parallel - explains the effects of internal resistance on battery voltage output	Guide learners to: distinguish between electric power and energy demonstrate the use of Multimeter for measurement of voltage • Show primary and secondary cells • Guide Students to identify part of Primary and Secondary Cells • Show students how to Test cells and Battery Condition. • Use instruments	Charts Battery Resistor circuit Video Multimeter • Dry cell (e.g. torch light battery) • Lead acid cell (e.g. car battery) Hydrometer • DC Voltmeter • Calculator • Primary Cell Connecting Wires • DC Voltmeter • Vero Board Batteries Connecting wires Multimeter Charts

	2.8 Explain with calculations how resistance affect battery	parallel connections. e.g. voltage in series and in parallel •Describe with calculations how resistance affect battery			and visual observation to show how to connect in: a. Series b. Parallel c. Series – Parallel	Videos Simulators Charts Charts Board
General Objective 3.0: Understand the Construction and functions of Resistors, Inductors and Capacitors. In a simple circuit. **Year 1, Term 1**						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
5-6	3.1 Explain using charts the various types and sizes of the following: a. Resistors b. Capacitors c. Inductors. 3.2 Explain the following resistors: a. Composition type resistor b. Wire wound type resistor c. Variable resistors d. Fixed resistors 3.3 State the functions of the following in circuit: a. Resistor b. Capacitor	3.1 Identify using charts the various types and sizes of the following: a. Resistors b. Capacitors c. Inductors. 3.2 Describe the following resistors: a. Composition type resistor b. Wire wound type resistor c. Variable resistors d. Fixed resistors Mention the functions of the following in circuit:	• Chalk/white board etc. • Inductors • Capacitors • Resistors Textbooks Internet Textbooks Internet Textbooks Internet	Guide students to: • Identity various types of resistors, Capacitors and Inductors • Connect Resistors and Capacitors in Series and in Parallel carryout testing the functions of the following in a circuit schematic board: Resistor, Capacitor, inductor in a circuit	Guide trainees to: • Identity various types of resistors, capacitors and inductors • Connect Resistors and Capacitor s in Series and in parallel support student to carry out test	Charts, pictures •Connecting wires • Vero Board • Capacitors • Resistors • Variable Resistors

	c. Inductor in a Circuit 3.4 Explain the constructional features of the following: Resistors, Capacitors and Inductors 3.5 Explain the power rating of a resistor 3.6 Describe using charts the power rating of different resistors. 3.7 Explain application of the following: a. Resistor b. Capacitor 3.8 Describe using chart the working Voltage of: a. Resistor b. Capacitor c. Inductor 3.9 Describe using charts the power rating of different: a. Resistor b. Capacitor	a. Resistor b. Capacitor c. Inductor in a Circuit Describe the constructional features of the following: Resistors Capacitors and Inductors State the power rating of a resistor Identify using charts the power rating of different resistors. To Explain application of the following: a. Resistor b. Capacitor c. Inductor 3.8 Identify using chart the working Voltage of: a. Resistor b. Capacitor c. Inductor 3.9 Identify using			functions of the following: Resistor and Capacitor, Inductor in the circuit	multimeter, functional power circuit board, live resistor ,capacitor and inductor Resistors, Capacitors, Inductors

		charts the power rating of different: a. Resistor b. Capacitor				
General Objective 4.0: Know the Values of Resistor(s), Capacitors and Inductors. Year 1, Term 1						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
WK 7	4.1 Explain the colour coding system of a. resistors b. capacitors c. inductors 4.2 Determine the following: a. Resistance of a resistor using colour codes b. capacitance of a capacitor using colour codes c. inductance of a capacitor using colour codes	Identify colour coding of resistor, capacitor and inductor • From colour code, show how to calculate the values of resistor, inductor and capacitor • Calculate the tolerance of resistors, inductor and capacitors • Calculate with the aid of charts the value of the tolerance of any: a. Resistor	• Whiteboard • Textbooks • Calculator • Color Coded resistors, capacitors and inductors • Coloured Resistors/Capaci tors •Writing materials. •Charts of colour codes resistors, capacitors and inductors	• Show colour coding of resistors. • Calculate using colour code the values of resistors, inductors and capacitors • Calculate using colour code the tolerance of resistors, inductors and capacitors Determine the value of a resistor tolerance, using colour code, capacitor polarity and inductor	Guide students to: • Identify colour coding of resistors. • Calculate using colour code the values of resistors, inductors and capacitors • Calculate using colour code the tolerance	• Using colour code calculate the values of resistors, capacitors and inductors.

	4.3 Identify using charts the tolerance of resistors, capacitors and inductors 4.4 Determine with the aid of charts the value of the tolerance of any: a. Resistor using colour codes b. Capacitors using colour codes c. Inductors using colour codes	using colour codes b. Capacitors using colour codes c. Inductors using colour codes			of resistors, inductors and capacitors Assist student to understand the resistor tolerance, capacitors and induction	power source , functional power, multimeter, sample of resistor , capacitor and induction

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ENGINEERING CRAFT PRACTICE						
MODULE:				**COURSE CODE: CES1-12**		**CONTACT HOURS:**
YEAR: 1	**TERM:** 1	**PRE: REQUISITE:**	**Theoretical:** 36 Hours **Practical:** 48 Hours			
Theoretical Content				**Practical Content**		
1. General Objective: 5.0 Know Ohm's Law and apply it to calculate resistance, voltage and current.						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
1	5.1 Explain Ohm's law. 5.2 Determine Resistance, Voltage and Current using Ohm's law e.g. - R= V/I 5.3 Show a. resistors in series b. resistors in parallel c. series and parallel connection 5.4 Show a. batteries in series b. batteries in parallel c. batteries in	5.1 State Ohm's law. 5.2 Show how to calculate Resistance, Voltage and Current using Ohm's law e.g. - R= V/I 5.3 Draw a. resistors in series b. resistors in parallel c. series and parallel connection 5.4 Draw a. batteries in series c. batteries in parallel	• White Board • Batteries • Resistors • Multi-meter • Textbooks • Power supply •DC Voltmeter •DC Ammeter markers	Guide students to measure current and voltage through and across unknown resistors and use it to calculate resistor, Measuring R, V by Using multi-meter. Build a simple circuit using Ohm's Law-Apply Ohm's Law to solve problems Calculating Resistance, Voltage	Guide students to measure current and voltage through and across unknown resistors and use it to calculate resistor value Demonstrate Measurement Teacher's Activities: Guide	Breadboard, resistors, wires, and power source. Worksheets, calculators, and reference materials. Multimeter, resistors, wires, and power source. Breadboard, resistors, wires, and power source

	series parallel connection 5.5 Show capacitors in series and parallel and capacitors in series parallel connection 5.6 State the implication of the connection modes in 5.3 - 5.5 5.7 Show the inductance and capacitance of inductors and capacitors connected in series and parallel.	c. batteries in series parallel connection 5.5 Draw capacitors in series and parallel and capacitors in series parallel connection as above. 5.6 Explain the implication of the connection modes in 5.3 - 5.5 5.7 Calculate the inductance and capacitance of inductors and capacitors connected in series and parallel. Teaching and discussion.		and Current Using Ohm's Law - Specific Objective: Apply Ohm's Law to calculate R, V and I. - .	students in building the circuit, provide feedback. Solving Problems Involving Ohm's Law Provide guidance, review student work worksheets, provide feedback Guided practice and group work.	

GOAL: This module is designed to introduce the trainee to the DC and AC current and voltage principles						
Year 1 Term 1	**General Objective 6.0: Understand the difference between AC and DC Current and Voltage. Year 1,**					
	THEORETICAL CONTENT			**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
2-3	6..1 Define AC and DC. 6.2 Explain the differences between AC and DC. 6.3 Explain the Characteristics of alternating current and direct current 6.4 Define peak value, mean value, RMS value, Frequency of AC.	Guide students to: 6.1Explain the definition 6.2 Explain AC and DC 6.2 Discuss. the differences between AC and DC. 6.3 Explain the Characteristics of AC and DC including waveform, frequency and Amplitude. 6.4 Define peak. value, mean value, RMS value,	markers Lesson note • White board • Signal Generator • Oscilloscope • Graph Paper Diagrams and illustrations markers Lesson note • White board •s.	Measure AC voltage and DC voltage current using a Multimimeter. Build simple AC and DC circuit using resistors, capacitors and batteries. Build simple Demonstrate by experiment Series and Parallel Resonance in an AC Circuit • Measure RMS value	Demonstrate measuring techniques Guide students in building the circuits Guide students to: • Demonstrate by experiment Series and Parallel Resonance in an AC Circuit • Measure RMS value and frequency	Multimeter and AC power source/ Breadboard, resistors, capacitors and batteries. Multimeter, wire and voltmeter AC and DC generator •resistors, inductors Faulty circuits and components

	6.5 Explain how to calculate peak value from RMS values of Current, and voltage, and vice versa 6.6 Describe the R.L.C configuration in AC circuit. 6.7 Explain the concept of resistance in AC circuit. 6.8 Determine inductive and capacitive reactance. XL = 2πfL (Inductive reactance) Xc = 1/(2πfC) (Capacitive reactance) 6.9 Explain the concept of impedance in AC circ	Frequency of Wave. 6.5 Calculate peak value from RMS values of Current, and voltage, and vice versa 6.6 Describe the simple treatment of R,L,C in AC circuit. 6.7 Explain the concept of resistance in AC circuit. 6.8 Calculate inductive and capacitive reactance. XL = 2πfL (Inductive reactance) Xc = 1/(2πfC) (Capacitive reactance) 6.9 Explain the concept of impedance in AC circuit		and frequency of an AC Demonstrate by experiment Series and Parallel Resonance in an AC Circuit • Measure RMS value and frequency of an AC • Graph Paper Diagrams and illustrations.	of an AC Guide students to: • Demonstrate by experiment Series and Parallel Signal Generator • Oscilloscope • AC Power Supply, • AC Voltmeter • Graph Paper Diagrams and illustration Resonance in an AC Circuit • Measure RMS value and frequency of an AC	- Multimeter and oscilloscope - Troubleshooting guides and resources Breadboard, resistors, wires, and power source Generator • Oscilloscope • AC Power Supply, • AC Voltmeter

General Objective 7.0: Understand the Principles of Transformer Operation and its Construction. Year 1, Term 1						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
4-5	7.1 Explain the Following concepts of Magnetism: a. temporary and permanent magnets b. magnetic field c. magnetic poles d. law of attraction and repulsion e. magnetic flux 7.2 Explain the effects of fields as applied to electro magnetism 7.3 State the colour code used for the winding of transformer.	7.1 Discuss the following concepts of Magnetism: a. temporary and permanent magnets b. magnetic field c. magnetic poles d. law of attraction and repulsion e. magnetic flux 7.2 Describe the effects of fields as applied to electro magnetism 7.3 Explain the colour code used for the winding of transformer. 7.4 Discuss with the aid of sketches the principles of operation of a single phase, double wound transformer.	• Magnet • Soft Iron • DC Power • Coil • Compass • Copper Coil • Permanent Magnet, •Magnetic Compass, • Insulated copper wire, •Soft iron core, •Power supply, •Pieces of iron, • Transformer Components. • A transformer • Chart • Calculator • Textbook • Lesson plan • Chalkboard • Different types of transformers Winding former, Industrial Site	Students to Verify characteristics of a Permanent Magnet and Connect a Simple Circuit to Produce a Temporary magnet. •Construct a Single, Phase Double wound transformer •Apply varnish to an iron sheets and winding conductors. •Identify type and parts of transformer	Guide students to: Verify •characteristics of a Permanent Magnet and Connect a Simple Circuit to Produce a Temporary magnet. •Construct a Single, Phase Double wound transformer •Apply varnish to an iron sheets and winding Conductors. •Identify type and Part of transformer Demonstration: Show students how to set up the transformer	Battery ,copper wire and nail. Soft iron, coil, dc power Compass, permanent magnet copper coil and Insulated copper wire Magnetic Compass, • Insulated copper wire, •Soft iron core, •Power supply, •Pieces of iron, • Transformer Components. • A transformer • Different types of transformers Winding former, Industrial Site visit Iron sheets (laminations), liquid varnish winding conductors

	7.4 Describe with the aid of sketches the principles of operation of a single phase, double wound transformer. 7.5 Explain the reasons for laminating the core of a transformer.	7.5 State the reasons for laminating the core of a transformer. .	visit Iron sheets (Lamination Auto		circuit safely, outlining procedures for taking measurements. - Guided Practice: Supervise students as they perform the practical setup and ensure they follow safety protocols. - Data Analysis: Assist students in analyzing their measurements, leading discussions on the results and their implications.	Winding former. Step-down/step up transformer Auto transformer - Equipment: - Single-phase double-wound transformers. - AC power supply units. - Multi meters and ammeters for measuring voltage and current. - Connecting wires and safety equipment (gloves, goggles).

General Objective 8.0: Analyse, Connect and Carry out Simple Calculations on Simple Electrical Circuit. Year 1, Term 1						
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
6-8	8.1 Define electric circuit 8.2 Explain the difference between series and parallel circuit 8.3 Explain how to determine the total resistance in a series DC circuit 8.4 Determine the voltage drop across each resistor of a series circuit 8.5 Explain how to calculate total resistance in series and in parallel. 8.6 Determine the Current in each arm of a parallel circuit 8.7 State the effect	8.1 Explain an electric circuit 8.2 Discuss the differences between series and parallel circuit 8.3 Calculate the total resistance in a series DC circuit 8.4 Calculate the voltage drop across each resistor of a series circuit 8.5 Calculate the total resistance in series and parallel circuits 8.6 Calculate the current in each arm of a parallel circuit. 8.7 Discuss the	DC circuit •Vero Board • Capacitors, •low voltage, • AC power supply, •Voltmeter •Ammeter and •Frequency meter. • Bread Board - Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation Worksheets and calculators - Online circuit simulation software	• Describe an electric circuit • Demonstrate how to connect resistors in series and in parallel to show the variation of Current and Voltage in the Circuit • Demonstrate by experiment, how to determine voltage drop across each resistor of a series circuit -Build simple series and parallel circuits using resistors and batteries. : Measure voltage and current in series and parallel circuits using industry-standard equipment. Build simple series and parallel circuits	Guide students to: •Connect resistors in series and in parallel to show the variation of Current and Voltage in the Circuit •Demonstrate by experiment, the effect of Resistors in Series and in parallel Demonstrate measurement techniques. - Supervise student practice. - Provide	Industrial workshop or laboratory. Breadboard and components (resistors, batteries, wires) Multimeter and oscilloscope - Industrial workshop or laboratory - Multimeter and oscilloscope - Industry-standard circuit testing equipment - Industrial workshop or laboratory - Faulty circuits an d components - Industry-standard troubleshooting equipment and software

	of capacitor in an electric circuit. 8.8 Calculate the total voltage and current in series and parallel connected cells. 8.9 State the current and voltage relationship in: a. An inductive circuit e.g. current leads the applied voltage. b. Capacitive circuit, e.g. current lags the applied voltage c. The combination of capacitance and inductance (i) in series (ii) in parallel. 8.10 Calculate impedance in an AC Circuit 8.11 Explain resonance in: a. a series circuit	effect of capacitor in an electric circuit. 8.8 Calculate the total voltage and current in series and parallel connected cells. 8.9 Discuss the current and voltage relationship in: a. an inductive circuit e.g. current leads the applied voltage. b. Capacitive circuit, e.g. current lags the applied voltage c. The combination of capacitance and inductance (i) in series (ii) in parallel. 8.10 Calculate impedance in an AC Circuit 8.11 Describe resonance in: a. a series circuit	- Oscilloscope and signal generator - Diagrams and illustrations - Oscilloscope and signal generator - Diagrams and illustrations - Worksheets and calculators - Online circuit simulation software	using resistors and batteries. Show the effect of capacitor in an electric circuit. Demonstrate the current and voltage relationship in: a. an inductive circuit e.g. current leads the applied voltage. b. Capacitive circuit, e.g. current lags the applied voltage c. The combination of capacitance and inductance (i) in series (ii) in parallel. Show how to calculate impedance in AC circuit Discuss resonance in: a. a series circuit b. a parallel circuit Discuss the meaning of	guidance on measurement safety Connect resistors in series and in parallel to show the variation of Current and Voltage in the Circuit • Demonstrate by experiment, the effect of Resistors in Series and in •Connect resistors in series and in parallel to show the variation of Current and Voltage in the Circuit Demonstrate	

	b. a parallel circuit 8.12 Define the meaning of a. Q factor b. Bandwidth 8.13 Calculate resonant frequency.	b. a parallel circuit 8.12 Explain the meaning of a. Q factor b. Bandwidth 8.13 Calculate resonant frequency.		a. Q factor b. Bandwidth Calculate resonant frequency.	measurement techniques. - Supervise student practice. - Provide guidance on measurement safety Conduct an experiment to verify the effect of capacitors/inductor in AC circuit	
Year 1 Term 1	**General Objective 9.0: Interpret Basic Electrical/Electronic Signs and Symbols.**					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
WK 9	9.1Explain basic signs and symbols in electrical installation. 9.2 Explain some electrical components and accessories used in domestic installation.	• Identify basic signs and symbols in electrical installation. • Identify some electrical components and accessories used in domestic installation. . State some	• Textbooks • Note • Whiteboard • Charts	- Provide students with diagrams and circuits containing various signs and symbols. - Show the electrical signs and symbols. State the common abbreviations used in electrical and	Guide students to: Provide students with diagrams and circuits containing various signs and symbols. • Sketch basic electrical	- Diagrams and circuits - Whiteboard and markers - Handouts and worksheets

	9.3 Describe some electrical symbols 9.4 Show the graphical symbols of components used in electronics/electrical system e.g. transistor, amplifiers, switch, socket outlet. etc.	electrical symbol State the graphical symbols of components used in electronics/electrical		electronic circuits. E.g I = Current C = Capacitance V = Voltage etc. • Sketch basic electrical symbols e.g. Switch, Lamp holders, Socket outlets etc.	symbols e.g. Switch, Lamp holders, Socket outlets etc. Explain the common abbreviations used in electrical and electronic circuits. E.g I = Current C = Capacitor V = Voltage etc. Guide students to draw the graphical symbols of components used in electronics/electrical system e.g. transistor,amplifiers, switch,	

					socket outlet, etc. Explain some electrical symbols	
Year 1 Term1	**General Objective 10.0: Understand the Operation, Uses and Limitations of Measuring Instruments. Year 1, Term 1**					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Learning Resources**
WK 11-12	10.1 Describe the parts of the following: Multi-meter, Ammeter, Voltmeter and Wattmeter 10.2 Explain how to recognize fault condition of measuring instrument. 10.3 Explain the procedure of how to calibrate measuring instrument for effective	10.1 Discuss the parts of the following: Multi-meter, Ammeter, Voltmeter and Wattmeter 10.2 Describe how to recognize fault condition of measuring instrument. 10.3 Show student how to calibrate measuring instrument for effective measurement	• Multimeter - digital and analogue • Ohmmeter • Note. • White Board • Multimeter, • Faulty electrical appliance Cables •Ammeter •Voltmeter •Wattmeter •Bridge meter •DC power source •AC power	• Identify basic electrical measuring instruments. • Measure current, voltage and resistance of electrical simple circuit using appropriate measuring instrument • Observe safety measures in the use of the electrical measuring instruments • Calibrate measuring	Guide students to: • Identify basic electrical measuring instruments. • Measure current, voltage and resistance of electrical simple circuit using appropriate measuring instrument • Observe safety measures in the use of	Measuring instruments (ammeters, voltmeters, ohmmeters) - Diagrams and illustrations Measuring instruments and calibration equipment - Circuits and test equipment - Handouts and worksheets - Faulty measuring instruments - Diagrams and illustrations - Handouts and

	measurement		source •connecting wires •Electronic Work Bench •soft-ware or equivalent	instrument for effective measurement	the electrical measuring instruments	worksheets

EVALUATION GUIDE FOR MODULE CESI 12 - BASIC ELECTRICITY

The student will be assessed on the basis of demonstrating an understanding of basic electrical theory
Students will be graded on the following Criteria:
a. Project (Process and Product) assessments.
b. Assignments and Tests
c. Terminal Examinations.

The laboratory reports should also be assessed and graded.

Assessment:

Type of Assessment	**Purpose and Nature of Assessment**	**Weighting (%)**
Skill (Psychomotor and Affective) Assessment	**Project Process and product**	**30%**
Assignment/Test	**Cognitive**	**10%**
Terminal Examination	**Cognitive/Psychomotor/Affective**	**60%**
	Total	**100%**

Recommended Textbooks & References: Recommended textbooks and references for a Basic Electricity course:

Textbooks

1. Electronics for Dummies by C.L. Chung (5th Ed.) - A beginner-friendly textbook covering basic electricity and electronics concepts.
2. Basic Electricity by Van Valkenburgh, Nooger, and Neville (8th Ed.) - A comprehensive textbook covering fundamental principles of electricity.
3. Electric Circuits by James W. Nilsson and Susan A. Riedel (12th Ed.) - A widely used textbook focusing on electric circuits and analysis.

