NATIONAL BOARD FOR TECHNICAL EDUCATION

CURRICULUM AND COURSE SPECIFICATION

FOR

NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY

DECEMBER, 2019

1.0 INTRODUCTION

This report proposes the National Innovation Diploma Curricula in (NID1 and NID2) for the integration of Solar Energy Technology into engineering curriculum in Nigerian Innovation Enterprise Institutions (IEIs). The proposed NID programme in Solar Energy Technology, is intended for students with wide range of background within the relevant sciences and Engineering discipline who have interest in solar energy technologies. The programme is intended to run on Part time/Full time basis. The programme in line with NBTE's regulations will be completed in two years and three years for full time and part time period respectively. It also provides students with required skills to develop, maintain and commercialize renewable energy products thereby giving them self-employment and at the same time saving the environment. The document presents proposed list of courses and their descriptions. A more detailed description of the course content/syllabus is also provided.

2.0 PHILOSOPHY

The philosophy of the solar energy programme for National Innovation Diploma is designed to allow students to develop a thorough understanding of contemporary science as applied to modern solar energy technology. This will create highly trained man-power for the future advancement of solar energy in science and technology and all round development of the country. The expectation is to ensure excellence in the area of solar energy technology. Continuing rapid growth in the solar energy industry has resulted in strong demand for skill and highly trained professionals who specialise in renewable and sustainable energy technologies in Nigeria and the world at large. There will be opportunity for NID programme in solar energy technology within the Nigerian Tertiary Institutions. This programme will appeal to students whose interest is more engineering based. The programme is designed for two years with minimum of 50 credit units' core courses per academic session and 6 credit units for the final year research project. Course work will span through four semesters and the projects work will also take place in the fourth semester.

Upon graduation, students with NID in Solar Energy will be able to:

- Understand the basic concept of renewable energy sources and technology.
- Contribute successfully to the Nigerian energy mix for sustainable Solar energy production.
- Improve the quality and productivity of Nigerian solar energy industry.

3.0 GOALS AND OBJECTIVES

The NID programme in Solar Energy Technology is aimed at producing technicians with the requisite knowledge and skills to install, repair and maintain basic solar energy technology systems. In that perspective this programme prepares technicians to acquire basic skills on solar energy technologies.

At the end of the programme the technician should be able to:

- Understand the basic fundamentals of Solar Energy Technologies
- Install, maintain and repair solar photo-voltaic systems
- Install, maintain and repair solar thermal systems
- Assemble Solar Energy systems
- Appreciate the impact of renewable energy sources socially, economically and on the environment
- Have basic knowledge of other renewable energy sources e.g. geo-thermal, wave, tidal and fuel cells
- Have basic knowledge and skills for further studies in the specialized field of renewable energy

4.0 ADMISSIONS REQUIREMENT

Candidates for admission into the programme should have a minimum of:

(i) Senior Secondary School Certificate (**SSSC**) or equivalent with at least 5 credit level passes including English Language, Mathematics, Physics, Chemistry and any other relevant subjects in not more than 2 sittings.

(ii) GCE ´O' Level or its equivalent (West African School Certificate/NECO) as in (i) above.

(iii) National Technical Certificate (**NTC**), NABTEB with 5 credits passes in Mathematics, English Language, Physics, Chemistry and Biology/Agricultural science and any other relevant subjects

5.0 DURATION OF STUDY

Expected duration for NID programme shall be two academic sessions consisting of four semesters of eighteen weeks each and Part Time.

6.0 CURRICULUM

The curriculum of NID programme consists of four main components. These are:

i. General Studies/Education
ii. Foundation courses
iii. Professional courses
iv. Supervised Industrial Work Experience Scheme (SIWES)

6.1 The General Education component shall include courses in:

i. Art and Humanities - English Language/Communication skills and History.

ii. Social Studies - Citizenship Education and Entrepreneurship

6.2 The General Education component shall account for not more than 15% of the total contact hours for the programme.

6.3 Foundation courses include courses in Economics, Mathematics, Pure Sciences, Technical Drawing, Descriptive Geometry, Statistics, etc. The number of hours for the Programme may account for about 10 - 15% of the total contact hours.

6.4 Professional courses are core courses of the programme which give the student the theory and professional skills he/she needs to practise his/her field of calling at the technician level. These may account for between 60 - 70% of the contact hours.

6.5 Student Industrial Work Experience Scheme (SIWES) shall be taken during the long vacation following the end of the second semester of the first year. See details of SIWES at section 11.0

6.6 Personal Logbook: Students are to maintain personal Logbook to record all the daily and weekly summary of all the practical activities for all the semesters.

7.0 CURRICULUM STRUCTURE

The structure of the National Innovation Diploma programme consists of four semesters of classroom, laboratory and workshop activities in the college, and a semester (3-4 months) of student Industrial Work Experience Scheme (SIWES). Each semester shall be of 18 weeks duration made up as follows:

a. 15 contact weeks of teaching, i.e. recitation, practical exercise, quizzes, test, etc, and

b. 3 weeks for registration and examinations. SIWES shall take place at the end of the second semester of the first year.

8.0 ACCREDITATION

The Diploma programme shall be accredited by the National Board for Technical Education (NBTE) before the National Innovation Diploma certificates can be awarded. The Details about the process of accrediting a programme for the award of the National Innovation Diploma are available from the Executive Secretary, National Board for Technical Education, Plot "B", Bida Road, P.M.B. 2239, Kaduna, Nigeria.

9.0 AWARD OF NATIONAL INNOVATION DIPLOMA

Conditions for the award of National Innovation Diploma include the following:

a. Satisfactory performance in all prescribed course work which may include class work, tests, quizzes, Workshop practice, laboratory work which should amount to a minimum of between 72 and 80 semester credit units.

b. Supervised industrial work experience for four months.

c. Satisfactory performance at all semester examinations.

d. Satisfactory completion of final year project work: normally continuous assessment contributes 30% while semester examinations are weighted 70% to make a total of 100%. The industrial training is rated on the basis of "satisfactory or unsatisfactory".