Reference Guides

1. Ugly's Electrical References by George V. Hart and Robert P. Hart (2020 Ed.) - A handy reference guide covering electrical theory, circuits, and safety.
2. Electrician's Pocket Manual by Rex Cauldwell (20th Ed.) - A compact reference guide covering electrical codes, formulas, and calculations.

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Textbooks

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2. Electrician's Pocket Manual by Rex Cauldwell (20th Ed.) - A compact reference guide covering electrical codes, formulas, and calculations.
3. NEC Code Book (2020 Ed.) - The official National Electric Code (NEC) reference guide.

Online Resources

1. All About Circuits - A comprehensive online resource covering electricity, electronics, and circuit analysis.
2. Electronics Tutorials by Williamson - A free online tutorial series covering basic electricity and electronics concepts.
3. Khan Academy: Electricity and Magnetism - A free online course covering electricity and magnetism fundamentals.

Software and Simulation Tools

1. SPICE (Simulation Program with Integrated Circuit Emphasis) - A widely used circuit simulation software.
2. Multisim - A popular circuit simulation and design software.
3. Falstad - A free online circuit simulation software.

These resources will provide a solid foundation for learning basic electricity concepts.

ROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN RENEWABLE ENERGY CRAFT PRACTICE		
Course: Introduction to Renewable Energy	**Course Code: CES1-13**	**Total Hours: 72HRS**
Year: 1 Term: 1	**Pre-requisite:**	**Practical:**
Goal: This module is designed to provide the trainee with the Basic knowledge of Renewable Energy		
General Objectives: On completion of this module, the trainee should be able to: **1. Understand the Sources of Energy** **2. Understand the Sources of Renewable Energy** **3. Understand the importance of Renewable Energy in solving climate change** **4. Understand Energy Transition**		

ROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ELECTRICAL AND SOLAR PV INSTALLATION AND MAINTENANCE						
MODULE: Introduction to Renewable Energy				**Course Code: CES1-13**		**Total Hours: 72HRS**
YEAR: 1	**TERM:** 1	**PRE: REQUISITE:**				
GOAL: This module is designed to provide the trainee with the Basic knowledge of Renewable Energy						
	Theoretical Content			**Practical Content**		
General Objective 1.0: Understand the Sources of Energy						
Week	**Specific Learning Outcomes**	**Teacher Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher Activities**	**Resources**
	1.1 Define Energy	Explain energy	Textbooks Internet			
	1.2 Explain the importance of Energy	State the importance of energy	Clip charts Pictures Videos Projectors	Describe importance of energy	Guide learners to: State importance of energy	Clip charts Pictures Videos Projectors
	1.3 Explain the sources of Energy: Renewable Non-Renewable	Describe the sources energy	Clip charts Pictures Videos Projectors	Classify energy sources: Renewable Non-Renewable	Classify energy sources: Renewable Non-Renewable	Clip charts Pictures Videos Projectors
	1.4 Explain forms of energy i. Mechanical ii. Electrical iii. Chemical iv. Heat	Describe forms of energy -Mechanical -Electrical -Chemical	Clip charts Pictures Videos Projectors	Discuss forms of energy	Identify forms of energy	Clip charts Pictures Videos Projectors

		-Heat				
	Theoretical Content			**Practical Content**		
General Objective 2.0: Understand the Sources of Renewable Energy						
Week	**Specific Learning Outcomes**	**Teacher Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher Activities**	**learning Resources**
	2.1 Define Renewable energy	Explain Renewable energy	Textbooks Internet	Describe Renewable energy	Guide learner to state renewable energy	
	2.2 Explain the difference between renewable and non-renewable energy 2.3 Explain the types of renewable energy sources i. Biomass energy ii Wind energy iii. Hydro energy iv. Solar energy v. Geothermal energy	Describe the difference between renewable and non-renewable energy Discuss the type of renewable energy sources i. Biomass energy ii. Wind energy iii. Hydro energy iv. Solar energy v. Geothermal energy		Identify the difference between renewable and non-renewable energy State various types renewable energy sources i. Biomass energy ii. Wind energy iii. Hydro energy iv. Solar energy v. Geothermal energy	differentiate between renewable and non-renewable energy List and describe various renewable energy sources	Charts Pictures Videos Charts Pictures Videos

	Theoretical Content			**Practical Content**		
General Objective 3.0: Understand the importance of Renewable Energy in solving climate change						
Week	**Specific Learning Outcomes**	**Teacher Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher Activities**	**Resources**
	3.1 Define the following i. Weather ii. Climate	Explain weather and climate	Textbooks Internet	Describe weather and climate change	Guide learners to: describe weather and climate change	White board, Maps, e-learning projector, videos.
	3.2 Explain types of weather: Sunny, cloudy, windy, snowy and rainy	Describe the various types of weather	White board, Maps, e-learning projector, videos.	Identify types of weather	identify types of weather	White board, Maps, E-learning, projector, videos.
	3.3 Explain the types of climates: temperate, polar, Mediterranean, etc. 3.4 Define global warming, climate change and ozone layer	Describe the various types of climates Explain what is global warming, climate change and ozone layer	White board, Maps, e-learning projector, videos.	Classify global warming, climate change and ozone layer	classify global warming, climate change and ozone layer	White board, Maps, E-learning projector, videos.
	3.5 Explain the importance of renewable energy in mitigating climate	Describe the importance of renewable energy in	White board, Maps, e-learning projector, videos.	Discuss the importance of renewable energy in	Mention the importance of renewable energy	White board, Maps, e-learning

	change	mitigating climate change		mitigating climate change	in mitigating climate change	projector, videos.
General Objective: 4.0 Understand Energy Transition						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**
	1.1 Define energy transition	Explain energy transition	Textbooks Internet	Identify forms of energy transition	Guide learner to: identify forms of energy transition	Pictures Charts Videos
	1.2 Explain the importance of Energy transition	Discuss the importance of energy transition				
	1.3 Explain energy transition in; i. Biofuel ii. Electricity etc.	Describe energy transition in; i. Biofuel ii. Electricity etc.		Identify energy transition in; Biofuel, Electricity, etc.	Identify energy transition in; Biofuel, Electricity, etc.	Pictures Charts Videos

EVALUATION GUIDE FOR MODULE CES1-13 INTRODUCTION TO RENEWABLE ENERGY

The student will be assessed on the basis of demonstrating an understanding of introduction to renewable energy.
Students will be graded on the following Criteria:

a. Project (Process and Product) assessments.
b. Assignments and Tests
c. Terminal Examinations.

The laboratory reports should also be assessed and graded.

Assessment:

Type of Assessment	**Purpose and Nature of Assessment**	**Weighting (%)**
Skill (Psychomotor and Affective) Assessment	**Project Process and product**	**30%**
Assignment/Test	**Cognitive**	**10%**
Terminal Examination	**Cognitive/Psychomotor/Affective**	**60%**
	Total	**100%**

Recommended Textbooks & References: Recommended textbooks for an Introduction to Renewable Energy course:

Textbooks

1. Renewable Energy: Power for a Sustainable Future by Godfrey Boyle (4th ed.) - A comprehensive and accessible textbook covering various renewable energy technologies.
2. Sustainable Energy: Choosing Among Options by Jeffrey Logan (3rd ed.) - A thorough textbook exploring the science, technology, and policy aspects of renewable energy.
3. Renewable Energy Systems: A Smart Energy Approach by Muhammad Kamran and Coimbatore Balaji (2nd ed.) - A modern textbook focusing on smart energy systems and renewable energy technologies.
4. Introduction to Renewable Energy by Vaughn C. Nelson (2nd ed.) - A concise and easy-to-understand textbook covering the basics of renewable energy.
5. Renewable Energy: Technology, Economics and Environment by Martin Kaltschmitt, Wolfgang Streicher and Andreas Wiese (7th ed.) - A detailed textbook covering the technical, economic, and environmental aspects of renewable energy.

Online Resources

1. National Renewable Energy Laboratory (NREL) - A wealth of information on renewable energy technologies, research, and development.
2. International Renewable Energy Agency (IRENA) - A global platform providing knowledge, guidance, and resources on renewable energy.
3. Renewable Energy Policy Network for the 21st Century (REN21) - A global network providing information, research, and analysis on renewable energy policy.

Supplements

1. Renewable Energy: A First Course by Robert E. Hebner (online course) - A free online course introducing the basics of renewable energy.
2. The Renewable Energy Handbook by William H. Kemp (online resource) - A comprehensive online resource covering various renewable energy technologies.

Programme: PROGRAMME: NTC IN ELECTRICAL AND SOLAR INSTALLATION & MAINTENANCE WORK	**Course Code: CES1-21**	**Total Contact Hours: 276HRS**
Course: CESI: 21 - DOMESTIC ELECTRICAL INSTALLATION		**Theoretical: hours/week**
Year: 2 Term: 1	**Pre-requisite:**	**Practical: hours/week**
Goal: This module is intended to provide the trainee with the knowledge and skill to enable him carry out complete electrical installations in a building and its associated equipment.		
General Objectives:		
One completion of this module, the trainee should be able		
1. Understand electrical/electronic working diagrams. 2. Know different types of domestic surface wiring techniques. 3. Know different types of domestic conduit wiring. 4. Understand the principles of protecting electrical devices and their installation. 5. Understand sequence for inspecting and testing domestic installations. 6. Understand the terms used in illumination. 7. Know types of lamps for illumination.		

Programme: National Technical Certificate in Electrical Installation and Maintenance Practice						
Course: Domestic Installation		**Course Code: CES1- 21**		**Contact Hours:**		
Course Specification:		**Theoretical/Practical**				
	Theoretical			**Practical**		
	General Objective:1.0: Understand Electrical/Electronic Working Diagrams. Year: 2, Term: 1					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	Learning Resources
1-6	1.1 Explain using charts, symbols used in electrical engineering drawing of an electrical installation. 1.2 Explain how to interpret the scale used in working drawing 1.3 Explain the electrical	1.1 Identify using charts, symbols used in electrical engineering drawing of an electrical installation. 1.2 Describe how to interpret the scale used in working drawing 1.3 List the electrical	• Chalk /white Board flip chart Text books Internet	• Discuss basic signs and symbols used in electrical installation. • Sketch basic electrical symbols e.g. Switch, Lamp holders, Socket outlets etc. • Mention some abbreviations of electrical symbols. • Identify some electrical components and accessories used in domestic	Guide students to: • Identify basic signs and symbols in electrical installation. • Sketch basic electrical symbols e.g. Switch, Lamp holders, Socket outlets etc. • Mention some abbreviations of electrical symbols. • Identify some electrical components and accessories used	● Scale rule ● Working drawing ● Drawing Paper and instruments. ● Soft-wares E.g. AutoCAD ● Electronic Work Bench etc ● Videos. ● Working drawing ● Industry Codes ● Videos ● Softwares

	accessories and components required for a job from the working drawing 1.4 Describe the distribution system from a working drawing	accessories required for a job from the working drawing 1.4 Discuss the distribution system from a working drawing		installations. • Locate the position of the various accessories on a working drawing • Draw electrical Installation Layout from a given living house plan	in domestic installations. •Locate the position of the various accessories on a drawing •Draw electrical Installation Layout from a given living house plan	• Working drawing • Industry Codes • Videos • Software
	2.0: Know Different Types of Domestic Surface Wiring Techniques Year:2, Term:1					
Week	**Specific earning Outcomes**	**Teacher Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher Activities**	**Learning Resources**
7-12	2.1 Describe the materials used for fixing cables to a surface 2.2 Explain cable types and sizes used for the	2.1 Discuss materials used for fixing cables to a surface 2.2 Discuss cable types and sizes used for the following:	Textbooks Industry Codes Internet , Textbooks Industry Codes Internet	• List the materials used for fixing cables to a surface Identify different types of cables, their rating and where they are	Guide students to: •Identify materials for fixing cables to a surface • Identify different types of cables, their rating and where they are applicable	• P.V.C cable (twin & earth), brass nails, clips, • wooden board • Accessories • Testing Instrument • Hand-tools • Insulation tape. • Cable display board. • P.V.C cable of different sizes, • socket outlets • distribution board • cooker control unit, • hand tools • Testing instruments • Screws • Energy meter

	following: Lighting, heating, cooker control unit and socket outlets. 2.3 Explain cable rating, maximum load demand and ambient temperature 2.4 Explain how to carry out simple, surface wiring of building (residential) using appropriate tools. 2.5 Explain	Lighting, heating, cooker control unit and socket outlets. 2.3 Discuss cable rating, maximum load demand and ambient temperature 2.4 Describe how to carry out simple, surface wiring of building (residential) using appropriate tools. 2.5 State	Textbooks Industry Codes Internet Textbooks Industry Codes Internet Textbooks Industry Codes Internet	applicable. Sketch and carryout simple surface wiring consisting of: Two points of light controlled by a switch using looping system. Ceiling fan Socket outlet (13 A&15A) Cooker control unit Distribution board Carryout wiring in a sequence order using	• Sketch and carryout simple surface wiring consisting of: two points of light controlled by a switch using looping system. • Ceiling fan • Socket outlet (13A &15A) • Cooker control unit • Distribution board Carryout wiring in a sequence order using	
	relevant statutory regulations regarding surface wiring 2.6 Explain the regulations of	relevant statutory regulations regarding surface wiring 2.6 Discuss the regulations of Electrical	Textbooks Industry Codes Internet	appropriate tools and techniques • Select and use appropriate tools and equipment for surface wiring.	appropriate tools and techniques • Select and use appropriate tools and equipment for surface wiring.	

	Electrical Board of Nigeria and **National Electricity Supply Industry (NESI)** on surface wiring.	Board of Nigeria and **National Electricity Supply Industry (NESI)** on surface wiring.		• Carry out test of completed surface wiring using appropriate instrument. Demonstrate compliance of the regulations of the **National Electricity Supply Industry (NESI)** on surface wiring.	• Carry out test of completed surface wiring using appropriate instrument. Comply with the regulations of the **National Electricity Supply Industry (NESI)** on surface wiring.	NESI Regulations

	General Objective 3.0: Know the types of Domestic Conduit Wiring. Year 2, Term 1					
Week	**Specific Learning Outcomes**	**Teacher Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher Activities**	**Learning resources**
13-24	3.1 Explain the meaning of conduit 3.2 Discuss the advantages and disadvantages of conduit installation. 3.3 Describe types of conduits; steel conduit, flexible conduit and pvc conduit. 3.4 Explain the applications of stock and dies taps and dies, hacksaw sticks 3.5 State relevant conduit statutory regulations 3.6 Explain appropriate procedures for	3.1 Discuss the term conduit 3.2 State the advantages and disadvantages of conduit installation. 3.3 Discuss types of conduits; steel conduit, flexible conduit and pvc conduit. 3.4 Describe the applications of stock and dies taps and dies, hacksaw sticks 3.5 Discuss relevant conduit statutory regulations 3.6 Describe appropriate procedures for	Textbooks Industry Codes Internet Textbooks Industry Codes Internet Textbooks Industry Codes Internet • IEE Regulation.	• Wire a point of light control by two-2-way switch using P.V.C and steel Conduit pipes. •Work safely at all time, complying with necessary health and safety regulations. • Describe conduit wiring methods in electrical installation. •Carryout the installation in accordance with safe working practices and IEE wiring regulations. •Sketch a conduit wiring	Guide students to: • Wire a point of light control by two-2-way switch using P.V.C and steel Conduit pipes. • Work safely at all time, complying with necessary health and safety regulations. Describe conduit wiring methods in electrical installation. •Carryout the installation in accordance with safe working practices and IEE wiring regulations. •Sketch a conduit wiring	• Flip chart • Chalk • white board. • Steel conduit, • PVC conduit & Flexible conduit. • Hacksaw, stacks, Taps & dies. •

	preparing conduit for Installation 3.7 Explain use of running coupler, conduit boxes, bend, elbows, tees and accessories for conduit work. 3.8 Explain how to determine the setting and bend permissible radial length 3.9 Explain how to test the installation as stipulated by the statutory regulations 3.10 Explain how to maintain tools and	preparing conduit for Installation 3.7 Discuss use of running coupler, conduit boxes, bend, elbows, tees and accessories for conduit work. 3.8 Discuss how to determine the setting and bend permissible radial length 3.9 Describe how to test the installation as stipulated by the statutory regulations 3.10 Describe how to maintain tools and	Textbooks Industry Codes Internet	diagram to be installed. Identify the materials and accessories used in conduit wiring. •Select and use appropriate tools and equipment for conduit wiring. •Draw in cables using fish tape •Carryout conduit wiring in a sequencing order using appropriate tools and techniques •Carry out test of completed conduit wiring	diagram to be installed. •Identify the materials and accessories used in conduit wiring. •Select and use appropriate tools and equipment for conduit wiring. •Draw in cables using fish wire •Carryout conduit wiring in a sequence order using appropriate tools and techniques •Carry out test of completed conduit wiring using	• Pieces of conduit with threads and without. Running coupler set, conduit boxes, bends, • Set 90 Degrees, 45 degrees and bend. P.V.C Pipes and its accessories. Steel pipes and its accessories. Hacksaw, reamers, pipe vice, threading tools, bending machines, tape rule, lighting accessories. Bending spring Hand trowel
	equipment used on conduit installation. 3.11 Describes how to maintain tools and equipment for conduit installation.	equipment used on conduit installation. 3.11 Discuss how to maintain tools and equipment for conduit installation.		using appropriate instrument. •Maintain tools used for conduit wiring	appropriate instrument. •Maintain tools used or conduit wiring.	

	General Objective 4.0: Understand the Principles of Protecting Electrical Devices and their installation. Year 2, Term 1					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
25-36	4.1 Explain common types of protective devices 4.2 Explain the principles of operations of circuit breakers and fuses in electrical installation	4.1 Discuss common types of protective devices 4.2 Describe the principles of operations of circuit breakers and fuses in electrical installation	Textbooks Internet Industry Codes	Describe common types of protective devices Discuss the principles of operations of circuit breakers and fuses in electrical installation • Demonstrate how to carry out wiring of a complete conduit installation consisting of:	Guide students to: List common types of protective devices Carry out wiring of a complete conduit installation consisting of:	• Single phase circuit breaker, 3 - phase circuit breaker, ELCB and fuse link.
	4.3 Explain the applications of circuit breakers and fuses in electrical installation 4.4 Explain how to	4.3 Discuss the applications of circuit breakers and fuses in electrical installation 4.4 Describe how to	IEE Tables for current rating flip chart	• Incoming mains • supply • Electrical energy • meter • Isolating fuse Switch board • with mains	• Incoming mains supply • Electrical energy meter • Isolating fuse • Switch board with mains	• Sketches and chalkboard • Circuit breakers and fuses

	determine current rating of fuses 4.5 Describe the earthing of electrical installations. 4.6 State the regulations relating to various types	determine current rating of fuses 4.5 Discuss the earthing of electrical installations. 4.6 Discuss the regulations relating to	Textbooks Internet Textbooks Internet Textbooks Internet Textbooks Internet Industry Codes	switch and two • circuit breakers ELCB Single power outlet using P.V.C Cable Single fluorescent lighting point controlled by a single switch	switch and two circuit breakers • ELCB • Single power outlet using P.V.C Cable • Single fluorescent lighting point controlled by a single switch using PVC Cable	● Energy meter ● Switchboard ● ELCB ● Fluorescent fitting ● Electric stove ● PVC Cables ● Relevant tools Measurement and Testing Instruments Online Cable sizing calculator Earth wire Multimeter Earth rods
	of protective devices. 4.7 Explain the use of current and voltage operated earth leakage circuit breaker observing relevant regulations.	various types of protective devices. 4.7 Describe the use of current and voltage operated earth leakage circuit breaker observing relevant regulations.	**IEE Tables for current rating**	using PVC Cable •An electrical stove. •Sketch the symbols of protective devices in electrical installation. •Identify basic protective devices used in electrical	•An electrical stove. •Sketch the symbols of protective devices in electrical installation. •Identify basic protective devices used in electrical installations.	Multimeter & Clamp Meter . Insulation Tester (Megger) Earth Loop Impedance Tester Portable Appliance Tester (PAT)

				installations. •Select the appropriate size and types of protective devices for a particular installation. •Locate	•Select the appropriate size and types of protective devices for a particular installation. •Locate protective devices in an	

				Protective Devices In An Electrical Installation Facility. • Identify Causes Of Abnormal Conditions In Electrical Installations. • Operate The Protective Devices In Accordance With Approved Procedures And Regulations.	Electrical Installation Facility. I• Identify Causes Of Abnormal Conditions In Electrical Installations. • Operate The Protective Devices In Accordance With Approved Procedures And Regulations.	