National Innovation Diploma should be awarded in four classes:

i.	Distinction	CGPA of 3.50 and above
ii.	Upper Credit	CGPA of 3.0 - 3.49
iii.	Lower Credit	CGPA of 2.50 - 2.99
iv.	Pass	CGPA of 2.00 - 2.49

10.0 GUIDANCE NOTES FOR TEACHERS

I. The new curriculum is drawn in unit courses. This is in keeping with the provisions of the National Policy on Education which stress the need to introduce the semester credit units which will enable a student who so wish to transfer the units already completed in an institution of similar standard from which he/she is transferring.

II. In designing the units, the principle of the modular system by product has been adopted, thus making each of the professional modules, when completed provides the student with technician operative skills, which can be used for employment purposes (self or otherwise).

III. As the success of the credit unit system depends on the articulation of programmes between the institutions and industry, the curriculum content has been written in behavioural objectives, so that it is clear to all the expected performance of the student who successfully completed some of the courses or the diplomates of the programme. This is slight departure in the presentation of the performance based curriculum which requires the conditions under which the performance are expected to be carried out and the criteria for the acceptable levels of performance. It is a deliberate attempt to further involve the staff of the department teaching the programme to write their own curriculum stating the conditions existing in their institution under which performance can take place and to follow that with the criteria for determining an acceptance level of performance. Departmental submission on the final curriculum may be vetted by the Academic Board of the institution. The aim is to continue to see to it that a solid internal evaluation system exists in each institution for ensuring minimum standard and quality of education in the programmes offered throughout the IEIs system.

IV. The teaching of the theory and practical work should, as much as possible, be integrated. Practical exercises, especially those in professional courses and laboratory work should not be taught in isolation from the theory. For each course, there should be a balance of practical to theory in the ratio of 70:30.

11.0 LOG BOOK

A personal Log-book to be kept by the students shall contain all the day-to-day, weekly summary, and semester summary of all the practical activities from day one to the end of the programme. This is to be checked and endorsed by the lecturers concerned at the end of every week.

11.0 GUIDELINES ON SIWES PROGRAMMES

For the smooth operation of the SIWES, the following guidelines shall apply:

11.1 Responsibility for placement of students.

a. Institutions offering the National Innovation Diploma programme shall arrange to place the students in industry. By April 30 of each year, six copies of the master-list showing where each student has been placed shall be submitted to the Executive Secretary, National Board Technical Education, which shall, in turn, authenticate the list and forward it to the Industrial Training Fund, Jos;

b. The placement officer should discuss and agree with industry on the following:

(i) A task inventory of what the students should be expected to experience during the period of attachment. It may be wise to adopt the one already approved for each field.

(ii) The industry-based supervisor of the students during the period. It should be noted that the final grading of the students during the period of attachment should be weighted more on the evaluation by his industry-based supervisor.

11.2 Evaluation of students during SIWES. In the evaluation of the student, cognisance should be taken of the following items:

1. Punctuality
2. Attendance
3. General Attitude to work
4. Respect for Authority

5. Interest in the field/technical area
6. Technical competence as a potential technician in his field.

11.3 Grading of SIWES: To ensure uniformity of grading scales, the institution should ensure that the uniform grading of students' work which has been agreed to by all IEIs is adopted.

11.4 The Institution-Based Supervisor: The institution-based supervisor should initial the log-book during each visit. This will enable him to check if standards are being met and to assist students having any problems regarding the specific assignments given to them by their industry-based supervisor.

11.5 Frequency of Visit: Institution should ensure that students placed on attachment are visited within one month of their placement. Other visits shall be arranged so that:

1) There is another visit, weeks after the first visit; and
2) the final visit in the last month of the attachment.

11.6 SIWES as a component of the curriculum: The completion of SIWES is important in the final determination of whether the student is successful in the programme or not. Failure in the SIWES is an indication that the student has not shown sufficient interest in the field or has no potential to become a skilled technician in his field. The SIWES should be graded on a successful or unsuccessful basis. Where a student has satisfied all other requirements but failed SIWES, he/she may only be allowed to repeat another four months' SIWES at his own expense.

12.0 FINAL YEAR PROJECT

Final year students in this programme are expected to carry out a project work. This could be on individual basis or group work. The project should, as much as possible incorporates basic element of design, develop, maintain and complete a marketable item or something that can be put to use. Project reports should be well presented and should be properly supervised. The departments should make their own arrangement of schedules for project work.

CURRICULUM TABLES

FIRST SEMESTER NID I

Course Code	Course Title	L	T	P	CU	CH
GNS 101	Use of English I	**2**	**-**	**-**	**2**	**2**
MTH 112	Algebra and Elementary Trigonometry	**2**	**1**	**-**	**3**	**3**
ICT 101	Introduction to Computing	**1**	**-**	**2**	**3**	**3**
MEC 112	Technical Drawing	**1**		**2**	**3**	**3**
SET 111	Introduction to Renewable Energy	**2**	**-**	**2**	**4**	**4**
SET 112	Electrical Engineering Science	**2**	**-**	**2**	**4**	**4**
SET 113	Fundamentals of Solar Thermal and PV Energy	**2**	**-**	**1**	**3**	**3**
				9	**22**	**22**

SECOND SEMESTER NID I

Course Code	Course Title	L	T	P	CU	CH
GNS 201	Use of English II	**2**	**-**	**-**	**2**	**2**
MEC 113	Basic Workshop Technology & Practice	**1**	**-**	**3**	**4**	**4**
EEC 124	Electronics I	**1**		**2**	**3**	**3**
SET 121	Trigonometry and Analytical Geometry	**2**		**2**	**4**	**4**
SET 122	Energy and Environment	**2**	**-**	**2**	**4**	**4**
SET 123	Measurement and Instrumentation I	**2**	**-**	**2**	**4**	**4**
SET 124	Solar System Component I	**1**	**1**	**-**	**2**	**2**
				11	**23**	**23**