Year 2, Term 1	**General Objective 5.0: Understand Sequence for inspecting and Testing of Domestic Installations. Year 2, Term 1**					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
12-24	5.1 Explain statutory safety regulations for life, properties and environment 5.2 Explain the procedure for inspecting electrical and mechanical connections for loose or partial contact. 5.3 Explain types of electrical Installation Test	• Discuss statutory regulations in electrical installation environment. 5.2 Describe the procedure for inspecting electrical and mechanical connections for loose or partial contact. 5.3 Describe following types of electrical Installation Tests: a. Polarity test b. Insulation resistance test c. Continuity test d. Earth leakage test		• Identify statutory regulations in electrical installation environment. Demonstrate how to inspect electrical and mechanical connections for loose or partial contact. Testing using appropriate instrument. Carry out earthing test • Apply statutory safety regulations for life, properties and environment •Inspect electrical and mechanical connection for loose	continuity testing using appropriate instrument. Carry out earthing test Guide students to: •Apply statutory safety regulations for life, properties and environment • Inspect electrical and mechanical for loose and partial contact test for polarity, continuity and insulation test. • Demonstrate the tightening of all loose contacts and joints. • Carryout polarity testing using appropriate instrument.	wiring board. • Multi-meter (analog/digital), bell, • battery, • test lamp. • Electrical & Mechanical machineries, • Electrical wire tracer Analog clamp meter Insulation resistance tester Earth leakage tester

				and partial contact • Demonstrate the tightening of all loose contacts and joints. Carryout polarity testing using appropriate instrument. Carry out continuity	Carry out	
				testing using appropriate instrument. Carry out earthing test	continuity testing using appropriate instrument. Carry out earthing test.	
	General Objective 6.0: Understand the terms used in Illumination. Year 2, Term 1					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning resources**
24-36	6.1 Define the following terms in respect of illumination: a. Luminous intensity (Symbol	6.1 Discuss the following terms in respect of illumination: a. Luminous intensity	Textbooks Industry Codes Internet	•Carryout experiment to measure the illuminating power of a given lamp. •Using illumination table, determine the	Guide students to: •Carryout experiment to measure the illuminating power of a given lamp. •Using illumination	Incandescent lamp, • Fluorescent lamp • Illumination Flip charts •Photometer

	I) b. Luminous flux (Symbol Φ) c. Illumination (Symbol E) 6.2 Explain the following terms: Cosine law, Brightness glare and photometry 6.3 Explain simple illumination terminologies like luminous intensity, lumen, lux etc. 6.4 Explain methods of denoting luminous intensity e.g. plan, horizontal luminous intensity, mean spherical luminous intensity. 6.5 Explain how to solve the mathematical problems in the	(Symbol I) b. Luminous flux (Symbol Φ) c. Illumination (Symbol E) 6.2 Discuss the terms Cosine law, Brightness glare and photometry 6.3 Discuss simple illumination terminologies like luminous intensity, lumen, lux etc. 6.4 Describe methods of denoting luminous intensity e.g. plan, horizontal luminous intensity, mean spherical luminous intensity. 6.5 Solve mathematical problems in the	Textbooks Internet Textbooks Internet Textbooks Internet Textbooks and reference materials on illumination and lighting. Textbooks Internet Group discussion, guidelines and assessment rubric.	number of lamps required in a given room or area.	table, determine the number of lamps required in a given room or area. 1. Measurement of Luminous Intensity - Students will measure the luminous intensity of a light source using a lux meter. 2. Calculation of Lumen - Students will calculate the lumen output of a light source using the formula: Lumen = Luminous Intensity x Solid Angle. 3. Measurement of Illuminance - Students will measure the illuminance of a	•Table of Illumination. 2. Lux meters and other measurement instruments. Calculators and computer software for calculations. Flip chart

	calculation of illumination using lumen method.	calculation of illumination using lumen method.			surface using a lux meter.	
	6.6 Define the following terms: a. Coefficient of utilization b. Maintenance factor 6.7 Explain spacing/Mounting height ratio	6.6 Discuss the following terms: a. Coefficient of utilization b. Maintenance factor 6.7 Describe spacing/Mounting height ratio	Textbooks Internet Textbooks Internet			
	General Objective 7.0: Know types of Lamps for Illumination. Year 2, Term 1					
Week	**Specific Learning Outcomes**	**Teacher Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher Activities**	**learning resources**
36-48	7.1 Explain different types of lamps	7.1 List different types of lamps	Textbooks Industry standars Internet	• Describe using sketches the incandescent lamp, Tungsten filament lamp, gas filled • Identify types of lamps • Identify the most appropriate	Guide students to: • Sketch different types of lamps • Identify the	.• Flip chart, chalk board, and the various lamps.

	7.2 Describe different types of fluorescent lamps 7.3 Explain the following terms: a. Emergency lighting b. Shades, and c. Reflectors	tungsten filament lamp, neon tube, hot and cold cathode (mercury & sodium lamps) 7.2 Discuss different types of fluorescent lamps 7.3 Describe the following terms: a. Emergency lighting b. Shades, and c. Reflectors		lighting system for a given room area e.g. hospital, library, sport complex, disco hall etc.	most appropriate lighting system for a given room area e.g. hospital, library, sport complex disco hall etc.	Rechargeable emergency lamp, Incandescent and tungsten lamps, neon tubes, emergency lamps shades and reflectors**,** fluorescent lamps etc.

Recommended textbooks and references for Domestic Electrical Installation:

Textbooks
1. "The Electrician's Guide to the 18th Edition IET Wiring Regulations" by The Institution of Engineering and Technology (IET) - A comprehensive guide to the UK's wiring regulations.
2. "Domestic Electrical Installation: A Guide to the 18th Edition IET Wiring Regulations" by Brian Scaddan - A practical guide to domestic electrical installation, covering the 18th edition IET Wiring Regulations.
3. "Electrical Installation Work" by Brian Scaddan - A detailed textbook covering electrical installation work, including domestic,

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE RENEWABLE ENERGY CRAFT PRACTICE		
Course: Introduction to Solar Photovoltaic Systems	**Course Code: CES1-31**	**Total Hours: 72HRS**
Year: 1 Term: 3	**Pre-requisite:**	**Practical:**
Goal: This module is designed to provide the trainee with the knowledge and skills of solar photovoltaic systems.		
General Objectives: On completion of this module, the trainee should be able to: 1. Know the Photovoltaic Technology 2. Understand the Photovoltaic System Applications 3. Understand the solar PV module		

General Objective:1.0: Know Photovoltaic Technology						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	1.1 Define Photovoltaic systems	Explain what is photovoltaic systems	· Textbooks · Internet	Identify photovoltaic system and their functions	Guide learner to identify photovoltaic system and their functions	Charts Videos Pictures
	1.2 Explain Photovoltaic principles	Describe photovoltaic principles		Demonstrate photovoltaic principles	Mention demonstrate photovoltaic principles	PV module Charts Videos Pictures
	1.3 Explain the different types of Photovoltaic systems options	Describe the different types of photovoltaic systems options		Identify the different types of photovoltaic systems options	identify the different types of photovoltaic systems options	PV module Charts Videos Pictures
	1.4 Explain the components and their functions in the photovoltaic systems	Discuss the components and their functions in the photovoltaic systems		Identify the components and their functions in the photovoltaic systems	Guide learners to identify the components and their functions in the photovoltaic systems	PV module Inverter Battery Charge controller Charts Videos

General Objective:2.0: Understand Photovoltaic Systems Applications						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	2.1 Explain the application of Photovoltaic systems -Water pumping - Street lighting - Power plants - Residential e. t. c	Describe the application of photovoltaic systems -Water pumping - Street lighting - Power plants - Residential	· Textbooks · Internet	Identify the application of photovoltaic systems	Guide learners to identify the application of photovoltaic systems	Charts Videos Pictures
	2.2 Explain the PV Air Conditioning and Refrigeration systems	Discuss the PV Air Conditioning and Refrigeration systems		Identify the PV Air Conditioning and Refrigeration systems	identify the PV Air Conditioning and Refrigeration systems	
	2.3 Explain hybrid PV Systems	Discuss hybrid PV Systems		Identify the hybrid PV Systems	Guide learners to identify the hybrid PV Systems	

	Theoretical	**Practical**			
General Objective:3.0: Understand the Solar Photovoltaic Panel					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	1.1 Define the solar panel	Explain solar panel	· Text books · Internet	Identify solar panel	identify solar panel solar panel	PV Modul (various)
	1.2 Explain the various types of panels i. Monocrystalline ii. Polycrystalline iii. Amorphous silicon (A-SI)	Describe solar panels and their types	· **Text books** · **Internet**	Identify the various types of solar panels	Guide learners to identify the various types of solar panel	PV Modul (various)
	1.3 Explain the components and their functions in the photovoltaic panel	Describe the components and their functions in the photovoltaic panel	· **Text books** · **Internet**	Identify the components and their functions in the photovoltaic panel	Guide learners to identify the components and their functions in the photovoltaic panel	Charts Videos PV Panel

EVALUATION GUIDE FOR MODULE CES1- 31 - INTRODUCTION TO SOLAR PV SYSTEMS

The student will be assessed on the basis of demonstrating an understanding of solar PV systems.
Students will be graded on the following Criteria:

2. Project (Process and Product) assessments.
3. Assignments and Tests
4. Terminal Examinations.

The laboratory reports should also be assessed and graded.

Assessment:

Type of Assessment	**Purpose and Nature of Assessment**	**Weighting (%)**
Skill (Psychomotor and Affective) Assessment	**Project Process and product**	**30%**
Assignment/Test	**Cognitive**	**10%**
Terminal Examination	**Cognitive/Psychomotor/Affective**	**60%**
	Total	**100%**

Recommended Textbooks & References: Recommended textbooks and references for Introduction to Solar PV Systems:

Textbooks

1. "Solar Photovoltaic Systems" by James P. Dunlop - A comprehensive textbook covering the fundamentals of solar PV systems.
2. "Photovoltaic Systems" by James W. Johnston - A detailed textbook focusing on the design, installation, and operation of solar PV systems.
3. "Solar PV Engineering Handbook" by Roger Messenger and Jerry Ventre - A practical handbook covering the engineering aspects of solar PV systems.
4. "Introduction to Photovoltaic Systems" by Muhammad H. Rashid - A concise textbook introducing the basics of solar PV systems.

Reference Guides

1. "NEC 2017 Handbook: Solar Photovoltaic Systems" - A comprehensive guide to the National Electric Code (NEC) requirements for solar PV systems.
2. "UL 1703: Standard for Flat-Plate Photovoltaic Modules and Panels" - A standard reference guide for solar PV module and panel design, testing, and certification.
3. "IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems" - A standard reference guide for interconnecting solar PV systems with the grid.

Online Resources

1. National Renewable Energy Laboratory (NREL) - A wealth of information on solar PV systems, including research, development, and deployment.
2. Solar Energy Industries Association (SEIA) - A trade association providing information, resources, and advocacy for the solar industry.
3. International Electrotechnical Commission (IEC) - Photovoltaic (PV) Systems - A global platform providing standards, testing, and certification for solar PV systems.

Software and Tools

1. PVsyst - A software tool for designing, simulating, and optimizing solar PV systems.
2. Helioscope - A software platform for designing, analyzing, and optimizing solar PV systems.
3. SolarPathfinder - A software tool for assessing solar radiation and shading for solar PV system design.

ROGRAMME: NATIONAL TECHNICAL CERTIFICATE RENEWABLE ENERGY CRAFT PRACTICE		
Course: Components and Electrical Connections in Solar Photovoltaic System	**Course Code: CES1- 32**	**Total Hours: 96HRS**
Year: 1 Term: 3	**Pre-requisite:**	**Practical:**
Goal: This module is designed to equip the trainee with the knowledge and skills on components and how to carry out Electrical connections		
General Objectives: On completion of this module, the trainee should be able to: 1. Know the types of Components in Solar Photovoltaic Systems 2. Know Electrical Connections in solar photovoltaic system 3. Understand the types of Electrical Power Protection		

Year	Theoretical			Practical		
	General Objective:1.0: Know the types of Components in Solar Photovoltaic Systems					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	1.1 Explain the types of components in solar PV system 1.2 Explain the various types of inverters	1.1 Explain the types of components in solar PV system 1.2 Describe the various types of inverters	· Text books · Internet	Identify the types of components in solar PV system Identify the various types of inverters	Guide learners to identify the various types of inverters	Inverters Charts Videos
	1.3 Explain the various types of charge controllers	Describe the various types of charge controllers	· Text books · Internet	Identify the various types of charge controllers	Guide learners to identify the various types of charge controllers	Charge Charts Videos
	1.4 Explain the various types of Batteries and classifications based on usage	Describe the various types of batteries and classifications base on usage	· Text books · Internet	Identify the various types of batteries and classifications base on usage	Guide learners to identify the various types of batteries and classifications base on usage	Batteries Charts Videos Pictures
	1.5 Explain the following: Electrical characteristics and structure	Describe the following: Electrical characteristics		Identify the components and their types	Guide the learner on the measuring parameters	Inverter Charge controller Battery

	- Important parameters of a solar panel - Measuring short circuit current (ISC) - Measuring open circuit voltage (VOC) - Performance of solar modules, STC vs. real life conditions - Interpreting datasheet - Shading and hotspots	and structure - Important parameters of a solar panel - Measuring short circuit current (ISC) - Measuring open circuit voltage (VOC) - Performance of solar modules, STC vs. real life conditions - Interpreting datasheet - Shading and hotspots				Multimeter Pyranometer Data sheets
	1.6 Explain types of cables and their uses	Describe types of cables	· Text books · Internet	Identify types and each of cables	Guide learners to identify the types and uses of each cable	Videos Pictures

	Theoretical			Practical		
General Objective:2.0: Know Electrical Connections in solar photovoltaic system						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	2.1 Explain the various types of electrical connections: - series - parallel	Describe the types of connections: - series and parallel	Textbooks Internet	Demonstrate how to carry out electrical connections in; Series Parallel	Guide the learners on how to carry out electrical connections in; Series Parallel	· Projector · White Board · E-leaning/ library/conventional · Multi meter · Inverters
	2.2 Explain the type of connections for solar panels: - Connecting similar panels in an array - Mismatching solar panels in an array	Describe the type of connections for solar panels	Textbooks Internet	Identify the types of connections for solar panels	identify the types of connections for solar panels	· Tools · Videos/projector · Charge controller · Solar panel battery · Cables
	2.3 Explain the types of	Describe the types of connections for	Textbooks Internet	Identify the types of connections for	Guide learners to identify the	· Tools · Videos/projector

connections for solar batteries: - Connecting batteries in series - Connecting batteries in parallel - Mismatching batteries in a battery bank 2.4 Explain the types and functions of various charge controllers: - Pulse width modulation - Maximum power point tracking	solar batteries Describe the types and functions of various charge controllers: - Pulse width modulation - Maximum power point tracking	Textbooks Internet	solar batteries Identify the types and functions of various charge controllers:	types of connections for solar batteries Guide learners to identify the types and functions of various charge controllers	· Charge controller · Solar panel · Battery · Cables · Tools · Videos/projector · Charge controller · Cables

	Theoretical			**Practical**		
General Objective:3.0: Understand the types of Electrical Power Protection						
Week	**Specific Learning specific learning Outcomes**	**Teacher's Activities**	**learning Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	3.1 Explain the types of protection on solar photovoltaic system: -Overcurrent protection devices - Lightning protection systems - Grounding	Describe the types of protection on solar PV systems	Textbooks Internet	Identify electrical power protection	Guide the learners to identify electrical power protection systems on Solar PV	· Text books · Laboratory manuals · Write Board
	3.2 Explain the types of circuit breakers: - AC circuit breaker - DC circuit breaker - Battery fuses - Disconnect switches - Combiner box - AC surge arrestors - DC surge arrestors - Thunder arrestor	Describe the types of circuit breakers: - AC circuit breaker - DC circuit breaker - Battery fuses - Disconnect switches - Combiner box - AC surge arrestors	Textbooks Internet	Select appropriate power protection device	Guide the learners to select appropriate device	· Laboratory · Multi Meter · Circuit Breakers · Surge Protectors · Capacitors · Fuses · Surge Arrestors · Combiner

		- DC surge arrestors - thunder arrestor				Box
	3.3 Explain the reasons for overcurrent protection in solar photovoltaic systems	Describe the reasons for overcurrent protection in solar photovoltaic systems	Textbooks Internet	Enumerate the reasons for overcurrent protection in solar photovoltaic systems	Guide learners to identify the reasons for overcurrent protection in solar photovoltaic systems	Charts Pictures Videos
	3.4 Explain the reasons for lightning protection solar in Photovoltaic systems	Describe the reasons for lightning protection in solar photovoltaic systems	Textbooks Internet	Enumerate the reasons for lightning protection in solar photovoltaic systems	Guide learners to enumerate the reasons for lightning protection in solar photovoltaic systems	Charts Pictures Videos
	3.5 Explain the effect of grounding in a solar Photovoltaic system	Discuss the effect of grounding in a solar photovoltaic system	Textbooks Internet	Identify the effect of grounding in a solar photovoltaic system	Guide learners to identify the effect of grounding in solar PV systems	Charts Pictures Videos

EVALUATION GUIDE FOR MODULE CES1-32 COMPONENTS AND ELECTRICAL CONNECTIONS IN SOLAR PV SYSTEM

Students will be graded on the following Criteria:

a. Project (Process and Product) assessments.
b. Assignments and Tests
c. Terminal Examinations.

The laboratory reports should also be assessed and graded.

Assessment:

Type of Assessment	**Purpose and Nature of Assessment**	**Weighting (%)**
Skill (Psychomotor and Affective) Assessment	**Project Process and product**	**30%**
Assignment/Test	**Cognitive**	**10%**
Terminal Examination	**Cognitive/Psychomotor/Affective**	**60%**
	Total	**100%**

Recommended Textbooks & References: Recommended textbooks and references for Components of Electrical Connections in Solar PV Systems:

Textbooks

1. "Solar Photovoltaic Systems" by James P. Dunlop - Covers electrical connections and components in solar PV systems.
2. "Photovoltaic Systems" by James W. Johnston - Focuses on electrical connections, wiring, and components.
3. "Solar PV Engineering Handbook" by Roger Messenger and Jerry Ventre - Covers electrical design, connections, and components.
4. "Electrical Connections for Solar PV Systems" by SEI (Solar Energy International) - A comprehensive guide to electrical connections.

Reference Guides

1. "NEC 2017 Handbook: Solar Photovoltaic Systems" - National Electric Code (NEC) requirements for solar PV systems.
2. "UL 1703: Standard for Flat-Plate Photovoltaic Modules and Panels" - Underwriters Laboratories (UL) standard for solar PV modules.
3. "IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems" - Institute of Electrical and Electronics Engineers (IEEE) standard for grid connection.

Online Resources

1. National Renewable Energy Laboratory (NREL) - Solar PV systems research, development, and deployment.
2. Solar Energy Industries Association (SEIA) - Solar industry advocacy, research, and resources.
3. International Electrotechnical Commission (IEC) - Photovoltaic (PV) Systems - Global standards for solar PV systems.

Components-Specific Resources

1. "McGraw-Hill's National Electrical Code (NEC) Handbook" - Covers electrical components, connections, and wiring.
2. "Electrical Components and Connections" by Delmar Cengage Learning - Focuses on electrical components, connections, and wiring.
3. "Solar PV Components: A Guide to Selection and Installation" by Solar Energy International (SEI) - Covers solar PV components, selection, and installati

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ELECTRICAL INSTALLATION AND MAINTENANCE WORK	**Course Code: CES2-11**	**Total Hours: 156 Hours**
Course: BATTERY CHARGING AND MAINTENANCE		**Theoretical: hours/week**
Year: 2 Term: 1	**Pre-requisite:**	**Practical: hours/week**
GOAL: The module is designed to provide the trainee with knowledge and skills to maintain and charge batteries efficiently		
General Objectives: On completion of this module, the trainee should be able to: 1. Understand the working principles of a cell and the constructional feature of a battery. 2. Know how to maintain and charge batteries. 3. Understand methods of charging battery 4. Understand battery charging process using solar PV system		

	Theoretical			**Practical**		
Year: 2 Term:1	**General Objective 1.0: Understand the working principles of a Cell and the Constructional features of a battery. Contact Hours 1-2**					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Students Activities**	**Learning Resources**
WK 5-6	1.1 Describe types of cells - Primary and Secondary cells. 1.2 Explain the working principle of Primary and Secondary cells 1.3 Describe the parts of the cells: a. container b. electrodes c. electrolyte	1.1 Discuss types of cells - Primary and Secondary cells. 1.2 Discuss the working principle of Primary and Secondary cells 1.3 Discuss the parts of the cells: a. container b. electrodes c. electrolyte	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	• Construct a simple cell of battery • Connect batteries for charging system in :(a) series (b) parallel • Prepare electrolyte for use in secondary cell • Measure the specific gravity (s.g) of the electrolyte	Guide students to: • Construct a simple cell of battery • Connect batteries for charging system in :(a) series (b) parallel • Prepare electrolyte for use in secondary cell • Measure the specific gravity (s.g) of the electrolyte	• Cells • Battery • Charts • Chalkboard • Chemicals • nsulated container •dilute sulphuric acid •zinc plate and copper plate Rechargeable batteries •battery

						charger • Electrolyte , acid and water, plastic container, hydrometer
Year:2 Term:1	**General Objective 2.0:** Know how to maintain and charge batteries maintain and charge Batteries. **Contact Hours: 1-2**					
Week	**Specific Learning Outcomes**	**Teacher Activities**	**learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
WK 1 - 12	2.1 Explain types of charging methods 2.2 Describe the materials, equipment and tools used for battery charging. 2.3 Describe the condition suitable for battery charging e.g. a. Observe	2.1 State types of charging methods 2.2 Discuss the materials, equipment and tools used for battery charging. 2.3 Discuss the condition suitable for battery charging e.g. a. Observe	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	• Discuss types of charging methods • Identify tools, materials and equipment used with batteries in a charging room. • Demonstrate how to prepare electrolyte. Observe all precautions. Use hydrometer to demonstrate how to test the specific gravity. • Identify parts of a charger.	Guide students to: • Carryout different charging method e.g. e. Trickle charging method f. Constant current method	• harging Equipment . • Acid • Potassium • Sulphuric Acid • Chalkboard. • Battery,

				Demonstrate how to carry out different charging method e.g. • Trickle charging method • Constant current method • Constant voltage		

	polarity and terminal b. the room should be well ventilated c. removes the vent covers d. use non corrosive base. Describe how to prepare electrolyte while observing necessary precautions. 2.3 Describe the various methods of charging battery e.g. Constant voltage, constant current, float charging, and trickle charging. 2.4 Describe the following	polarity and terminal b. the room should be well ventilated c. removes the vent covers d. use non corrosive base. 2.3 Explain how to prepare electrolyte while observing necessary precautions. 2.4 Explain the various methods of charging battery e.g. Constant voltage, constant current, float charging, and trickle charging. 2.5 Discuss the following types of	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	method d. Floating method • Demonstrate how to prepare electrolyte. Observe all precautions. Use hydrometer to demonstrate how to test the specific gravity. • Identify parts of a charger. • Observe the regulation guiding battery charging. • Detect the condition of cells in a battery • Maintain and replace faulty cells. •	g. Constant voltage method h. Floating method Identify tools, materials and equipment used with batteries in a charging room. • Demonstrate how to prepare electrolyte. Observe all precautions. Use hydrometer to demonstrate how to test the specific gravity. • Identify parts of a charger. • Observe the regulation guiding battery charging. • Detect the condition of cells in a battery • Maintain and replace faulty	•Battery charger •Connecting cables • Hydrometer •Battery thermometer • Voltmeter •Ammeter

	types of charging: a. Trickle charging b. Floating charging c. Equalizing charging d. Ordinary Charging e. Initial charging. 2.6 Explain how to determine the specific gravity of electrolyte using the hydrometers 2.7 Describe charge and discharge condition. 2.8 Explain how to protect terminals from corrosion. Safeguard the battery, cells in	charging: a. Trickle charging b. Floating charging c. Equalizing charging d. Ordinary charging e. Initial charging. 2.6 Describe how to determine the specific gravity of electrolyte using the hydrometers 2.7 Explain charge and discharge condition. 2.8 Describe how to protect terminals from corrosion. Safeguard the battery, cells in a	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	• Seal battery tops with sealing compound. Observe and identify charging and discharging condition of a secondary cell/battery Maintain and replace damaged battery cell/cells	cells. • Seal battery tops with sealing compound. Observe and identify charging and discharging condition of a secondary cell /battery Maintain and replace damaged battery cell/cells	
	a charge condition. 2.9 Describe the constructional features of a charger. 2.10 Explain the	charge condition. 2.9 Discuss the constructional features of a charger. 2.10 Describe the	- Whiteboard and markers - Diagrams and illustrations	sketch the features of battery charger Analyse the charging efficiency of the battery charger.	support students to sketch battery charger correctly Ensure student analyse battery	

	charging process of a battery. 2.11 Explain the necessary statutory regulation while charging 2.12 Explain how to detect faulty cells in a battery using voltage tester 2.13 Explain how to maintain and replace fault cells in a battery	charging process of a battery. 2.11 Describe the necessary statutory regulation while charging 2.12 Describe how to detect faulty cells in a battery using voltage tester 2.13 Describe how to maintain and replace fault cells in a battery	- PowerPoint presentation projeter.	Maintain statutory regulation while charging. Carry out Battery cell fault detection using voltage tester.	charger correctly Encourage students to maintain charging regulation correctly. Ensure students conduct Battery cell fault detection using appropriate equipment.	

	2.14 Explain how to seal battery top with the appropriate sealing compound.	2.14 Describe how to seal battery top with the appropriate sealing compound.	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	Demonstrate how to seal battery top with the appropriate sealing compound.	Carry out activity to show how to seal battery top with the appropriate sealing compound.	

Year:2 Term:2	**General Objective 3.0: Understand methods of charging battery. Contact Hours: 3-2**					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
	3.1 Enumerate methods of charging battery 3.2 Explain the effects of polarization and local action 3.3 Explain types of battery charger 3.4 Explain factors	3.1 Discuss methods of charging battery 3.2 Describe the effects polarization and local action 3.3 Describe types of battery charger 3.4 Explain factors that are	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	• Identify parts of a battery • Use hydrometer to measure specific gravity • Connect battery for charging to match with battery charger voltage	Guide students to: • Identify parts of a battery • Use hydrometer to measure specific gravity • Connect battery for charging to match with battery charger voltage	• Battery • Hydro meter • Electrolyte • Distilled water • Multi meter • Battery connector • Battery charger • Chalk/White board Neutralizing agent
	to consider when selecting a battery charger 3.5 Explain safety precautions necessary in charging room	needed to consider when selecting a battery charger 3.5 Describe safety precautions necessary in charging room	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation			

	Theoretical			**Practical**		
Year:2 Term:3	**General Objective 4.0: Understand battery charging process using solar PV.** Contact Hours: 1-4					
Week	**Specific Learning Objectives**	**Teacher Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Students Activities**	**Learning Resources**
	4.1 Explain the battery charging process using photovoltaic system 4.2 Explain the procedures for solar system installation for battery charging a. Site Assessment	4.1 Describe the use of photovoltaic system in charging battery 4.2 Describe the stages for solar system installation	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	• Charging battery using photovoltaic system	Guide students to: Charge battery using photovoltaic system	•PV panel Charge •controller (MPPT, PWM) •Inverter •Cable •Circuit breaker •Switches •Plug •Socket lug
	i. Minimum shade kilowatt/hour per square meter per day b. Calculate energy demand c. Inverter rating d. Daily energy supply to inverter e. system voltage f. sizing of battery g. sizing PV array g. sizing of cable		Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation			•Screws •Clips •Nails •Drilling machine •Tool box

EVALUATION GUIDE: BATTERY CHARGING AND MAINTENANCE

Assessment:

Type of Assessment	**Purpose and Nature of Assessment**	**Weighting (%)**
Skills (psychomotor & Affective	**Product and Process**	**30%**
Assignment & Test	**Cognitive**	**10%**
Terminal Examination	**Cognitive, psychomotor & Affective**	**60%**
	Total	**100%**

Recommended Textbooks & References:

Recommended textbooks and references for a Battery Charging and Maintenance course:

Textbooks

1. "Battery Technology Handbook" by R. David Prengaman - A comprehensive guide to battery technology, including charging and maintenance.
2. "Charging and Testing Lead-Acid Batteries" by Delmar Cengage Learning - A practical textbook focusing on lead-acid battery charging and testing.
3. "Battery Maintenance and Repair" by McGraw-Hill - A detailed textbook covering battery maintenance and repair techniques.
4. "Electric Vehicle Battery Technology" by CRC Press - A comprehensive guide to electric vehicle battery technology, including charging and maintenance.

Reference Guides

1. "Battery Charger Handbook" by Schumacher Electric Corporation - A practical guide to battery chargers and charging techniques.
2. "Battery Testing and Maintenance" by Fluke Corporation - A comprehensive guide to battery testing and maintenance.
3. "Lead-Acid Battery Handbook" by ILZRO (International Lead and Zinc Research Organization) - A detailed guide to lead-acid battery technology, including charging and maintenance.

Online Resources

1. Battery University - A comprehensive online resource for battery technology, including charging and maintenance.
2. National Renewable Energy Laboratory (NREL) - Energy Storage - A wealth of information on energy storage, including battery technology.
3. International Association of Electrical Inspectors (IAEI) - Battery Safety - A guide to battery safety, including charging and maintenance.

Software and Tools

1. Battery Management System (BMS) Software by Texas Instruments - A software tool for designing and optimizing battery management systems.
2. Battery Tester Software by Fluke Corporation - A software tool for testing and analyzing battery performance.
3. Battery Charging and Maintenance Software by Schumacher Electric Corporation - A software tool for optimizing battery charging and maintenance.

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ELECTRICAL AND SOLAR INSTALLATION AND MAINTENANCE CRAFT PRACTICE		
Course: Solar PV System Size and Site evaluation	**Course Code: CES2-12**	**Total Hours: 96HRS**
Year: 2 Term: 1	**Pre-requisite:**	**Practical:**
Goal: This module is designed to provide the trainee with the knowledge and skills of system sizing and site evaluation		
General Objectives: On completion of this module, the trainee should be able to: 1. Know System Sizing and Load carrying Capacity 2. Know On-Site measurement for Solar PV Installation 3. Understand Shade analysis and Sun Path Chart		

	Theory			**Practical**		
General Objective:1.0: Know System Sizing and Load Capacity in Solar PV						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	1.1 Explain System Sizing	Describe system sizing	white board, textbooks	Carryout system sizing	Guide learners to: carryout system sizing	Calculator Writing material
	1.2 Explain the types and specifications of Electrical load - AC loads - DC loads	Describe the types and specifications of electrical load - AC loads - DC loads	White board, textbooks	Identify the types and specifications of electrical loads	identify the types and specifications of electrical loads	Multimeter Pictures Videos Charts
	1.3 Explain sizing the Battery and develop a load profile through the following: i. Evaluate the energy demand ii. Deciding the days of autonomy iii. Deciding on the system voltage iv. Choosing the right type and quantity of batteries v. Choosing the right battery bank configuration	Describe sizing the battery and develop a load profile	White board, textbooks	Perform sample loading analysis	perform sample loading analysis	Calculator Writing material

	vi. Deciding the depth of discharge					
	1.4 Explain sizing of the PV array, the charge Controller, the inverter and cable	Describe sizing of the PV array, the charge Controller, the inverter, cable	White board, textbooks	Calculate the sizes of PV array, charge controller, inverter, etc.	Guide learners to calculate the sizes of PV array, charge controller, inverter, etc.	Calculator Writing material

	Theoretical content		**Practical**			
General Objective:2.0: Know On-Site Measurement for Solar PV Installation						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	2.1 Define site measurement	Explain the term site measuremen t	Textbooks Whiteboard	Demonstrate site measurement	Guide learners to: perform measurement	Tape rule
	2.2 Explain the types of site measurement for Solar Irradiance	Describe the various types of measuremen t for Solar irradiance	Textbooks Whiteboard	Demonstrate how to measure solar irradiance	how to measure solar irradiance	Projector, Videos, Measuring instrument, Tool box
	2.3 Explain the types of site measurement: - Lengths	Discuss the various types of	Textbooks Whiteboard	Demonstrate how measurements are taken for solar	on how measurement is taken for solar	Projector, Videos, Measuring instrument, Tool

	- Angles - Voltage - Current - Resistance - Area	measuremen t: - Lengths - Angles - Voltage - Current - Resistance - Area		installations	installations	box

	Theoretical Content			**Practical Content**		
	General Objective 3.0: Understand Shade Analysis and Sun Path Chart					
	Specific Learning Outcome	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
	3.1 Explain the effects of Shading	Describe the effects of shading	Textbooks internet	Demonstrate how to observe appropriate shade	Guide learners to: observe appropriate shade	Pyranometer Inclinometer Tape rule
	3.2 Explain the Sun Path Chart: - Generating the sun path chart - Interpreting the sun path chart	Describe the sun path chart: - Generating the sun path chart - Interpreting the sun path chart	Textbooks Internet	Carry out measurement on inclination angle	carry out measurement on inclination angle	Pyranometer Inclinometer Tape rule

	3.3 Explain the factors of Inclination and azimuth	Describe the factors of Inclination and azimuth	Textbooks Internet	Enumerate the factors of Inclination and azimuth	enumerate the factors of Inclination and azimuth	Pyranometer Inclinometer Tape rule
	3.4 Explain the effect of required area for inter-row spacing	Describe the effect of required area for inter-row spacing	Textbooks Internet	Demonstrate the effect of required area for inter-row spacing	identify the effect of required area for inter-row spacing	Pyranometer Inclinometer Tape rule
	3.5 Explain the possible surfaces for installations: - Roof mounting - Ground mounting - Top of pole mounting - Building integration	Discuss the possible surfaces for installations: - Roof mounting - Ground mounting top - Top of pole mounting - Building integration	Textbooks Internet	Identify appropriate surfaces	identify appropriate surfaces	Pyranometer Inclinometer Tape rule Charts Pictures Videos

EVALUATION GUIDE: SOLAR PV SYSTEM SIZE AND SITE EVALUATION

Students will be graded on the following Criteria:
a. Project (Process and Product) assessments.

5. Assignments and Tests
6. Terminal Examinations.

The laboratory reports should also be assessed and graded.

Assessment:

Type of Assessment	**Purpose and Nature of Assessment**	**Weighting (%)**
Skill (Psychomotor and Affective) Assessment	**Project Process and product**	**30%**
Assignment/Test	**Cognitive**	**10%**
Terminal Examination	**Cognitive/Psychomotor/Affective**	**60%**
	Total	**100%**

Recommended Textbooks & References:

Here are some highly recommended textbooks and references for Solar PV System Size and Site Evaluation:

Textbooks
1. "Solar Photovoltaic Systems" by James P. Dunlop - Covers solar PV system design, sizing, and site evaluation.
2. "Photovoltaic Systems" by James W. Johnston - Focuses on solar PV system design, installation, and evaluation.
3. "Solar PV Engineering Handbook" by Roger Messenger and Jerry Ventre - Covers solar PV system design, engineering, and evaluation.
4. "Solar Site Assessment and Evaluation" by SEI (Solar Energy International) - A comprehensive guide to solar site assessment and evaluation.

Reference Guides
1. "Solar PV System Design and Installation Manual" by NABCEP (North American Board of Certified Energy Practitioners) - A detailed guide to solar PV system design, installation, and evaluation.
2. "ASCE Standard 45W: Standard Practice for the Structural Design of PV Arrays" - American Society of Civil Engineers (ASCE) standard for structural design of PV arrays.
3. "IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems" - Institute of Electrical and Electronics Engineers (IEEE) standard for grid connection.

Online Resources
1. National Renewable Energy Laboratory (NREL) - Solar Resource Assessment - A wealth of information on solar resource assessment and site evaluation.
2. Solar Energy Industries Association (SEIA) - Solar Site Assessment - A guide to solar site assessment and evaluation.
3. International Association of Electrical Inspectors (IAEI) - Solar PV Inspection and Evaluation - A guide to solar PV inspection and evaluation.

Software and Tools
1. PVsyst - A software tool for designing and simulating solar PV systems.
2. Helioscope - A software platform for designing, analyzing, and optimizing solar PV systems.
3. SolarPathfinder - A software tool for assessing solar radiation and shading for solar PV system design.

These textbooks, references, and online resources provide a comprehensive foundation for understanding solar PV system size and site evaluation principles and practices.

Programme: National Technical Certificate in Electrical Installation and Maintenance Work	**Course Code: CES1- 33**	**Total Hours: 240Hours**
Course: SOLID STATE DEVICES AND CIRCUITS		**Theoretical: hours/week**
Year: 1 **Term: 3**	**Pre-requisite:**	**Practical: hours/week**

GOAL: The module is aimed at making the trainee to understand the basic solid-state devices and apply this information to simple circuits.

General Objectives:

On completion of this module, the student should be able to:

1. Understand the basic principles, characteristics and application of common electronic devices.
2. Understand the principles of operation and construction of power supply and be able to construct simple power supply unit.
3. Know the basic principles of design of electronic circuits.

	Theoretical			**Practical**		
	General Objective 1.0: Understand the basic principles, characteristic and application of common electronic devices					
	Year:1, Term:3					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Students Activities**	**Learning Resources**
1 - 12	1.1 Explain intrinsic materials, Extrinsic material and Semiconductors. 1.2 Explain the concept of semi-conductor diode. 1.3 Explain characteristics and operation of a diode. 1.4 Explain characteristic graph of the diode. 1.5 Explain how diode action rectifies AC to	1.1 Discuss intrinsic materials, Extrinsic material and Semiconductors. 1.2 Discuss the concept of semi - conductor diode. 1.3 Describe characteristics and operation of a diode. 1.4 Discuss characteristic graph of the diode. 1.5 Describe how diode action rectifies AC to	Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	Outline the characteristics of: • Semi-conductor diode • Transistors (npn & pnp) • Zener diodes • Field effect transistors etc. • Test to differentiate the two types of transistors. • Test to investigate the characteristic of zener diodes and FET. • Setup a	Guide students to: Outline the characteristics of: • Semi-conductor diode • Transistors (npn & pnp) • Zener diodes • Field effect transistors etc. • Test to differentiate the two types of transistors. • Test to investigate the characteristic of zener diodes and	Oscilloscope Transformer Chalk/White Board Transistor data sheets Electronic component Test equipment (e.g. oscilloscope), Transistor manuals. Transformers, Diodes Connecting wires. Bread Board Multi-meter, Photoelectric devices Test equipment Chalkboard

	DC. 1.6 Explain half wave/full wave rectification 1.7 Describe the effect of filter on output DC ripples. 1.8 Explain the principles of operation of a transistor e.g. PNP, NPN. 1.9 Explain the characteristics graphs of a transistor. 1.10 Explain Load line on out-put characteristic graphs. 1.11 Determine power gain from load line.	DC. 1.6 Discuss ½ wave/full wave rectification 1.7 Discuss the effect of filter on output DC ripples. 1.8 Discuss the principles of operation of a transistor e.g. PNP, NPN. 1.9 Draw the characteristics graphs of a transistor. 1.10 Draw Load line on out-put characteristic graphs. 1.11 Explain the determination	Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	circuit to show the operation of half-wave and fullwave rectification . Identify and know the operation of IC's and their Phototransistors, photo diodes, and photo transistors . Zener diodes, thyristors, FETS, triacs, diacs etc. *Identify the pins of an IC and its sockets. *Test transistors	FET. Setup a circuit to show the operation of half-wave and fullwave rectification . Identify and know the operation of IC's and their Phototransistors, photo diodes, and photo transistors. Zener diodes, thyristors, FETS, triacs, diacs etc. *Identify the pins of an IC and its sockets.	Zener diodes Thyristors, etc IC IC data Documentation IC socket Sample of ICs • Transistor, IC, diode Tester Oscilloscope IC's, Transistors Diodes, Voltmeter oscilloscope connection cables.

	1.12. Describe the principles of operation of photo-electric devices. a. Photo resistors, b. Photodiodes, c. Photo transistors 1.13 Describe the construction and operation of the following devices: a. Zener diodes b. Tunnel diodes c. Thyristors d. Field effect transistors e. Triac and Diac f. Unijunction Transistors 1.14 State the	of power gain from load line. 1.12. Explain the principles of operation of photo-electric devices. a. Photo resistors, b. Photodiodes, c. Photo transistors 1.13 Discuss the construction and operation of the following devices: a. Zener diodes b. Tunnel diodes c. Thyristors d. Field effect transistors e. Triac and Diac f. Unijunction Transistors 1.14 Discuss	Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	IC'S and Diodes. • *Measure voltage and frequency using oscilloscope . Test various types of Semiconductor devices Identify IC pins, Test transistors Diodes and other semiconductor devices. • Use oscilloscope to measure voltage and frequency.	• *Test transistors IC'S and Diodes. • *Measure voltage and frequency using oscilloscope . • *Test various types of Semiconductor devices symbols. Guide students to: Identify IC pins, Test transistors Diodes and other semiconductor	

	application of devices in 1.13 above e.g. use of thyristors in the spiral central of AC motors, lighting dimmers. 1.15 Explain integrated circuit (IC) as a means of packaging electronic circuits. 1.16 Describe parts of the Oscilloscope.	the application of devices in 1.14 above e.g. use of thyristors in the spiral central of AC motors, lighting dimmers. 1.15 Discuss integrated circuit (IC) as a means of packaging electronic circuits. 1.16 Discuss the functional parts of the Oscilloscope.	Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation		devices. Use oscilloscope to measure voltage and frequency. •Determine various wave forms using Oscilloscop e.	