THIRD SEMESTER NID II

Course Code	Course Title	L	T	P	CU	CH
MTH 122	Calculus	**1**	**1**	**-**	**2**	**2**
MEC 217	Technical Report Writing	**2**	**-**	**-**	**2**	**2**
EEC 129	Electrical Installation	**1**	**-**	**2**	**3**	**3**
SET 211	Solar System Components II	**1**		**2**	**3**	**3**
SET 212	Solar Energy Technology & Applications I	**2**	**-**	**1**	**3**	**3**
SET 213	Measurements and Instrumentation II	**2**	**-**	**2**	**4**	**4**
SET 214	Solar Energy System Design I	**1**		**2**	**3**	**3**
SET 215	Introduction to Green Economics	**2**	**-**	**1**	**3**	**3**
				12	**23**	**23**

FOURTH SEMESTER NID II

Course Code	Course Title	L	T	P	CU	CH
EED 126	Introduction to Entrepreneurship	**1**	**-**	**2**	**3**	**3**
SET 222	Solar Energy Technology and Application II	**2**	**-**	**2**	**4**	**4**
SET 223	Solar Energy System Design II	**2**		**2**	**4**	**4**
SET 224	Solar System Evaluation	**2**	**-**	**2**	**4**	**4**
SET 225	Final Year Project	**-**	**-**	**6**	**6**	**6**
				14	**21**	**21**

USE OF ENGLISH 1

GNS 101

ALGEBRA AND ELEMENTARY TRIGONOMETRY

MTH 112

PROGRAMME: NATIONAL INNOVATIVE DIPLOMA IN SOLAR ENERGY TECHNOLOGY

COURSE TITLE: INTRODUCTION TO COMPUTING

COURSE CODE: ICT 101

CREDIT HOURS 3 HOURS

DURATION: Hours/Week Theory: 1 hr Practical: 2 hrs

GOAL: This course is designed to acquaint students with basic knowledge of Computer

GENERAL OBJECTIVES

On completion of this course the student should be able to:

1.0. Understand the roles of Computers in Modern Society
2.0. Understand computer Hardware Components
3.0. Know the concept of software
4.0. Know the various types of computer data processing Techniques
5.0. Know the basic procedures for operating computer systems
6.0. Understand security and safety procedures within a computer environment.
7.0. Understand the concept of a computer Networks
8.0. Understand the use of the Internet

PROGRAMME: NATIONAL INNOVATIVE DIPLOMA IN SOLAR ENERGY TECHNOLOGY						
COURSE: INTRODUCTION TO COMPUTING				**COURSE CODE: ICT 101**		**CREDIT HOURS: 3**
YEAR: 1	**SEMESTER: 1**		**PRE-REQUISITE**	**Theoretical: 1hr Practical : 2 hrs**		
GOAL: This course is designed to acquaint students with the basic knowledge of Computer						
Theoretical Content				**Practical Content**		
General Objective: 1.0 Understand the role of the computer in modern society						
Week	Specific Learning Outcome	Teachers Activities	Learning Resources	Specific Learning Objectives	Teachers Activities	Learning Resources
1-3	1.1. Define the computer 1.2. Describe the development of computers in particular. Abacus, Pascal, Babbage, Hollerath and the ENIAC 1.3. Classify computers according to generation from the 1st to 5th generations (and any subsequent generations) 1.4. Distinguish between analog, digital and hybrid computers 1.5. Explain the social implications on society, in particular privacies and quality of life 1.6. List the benefits of computers to the society	• Define computer • Trace the history of computer. • Classify the computer according to generations • Distinguish between types and classes of computers. • Highlight the implications of computers to the society. • Outline the benefit of computer to the society.	White Board and Marker. PC loaded with Power point and connected to multimedia projector	Identify different types of computers Classify computer system	Guide students to identify and classify computer systems	Networked PCs loaded with software packages. Computer charts PC loaded with computer images

		• Distinguish between types and classes of computers. • Highlight the implications of computers to the society. • Outline the benefit of computer to the society.				
	General Objective : 2.0 Understand Computer Hardware Components					
4-5	2.1. Describe computer hardware components 2.2. List some input and output devices 2.3. Describe the functions of The input and output devices 2.4. Describe the functions of the CPU 2.5. List some auxiliary units 2.6. Describe the functions of the auxiliary memory 2.7. Define bits, nibbles, bytes, word and storage size 2.8 Describe the computer hardware configuration	• Discuss the basic Hardware components. • Discuss the various components and functions. • Discuss the configuration of typical computer system.	White Board and Marker. PC loaded with Power point and connect to Multimedia Projector	Identify the various components of a computer system Identify the various components of a computer system	Guide the students on how to identify the various components of a computer system	A DEMO PC showing its components

	General Objective: 3.0 Know the concept of Software					
6-7	3.1 Define Software 3.2 Classify computer software 3.3 Describe types of programming languages: • Machine • Curve • High-level 3.2 Explain source and object code 3.5 Define a translator 3.6 Describe types of translators: assembles, compiler, interpreter 3.7 Explain the use of package programmes	• Discuss software and its various types. • Explain computer packages and its various types • Explain safety software and its various types.	White Board and Marker . PC loaded with Power point and connected to multimedia projector	Identify computer packages on computer system Identify system software on computer system	Guide students to identify computer packages on computer systems Guide students to identify system software on computer system	PCs loaded with different computer softwares
	General Objective: 4.0 Know the various types of computers data processing Techniques					
8	4.1 Define Batch processing, Real time processing, Time sharing and distributed processing 4.2 Differentiate between Batch processing, Real time processing, Time sharing and Distributed processing systems 4.3 Explain multi-tasking, multi programming, multi	• Explain offline and online concepts • Describe batch processing, real time, time sharing and distributed processing • Differentiate between batch processing, real time processing, time-sharing	White Board. Marker PC loaded with Application packages and connected to multi-media projector	Solve life problems requiring the application of the various modes	Guide the students on how to identify real life problems requiring the various data processing techniques	Networked PCs loaded with different computer packages