	General Objective 2.0: Understand the Principles, Construction and Operation of Power Supply and be able to Construct Simple Power Supply Unit. Year:1, Term:3					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**learning resources**
1 - 12	2.1 Define the term power supply. 2.2 Describe the principles of operation of a power supply unit. 2.3Distinguish between transformer and transformerless (switch mode) power supply units. 2.4 Explain the effect of a capacitor and inductor in a power supply unit.	2.1 Describe the term power supply. 2.2 Discuss the principles of operation of a power supply unit. 2.3Diffentiate between transformer and transformerless (switch mode) power supply units. 2.4 Discuss the effect of a capacitor and inductor in a power supply unit.	•Chalk/Board Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	• demonstrate how to construct a stabilized low voltage DC power supply unit using zener diodes and regulator IC's. Demonstrate how to Measure the voltage and wave form in a power circuit. Demonstrate how to Measure the effectiveness of capacitor and induction in a power supply unit.	Guide students to: • Construct a stabilized low-voltage DC power supply unit using zener diodes and regulator IC's. Measure the voltage and wave form in a power circuit. Measure the effectiveness of capacitor and induction in a power supply unit	Electronics components, transformer, sample DVD power unit, Vero board, etc. •Chalk/Board • Power supply Test equipment Circuit diagrams • Stabilizer • Switched mode

	2.5 Explain the difference between regulators and stabilizers	2.5 Describe the difference between regulators and stabilizers	Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation			
	General Objective 3.0: Know the basic principles of design of electronic circuits. Year:1, Term: 3					
Week	**Specific Learning Outcomes**	**Teacher Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teachers Activities**	**Learning Resources**
5 - 24	3.1 Explain the concept and purpose of an oscillator 3.2 Explain the operation of the following Oscillators: a. LC Oscillators, b. Hartley Oscillator c. Colpit Oscillators, d. Tuned Oscillators.	3.1 Discuss the concept and purpose of an oscillator 3.2 Describe the operation of the following Oscillators: a. LC Oscillators, b. Hartley Oscillator c. Colpit Oscillator d. Tuned Oscillators.	Chalk/Board • Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	Construct a simple oscillator circuit (monostable and Astable) multivibrators using transistors and 555 timer ICs.	Guide students to construct a simple oscillator circuit (monostable and Astable) multivibrators using	Oscillators Test equipment • Multivibrators Test equipment Power unit & multimeter.555 timer IC, LED, transistors, resistors, capacitors, vero board, soldering iron and connecting wires

	3.3 Explain monostable multivibrator, Astable multivibrators, Bistable Multivibrator. 3.4 Explain the use of binary numbers in Electronic Circuits.	3.3 Describe monostable multivibrator, Astable multivibrators, Bistable Multivibrator. 3.4 Discuss the use of binary numbers in Electronic Circuits.				
	3.5 Draw simple circuits to illustrate different logic circuits and explain their function. 3.6 Explain how an AND gate can be converted to NAND Gate OR Gate to NOR Gate using their symbol.	3.5 Use simple circuits to illustrate different logic circuits and explain their function. 3.6 Describe how an AND gate can be converted to NAND Gate OR Gate to NOR Gate using	• Chalk Board .Flip-chart	Carryout simple experiment to demonstrate logic circuit.	Guide students to carryout simple experiment to demonstrate logic circuit.	Gates Test equipment AND Gate, OR gate, NAND gate, NOR gate. Power supply, led & connection wires Schematic diagram Drawing instrument and materials Multimedia (Projector)
	3.7 Explain how to draw the truth table of a gate. Show how to determine the output from the truth table. •	their symbol. 3.7 Describe how to draw the truth table of a gate. Show how to determine the output from the truth table. •		Demonstrate the drawing and determine output functions from the truth table.	Demonstrate the drawing and determine output functions from the truth table to students.	Truth table

EVALUATION: SOLID STATE DEVICES AND CIRCUITS

Assessment:

Type of Assessment	Purpose and Nature of Assessment	Weighting (%)
Skills (psychomotor & Affective	Product and Process	30%
Assignment & Test	Cognitive	10%
Terminal Examination	Cognitive, psychomotor & Affective	60%
	Total	100%

Recommended Textbooks & References:

Recommended textbooks and references for a Solid State Devices and Circuits course:

Textbooks

1. "Solid State Electronic Devices" by Ben Streetman and Sanjay Banerjee - A comprehensive textbook covering solid-state devices and circuits.
2. "Microelectronic Circuits" by Adel S. Sedra and Kenneth C. Smith - A widely used textbook focusing on microelectronic circuits and devices.
3. "Electronic Devices and Circuits" by David A. Bell - A practical textbook covering electronic devices, circuits, and applications.
4. "Semiconductor Devices: Physics and Technology" by Simon M. Sze and Kwok K. Ng - A detailed textbook focusing on semiconductor devices and physics.

Reference Guides

1. "The Art of Electronics" by Paul Horowitz and Winfield Hill - A comprehensive reference guide covering electronic circuits, devices, and systems.
2. "Microelectronic Devices and Circuits" by Mark S. Lundstrom - A detailed reference guide focusing on microelectronic devices and circuits.
3. "Semiconductor Device Fundamentals" by Robert F. Pierret - A comprehensive reference guide covering semiconductor device fundamentals.

Online Resources

1. National Institute of Standards and Technology (NIST) - Semiconductor and Dimensional Metrology - A wealth of information on semiconductor devices and metrology.
2. IEEE Electron Devices Society - A professional organization providing resources, publications, and conferences on electron devices.
3. EDN Network - Electronic Design - A comprehensive online resource covering electronic design, devices, and circuits.

Software and Tools

1. SPICE (Simulation Program with Integrated Circuit Emphasis) - A widely used software tool for simulating electronic circuits and devices.
2. LTspice - A free software tool for simulating electronic circuits and devices.
3. COMSOL Multiphysics - A software tool for simulating and analyzing electronic devices and circuits.

<table>
<tr><td colspan="4">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE ELECTRICAL AND SOLAR INSTALLATION AND MAINTENANCE CRAFT PRACTICE</td></tr>
<tr><td colspan="2">Course: Installations of Solar Photovoltaic Systems</td><td colspan="1">Course Code: CES2-21</td><td>Total Hours:
96HRS</td></tr>
<tr><td colspan="2">Course: Installations of Solar Photovoltaic Systems</td><td colspan="2">Course Code: CES2-21</td><td>Total Hours: 96HRS</td></tr>
<tr><td colspan="2">Year: 2 Term: 2</td><td colspan="2" rowspan="2">Pre-requisite:</td><td>Theoretical:</td></tr>
<tr><td colspan="2"></td><td>Practical:</td></tr>
<tr><td colspan="5">Goal: This module is designed to provide the trainee with the knowledge and skills on simple installation of solar photovoltaic systems</td></tr>
<tr><td colspan="5">General Objectives: On completion of this module, the trainee should be able to:
1. Understand Electrical drawings
2. Know how to Install the Solar PV Components
3. Know how to Connect the Solar PV Components</td></tr>
</table>

	Theory			Practical		
General Objective:1.0: Understand Electrical Drawings						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	1.1 Explain the Types of Electrical symbols: - Circuit drawing - Diagrams - Working drawings - As built drawings	Describe the types of Electrical symbols: - Circuit drawing - Diagrams - Working drawings - As Built drawings	· Text books · E-learning	Identify electrical symbols	Guide learners to identify electrical symbols	· Projector · Electrical Circuit Diagrams · Drawing Instruments · Charts · Symbols
	1.2 Explain types of electrical drawings	Describe types of electrical drawing	· Text books · E-library · E-learning	Draw electrical diagrams	Guide learners to draw electrical diagrams	· Drawing Instruments · Charts · Symbols
	1.3 Explain instruments for electrical drawing	Describe various instruments for electrical drawing	· Text books · e-library · e-learning	Demonstrate the use of drawing instruments	Guide the learner to use drawing instruments	· Projector · Electrical Circuit Diagram · Charts · Symbols

	Theory			**Practical**		
General Objective:2.0: Know how to install the Solar PV Components						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	2.1 Explain how to install the Panels.	Describe how to install the panels. i.e.	· Text books · E-library · E-learning	Demonstrate how to install the panels either on the roof top or using prefabricated mounts	Guide the learners on how to install the panels either on the roof top or using prefabricated mounts	· Projector · White Board · Videos · Tools Box · Modules
	2.2 Explain how to install Batteries	Describe how to install batteries	· Text books · E-library · E-learning	Demonstrate how to install batteries	Guide the learners on how to install batteries	· Inverter · PV · Accessories
	2.3 Explain how to install Charge controller	Describe how to install charge controller	· Text books · E-library · E-learning	Demonstrate how to install charge controller	Guide the learners on how to install charge controller	· Battery · Charge Controller · Inverter · PV · Accessories
	2.4 Explain how to install Inverter	Describe how to install inverter	· Text books · E-library · E-learning	Demonstrate how to install inverter	Guide learners on how to install inverter	· Battery · Charge Controller · Inverter · PV Accessories

	2.5 Explain the Dos and Don'ts on the installations of Batteries	Describe the dos and don'ts on the installations of batteries	· Text books · e-library · e-learning	Demonstrate how to connect the batteries either in series or parallel depending on your desired output	Guide the learners on how to connect the batteries either in series or parallel depending on your desired output	· Battery · Charge Controller · Inverter · PV · Accessories
	2.6 Explain the Dos and Don'ts on the installations of charge controller 2.7 Explain the Dos and Don'ts on the installations of inverter and its requirements	Describe the dos and don'ts on the installations of charge controller Describe the dos and don'ts on the installations of inverter and its requirements	· Text books · e-library · e-learning	Demonstrate how to connect the charge controller to the solar PV systems depending on the capacity of the output Demonstrate how to install the inverter in the solar PV systems depending on the output	Guide the learners on how to connect the charge controller to the solar systems depending on the capacity of the output Guide the learners on how to install the inverter in the solar PV system depending on the output	· Battery · Charge Controller · Inverter · PV Modules · Accessories

	2.8 Explain the types of Tools and Instruments; · Measuring instrument · tools · Other tools	Describe the types of tools and Instruments; · Measuring instrument · Installation tools · Other tools		Identify the types of tools and Instruction; · Measuring instrument · Installation tools · Other tools	Guide the learners to types of tools and Instruction; · Measuring instrument · Installation tools · Other tools	· Battery · Charge Controller · Inverter · PV · Accessories
	2.9 Explain installation accessories	Describe installation accessories		Identify the installation accessories	Guide the learners to identify installation accessories	Accessories
	General Objective:3.0: Know how to Connect the Solar PV Components					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	3.1 Explain the connection sequence of Solar PV components	Describe the connection sequence of solar PV components	· Text books · Projector · E-library · E-learning	Demonstrate the connection sequence of solar PV system	Guide the learners on connection sequence of solar PV system	PV Model Multimeter Ammeter Voltmeter Clamp meter Videos
	3.2 Explain the precaution to be observed when connecting Solar PV components	Describe the precaution to be observed when connecting solar PV components	· Text books · Projector · E-library · E-learning	Demonstrate how to observe precaution measures when connecting solar PV components	Guide the learners on how to observed precaution measures when connecting solar PV components	PV Model Multi meter Ammeter Voltmeter Clamp meter
	3.3 Explain the	Describe the	· Text books	Identify types of	Guide learners to	Cables

	types of cables and wires - Armond cables - Copper cables - Flexible cables	various types of cables and wires	· Projector · E-library · E-learning	cables and wires	identify types of cables and wires	Wires
	3.4 Explain the rules and regulations for wiring in Solar PV systems	Describe the rules and regulations for wiring in solar systems	· Text books · Projector · E-library · E-learning			Relevant Regulations
	3.5 Explain the effects of; ● Voltage drops ● E.M.F ● P.D.	Describe the effects; ● Voltage drops ● E.M.F. ● P.D.		Demonstrate how to measure; ● Voltage drops ● E.M.F. ● P.D.	Guide the learners on how to measure; ● Voltage drops ● E.M.F. ● P.D.	PV Model Multi meter Ammeter Voltmeter Clamp meter

EVALUATION GUIDE: INSTALLATION OF SOLAR PV SYSTEMS

Students will be graded on the following Criteria:

7. Project (Process and Product) assessments.
8. Assignments and Tests
9. Terminal Examinations.

The laboratory reports should also be assessed and graded.

Assessment:

Type of Assessment	Purpose and Nature of Assessment	Weighting (%)
Skill (Psychomotor and Affective) Assessment	Project Process and product	30%
Assignment/Test	Cognitive	10%
Terminal Examination	Cognitive/Psychomotor/Affective	60%
	Total	100%

Recommended Textbooks & References:

Recommended textbooks and references for Components of Electrical Connections in Solar PV Systems:

Textbooks
1. "Solar Photovoltaic Systems" by James P. Dunlop - Covers electrical connections and components in solar PV systems.
2. "Photovoltaic Systems" by James W. Johnston - Focuses on electrical connections, wiring, and components.
3. "Solar PV Engineering Handbook" by Roger Messenger and Jerry Ventre - Covers electrical design, connections, and components.
4. "Electrical Connections for Solar PV Systems" by SEI (Solar Energy International) - A comprehensive guide to electrical connections.

Reference Guides
1. "NEC 2017 Handbook: Solar Photovoltaic Systems" - National Electric Code (NEC) requirements for solar PV systems.
2. "UL 1703: Standard for Flat-Plate Photovoltaic Modules and Panels" - Underwriters Laboratories (UL) standard for solar PV modules.
3. "IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems" - Institute of Electrical and Electronics Engineers (IEEE) standard for grid connection.

Online Resources
1. National Renewable Energy Laboratory (NREL) - Solar PV systems research, development, and deployment.
2. Solar Energy Industries Association (SEIA) - Solar industry advocacy, research, and resources.
3. International Electrotechnical Commission (IEC) - Photovoltaic (PV) Systems - Global standards for solar PV systems.
Components-Specific Resources
1. "McGraw-Hill's National Electrical Code (NEC) Handbook" - Covers electrical components, connections, and wiring.
2. "Electrical Components and Connections" by Delmar Cengage Learning - Focuses on electrical components, connections, and wiring.
3. "Solar PV Components: A Guide to Selection and Installation" by Solar Energy International (SEI) - Covers solar PV components, selection, and installation.

<table>
<tr><td colspan="3">PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ELECTRICAL AND SOLAR INSTALLATION AND MAINTENANCE CRAFT PRACTICE</td></tr>
<tr><td>Course: Maintenance and Troubleshooting of Solar PV System</td><td>Course Code: CES2- 22</td><td>Total Hours: 72HRS</td></tr>
<tr><td>Year: 2 Term: 2</td><td rowspan="2">Pre-requisite:</td><td>Theoretical:</td></tr>
<tr><td></td><td>Practical:</td></tr>
<tr><td colspan="3">Goal: This module is designed to provide the trainee with knowledge and skills on simple Maintenance and Troubleshooting of Solar Photovoltaic Systems</td></tr>
<tr><td colspan="3">General Objectives: On completion of this module, the trainee should be able to:
1. Understand troubleshooting in Solar Photovoltaic Systems
2. Know how to carryout maintenance of Solar Photovoltaic Systems
3. Understand possible faults that may occur in Solar installation and correct them</td></tr>
</table>

Year	Theoretical		Practical			
	General Objective:1.0: Understand troubleshooting in solar photovoltaic systems					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	1.1 Define: i. Troubleshooting ii. Maintenance	Explain what is troubleshooting and maintenance	Text books Internet	Demonstrate how to carryout troubleshooting and maintenance task	Guide leaners to: carryout troubleshooting and maintenance tasks	· Modules · Testing kits · Tool box
	1.2 Explain the steps involved in troubleshooting of Solar installations	Describe the various steps in troubleshooting of solar PV installation	Text books Internet	Demonstrate how to carryout trouble shooting in solar PV installations	carry out troubleshooting in solar PV installations	· MultiMetre · Projector · Ammeter · Code Manual · Videos
	1.3 Explain the steps involved in carryout troubleshooting using relevant Code and standards	Describe the stages involve in carryout troubleshooting using codes and standards	Text books Internet	Comply with relevant codes and standards in carrying out troubleshooting of PV systems	Comply with relevant codes and standards in carrying out troubleshooting of PV systems	Relevant codes and standards

	Theoretical			Practical		
General Objective:2.0: Know how to carryout Maintenance of Solar PV installations						
Week	Specific Learning Outcomes	Teacher's Activities	Resources	Specific Learning Objectives	Teacher's Activities	Learning Resources
	2.1 Define the following i. Routine maintenance ii. General maintenance	Explain routine and general maintenance	· Text books · E-library	Demonstrate how to carry out routine and general maintenance in solar PV installations	Guide learners on how to carryout routine and general maintenance on PV installations	· Projector Write Board Maintenance Manuals Videos
	2.2 Explain the procedure involved in routine maintenance	Describe the procedure involved in carry out routine maintenance		Demonstrate the procedure involved in carry out routine maintenance	Perform the procedure involved in carry out routine maintenance	
	2.3 Explain the procedure involved in general maintenance	Describe the procedure involve in general maintenance		Demonstrate the procedure involve in carry out routine maintenance	carry out routine maintenance	
	2.4 Explain the advantages and disadvantages of routine and general maintenance	Describe the advantages and disadvantage of routine and general maintenance		Discuss the advantages and disadvantage of routine and general maintenance	State the advantages and disadvantage of routine and general maintenance	
	2.5 Explain the	Describe the				

	challenges involved in routine and general maintenance	challenges involved in routine and general maintenance				
	Theoretical			**Practical**		
General Objective:3.0: Understand possible faults that may occur in Solar PV installation and correct them						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	3.1. Explain possible faults in Solar PV installation; · Connections · Shading · Mismatch Components · Wrong size	Describe possible faults in solar PV installation and use	Textbooks Internet	Identify possible faults in solar PV installation and use	Guide the learner to identify possible faults in solar PV installation and use	Multi meter Tools box
	3.2 Explain possible faults in Solar PV use i. Charging/Discharge ii. Over loading iii. Connection	Describe possible faults in solar PV use I Charge/discharge ii.Over loading iii.Connection	Textbooks Internet			
	3.3 Explain the factors that affect efficiency of the PV system	Discuss the factors that affect the efficiency of the PV system	Textbooks Internet	Identify the factors that affect the efficiency of the PV system	Guide the learner to identify the factors affecting the efficiency of the PV system	Multi meter Tools box

EVALUATION GUIDE: MAINTENANCE AND TROUBLESHOOTING OF PV SYSTEM

Assessment:

Type of Assessment	**Purpose and Nature of Assessment**	**Weighting (%)**
Skill (Psychomotor and Affective) Assessment	Project Process and product	30%
Assignment/Test	Cognitive	10%
Terminal Examination	Cognitive/Psychomotor/Affective	60%
	Total	100%

Recommended Textbooks & References:

Recommended textbooks and references for a Maintenance and Troubleshooting of PV System course:

Textbooks

1. "Photovoltaic Systems: Design, Installation, and Operation" by James W. Johnston - Covers maintenance and troubleshooting of PV systems.
2. "Solar Photovoltaic Systems: Installation, Maintenance, and Repair" by Sean White - Focuses on installation, maintenance, and repair of PV systems.
3. "PV System Maintenance and Troubleshooting" by Solar Energy International (SEI) - A comprehensive guide to PV system maintenance and troubleshooting.
4. "Troubleshooting Photovoltaic Systems" by David W. Burns - A practical guide to troubleshooting PV systems.

Reference Guides

1. "NEC 2017 Handbook: Solar Photovoltaic Systems" - National Electric Code (NEC) requirements for PV systems.
2. "UL 1703: Standard for Flat-Plate Photovoltaic Modules and Panels" - Underwriters Laboratories (UL) standard for PV modules.
3. "IEEE 1547: Standard for Interconnecting Distributed Resources with Electric Power Systems" - Institute of Electrical and Electronics Engineers (IEEE) standard for grid connection.

Online Resources

1. National Renewable Energy Laboratory (NREL) - PV System Maintenance and Troubleshooting - A wealth of information on PV system maintenance and troubleshooting.
2. Solar Energy Industries Association (SEIA) - PV System Maintenance and Repair - A guide to PV system maintenance and repair.
3. International Association of Electrical Inspectors (IAEI) - PV System Inspection and Maintenance - A guide to PV system inspection and maintenance.

Software and Tools

1. PVsyst - A software tool for designing and simulating PV systems.
2. Helioscope - A software platform for designing, analyzing, and optimizing PV systems.
3. SolarPathfinder - A software tool for assessing solar radiation and shading for PV system design.

Programme: NATIONAL TECHNICAL CERTIFICATE IN ELECTRICAL AND SOLAR INSTALLATION AND MAINTENANCE WORKS	**Course Code: CES1-** 22	**Total Hours: 96 Hours**
Course: ELECTRICAL/ELECTRONICS DRAWING		**Theoretical: hours/week**
Year: 2 Term: 2	**Pre-requisite:**	**Practical: hours/week**

General Objectives: The module is designed to enable the trainee to understand the block and basic diagrams in circuit development.