	processing	and distributed processing system. • Describe multi-tasking and multi processing				
	General Objective: 5.0 Know the basic procedures for operating Computer System					
10-11	5.1 Explain basic computer operations setting up, start up, shot down, etc. how to operate a computer system 5.2 Explain storage initialization and formatting.	• Discuss the principles and procedures of operating the computer system, the setting up, start up and shut-down systems • Discuss initialization and formatting of storage devices such as disks and diskettes	White Board. Marker PC loaded with multi-media projector CDs External Hard-drives, Flash drives	Be able to boot and shut down computer system Format Storage media	Guide the students on how to operate the computer. Guide students on how to format storage media	Networked PCs and storage media such as diskettes, flash, CDs
	General Objective: 6.0 Understand security and safety procedures within a computer environment**.**					
11-12	6.1 Define Computer Security 6.2 Explain Data Control Techniques 6.3 Understand security methods in computer installation and the need for users passwords, anti-viruses 6.4 Explain methods of preventing hazards such as fire floating and sabotage	• Explain data control techniques. • Describe standard operating procedures of a computer installation. • Explain the need for computer room security. • Explain computer system auditing • Explain methods of	White Board and Marker PC loaded with Relevant software packages and connected to multi media projector	Create password on computer system Installation of computer anti-viruses	Guide students on how to create simple password that they could easily remember Guide students on how to install anti viruses	Networked PCs Anti-virus software

		preventing hazards fire, floating and sabotage etc. • Describe file security methods in computer installations. • Explain the need for file security in computer installation. • Explain the user passwords and user name.				
	General Objective: 7.0 Understand the concept of a computer networks					
12 - 13	7.1 Define and explain Network. 7.2 Describe different types of network topologies such as star, ring and bus. 7.3 Explain LAN, MAN and WAN. 7.4 Explain the benefits of networks in an organization	• Define computer network. • Explain different types of network organization such as star, ring, bus etc. • Describe different types of network: LAN, WAN • Discuss the benefits of networks in an organization	White Board Marker PC loaded with power point and connected to OHP	Identify various computer topologies Find out different organizations using the different topologies.	Guide the students on how to identify various network topologies	Networked PCs
	General Objective: 8.0 Understand the use of the internet					
14 - 15	8.1 Define internet and describe its resources 8.2 Explain the processes	• Define internet • Describe resources of internet	White Board and Marker. PC loaded with	Search for materials on the internet.	Guide students on how to search for materials on the internet	Networked PCs connected to the internet.

	involved in searching the internet for materials 8.3 Explain the concept of E-Mail 8.4 Explain cybersecurity	• Explain the processes involved in browsing and searching the internet. • Explain the meaning of ISP. • Explain the concept of email address. • Describe the processes of acquiring an e-mail address. • Describe the process of sending and receiving an email. • Discuss cyber security and preventing measures	power point and internet browser and connected to OHP	Compose and send Email.	Demonstrate how to compose and send Email.	
	Assessment Criteria					
	Course Work	Course Test 20%	Practical 20%	Examination/ Project/Portfolio 60%		

PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY

COURSE TITLE: TECHNICAL DRAWING

COURSE CODE: MEC 112

DURATION: **3Hrs/Week**

GOAL: This course is designed to enable students acquire adequate knowledge and skills in the use of drawing instruments, graphical communication, construction of simple geometric figures and shapes, appreciation of isometric, oblique and single orthographic projections

GENERAL OBJECTIVES:

On completion this course, students should be able to:

1.0 Know different drawing instruments, equipment and materials used in technical drawing

2.0 Know graphical communication

3.0 Know the construction of simple geometrical figures and shapes,

4.0 Know isometric and oblique projections

5.0 Know simple orthographic projectors

6.0 Understand the intersection of regular solids

PROGRAMME: **NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY**						
COURSE: **TECHNICAL DRAWING**	COURSE CODE: **MEC 112**		CONTACT HOURS: 3Hours/week			
COURSE SPECIFICATION: **Theoretical Course**			**Course Specification: Practical Content**			
GOAL:	This course is designed to enable students acquire adequate knowledge and skills in the use of drawing instruments, graphical communication, construction of simple geometric figures and shapes, appreciation of isometric, oblique and single orthographic projections					
General Objective 1.0: Know different Drawing Instruments, Equipment and Materials use in Technical drawing.						
Week	**Specific Learning Outcome**	**Teaching Activities**	**Learning Resources**	**Specific Learning Objective**	**Teaching Activities**	**Learning Resources**
	1.1 Identify the different types of drawing instruments, equipment and materials. 1.2 Outline the uses of the various instruments, equipment and materials. 1.3 State the precautions necessary to preserve items 1.1 above. 1.4 Use each of the items in 1.1 above. 1.5 Maintain various drawing instruments and equipment.	• Present to students all drawing instruments: a. Drawing set b. T-Square c. Drawing board d. Set squares e. Types of pencils (H to B) Explain the uses of all of the above. Explain how to take care various drawing instruments and equipment	•Black board ruler (1m) • Black board Tee Square • Black board compass • Blackboard protector • Adjustable set- square •60 set square •45 set square •French curve set •Templates •Duster •Chalk •Complete Students' drawing Set • Drawing table and Board			
	General Objective 1.0: Know different Drawing Instruments, Equipment and Materials use in Technical drawing.					
	2.1 Explain graphics and different types of graphic present	• Ask the students to	Black board ruler			

	2.2 Illustrate various convention present in graphical productions of construction lines, finished lines, hidden and overhead details projections, centre lines, break lines, dimensioning of plane, elevation and sections of objects. 2.3 Layout of drawing sheets with the following: (a) Margins (b) Title block etc. 2.4 State the various standards of drawing sheets. 2.5 Print letters and figures of various forms and characters. 2.6 Illustrate conventional signs, symbols and appropriate lettering characters.	Illustrate in a drawing the various types of lines based on BS 308 1972 Part 2. and assess. • Ask the students to set drawing area on A1 paper with a title block and the boarder lines and assess. • Ask students to illustrate technical lettering in capital and small letters, using, free hand and using letter stencils and assess. •Ask students to identify the various standard sheets Ao -A4 and assess. Print letters and figures of various forms and characters. Ask students to draw conventional signs and symbols and assess.	(1m) Black board Tee-Square • Black board compass • Blackboard protector Adjustable set-square 60 set square 45 set square French curve set Templates Duster Chalk • Complete drawing table Black board ruler (1m) Black board Tee-Square • Black board compass • Blackboard protector Adjustable set-square 60 set square 45 set square French curve set			
	General Objective 3.0: Know different Drawing Instruments, Equipment and Materials use in Technical drawing.					
	3.1 Explain the purpose of geo-metrical construction in drawing parallel. 3.2 Construct parallel and perpendicular lines	• Ask students to illustrate the construction of simple geometrical figures • Ask students to construct parallel and perpendicular lines	• Black board ruler (1cm) • Black board Tee-Square • Black board compass			