On completion of this module, the trainee should be able: -

1. Understand block and basic diagrams in circuit development.
2. Understand electronic component symbols
3. Understand Basic circuits
4. Understand Schematic diagrams
5. Understand Industrial control wiring diagrams
6. Understand Electrical building construction wiring diagrams

	Theoretical			**Practical**		
Year: 1	**General Objective 1.0: Understand the Block and Basic Diagrams in Circuit Development.**					
Term: 2						
Week	**Specific Learning Outcomes**	**Teacher Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher Activities**	**Learning Resources**
WK 1-3	1.1 Explain the purposes of block flow and logic diagrams. 1.2 Explain symbols used in preparation of block and logic diagrams. 1.3 Explain how to plan an arrangement of block symbols to produce Intelligible block and flow diagrams.	1.1 Discuss the purposes of block flow and logic diagrams. 1.2 Discuss symbols used in preparation of block and logic diagrams. 1.3 Discuss how to plan an arrangement of block symbols to produce Intelligible block and flow diagrams.	• Flip-chart	1.1 Sketch block flow and logic diagrams. 1.2 Draw symbols used in preparation of block and logic diagrams. 1.3 Plan an arrangement of block symbols to produce Intelligible block and flow diagrams.	Guide students to: • Sketch blocks flow and logic diagrams with their symbols. • Draw block diagrams for electronic systems e.g. Radio, TV etc. • Draw flow diagrams for typical industrial production	• Sketch blocks flow and logic diagrams with their symbols. • Draw block diagrams for electronic systems e.g. Radio, TV etc. • Draw flow diagrams for typical industrial production

	1.4 Describe drafting procedure for preparation of simple block diagrams. 1.5 Explain the elements of logic symbols diagrams	1.4 Discuss drafting procedure for preparation of simple block diagrams. 1.5 Discuss the elements of logic symbols diagrams				
	General Objective 2.0: Understand the Electronic Component Symbols					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
WK 4, 5 & 6	2.1 Explain signs and symbols in drawings. 2.2 Explain the basic functions of	2.1 Discuss signs and symbols in drawings. 2.2 Discuss the basic functions of	• Textbooks • Internet	Identify electronic component symbols.	Guide students to: Identify electronic component	• Electronic components • Charts

	commonly used electronic component 2.3 Explain the need for electronic symbols and schematic diagrams. 2.4 Discuss component symbol and shape to component functions.	commonly used electronic component 2.3 Discuss the need for electronic symbols and schematic diagrams. 2.4 Relate the relationship between component symbol and shape to component functions.	•Textbooks •Internet	• Sketch physical structures of common components, e.g. Resistors, diodes, transistors, potentiometer, etc.	symbols. Sketch physical structur es of common components, e.g. Resistor s, diodes, transisto rs, potentio meter, etc.	diodes, transistors, potentiometer resistors
	General Objective 3.0: Understand Basic Circuits.					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning resources**
WK 7-8	3.1 Explain electronic symbols in a circuit application e.g. in a simple amplifier.	3.1 Discuss electronic symbols in a circuit application e.g. in a simple amplifier.	• Textbooks • Internet	• Sketch electronics symbols in a circuit application of a simple amplifier Trace a diagram of popular circuits e.g. single and double stage common emitter amplifier	Guide students to: • Sketch electronics symbols through circuit application of a simple amplifier Trace a diagram of popular circuits e.g. single and double stage common emitter amplifier	• Charts • Drawing instruments • Printed circuit. • Schematic diagram

	3.2 Explain the purpose of schematic diagram. 3.3 Describe the basic elements needed in electronic circuit 3.4 State the basic circuits which make up a complete electronic device. 3.5 Explain how to trace a diagram of	3.2 Describe the purpose of schematic diagram. 3.3 List the basic elements needed in electronic circuit 3.4 Describe the basic circuits which make up a complete electronic device. 3.5 Discuss how to trace a diagram of popular	• Textbooks • Internet	• Draw a schematic diagram and explain how it functions. Demonstrate how to build simple electronics circuits Demonstrate how to trace a diagram of popular circuits e.g. single stage, common emitter amplifier, 2stage common emitter amplifier, power supply unit etc	• Draw schematic diagram and explain how it functions. Build simple electronics circuits Trace a diagram of popular circuits e.g. single stage, common emitter amplifier, 2stage common emitter amplifier, power supply unit etc	

	popular circuits e.g. single stage, common emitter amplifier, 2-stage common emitter amplifier, power supply unit etc.	circuits e.g. single stage, common emitter amplifier, 2stage common emitter amplifier, power supply unit etc.				
YEAR: 1 TERM: 2	**General Objective 4.0: Understand Schematic Diagrams**					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	Learning Resources
- WK 9	4.1 Explain the need for conformity in drawing schematic drawings. 4.2 Explain symmetry and balance in drawing schematic diagram.	Discuss the need for conformity in drawing schematic drawings. Discuss symmetry and balance in drawing schematic diagram.	• Chalkboard/Whiteboard	• Place symbols appropriately with spacing for maximum legibility • Draw the schematic diagram	Guide students to: • Place symbols appropriately with spacing for maximum legibility	• Schematic diagram • Drawing materials. • Prepared drawings

	4.3 Draw the stages of a schematic diagram in proper sequential manner. 4.4 Explain how to convert a breadboard circuit into a proper schematic diagram.	Explain the stages of a schematic diagram in proper sequential manner. Discuss how to convert a bread-board circuit into a proper schematic diagram.		• Identify properly drawn schematic diagram. Show symbol placement and space • arrangement t for maximum legibility. Develop consistency in components code or reference • location on the schematic diagram. Convert bread board circuit to a schematic diagram and vice versa	• Draw the schematic diagram • Identify properly drawn schematic diagram. Show symbol • placement and space arrangeme nt for maximum legibility. Develop consistency in • component s code or reference location on the schematic diagram. Convert bread board circuit to a • schematic	

					diagram and vice versa	
	General Objective 5.0: Understand Industrial control Wiring Diagrams.					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
WK 10	5.1 Explain the differences between industrial and residential wiring diagrams compared to electronic wiring diagrams. 5.2 Explain how to read industrial control wiring diagrams. 5.3 State	Describe the differences between industrial and residential wiring diagrams compared to electronic wiring diagrams. Discuss how to read industrial control wiring diagrams. Describe	• Textbooks • Internet	• Identify the difference between electronics wiring diagrams and industrial and residential wiring diagrams. • Show how to read industrial control wiring diagrams. • Draw simple industrial control wiring. • Sketch and draw all	Guide students to: • Identify the difference between electronics wiring diagrams and industrial and residential wiring diagrams. • Show how to read industrial control wiring diagrams. • Draw simple industrial control wiring.	• Drawings. • Charts • Schematic diagrams • Drawing instruments and materials.
	electrical symbols used in power distribution	electrical symbols used in power distribution		common components and symbols used in power distributions	• Sketch and draw all common components and	

	diagrams. .	diagrams. .		diagrams.	symbols used in power distributions diagrams.	
	General Objective 6.0: Understand Electrical Building Construction Wiring Diagrams					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
WK 11-12	6.1 Explain the difference between schematic and single line diagrams. 6.2 Explain how to read single line diagrams. 6.3 List electrical symbols used in architectural plans.	6.1 Discuss the difference between schematic and single line diagrams. 6.2 Discuss how to read single line diagrams. 6.3 Describe electrical symbols used in architectural plans.	•Chalkboard/White board	• Identify electrical symbols used in architectural plans. • Draw schematic and single line diagrams and explain the difference between them. • Procure single line diagram and	Guide students to: • Identify electrical symbols used in architectural plans. • Draw schematic and single line diagrams and explain the difference between them. • Procure single line diagram	• Single line diagram. • Point to point diagram • Charts of electrical symbols and drawing.
				show students how to read it. • Draw electrical symbols used in architectural plans	and show students how to read it. • Draw electrical symbols used in architectural plans.	.

	6.4 Explain how basic lighting circuits are wired. 6.5 Explain how to determine the cable size needed under different load conditions.	6.4 Discuss how basic lighting circuits are wired. 6.5 Discuss how to determine the cable size needed under different load conditions.	Textbooks Internet Chalkboard/whiteboard	Produce a sketch of residential system of wiring •Produce a sketch of the wiring of residential building. •Show how lighting circuits and power circuits are wired. Identify the difference between ring mains and radial wiring Draw and wiring of residential building.	Produce a sketch of residential system of wiring •Produce a sketch of the wiring of residential building. • Show how lighting circuits and power circuits are wired. • Identify the difference between ring mains and radial wiring Draw and wiring of residential building	Plan of a house. •Drawing materials and instruments

EVALUATION GUIDE: ELECTRICAL/ELECTRONICS DRAWING

Assessment:

Type of Assessment	Purpose and Nature of Assessment	Weighting (%)
Skills (psychomotor & Affective	Product and Process	30%
Assignment & Test	Cognitive	10%
Terminal Examination	Cognitive, psychomotor & Affective	60%
	Total	100%

Recommended Textbooks & References:

Recommended textbooks and references for an Electrical/Electronic Drawing course:

Textbooks

1. "Electrical Drawing and Design" by David J. Krohn - A comprehensive textbook covering electrical drawing and design principles.
2. "Electronics Drawing and Design" by C. L. Chen - A practical textbook focusing on electronics drawing and design.
3. "Engineering Drawing and Design" by David A. Madsen and David P. Madsen - A widely used textbook covering engineering drawing and design principles.
4. "Electrical and Electronics Drawing" by K. C. Chopra - A detailed textbook covering electrical and electronics drawing principles.

Reference Guides

1. "ANSI Y14.5-2009: Dimensioning and Tolerancing" - American National Standards Institute (ANSI) standard for dimensioning and tolerancing.
2. "IEEE Std 91-1984: Graphic Symbols for Electrical and Electronics Diagrams" - Institute of Electrical and Electronics Engineers (IEEE) standard for graphic symbols.
3. "IEC 60617: Graphical Symbols for Diagrams" - International Electrotechnical Commission (IEC) standard for graphical symbols.

Online Resources

1. National Institute of Standards and Technology (NIST) - Engineering Drawing and Design - A wealth of information on engineering drawing and design.
2. IEEE - Electrical and Electronics Drawing Resources - A collection of resources, including standards, tutorials, and software.
3. AutoCAD - Electrical and Electronics Drawing Tutorials - A comprehensive tutorial series covering electrical and electronics drawing using AutoCAD.

Software and Tools

1. AutoCAD - A widely used software tool for creating electrical and electronics drawings.
2. SolidWorks Electrical - A software tool for designing and documenting electrical systems.
3. EPLAN - A software tool for creating electrical and electronics drawings, including schematics and wiring diagrams.

PROGRAMME: NATIONAL TECHNICAL CERTIFICATE IN ELECTRICAL AND SOLAR INSTALLATION AND MAINTENANCE CRAFT PRACTICE		
Course: Solar Thermal Technology	**Course Code: CES2-23**	**Total Hours: 96HRS**
Year: 2 Term:2	**Pre-requisite:**	**Practical:**
Goal: This module is designed to provide the trainee with the knowledge and skills in solar thermal Technology		
General Objectives: On completion of this module, the trainee should be able to: 1. Understand Solar Thermal Conversion 2. Understand Solar Thermal Collectors 3. Know construction of Solar Thermal Collectors 4. Know installation of Solar Thermal Collectors		

	Theoretical			**Practical**		
General Objective:1.0: Understand Solar Thermal Conversion Technology						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	1.1 Define Solar thermal conversion	Explain solar thermal conversion	Textbooks Internet	Discuss solar thermal conversion	Guide learners to state solar thermal conversion	Pyranometer Charts Pictures
	1.2 Explain Solar thermal collectors	Describe solar thermal collectors		Identify solar thermal collectors	identify solar thermal collectors	
	1.3 Explain the following; · Sun · Solar radiation/irradiation · Solar constant · Solar absorption · Angle of tilt	Describe the following; · Sun · Solar radiation/irradiation · Solar constant · Solar absorption · Angle of tilt		**Demonstrate how to measure solar radiation**	**measure solar radiation**	**Pyrometer Charts Pictures**
	1.4 Explain the importance of solar thermal systems	Describe the importance of solar thermal systems		Discuss the importance of solar thermal systems		
	General Objective:2.0: Understand Solar Thermal Collectors					
	2.1 Explain types of Solar thermal collectors i. Flat collectors	Discuss types of solar thermal collectors, flat and concentrated	Textbooks Internet	Identify types of solar thermal	Guide earners to identify types of solar	Model Charts Pictures

	ii. Concentrated collectors	collectors		collectors and their components	thermal collectors and their components	Videos
	2.2 Explain the principles of conversion in Solar thermal collectors i. Flat collectors ii. Concentrated collectors	Explain the principles of conversion in solar thermal collectors, flat and concentrated collectors		Discuss the principles of conversion in solar thermal collectors, flat and concentrated collectors	State the principles of conversion in solar thermal collectors, flat and concentrated collectors	
	2.3 Explain the basic components of Solar thermal collectors	Describe the basic components of solar thermal collectors		Identify the basic components of solar thermal collectors	identify the basic components of solar thermal collectors	
General Objective:3.0: Know construction of Solar Thermal Collectors						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Objectives**	**Teacher's Activities**	**Learning Resources**
	3.1 Explain the materials required in construction of Solar thermal collectors	Describe the construction of solar thermal collectors	Textbooks Internet	Construct solar thermal collector	Guide learners to construct solar thermal collector	Tool box Charts Drawings Videos
	3.2 Explain the tools and	Describe the tools and		Test solar	test solar	Test

	equipment used in construction of Solar thermal collectors	equipment used in construction of solar thermal collectors		thermal collector	thermal collector	instruments
	3.3 Explain the construction stages of solar thermal collectors; · Measurement · Marking out · Cutting to Size and Shape · Assembling · Finishing · Testing	Describe the construction stages of solar thermal collectors; · Measurement · Marking out · Cutting to Size and Shape · Assembling · Finishing · Testing		Demonstrate the stages for the construction of solar thermal collectors; · Measurement · Marking out · Cutting to Size and Shape · Assembling · Finishing · Testing	Follow stages for the construction of solar thermal collectors; · Measurement · Marking out · Cutting to Size and Shape · Assembling · Finishing · Testing	
	Theoretical			Practical		
General Objective:4.0: Know installation of Solar Thermal Collectors						
Week	Specific Learning Outcomes	Teacher's Activities	Resources	Specific Learning Objectives	Teacher's Activities	Learning Resources
	4.1 Explain tool and equipment required in solar thermal collector installation	Describe tool and equipment required in solar thermal collector installation	Textbooks Internet	Install a solar thermal collector	Guide learner to install solar thermal collector	Tool box Components PPEs
	4.2 List the PPEs required in installation of solar thermal collectors	Describe the PPEs required in installation of solar thermal collectors	Textbooks Internet			PPEs

	4.3 Explain the installation procedure of solar thermal collectors	Describe the installation procedure of solar thermal collectors	Textbooks Internet	Install solar thermal collectors	The installation of solar thermal collectors	Inclinometer Pressure Gauge Thermometer Sprit level
	4.4 Explain the assembly stages in the installation of solar thermal collectors	Describe the assembly stages in the installation of solar thermal collectors	Textbooks Internet	Assemble solar thermal collectors	assemble solar thermal collectors	
	4.5 Explain how to test run the installed solar thermal collector	Discuss how to test run the installed solar thermal collector	Textbooks Internet	Test a solar thermal collector	test solar thermal collector	Thermometer Pressure Gauge

EVALUATION GUIDE: SOLAR THERMAL TECHNOLOGY

Students will be graded on the following Criteria:

10. Project (Process and Product) assessments.
11. Assignments and Tests
12. Terminal Examinations.

The laboratory reports should also be assessed and graded.

Assessment:

Type of Assessment	Purpose and Nature of Assessment	Weighting (%)
Skill (Psychomotor and Affective) Assessment	Project Process and product	30%
Assignment/Test	Cognitive	10%
Terminal Examination	Cognitive/Psychomotor/Affective	60%
	Total	100%

Recommended Textbooks & References:

Recommended textbooks and references for a Solar Thermal Technology course:

Textbooks
1. "Solar Thermal Systems: Design and Installation Manual" by Solar Energy International (SEI) - A comprehensive guide to solar thermal system design and installation.
2. "Solar Thermal Energy Systems" by R. H. Marshall and B. J. Brinkworth - Covers solar thermal energy system design, installation, and operation.
3. "Thermal Energy Systems: Design and Analysis" by C. F. Kettleborough - Focuses on thermal energy system design, analysis, and optimization.
4. "Solar Water Heating Systems: A Guide to Planning, Design, and Installation" by Bob Ramlow and Benjamin Nusz - A practical guide to solar water heating system design, installation, and maintenance.

Reference Guides
1. "ASHRAE Handbook: HVAC Systems and Equipment" - American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) handbook covering HVAC systems and equipment.
2. "Solar Rating and Certification Corporation (SRCC) - OG-300: Solar Water Heaters" - SRCC standard for solar water heaters.
3. "International Organization for Standardization (ISO) 9806:2017 - Solar Energy - Solar Thermal Systems" - ISO standard for solar thermal systems.

Online Resources
1. National Renewable Energy Laboratory (NREL) - Solar Thermal Systems - A wealth of information on solar thermal systems, including research, development, and deployment.
2. Solar Energy Industries Association (SEIA) - Solar Thermal Resources - A guide to solar thermal resources, including system design, installation, and maintenance.
3. International Solar Energy Society (ISES) - Solar Thermal Systems - A comprehensive resource on solar thermal systems, including research, development, and deployment.

Software and Tools
1. TRNSYS - A software tool for simulating solar thermal systems and other thermal energy systems.
2. Polysun - A software tool for designing and simulating solar thermal systems.
3. Solar Thermal System Design Software by F-Chart Software - A software tool for designing and optimizing solar thermal systems.

Programme: ADVANCED NATIONAL TECHNICAL CERTIFICATE IN ELECTRICAL AND SOLAR INSTALLATION & MAINTENANCE WORKS	**Course Code: CES2-13**	**Total Hours: 286Hours**
Course: Industrial Electrical Installation		**Theoretical:**
		hours/week
Year: 2 TERM: 1	**Pre-requisite:**	**Practical: hours/week**
Goal: The module is intended to provide the trainee with further knowledge and skill to enable him carry out all types of domestic and industrial electrical installation and maintenance work.		
Genral Objectives: On completion of this module, the trainee should be able to: 1. now installations of special electrical system. 2. Know how to make and interpret electrical wiring drawing of equipment contained in the manufacturer's drawing. 3. Know distribution and utilization of AC and DC power supply in industrial and outdoor installations up to 11 KV. 4. Understand needs and techniques to protect electrical installations from lighting and corrosion. 5. Know installation of discharge lamps. 6. Understand the working principles, installation and maintenance of types of lifts, escalators and elevators. 7. Know the effects of power factor and how power factor may be improved 8. Know the testing and maintenance of overhead distribution and transmission systems.		

	Theoretical			**Practical**		
	General Objective:1.0 Know installations of some important electrical system					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
WK 1-3	1.1 Explain the safety precautions necessary for the following special Installations: • Fire alarm, • Fire detector • Air conditioning system	1.1 Describe the safety precautions necessary for following special Installations: • Fire alarm, • Fire detector • Air conditioning system	•Chalkboard/ whiteboard chart. lay out diagram text books	• Fire alarm, • Fire detector • Air conditioning system	Guide students to: • Fire alarm, • Fire detector • Air conditioning system	special installatio ns; a) Fire alarm b) Fire detect or Air conditi oner:

	1.2 Describe the materials used for special Installation listed in 1.1. 1.3 Explain the following Installations: • single-phase meter • 3-phase meter (KWH) • Maximum demand meter 1.4 Explain the following:	1.2 Discuss the materials used for special Installation listed in 1.1. 1.3 Describe the following Installations: • single-phase • 3-phase meters (KWH) • Maximum demand meters 1.4 Describe the		a. Farm and horticultura l electrical Installation b. Standby plants and their automatic operation; c. Fire Alarm; d. Fire Detector; e. Neon Discharge Lamp; f. Central Air Conditioning System Install fire alarm, neon, mercury and halogen discharge	a. Install the systems listed in 1.1 above e.g. a. Farm and horticultural electrical Installation b. Standby plants and their automatic operation; c. Fire Alarm; d. Fire Detector e. Neon Discharge f. Lamp; g. Central Air Conditioning System etc. Install fire alarm, neon, mercury and halogen	Note. c) Fire Alarm d) Fire Detector e) Neon Discharge Lamp f) Air Condition system g) Textbooks. h) Single-phase i) 3-phase j) e meters k) Lightning l) Arrestor m) Earthing lead • Earth continuity conductor. n) Fire alarm

	• Causes of corrosion in special electrical installation as listed in 1.1 above. • State methods of protection against corrosion in special electrical installation as listed in 1.1 above. 1.5 Explain the following installations protection features: • Earthing • Multiple earthing • Earth	following: • Causes of corrosion in special electrical installation as listed in 1.1 above. • State methods of protection against corrosion in special electrical installation as listed in 1.1 above. 1.5 Discuss the following installations protection features: • Earthing • Multiple earthing		lamps. c. Install single-phase, 3phase meters (KWH) and maximum demand meter d. Install 3phase prepaid meter and maximum demand meter e. Install lightning arrester and earthing system in a building. f. Install	discharge lamps. c. Install single-phase, 3-phase meters (KWH) and maximum demand meter d. Install 3phase prepaid meter and maximum demand meter e. Install lightning arrester and earthing system in a building. f. Install protective devices against	Strip/ wire earthing Earthling through water man Rod earthling Pipe earthling Plate earthling.

	electrode 1.6 Explain the	• Earth electrode		protective devices against	lightning strokes.	conduit and • its accessories

	following types of earthing: • Strip/wire earthing • Earthing through waterman • Rod earthing • Pipe earthing • Plate earthing. 1.7 Describe the application of Single-phase Instruments (Measuring) 1.8 State the methods of Connections of Instrument transformers	1.6 Explain the following types of earthing: • Strip/wire earthing • Earthing through waterman • Rod earthing • Pipe earthing • Plate earthing. 1.7 Explain the application of Single-phase Instruments (Measuring) 1.8 Describe the methods of Connections of Instrument transformers		lightning strokes. g. Test all types of Installation listed in a to h. Wire electrical items in the following explosive or hazardous situations; i. extremes of temperature ii. Corrosive atmosphere	g. Test all types of Installation listed in a to f h. Wire electrical items in explosive or hazardous situations such as i. extremes of temperature ii. Corrosive atmosphere	, trunking