	3.3 Construct and bisect lines, angles and areas 3.4 Divide a straight line into given number of equal parts. 3.5 Identify polygons (regular or irregular) 3.6 Construct regular polygons with N sides in a given circle, given (a) distance across flats (b) distance across corners 3.7 Define a circle 3.8 Explain the properties of a circle, e.g. radius, diameter, normal, tangent, circumference etc.	• Ask students to construct and bisect lines, angles and areas. • Ask student to divide a straight line into a given number of equal parts using the compasses. • Ask students to differentiate between regular polygon. • Construct regular polygons with N sides in a given circle, given (a) distance across flats (b) distance across corners Give the definition of a circle Explain the properties of a circle, e.g. radius, diameter, normal, tangent, circumference etc.	• Black board projector • Adjustable set-square • 60 set square • 45 set square • French curve set • Templates • Duster • Chalk • Complete • Drawing table and polygons and assess • Ask students to conduct regular polygon with N side and assess			
	General Objective 4: 0 Know how to construct of simple geometrical figures and shapes					
	4.1 Carry out simple geometrical constructions on circles e.g: a. Diameter of a circle of given circumference b. The circumference to circle of given diameter. c. A circle to touch a given smaller circle and a given line.	• Show how to construct plane and diagonal scales. \ • Explain the various properties of a circle. • Illustrate simple geometrical constructions on circles listed in 4.1	• Black board ruler (1m) • Black board Tee-Square • Black board compass			

	d. A circle to pass through 2 points and touch a given line. e. A circle to touch a given smaller circle and a given line. f. Tangents to circles at various points g. An arc of radius tangent to two lines at an angle to less than and more than 90 tangent to two circles h. An area externally tangent to two circles i. Inscribing and circumscribing circles. 4.2 Define an ellipse 4.3 Construct ellipse by using (a) trammel method (b) concentric circle method 4.4 Explain the following draughting techniques : (a) Projection method (b) Measurement method (c) Transposition method 4.5 Construct plane scales and diagonal scales, using appropriate instruments	• Show the different methods of constructing ellipses. • Explain the meaning of an ellipse. • Show how to construct an ellipse using the various methods. • Explain the various draughting techniques listed in 4.4. • Illustrate how to construct plane shapes and diagonals scales using appropriate instruments.	• Blackboard protector • Adjustable set-square • 60 set square • 45 set square • French curve set • Templates • Duster • Chalk • Complete drawing table • Black board ruler (1m) • Black board • Tee-Square • Black board compass			

	General Objective 5: 0 Know the Isometric and Oblique Projects					
	5.1 Differentiate between isometric and oblique projections. 5.2 Draw a square in isometric and oblique forms. 5.3 Draw a circle in Isometric and oblique Forms. 5.4 Draw an ellipse in Isometric and oblique forms. 5.5 Draw a polygon with a minimum of eight sides in Isometric and oblique forms. 5.6 Dimension holes, circles, arcs and angles correctly on isometric and oblique forms. 5.7 Use appropriate convention symbols and abbreviations.	• Explain isometric and oblique projections. • Illustrate how to construct a square in isometric and oblique projections. • Illustrate how to construct a circle in Isomeric and Oblique forms • Illustrate how to draw an ellipse in Isometric and Oblique forms • Illustrate how to draw a polygon in isometric and oblique projections • Illustrate how to dimension holes circles, arcs and angles in isometric and oblique projection and label with appropriate conventional symbols and abbreviations	• Black board ruler (1m) • Black board Tee-Square • Black board compass • Blackboard protector • Adjustable set-square • 60 set square • 45 set square • French curve set • Templates • Duster • Chalk • Complete drawing table			
	General Objective 6: 0 Know Single Othographic Projects					
	6.1 Explain the principle of orthographic projection. 6.2 Explain the principle planes of projection	• Ask students to differentiate between first and third angle orthographic projection. • Explain the vertical and horizontal planes in orthographic projection.	• Black board ruler (1m) • Black board Tee-Square • Black board ruler (1m) • Black board			

	(a) Vertical plane (b) Horizontal plane. 6.3 Explain why the first and third angles are used and the second and fourth angles not used. 6.4 Project views of three-dimensional objects on to the basic planes of projection in both first and third angle to obtain: - (a) the front view or elevation (b) the top view or plan.	• Show students how to construct orthographic projections of simple objects in first and third angle orthographic projections. • Show students how to project views of three-dimensional objects on to the basic planes of projection in both first and third angle to obtain: - (a) the front view or elevation (b)the top view or plan	Tee-Square • Black board compass • Blackboard protector • Adjustable set-square • 60 set square • 45 set square • French curve set			
	General Objective 7.0 Understand the Intersections of Regular Solids					
	7.1 Explain interpretation or inter-sections of solids. 7.2 Draw the lines of intersections of the following regular solids and planes in both first and third angles. a. Two square-prisms meeting at right angles. b. Two dissimilar square prisms meeting at and angle. c. Two dissimilar square prisms meeting to an angle. d. A hexagonal prism meeting a square prism at right angles.	• Give examples of intersection of solids • Illustrate how to construct: a. Two square-prisms meeting at right angles a. Two dissimilar square prisms merely b. Two dissimilar square prisms meeting 60 c. An hexagonal prism meeting a square prism d. Two dissimilar cylinders meeting	• Blackboard ruler (1m) • Blackboard Tee-Square • Black board compass Blackboard protector • Adjustable set-square • 60 set square • 45 set square • French curve set • Templates • Duster • Chalk • Complete drawing table			

	e. Two dissimilar cylinders meeting at an angle. f. Two dissimilar cylinders meeting at right angle, their centres not being in the same vertical plane.	at an angle e. Two dismal cylinders meeting at right angle, then centres at long in the same vertical place as in 6.2.				