	General Objective 2.0: Know how to make and interpret electrical wiring drawings of equipment					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	Learning resources
WK 2	2.1 List symbols as contained in electrical wiring drawing as stipulated in IEEE standard. 2.2 Explain how to make accurate sketches and drawings of electrical circuits. 2.3 Explain the interpretation of electrical diagrams	2.1 Describe symbols as contain in manufacturer's electrical wiring drawing as stipulated in IEEE standard. 2.2 Discuss how to make accurate sketches and drawings of electrical circuits. 2.3 Discuss the interpretation of electrical diagrams	• Chalk Board Sample of Electrical drawings Drawing instruments.	• Identify symbols and drawing of electrical circuit. • sketch symbols and drawing of electrical circuit. • Interpret electrical diagram/drawings	Guide students to: • Identify symbols and drawing of electrical circuit. • sketch symbols and drawing of electrical circuit. • Interpret electrical diagram/drawings	• charts, drawing instrument protractors markers

	General Objective 3.0: Know distribution and utilization of AC and DC power supply in industrial and outdoor installations up to 11 KV					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Student's Activities**	**Learning resources**
WK 3-5	3.1 Describe the distribution of electrical loads in buildings/building sites, factories including substations. 3.2 Explain high voltage (HV)substation with bulk High-Tension supply and power transformer 3.3 Describe the types of cables	3.1 Discuss the distribution of electrical loads in buildings/building sites, factories including substations. 3.2 Describe high voltage (HV)substation with bulk High-Tension supply and power transformer 3.3 Discuss the types of cables	• Chalk Board • Drawings • 11KV cables. • HV lightning arrestors. • HV circuit breakers. • power transformer . isolators . instrument transformers	• Calculate the rating of protective devices in an electrical installation. • Install electrical protective devices. • Calculate the protective devices short circuit	Guide students to: calculate the rating of protective devices in an electrical installation. • Install electrical protective devices. • Calculate the protective devices short-	• HV Transformers • Circuit breakers and Isolators • Lightning arrestors,

	used in electrical systems up to 11KV 3.4 Explain type of protective devices used in electrical systems up to 11KV 3.5 Explain the effects of ambient temperature on grouping circuit protections 3.6 Calculate the rating of protective devices in an electrical installation. 3.7 Explain how to Install Cable and protective devices in an electrical installation.	used in electrical systems up to 11KV 3.4 Describe type of protective devices used in electrical systems up to 11KV 3.5 Discuss the effects of ambient temperature on grouping circuit protections 3.6 Guide students to calculate the rating of protective devices in an electrical installation. 3.7 Describe how to Install Cable and protective devices in and electrical installation.		• fault rating of a consumer Installation. Install • Switchgear, protective devices, transformer s using • suitable cables. Organize a site visit to NESI utility installation to identify Power system components	circuit fault rating of a consumer Installation. Install • Switchgear, protective devices, transformer s using suitable cables. Organize a site visit to NESI utility installation to • identify Power system components	• a. Circuit breaker b. Isolators.
	3.8 Describe cables used on systems up to 11KV and the type of protective devices. 3.9 Explain how to install control devices in an electrical installation. 3.10 Explain the	3.8 Discuss cables used on system up to 11KV and the type of protective devices. 3.9 Describe how to install control devices in an electrical installation. 3.10 Discuss the following excess current protection				

	following excess current protection devices: a. HV circuit breakers b. HV Isolators	devices: a. HV circuit breakers b. HV Isolators				
	General Objective 4.0: Understand the needs and techniques to protect electrical installations from lightning and corrosion					
Week	**Specific Learning**	**Teacher's activity**	**learning Resources**	**Specific**	**Teacher's**	**Learning resource**
	specific learning Outcomes	**teachers Activities**	Learning resources	**Learning Outcomes**	**teachers Activities**	Learning resources
WK 6-7	4.1 Explain the necessity of protecting electrical installations against lightening. 4.2 Explain the following as they relate to earthing; a. Measurement of earth electrode resistance b. Earth leakage protection c. Protective multiple earthing.	4.1 Discuss the necessity of protecting electrical installations against lightening. 4.2 Describe the following as they relate to earthing; a. Measurement of earth electrode resistance b. Earth leakage protection c. Protective multiple earthing.	• Chalk/white board	Carry out earthing on an electrical installation system.	Guide students to: Carry out earthing on an electrical installation system.	• lightning arrestor electrode, resistors. • Megger, • Earth electrode • Earth continuity conductor • earth electrodes • Earth Resistance Tester Main switch.

	4.3 Explain the principles of cathodic protection. 4.4 State application of cathodic protection in protecting electrical installation from lightening. 4.5 Describe the causes of corrosion of electrical Installation. 4.6 Describe the methods of protection against Corrosion of electrical Installation.	4.3 Describe the principles of cathodic protection. 4.4 Discuss application of cathodic protection in protecting electrical installation from lighting. 4.5 Discuss the causes of corrosion of electrical Installation. 4.6 Discuss the methods of protection against Corrosion of electrical Installation.	• Chalk/white board.	Apply methods of protection against corrosion of electrical installation.	Guide students to apply methods of protection against corrosion of electrical installation.	Anticorrosive materials

	General Objective 5.0: Know the installation of discharge lamps					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Student's Activities**	**Learning resources**
WK 8	5.1 Describe the materials used for special lighting system e.g. discharge lamps and signs. 5.2 Describe types	5.1 Discuss the various materials used for special lighting system e.g. discharge lamps and signs. 5.2 Discuss types of	• Chalk/white board	• Select materials used for special lighting system e.g. discharge lamps and signs. • Install	Guide students to: • Select materials used for special lighting system e.g. discharge lamps and signs. • Install discharge	• copper wire. • tools. • lightning lamps. • Discharge lamps • Neon discharge lamps . • mercury discharge

	of discharge lamps 5.3 Explain the advantages and disadvantages of discharge lamps	discharge lamps. 5.3 Discuss the advantages and disadvantages of discharge lamps		discharge lamps and signs and their associated control gears.	lamps and signs and their associated control gears.	lamps • Sodium discharge lamp.
	General Objective 6.0: Understand working principle, installation and maintenance of types of lifts, escalators and elevators					
Week	**Specific Learning**	**Teacher's**	**Resources**	**Specific**	**Student's**	**learning resources**
	Outcomes	**Activities**		**Learning Outcomes**	**Activities**	
WK **9**	6.1 Describe the Construction of Lifts, escalators and elevators. 6.2 Explain the principles of operation of the following: •Escalator • Elevator •Lift. 6.3 Describe methods of scaffolding, lifting and handling equipment, ladders during installations.	6.1 Discuss the Construction of Lifts, escalators and elevators. 6.2 Describe the principles of operation of the following: •Escalator • Elevator •Lift. 6.3 Discuss methods of scaffolding, lifting and handling equipment and ladders during installations. 6.4 Describe the applications of basic regulations in the	• Chalk/white board • Scaffolding • Ladder. Electronic control lift . pneumatic control lift . Scaffold set and working tools. .Escalators	•Identify types of lift control system e.g. electronic control and pneumatic control. •Apply the relevant regulations in the assembling of scaffolds. •Install lift well and lift equipment in correct sequence. •Install the following: a. machine	Guide students to: • Identify types of lift control system e.g. electronic control and pneumatic control. Apply the relevant regulations in the assembling of scaffolds. • Install lift well and lift equipment in correct sequence. • Install the following: a. machine	b. electronic control Elevator c. Lift. copper wire, adder. Scaffolds. escalators viideo tutorials

		use				
	6.4 Explain the applications of basic regulations in the use of Scaffolds.	of Scaffolds.		room equipment; b. escalators. • Install types of lift control system e.g. electronic control, pneumatic control etc. test above. • Test installed lifts. • Commission the above.	room equipment; b. escalators. • Install types of lift control system e.g. electronic control, pneumatic control etc. test above. • Test installed lifts. • Commission the above.	

	General Objective 7.0: Know the effects of power factor and how power factor may be improved					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Student's Activities**	**learning resources**
Wk 10	7.1 Explain the term power factor. 7.2 State the advantages and disadvantages of low power factor 7.3 Explain with the aid of diagrams how power factor can be improved using static	7.1 Describe the term power factor. 7.2 Explain the advantages and disadvantages of low power factor 7.3 Describe with the aid of diagrams how power factor can be	Textbook Internet Chalkboard/White board Marker	• Install the following to improve power factor: a. Static capaci tors b. Synch ronous motor Phase modifi es.	Guide students to: • Install the following to improve power factor: a. Static capacito rs b. Synchro nous motor c. Phase modifies	• Capacitors • synchronous motor • Static capacitors, . Electric motor . Static capacitors . Synchronous

	capacitors/synchr onous phase machines. 7.4 Describe individual load and overall system improvement of power factor.	improved using static capacitors/synch ronous phase machines. 7.4 Describe individual load and overall system improvement of power factor.				motor . Phase modifiers

	General Objective 8.0: Know testing and maintenance of overhead distribution and transmission system					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	learning resources
WK 11-12	8.1 Describe the parts of overhead lines. 8.2 Describe faults associated with overhead lines. 8.3 Describe the tests to locate faults and conditions of Insulation of overhead lines. 8.4 State the safety procedures for live-lines and dead-lines maintenance.	8.1 Discuss the parts of overhead lines. 8.2 Discuss faults associated with overhead lines. 8.3 Discuss the tests to locate faults and conditions of Insulation of overhead lines. 8.4 Explain the safety procedures for live-lines and dead-lines maintenance	•Chalkboard/W hiteboard . Textbook • Internet	• Test and maintain overhead distributi on and transmiss ion systems	• With aid of test instruments, guide the students to carry out: a. Overhead distribution b. Transmissio n system Maintenance of lines safely	electrical overhead system. Multimeter ressure tester, insulating materials, measuring instrument he overhead lines

	8.5 Explain how to maintain distribution/transmission systems.	8.5 Describe how to maintain distribution/transmission systems.				

EVALUATION GUIDE: INDUSTRIAL ELECTRICAL INSTALLATION

Assessment:

Type of Assessment	Purpose and Nature of Assessment	Weighting (%)
Skills (psychomotor & Affective)	Product and Process	30%
Assignment & Test	Cognitive	10%
Terminal Examination	Cognitive, psychomotor & Affective	60%
	Total	100%

Recommended Textbooks & References:
Recommended textbooks and references for an Industrial Electrical Installation course:

Textbooks
1. "Industrial Electrical Installation" by E. L. Ewing - A comprehensive textbook covering industrial electrical installation principles and practices.
2. "Electrical Installations in Hazardous Areas" by T. A. Toms - Focuses on electrical installations in hazardous areas, including industrial settings.
3. "Industrial Power Systems" by Ralph E. Fehr - Covers industrial power systems, including electrical installation, distribution, and control.
4. "Electrical Installation Design and Testing" by Brian Scaddan - A practical textbook covering electrical installation design, testing, and verification.

Reference Guides
1. "National Electric Code (NEC) Handbook" - A comprehensive guide to the NEC, covering industrial electrical installations.
2. "IEEE Std 141-1993: Recommended Practice for Electric Power Distribution for Industrial Plants" - Institute of Electrical and Electronics Engineers (IEEE) standard for electric power distribution in industrial plants.
3. "NFPA 70: National Electric Code (NEC)" - National Fire Protection Association (NFPA) standard for electrical installations.

Online Resources
1. National Fire Protection Association (NFPA) - Industrial Electrical Installation Resources - A collection of resources, including standards, guides, and training.
2. Institute of Electrical and Electronics Engineers (IEEE) - Industrial Power Systems Resources - A wealth of information on industrial power systems, including electrical installation and distribution.
3. International Association of Electrical Inspectors (IAEI) - Industrial Electrical Installation Resources - A guide to industrial electrical installation resources, including standards, guides, and training.

Software and Tools
1. ETAP - A software tool for designing, analyzing, and optimizing industrial electrical power systems.
2. SKM PowerTools - A software tool for designing, analyzing, and optimizing industrial electrical power systems.
3. AutoCAD Electrical - A software tool for designing and documenting industrial electrical installations.

PROGRAMME: Advanced National Technical Certificate in Electrical and Solar Installation and Maintenance Works	**Course Code: CES3-11**	**Total Hours: 216 Hours**
Course: WINDING		**Theoretical: hours/week**
Year: 3 **TERM: 1**	**Pre-requisite:**	**Practical: hours/week**
Goal: The module is designed to provide the trainee with knowledge and skills to enable him wind or rewind heavy duty machines above 10 KVA.		
General Objectives: On completion of this module, the trainee should be able to: 1. Understand the features of Motors and Generators 2. Know how to wind and rewind DC motors and generators 3. Know how to wind and rewind AC motors and generators 4. Know how to wind and rewind single-phase and three-phase transformers.		

	General Objective 1.0: Understand the features of Motors and Generators. Year 3, Term 1					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning resources**
	1.1 Explain types	1.1 Describe types	,	. Connect	Guide	• Copper wire
WK 1- 6	of motors 1.2 Explain types of Generators 1.3 Describe lap and wave winding. 1.4 Compare duplex and simplex winding 1.5 Describe the types of field connections from a given circuit diagram. 1.6 Describe the methods of reversing rotation and the connections required.	of motors 1.2 Describe types of Generators 1.3 Discuss lap and wave winding. 1.4 Distinguish between duplex and simplex winding 1.5 Discuss the types of field connections from a given circuit diagram. 1.6 Discuss the methods of reversing rotation and the connections required.	• Chalk/white Board • Textbooks • Internet	electric motor and reverse the connection by interchanging the phases Connect to single phase and three phase generators . Install interpoles to overcome armature reaction. Wind and rewind	• students to: connect and reverse the rotation of an electric motor by interchanging the phases -Guide students to: Connect to single phase and three phase generators . Install interpoles to overcome armature reaction.	Motor and Generators Insulation materials e.g. varnish, paint, etc. Insulating Materials Motor •Motor/Brush • DC. Motors and DC Motors DC Generators Inter-poles

	1.7 Describe the effects of armature reaction. 1.8 Explain the purpose of inter-poles. 1.9 Describe the method of construction and materials used for inter--poles. 1.10 State and sketch inter-poles connections. 1.11 Describe how polarity is obtained. 1.12 Describe the effect of brush position on commutation.	1.7 Discuss the effects of armature reaction. 1.8 Describe the purpose of inter-poles. 1.9 Discuss the method of construction and materials used for inter--poles. 1.10 Describe interpoles connections. 1.11 Discuss how polarity is obtained. 1.12 Discuss the effect of brush position on commutation.		complex DC motors and generators. • Test wound and rewound DC Motors and generators for performance.	-Wind and rewind complex DC motors and generators. - Test wound and rewound DC Motors and generators for performance.	

	General Objective 2.0: Know how to wind and rewind DC motors and generators. Year 3, Term 1					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning resources**
6-12	2.1 Describe types of winding for a DC motor or generator. 2.2 Describe the layout of Simple lap winding using both progressive and retrogressive connections. 2.3 Describe types of armature slots and their applications. 2.4 Explain how to develop winding diagram for lap and wave connected armature.	2.1 Discuss types of winding for a DC motor or generator. 2.2 Discuss the layout of Simple lap winding using both progressive and retrogressive connections. 2.3 Discuss types of armature slots and their applications. 2.4 Describe how to develop winding diagram for lap and wave connected armature.	Chalk/white Board Textbook Internet	. Design lap and wave winding for armature and determine coil span from the number of slots . Select different insulation materials for different types of machines. 1.5 Develop winding diagram for lap and wave connected armature.	Students to carry out lap and wave windings. Select and apply the insulation materials in carrying out the winding activity.	Copper wire, Tools Insulation materials e.g. varnish, paint, etc. Insulating Material Motor Motor/Brush Motor and Generators DC. Motors and Generators

	2.5 Explain how to determine Coil span from the number of poles and number of armature slots. 2.6 Explain the use of shield winding. 2.7 Explain the use of dummy coils in wave wound armatures. 2.8 State the functions of equalizer in lap winding. 2.9 State the reasons for Varnishing 2.10 State the need for different classes of	2.5 Describe how to determine Coil span from the number of poles and number of armature slots. 2.6 Discuss the use of shield winding. 2.7 Describe the use of dummy coils in wave wound armatures. 2.8 Explain the functions of equalizer in lap winding. 2.9 Explain the reasons for Varnishing 2.10 Explain the need for different classes of	.	1.6 Determine Coil span from the number of poles and number of armature slots.		• DC. Motor and generators DC Motors DC Generators Inter-poles
	insulation. 2.11 Explain the criteria for select insulation suitable for a given material 2.12 State the effects on frame size for a given output of the following: a. Enclosure b. Ratings c. Types of insulation 2.13 State the application of DC	insulation. 2.11 Describe the criteria for select insulation suitable for a given material 2.12 Explain the effects on frame size for a given output of the following: a. Enclosure b. Ratings c. Types of insulation 2.13 Discuss the application of DC				

	Generator 2.14 State classes of insulation and list insulation materials. 2.15 Explain the procedure for winding/rewinding of the following: a. DC motor b, Generator	Generator 2.14 Describe classes of insulating materials. 2.15 Describe the procedure for winding/rewinding of the following: a. DC motor b, Generator				
	General Objective 3.0: Know how to wind and rewind AC Motors and Generators.					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Student's Activities**	**Learning resources**
12-24	3.1 Describe the layout of AC winding of both concentric and distribution types. 3.2 Explain single	3.1 Discuss the layout of AC winding of both concentric and distribution types. 3.2 Describe single	Black/white board Textbooks Internet	•Arrange the start and run winding in a 3phase motor. •Mark 3phase	Guide students to: • Arrange the start and run winding in a 3-phase motor.	•flip- Chart • 1 and 3-phase motors; . Ac Motors . Ac generators

	layout and two layout arrangements of Stator Coil. 3.3 Explain coil pitch in Concentric and distribution windings. 3.4 Explain how the required magnetic poles are produced in a three-phase Stator winding.	layout and two layout arrangements of Stator Coil. 3.3 Describe coil pitch in Concentric and distribution windings. 3.4 Describe how the required magnetic poles are produced in a three-phase Stator winding.	.	terminals of an AC motor • Wind and Rewind AC motor and generator	• Mark 3phase terminals of an AC motor • Wind and Rewind AC motor and generator	Winding Machine . Working tools . Winding Wires . Insulation tester
	3.5 Describe with sketches, the winding connection of a two-speed AC motor of pole changing and dual	3.5 Discuss with sketches, the winding connection of a two-speed AC motor of pole changing and dual	• Chalk/white Board • 3-phase Motors • Winding coils.			

	wound types. 3.6 Describe the arrangement of Start and run winding in 3phase motor. 3.7 State terminal markings as used in 3-phase motors. 3.8 Explain how to wind/rewind AC motor and generator 3.9 Explain how to test for performance of rewound AC motor. 3.10 Explain how to test for performance of rewound generator.	wound types. 3.6 Discuss the arrangement of Start and run winding in 3phase motor. 3.7 Explain terminal markings as used in 3-phase motors. 3.8 Describe how to wind/rewind AC motor and generator 3.9 Discuss how to test for performance of rewound AC motor. 3.10 Discuss how to test for performance of rewound generator.				

	General Objective 4.0: Know how to wind and rewind Single - Phase and Three-Phase Transformers					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Student's Activities**	**Learning Resources**
WK 24-36	4.1 Describe types of transformers. 4.2 Explain how to Identify terminal marking on transformer winding and its purpose. 4.3 Describe the disc and layer types of transformer winding used in 3phase transformers. 4.4 Describe the methods of Securing turn as used in 3-phase transformers	4.1 Discuss types of transformers. 4.2 Describe how to Identify terminal marking on transformer winding and its purpose. 4.3 Discuss the disc and layer types of transformer winding used in 3phase transformers. 4.4 Discuss the methods of Securing turn as used in 3-phase transformers	Chalkboard/White board Textbooks Internet	• Identify types of transformers. • Identify terminal markings. • Identify transformer ratings, tap – changers and other parts. • Wind/rewind transformers	Guide students to: • Identify types of transformers. • Identify terminal markings. • Identify transformer ratings, tap – changers and other parts. • Wind/rewind transformers	• winding Coil • Megger, Ohmmeter 3-phase transformer • Winding Coil • Megger, Ohmmeter 3-phase transformer • Autotransform
	4.5 Explain the term rating of transformers. 4.6 Explain the reasons for rating transformers in KVA. 4.7 Explain the use of tap	4.5 Describe the term rating of transformers. 4.6 Discuss the reasons for rating transformers in KVA. 4.7 Describe the use of				

	changers and edge packing. 4.8 Explain the procedure for winding/rewinding transformer 4.9 Explain how to test rewound transformers.	tap changers and edge packing. 4.8 Describe the procedure for winding/rewinding transformer 4.9 Describe how to test rewound transformers.				