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	INTRODUCTION TO RENEWABLE ENERGY
COURSE CODE	SET 111
YEAR:	YEAR 1, SEMESTER 1
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	This Course is designed to acquaint the students with alternative energy sources.

GENERAL OBJECTIVES:

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

1.0 Understand the basic concept of renewable energy

2.0 Understand conventional and emerging renewable energy sources

3.0 Understand various solar thermal applications

4.0 Understand the concept and applications of solar PV

5.0 Understand the concept and applications of wind energy

6.0 Understand the concept and application of biomass energy

7.0 Understand the concept of energy storage systems

PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY						
COURSE: Introduction to Renewable Energy		**Course Code:** SET 111		**Contact Hours:** 4HRS/WK L = 2 P = 2		
Goal: The Course is designed to acquaint the students with alternative energy sources						
Course Specification: Theoretical content				**PRACTICAL CONTENT**		
Week	**General Objective 1.0: Understand the basic concept of renewable energy**					
	Specific Learning Outcome:	**Teachers Activities**	**Resources**	**Specific Learning Outcome:**	**Teacher Activities**	**Resources**
1 -2	1.1 Define energy 1.2 Define different types of energy 1.3 Explain classification of energy into fossils and non-fossils 1.4 Explain classification of energy into renewable and non-renewable 1.5 Explain the advantages and disadvantages of renewable energy	1.1 Explain the activities in details in 1.1 to 1.5 1.2 Assess the students	Recommended text books, Lecture notes, related journals and materials and internet	• Classify Energy source/types	• Guide students to classify types and sources of energy	• Charts • Pictures • Solar Atlas • RE Modules
	General Objective 2.0: Understand conventional and emerging renewable energy sources					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
3	2.1 Classify the renewable energy sources as conventional and new-emerging 2.2 Explain renewable energy sources ▪ Solar thermal ▪ Solar PV ▪ Wind	1.2 Explain renewable and non-renewable energy sources 1.2 Explain the	• Text books, • Lecture notes, • Related journals • Materials and • Internet	2.1 Identify simple renewable energy devices/systems e.g solar panels, portable wind mills, solar dryers etc.	• Guide students to identify renewable energy devices/systems.	• Solar panels, • Avometers, • DC bulbs, cables, solar cooker, portable wind mill etc.

	▪ Hydro ▪ Biomass 2.3 Explain emerging renewable energy sources: ▪ Tidal ▪ Geothermal ▪ Hydrogen fuel	conventional renewable energy sources 1.3 Explain new emerging renewable sources				
	General Objective 3.0: Understand the concept and applications of solar PV					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
7-8	3.1 Explain Solar Photovoltaic Generation 3.2 Explain different types of solar photovoltaic cells 3.3 Explain the solar photovoltaic circuit properties 3.4 Explain the applications of solar photovoltaic systems: ▪ Solar PV home system ▪ Solar street light ▪ Solar water pumping system	3.1 Explain the activities in details in 3.1 to 3.5 3.2 Assess the students	• Projector, • Text books, • Lecture notes, • Journals, • Materials and • Internet	3.1 Identify solar PV systems: home, street light and solar water pumping system	• Show students different type of photovoltaic systems installed. • Take a guided tour to physical project sites for identification	• Solar panels, • Inverter, • Battery, charge controller, • Solar pump, cables, • DC lamp, • AC lamp, etc.

	3.5 Explain social and environmental aspects of solar PV systems					
	General Objective 4.0: Understand the concept and applications of wind energy					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
9- 10	4.1 Explain wind energy potentials 4.2 Explain wind characteristics 4.3 Explain principle of operation of wind turbines 4.4 Explain power extraction by a wind turbine 4.5 Explain types of wind turbine 4.6 Explain blade element theory 4.7 Explain electricity generation by wind turbines 4.8 Explain social and environmental aspects of wind power system	4.1 Explain the activities in details in 4.1 to 4.8	• Text books, • Lecture notes, • Journals • Materials and • Internet	4.1 Identify various types/parts of wind turbine. 4.2 Demonstrate measurements of wind speed. 4.3 Demonstrate measurement of wind direction.	• Show different components of wind turbine and their uses. • Guide the students to measure wind speed and wind direction.	• Prototype of wind turbine system, • Anemometer, • Wind vane. etc.
	General Objective 5.0:Understand the concept and applications of small hydropower systems					

Week	Specific Learning Outcome	Teachers Activities	Resources	Specific Learning Outcome	Teachers Activities	Resources
11-12	5.1 Explain principle of operation of hydropower systems 5.2 Explain power extraction by hydro turbine 5.3 Explain types of hydro turbine 5.4 Explain classification of hydro power 5.5 Explain social and environmental aspects of hydro power systems	5.1 Explain the activities in details in 5.1 to 5.6	• Text books, • Lecture notes, • Related journals • Materials and • Internet	5.1 Identify various components of small hydro power systems.	• Guide the students to know the different types of hydropower turbines and their functions	• Prototype or models of small hydro power. • Pictures of Excursions • Water Reserviour
	General Objective 6.0: Understand the concept and application of biomass energy					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
13-14	6.1 Explain overview of Biomass energy resources and potentials 6.2 Explain the Fuel content of Biomass 6.3 Explain the method of extracting energy from biomass: • Direct combustion, • gasification,	6.1 Explain the activities in details in 6.1 to 6.6	• Text books, • Lecture notes, • Related journals, • Materials • Internet	6.1 Identify the various types of biomass materials and machinery e.g: jatrophacurcas, sugar cane, maize, animal dumps, human faeces etc.	• Show different type of Biomass energy products, biogas digesters and biofuels	• Prototype of Biomass energy products, • Digesters, • Cylinders, • Bunners, • Soxhlet extractors, • Biodigesters

	• pyrolysis and • anaerobic digestion 6.4 Explain the principles and mechanism of bioconversion of waste 6.5 Explain the principles of biofuel production 6.6 State the advantages and disadvantages of biofuel production					
	General Objective 7.0: Understand the concept of energy storage systems					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
15	7.1 Explain the importance of energy storage 7.2 Explain biological storage system 7.3 Explain chemical storage system 7.4 Explain heat storage system 7.5 Explain batteries and accumulators 7.6 Explain fuel cells	7.1 Explain the activities in details in 7.1 to 7.6	• Text books, • Lecture notes, • Related journals • Materials and • Internet	7.1 Identify various storage systems. 7.2 Demonstrate energy storage in batteries and water	• Guide the students to demonstrate energy storage.	• Rechargeable batteries, water etc.
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	ELECTRICAL ENGINEERING SCIENCE
COURSE CODE	SET 112
YEAR:	YEAR 1, SEMESTER 1
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	This course is designed to introduce the students with the basic knowledge of current flow in both electric and magnetic circuits.

GENERAL OBJECTIVES:

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

1.0 Understand the concept of the electric current flow

2.0 Know various types of energy and their inter-relationships

3.0 Understand the concept of simple DC circuit and circuit theorems

4.0 Understand the concept of electrostatics, electric charge and capacitance of capacitors

5.0 Understand the concept of magnetism and magnetic circuits

6.0 Understand the concept of electromagnetism and electromagnetic induction

7.0 Understand the concept of inductance and its applications

8.0 Understand the fundamentals of a.c. theory

PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY						
COURSE: SCIENCE OF SOLAR ENERGY SYSTEMS			**Course Code:** SET 112	**Contact Hours:** 4HRS/WK L = 2 P = 2		
Goal: The course is designed to introduce the students with basic knowledge of current flow in both electric and magnetic circuits						
Course Specification: THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**General Objective 1.0: Understand the concept of the Electric Current Flow**					
	Specific Learning Outcome:	**Teachers Activities**	**Learning Resources**	**Specific Learning Outcome:**	**Teacher Activities**	**Resources**
1-3	1.1 Define an atom 1.2 Explain the structure and composition of an atom 1.3 Differentiate between conductors, insulators and semi-conductors 1.4 Explain the concepts of current and electron flow 1.5 Define electric current, potential difference electromotive force (e.m.f), resistance and symbols. 1.6 State multiples and sub-multiples of Electric quantities; (e.g. Mega 10^6, kilo 10^3, etc)	• Explain atomic structure and its composition • Explain the electron mobility • Explain with the aid of diagrams how the current & electron flow • Explain the formulae and symbols for current flow, p.d. or e.m.f. resistance • Explain quantities of electricity and their units.	Chalk Board Chalk Textbooks Charts	• Draw atomic structure and its composition • Measure Electronic current, voltage and potentials difference	• Guide students to draw atomic structure and its compositio n • Guide students to measure Electronic current, voltage and potentials difference •	• Atomic Model • Voltmeter • Multimeter • Ammeter • Gostart •
	General Objective 2.0: Understand various types of energy and their inter-relationships					
	2.1 Explain various types of energy	• Explain the sources of	Chalk Board Chalk	• Measure various	• Guide students to	• Thermometer

	2.2 Explain the relationship between electrical, mechanical and thermal energy 2.3 State SI units of various types of energy 2.4 State Joule's Law 2.5 Solve problems involving Joule's Law	various energy generations • Show how they are related to electrical energy • Explain their units • Solve problems	Textbooks Charts	quantities of energy and convert to SI units where applicable.	measure various quantities of energy and convert to SI units where applicable.	• And Thmocouple Solar and meters, etc.
	General Objective 3.0: Understand the concept of simple DC circuit and circuit theorems					
1 - 2	3.1 Define DC current 3.2 State analogy between current flow and water flow 3.3 Describe basic D.C circuits 3.4 State the relationship between resistance of a conductor, its resistivity, length and area. 3.5 Solve problems involving resistivity and conductivity 3.6 Deduce the equivalent resistance for series and parallel circuit	• Explain the definition of current. • Explain how flow of current is similar to the flow of water • • Explain how to obtain resistivity and conductivity from the formula R =ρ1/a • Explain how to obtain resistivity from the formula R =ρ1/a	• Text books, • Lecture notes, • Related journals, • Materials and • Internet	• Carry out experiments on series and parallel circuits • Draw the basic d.c circuit with source • Verify Kirchoff's law with d.c circuits. • Verify superposition principles • Draw the circuit	• Teachers should ensure necessary precautions are taken during the experiment	• Resistors, • capacitors, • voltmeter, • ammeter, • ohmmeter, • cables, • emf sources

	3.7 Explain Kirchoffs laws 3.8 Explain superposition principles 3.9 Solve problems invoving series and parallel circuit using kirchoffs laws and superposition principles	• Explain the differences between the Kirchoff's laws and super position principles. Give exampes		diagrams for series and parallel connections •		
	General Objective 4.0: Understand the concept of electrostatics, electric charge and capacitance of capacitors					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
3-5	4.1 Explain electric charge 4.2 State Coulomb's law. 4.3 Solve problems involving coulomb's law 4.4 Define electric field strength, electric flux density, permitivity, relative permitivity, field intensity, potential and electric flux 4.5 Solve problems involving the terms in 4.4 4.6 Define capacitance 4.7 Derive an expression for the capacitance of parallel plate capacitors in terms of	• Explain sources of electric charges and electrostatic charges • Explain the mathematical formula for the electric charge, electrostatic charges. • Explain energy store in Capacitor	• Textbooks, • Lecture notes, • Related journals • Materials and • Internet	• Perform experiment on charging and discharging of a capacitor. • Guide students to perform mathematical formula for the electric charge and electronic charges •	• Teachers should ensure necessary precautions are taken during the experiment .	• Resistors, • Capacitors, • voltmeter, • Ammeter, • Ohmmeter, • Cables, • emf sources, etc.

	area, the distance between plates and permitivity of the dielectric 4.8 Derive an expression for the capacitance of parallel plate capacitors in terms of area, the distance between plates and permitivity of the dielectric 4.9 Derive an expression for the capacitance of a capacitor with composite dielectrics. 4.10 Derive an expression for the voltage distribution between series connected capacitors 4.11 Deduce an expression for the equivalent capacitance for capacitors connected in series and in parallel 4.12 Derive an expression for the energy stored in a capacitor 4.13 Solve problems involving 4.8 to 4.12.					
	General Objective 5.0: Understand the concept of magnetism and magnetic circuits.					