EVALUATION GUIDE FOR MODULE CES3-11 WINDING (ANTC)

Type of Assessment	**Purpose and Nature of Assessment**	**Weighting (%)**
Skills (psychomotor & Affective)	**Product and Process**	**30%**
Assignment & Test	**Cognitive**	**10%**
Terminal Examination	**Cognitive, psychomotor & Affective**	**60%**
	Total	**100%**

Recommended Textbooks & References:

Recommended textbooks and references for an Electrical Machines Winding course:

Textbooks

1. "Electrical Machines: Fundamentals, Design, and Applications" by James L. Kirtley Jr. - Covers electrical machine fundamentals, design, and applications, including winding design.
2. "Electric Machinery Fundamentals" by Stephen J. Chapman - Focuses on electric machinery fundamentals, including winding design and analysis.
3. "Electrical Machine Design" by David A. Staton, Thomas M. Jahns, and Thomas J. E. Miller - A comprehensive textbook covering electrical machine design, including winding design.
4. "Winding and Re-winding of Electric Motors and Generators" by John J. Shea - A practical textbook focusing on winding and re-winding of electric motors and generators.

Reference Guides

1. "NEMA Standards Publication No. MG 1-2016: Motors and Generators" - National Electrical Manufacturers Association (NEMA) standard for motors and generators, including winding design requirements.
2. "IEEE Std 43-2013: Recommended Practice for Testing Insulation Resistance of Electric Machinery" - Institute of Electrical and Electronics Engineers (IEEE) standard for testing insulation resistance of electric machinery.
3. "IEC 60034-1:2010: Rotating electrical machines - Part 1: Rating and performance" - International Electrotechnical Commission (IEC) standard for rotating electrical machines, including winding design requirements.

Online Resources

1. National Institute of Standards and Technology (NIST) - Electrical Machines and Drives - A wealth of information on electrical machines and drives, including winding design and analysis.
2. Institute of Electrical and Electronics Engineers (IEEE) - Electrical Machines Committee - A comprehensive resource on electrical machines, including winding design and analysis.
3. International Association of Electrical Inspectors (IAEI) - Electrical Machines and Equipment - A guide to electrical machines and equipment, including winding design and inspection.

Software and Tools

1. JMAG - A software tool for designing and analyzing electrical machines, including winding design.
2. Motor-CAD - A software tool for designing and analyzing electric motors, including winding design.
3. Infolytica's MotorSolve - A software tool for designing and analyzing electric motors, including winding design.

Programme: National Technical Certificate In Electrical and Solar PV Installation & Maintenance Work	**Course Code: CES3-12**	**Total Hours: 216 Hours**
Course: CABLE JOINTING		**Theoretical: hours/week**
Year: 3 **Term: 1**	**Pre-requisite:**	**Practical: hours/week**
GOAL: The module is designed to provide the trainee with the knowledge and skills to enable him undertake, with proficiency, various methods of cable jointing and terminations		

GOAL: The module is designed to provide the trainee with the knowledge and skill to enable him/her undertake with proficiency various methods of cable jointing and terminations

General Objectives:

On completion of this module, the trainee should be able to:

1. Know how to make simple joints and terminations.
2. Know types of armoured cables, their applications and the procedure of jointing and terminations.
3. Understand the installation of overhead conductors and cable for distribution/transmission system.
4. Know the type of Data and Communication Cabling Methods.

Programme: National Technical Certificate in Electrical Installation and Maintenance Practice						
Course: Cable Jointing		**Course Code: CES3- 12**		**Contact Hours:**		
General Objective: 1.0: Know how to make Simple Joints and Terminations. Year 3, Term 1						
	Theoretical			**Practical**		
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning resources**
1-12	1.1 List the tools used for cable jointing 1.2 Describe the use of materials related to cable jointing and terminations e.g. soldering bit, blow lamp, strippers, soldering lugs, electric soldering iron, pot and ladle, pliers etc.	1.1 Describe the tools used for cable jointing 1.2 Discuss the use materials related to cable jointing and terminations e.g. soldering bit, blow lamp, strippers, soldering lugs, electric soldering iron, pot and ladle, pliers etc.	Whiteboard and markers- Diagrams PowerPoint presentation Chalk/white board • - Diagrams and illustrations - Handouts and worksheets - Industry standards documents - Case studies and scenarios - Handouts and worksheets	Make two basic types of joints: • Married joint • Tee- joint Solder a jointed cable Identify IEE regulation with regards to joints and termination Demonstrate	Guide students to: Make two basic types of joints: • Married joint • Tee- joint Solder a jointed cable Identify IEE regulation with regards to joints and termination Demonstrate how carry out married	• Tools box • Equipment • Materials •Different sizes of cables. • PVC cables Conductors • Insulators • Cables • Lugs • Glands Multistranded cupper cable, cutter-pliers, pliers, electrician Safety equipment

	1.3 Describe types of insulating materials e.g. PVC cables, etc. 1.4 Describe different types of Conductors e.g. Copper, aluminium, etc. 1.5 State the advantages and disadvantages of different conducting materials. 1.6 Describe sizes of cable lugs and glands. 1.7 Describe the hazards involve in installation of cable	1.3 Discuss types of insulating materials e.g. PVC cables, etc. 1.4 Discuss different types of Conductors e.g. Copper, aluminium, etc. 1.5 Explain the advantages and disadvantages of different conducting materials. 1.6 Discuss sizes of cable lugs and glands. 1.7 Discuss the hazards involve in installation of cable	- Industry standards documents - Case studies and scenarios - Handouts and worksheets	how carry out married and T-joints Carryout jointing of different cables in accordance with relevant safe work practices Identify the different types of simple joints e.g. T-joint and married join Carryout the jointing of cables using more than one type of joints Identify the methods of cable termination	and T-joints Carryout jointing of different types of cables in accordance with relevant safe work practices Identify the different types of simple joints e.g. T-joint and married join Carryout the jointing of cables using more than one type of joints Identify the methods of cable termination.	knife Multi-core cable, cable lugs, glands, solder, soldering iron, soldering flux, blow lamp Cables, Gland, cable lugs.

	General Objective 2.0: Know types of armoured cables, their applications and the procedure of jointing and terminations. Year 3, Term 1					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
6-12	2.1. Describe types of cable for underground electrical installation works e.g. Heeled cable, Screened or H-type Cable, HSL - type Cable, (screened lead), single and three cord 132KV oil filled cable, external gas pressure and impregnated cable, PVC armoured.	2.1. Discuss types of cable for underground electrical installation works e.g. Heeled cable, Screened or H-type Cable, HSL - type Cable, (screened lead), single and three cord 132KV oil filled cable, external gas pressure and impregnated cable, PVC armoured.	• Chalkboard - Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	• Select and prepare different armoured cable ends. • Join and terminate armoured cables at intermediate positions. • Carryout termination of joints • Using cable lugs. Identify different types and sizes of underground	Guide students to: • Select and prepare different armoured cable ends. • Join and terminate armoured cables at intermediate positions. • Carryout termination of joints • Using cable lugs. Identify different types and sizes	• Materials for preparing Trench • Planks • Jacks and rollers • Gland Boxes • Gas • Armoured cable, • jointing kits, • blow lamp, • impregnated tape • Cables Tools •cable lugs solder

Year 3, Term 1 1-12	2.2 Describe the preparation of trench to appropriate depth for cable laying 2.3 Describe the laying of cables in trench using appropriate methods e.g. Jacks and rollers, Winches etc. 2.4 Describe the following materials and tools used for joints and termination in underground cables e.g. glands boxes, pot and ladles, metals, blow lamps. 2.5 Describe cable joints/terminations e.g. tee, straight, finals terminations. 2.6 Describe how to	2.2 Discuss the preparation of trench to appropriate depth for cable laying 2.3 Discuss the laying of cables in trench using appropriate methods e.g. Jacks and rollers, Winches etc. 2.4 Discuss the following materials and tools used for jointing and termination in underground cables e.g. glands boxes, pot and ladles, metals, blow lamps. 2.5 Discuss	Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation Case studies and scenarios - Industry reports and articles - Handouts and worksheets	cables lugs. • Identify different types of cable that can be used for underground installation works. • Repair damaged underground cable •Test for continuity and Insulation Resistance • Set-up the basic instruments used in testing underground cables and their functions e.g. loop tester, bridge megger etc • Carry out various tests associated with underground cables e.g. insulation, continuity etc. •Carry out underground cable installation in line with IEE regulations.	of underground cables lugs. • Identify different types of cable that can be used for underground installation works. • Repair damaged underground cable Test for continuity and Insulation Resistance • Set-up the basic instruments used in testing underground cables and their functions e.g. loop tester, bridge megger etc • Carry out various tests associated with underground cables e.g. insulation, continuity etc.	•pot and ladle. I.E.E. Regulation Instruments • Chalkboard Short length 4x2.5 mm2 armoured cable 12x1.5 mm2 armoured cable 19x1.5 mm2 armoured cable, Cable lugs Cable glands PVC armouring •Paper impregnated •Armouring. - Bolting equipment and materials - Practice boards and components - Safety equipment and tools

	solder underground cable joints 2.7 Describe types of armouring used in underground cable	cable joints/termination e.g. tee, straight, finals terminations. 2.6 Discuss how to solder underground cable joints 2.7 Discuss types of armouring used in underground cable		• Apply I.E.E. regulation relevant to underground cable works. • Test for conformity of wire and insulation • Students to visit an underground cable installation activity	• Carry out underground cable installation in line with IEE regulations. • Apply I.E.E. regulation relevant to underground cable works. • Test for conformity of wire and insulation • Students to visitan underground cable installation activity	- Crimping equipment and materials - Practice boards and component - Safety equipment and tools

	General Objective 3.0: Understand the Installation of overhead conductors and Cable for Distribution and Transmission System. Year 3, Term 1					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
1-12	3.1 Explain how to identify cable/wire, tools and equipment used in overhead distribution/transmission system e.g. draw vices, safety belt, ladder, insulators, cross arm and spindle. 3.2 Explain how to erect poles to site and erect them correctly e.g. erect at appropriate pole span and firmly to ground	3.1 Discuss transmission and distribution stating tools and equipment used in the two systems. 3.2 Describe how to convey poles to site and how to erect them.	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	• Select cable/wires and tools used in overhead transmission/distribution system • Convey poles and overhead conductors to the site • Dig and erect poles with stay wire • Draw lines with appropriate tools • Make proper joints and	Guide students to: • Select cable/wires and tools used in overhead transmission/ distribution system • Convey poles and overhead conductors to the site Dig and erect poles with stay wire Draw lines with appropriate tools	Safety belt Ladder Stay wire Pole, Cross arm Soldering equipment and materials - Practice boards and components - Safety equipment and tools Draw-vice

	3.3 State the uses and parts of stay wires. 3.4 Explain how to draw overhead lines with appropriate tension. 3.5 State the uses of different overhead material used in high tension. 3.6 Explain the procedure of proper joint and terminations.	3.3 Explain the uses and parts of stay wires. 3.4 Describe how to draw overhead lines with appropriate tension. 3.5 Discuss the uses of different overhead material used in high tension. 3.6 Outline the procedure of proper joint and termination	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation	terminations where applicable • Identify different wires and tools used in overhead distribution/transmission system • Sketch diagrams of common tools used in overhead distribution/transmission system • Identify types of poles for overhead installation and erect poles at appropriate pole span and firmly in the ground. Identify types of stay wires • Demonstrate the making of proper joints and terminations.	• Make proper joints and terminations where applicable • Identify different wires and tools used in overhead distribution/transmission system • Sketch diagrams of common tools used in overhead distribution/transmission system • Identify types of poles for overhead installation and erect poles at appropriate pole span and firmly in the ground. Identify types of stay wires • Demonstrate the making of proper joints and terminations.	

	General Objective 4.0: Know the type of Data and Communication Cabling Methods. Year 3, Term 1					
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Learning Resources**
1-12	4.1 Describe types of Data Communication cables 4.2 Explain the uses of cable RG.6 4.3 List the tools for termination of co-axial and fibre optic cables. 4.4 Describe procedures for co-axial and	4.1 Discuss types of Data Communication cables 4.2 Describe the uses of cable RG.6 4.3 Explain the tools for termination of co-axial and fibre optic cables. 4.4 Discuss procedures for co-axial and	- Whiteboard and markers - Diagrams and illustrations - PowerPoint presentation projector	• Identify the tools for coaxial cable and fibre optic cable Termination • Carryout the termination of co-axial cable and fibre optic cable • Maintain the tools used in carrying out	Guide students to: • Identify the tools for co-axial cable and fibre optic cable Termination • Carryout the termination of coaxial cable and fibre optic cable • Maintain the tools used in carrying out co-	Cable Communication Equipment. • Samples RG.6 cable Cable (5 pairs) • Tools • PABX Co-axial cable fire optic cable Termination kits.

	fibre optic cables terminations.	fibre optic cables terminations.		co-axial cable and fibre optic cable Termination • Store appropriately the tools used in carrying out Co-axial cable and fibre optic cable Termination	axial cable and fibre optic cable Termination • Store appropriately the tools used in carrying out coaxial cable and fibre optic cable Termination	

EVALUATION GUIDE

CABLE JOINTING

Assessment:

Type of Assessment	Purpose and Nature of Assessment	Weighting (%)
Skills (Psychomotor & Affective	Product and process	30%
Assignment & Text	Cognitive	10%
Terminal Examination	Cognitive, Psychomotor & Affective)	60%
	Total	100%

Recommended Textbooks & References:

Recommended textbooks and references for a Cable Jointing course:

Textbooks

1. "Cable Jointing and Termination" by EATON (formerly Cooper Industries) - A comprehensive guide covering cable jointing and termination techniques.
2. "Electrical Cable Jointing and Testing" by The Institution of Engineering and Technology (IET) - A practical textbook focusing on electrical cable jointing and testing.
3. "Cable Jointing and Testing Handbook" by 3M - A handy reference guide covering cable jointing and testing procedures.
4. "Jointing and Terminating Power Cables" by Prysmian Group - A detailed textbook focusing on jointing and terminating power cables.

Reference Guides

1. "BS 7888:2018 - Specification for PVC-insulated cables for electricity supply" - A British Standard reference guide for PVC-insulated cables.
2. "IEC 60287: Electric cables – Calculation of the current rating" - An International Electrotechnical Commission (IEC) standard reference guide for calculating cable current ratings.
3. "National Electric Code (NEC) Article 300: Wiring Methods" - A reference guide covering wiring methods and cable installation requirements.

Online Resources

1. Institution of Engineering and Technology (IET) - Cable Jointing and Termination - A wealth of information on cable jointing and termination techniques.
2. EATON (formerly Cooper Industries) - Cable Jointing and Termination Resources - A collection of resources, including guides, videos, and webinars.
3. Prysmian Group - Cable Jointing and Testing Resources - A range of resources, including guides, videos, and technical papers.

Software and Tools

1. CableCalc - A software tool for calculating cable sizes and current ratings.
2. Jointing and Testing Software by 3M - A software tool for designing and testing cable joints.
3. Cable Design Software by Prysmian Group - A software tool for designing and optimizing cable systems.

S/N	DESCRIPTION OF ITEMS	QUANTITY REQUIRED
1.	Workbenches	15
2.	Crowbars	6
3.	Conduit bending machine	6
4.	Conduit threading machine	3
5.	Conduit vices	8
6.	Clamps	8
7.	Winding machine	2
8.	Battery charger	3
9.	Grease gun	3
10.	Wiring boards	45
11.	Oil can	8
12.	Ladder (adjustable)	6
13.	Blow lamp	10
14.	Pot and ladle	10
15.	Goggles	15
16.	Electric soldering iron 15/45 watts	30
17.	Soldering bit	15
18.	Gas welding set	2
19.	Step- Ladder	5
	MEASURING INSTRUMENTS	
20.	AC & DC Ammeter	45

21.	AC & DC Voltmeter	45
22.	Avometer	30
23.	Wattmeter	15
24.	Megger	10
25.	Tachometer	10
26.	Energy meter	10
27.	Neon Tester & Voltage check tester	30
28.	Steel rule	35
29.	Oscilloscope	3
30.	Hydrometer	10
31.	Ohmmeter	45
32.	Micrometer	40
33.	Spirit level	45
34.	Tong tester (Clip-on-ammeter)	20
35.	Growler	10
36.	Bridge Megger	8
37.	Pedestal drilling machine	3
38.	Electric portable drilling machine	8
39.	PV panel	4
40	MPPT charge controller	4
41	Inverter	4
42	PWM charge controller	4
43	PV tester	4
HAND TOOLS		

39.	Flat screw driver: - small - medium - large	 35 sets 35 sets 35 sets
40.	Philip's screwdriver	20 sets
41.	Jeweler's screwdriver	20 sets
42.	Allen keys	10 sets
43.	Strippers	45
44.	Long nose pliers	45
45.	Combination pliers	45
46.	Side cutters	45
47.	Hacksaw blades	15 pkts
48.	Hacksaws	35
49.	Hammers (assorted)	45
50.	Mallets (rubber, wooden)	10 each
51.	Spanners (flat, ring & sockets)	10
52.	Flat files 250mm (rough)	45
53.	Flat files 250mm (smooth)	45
54.	Tri-square 250mm (rough)	30
55.	Tri-square 250mm (smooth)	30
56.	Square files 250mm (rough)	30
57.	Square files 250mm (smooth)	30
58.	Round files 250mm (smooth)	30
59.	Chisels (cold)	10 sets

60.	Taps and Wrenches	5 sets
61.	Dies & Stock	5
62.	Drills	5 boxes
63.	Screw extractors	5 boxes
64.	Tester screwdrivers	45
65.	Electrician's knife	45
66.	Rawl plug	45 pkts
67.	Pipe wrenches	20
68.	Gimlet	30 sets
69.	Centre punch	30
70.	Scribers	30
71.	Compressing tool	15
72.	Ringing tool	15
73.	Tin snips	10
OTHER ITEMS / EQUIPMENT		
74.	Resistors (assorted)	300
75.	Rheostat	50
76.	Inductors (assorted)	200
77.	Capacitors (assorted)	200
78.	Transformers (assorted)	50
79.	D.C. Motors	15
80.	D.C. Generators	5
81.	A.C. Motors (single and 3-phase)	10
82.	Starters (assorted)	10 each
83.	AC Generator (single/3-phase)	3

84.	Bell and Battery set	20
85.	Heater (oven)	2
86.	Lead-acid batteries (life)	5
87.	Knife-batteries (life)	5
88.	Earth-loop tester	4
89.	Fire extinguishers	8
90.	Sand Buckets	8
91.	Water Buckets	8
92.	First aid box	2
	CONSUMABLE MATERIALS	
93.	Bread boards	45
94.	Vero boards	45
95.	Printed circuit boards	45
96.	Conduit pipes of various sizes	Several
97.	Conduit accessories for various sizes of conduit pipes	Several
98.	Fish wires	10
99.	Copper wires of various gauges	Several
100.	Insulation vanish	2 tins
101.	Leatheroid	Several
102.	Cotton tapes	Several
104.	Cables of various sizes and cores	Several
105.	Tapes (PVC, Vanish, Rubber)	Several
106.	Junction boxes (for underground termination)	Several
107.	Switches of various types	100 each
108.	Fluorescent fittings	20

109.	Discharge lamps of various types	10 each
110.	Underground cables and accessories	Several
111.	MICC cables and accessories	Several
112.	Soldering sticks	Several
113.	Sealing wax	Several
114.	Sulphuric acid	1 jerry can
115.	Pattery plates (grids, lead peroxide, spongy Lead	Several
116.	Plastic basin	2
117.	P.V.C. Pipes and accessories	5 bundles
118.	P.V.C. cement or glue	Several
119.	Distiller for distilling water	2
120.	Trunkings and accessories	Several
121.	Lamp holders (assorted)	Several
122	Stay wires and accessories	3 sets
123.	Porcelain insulators (for overhead)	5 each
124.	Earth rods and accessories	5 each
125.	Plugs (assorted)	Several
126.	Buzzers	45
127.	Fuses (different ratings)	Several
128.	Switch socket outlets (5A, 13A, 15A,)	45 each
129.	Joint boxes	200
130.	Battery: Lead acid Alkaline	 5 5
131.	Trainer kit	Several

SOLAR PV INSTALATION EQUIPMENT and tools		
S/N	**DESCRIPTION OF ITEMS**	**QUANTITY REQUIRED**
1	Solar panels(250watts/36v)	12
2	Solar inverter /ups	3
3	Solar rack	30
4	Net meter	5
5	Solar panel hanger	15
6	Battery operated drill	15
7	Fall protection	15
8	Hacksaw	10
9	Flat pry bar	15
10	Screw drivers	15
11	Wire cutters	10
12	Mountain brackets	15
13	Charge controller	15
14	Battery	5
15	DC and AC cables	15
16	Crimpers	10
17	Ladder	5
18	Wire stripers	15
19	Combiner boxes	3
20	Wrenches	

List of Laboratories/Workshops and Equipment

LIST OF LABORATORIES
1. Chemistry Lab.
2. Physics Lab.

LIST OF WORKSHOPS
1. Metal Workshop
2. Electrical Installation Workshop

FEBUARY 2025 EXPERT GROUP DEVELOPMENT/REVIEW COMMITTEE

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