Week	Specific Learning Outcome	Teachers Activities	Resources	Specific Learning Outcome	Teachers Activities	Resources
6-7	5.1 Define magnetic flux, magnetic flux density magnetic motive force, magnetic field strength, reluctance, permeability of free space (magnetic constants), relative permeability 5.2 State the symbols, units and relationship of terms in 5.1 5.3 State analogy between electrical and magnetic circuit 5.4 Solve simple magnetic circuit problems 5.5 Distinguish between soft and hard magnetic materials	• Explain the general concept of magnetism and electromagnetism • Explain how to derive formulae for field strength force etc • Explain analogies between electrical and magnetic circuits • Solve problems in the class	• Text books, • Lecture notes, • Related journals and • Materials,	5.1 Determine by experiment the B-H curve for magnetic material (Hysterisis curve) 5.2 Perform experiment on a magnetic energy loss in a magnetic material 5.3 Draw the electrical equivalent of a magnetic circuit, with or without air-gap	• Guide the students to carry out the activities in 5.1 to 5.2 with minimum error	• Magnet, inductors, • Voltmeter, • Ammeter, • Flux meter Etc. .
	General Objective 6.0: Understand the concept of electromagnetism and electromagnetic induction					

Week	Specific Learning Outcome	Teachers Activities	Resources	Specific Learning Outcome	Teachers Activities	Resources
8-9	6.1 Explain the magnetic effect of electric current 6.2 Explain the force on a current carrying conductor in a magnetic field 6.3 State the direction of force in 6.3 6.4 Derive the expression for the magnitude of the force in 2.4 (i.e. F = BIL Newton) 6.5 Explain the concept of electromagnetic induction 6.6 State Faraday's Laws of electromagnetic induction 6.7 State Lenz's law of electromagnetic induction 6.8 Derive the expressions for magnitude of e.m.f induced in a conductor or a coil 6.9 Solve problems involving 6.6 to 6.10 above	• Explain the concept of electric field and electromagnetic Induction G68	• Textbooks, • Lecture notes, • Related journals, • Materials and • Internet	• Verify by experiment faraday's law of electromagnetic induction • Draw magnetic fields around straight conductors, adjacent parallel conductors and solenoids • Perform experiment on Lenz's law of electromagnetic induction • Determine by experiment the inductance of a coil	• Guide the students to perform the experiments with minimum error	• Magnet, • Inductors, • Voltmeter, • Ammeter, • Flux meter, etc.

	6.10 State the applications of electromagnetic induction			• Perform experiment to determine energy loss in an inductor		
	General Objective 7.0: Understand the concept of inductance and its applications					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
10-11	7.1 Define self and mutual inductance 7.2 State the symbols and units of the terms in 7.1 above 7.3 State the expression for the equivalent inductance of inductances connected in series and in parallel 7.4 State the expression for the induced voltage across an inductor 7.5 State the expression for inductance in coupled coils connected in series aiding or opposing	• Explain mutual inductance and how to calculate various parameters • Explain with examples how energy stored is	• Projector, • Text books, • Lecture notes, • Related journals, • Materials and • Internet	• Perform experiment on serial and parallel inductive circuit • Draw the operation of the induction coiled in a car ignition system	• Guide the students to perform the experiments with minimum error.	• Magnet, • Inductors, • Voltmeter, • Ammeter, • Flux meter, etc.

	7.6 Derive an expression for energy stored in an inductor 7.7 Solve problem involving 7.3 to 7.6					
	General Objective 8.0: Understand the fundamentals of AC. theory					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
12-15	8.1 Explain the production of an alternating e.m.f. by a rotating coil in a magnetic field 8.1 Define r.m.s, instantaneous, average, and peak values, period, and frequency of an a.c. waveform 8.2 State relationship between instantaneous, and peak valves of a sinusoidal wave 8.3 Solve problems involving 8.2. to 8.4 8.4 Solve problems graphically on a.c. circuits with different combinations of resistance, inductance and capacitance	• Explain in detail the theory of alternating current and voltage • Solve problems on A.C circuits	• Text books, • Lecture notes, • Related journals, • Materials, & • Internet	• Perform experiment to measure the frequency, period and amplitude of sinusoidal signal • Sketch a.c. waveforms both to scale and not to scale • Carryout experiment to obtain serial and parallel resonance of A.C circuit • Determine by experiment	Guide the students to perform the experiments with minimum error.	• Oscilloscope, • Signal generator, • Voltmeter, • Ammeter, • Resistor, • Inductors, • Capacitors, etc.

	8.5 Differentiate between series and parallel resonance 8.6 Explain phase lag or phase lead as applied to a.c. circuits 8.7 Explain the difference between single-phase and three-phase supply 8.8 State advantages and disadvantages of three phase supply over single phase supply			the Q-factor of a series and parallel RLC circuit . .		
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	SOLAR ENERGY AND PV
COURSE CODE	SET 113
YEAR:	YEAR 1, SEMESTER 1
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	The course is intended to provide the students with the knowledge and skills in the principles and Operations of Solar Collectors and PV Array

GENERAL OBJECTIVES:

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

1.0 Know the terminologies in Solar thermal and PV Energy

2.0 Know the Empirical and Computer based Design Systems

3.0 Know the factors that reduce or enhance the amount of solar energy collected by a PV array

4.0 Understand Collector Parameters, Shading and Method of Solar Powered Shading

5.0 Understand the sun's apparent movement and the solar window

6.0 Understand Collector Parameters, Measurement and description of Collector Components

7.0 Understand Solar orientation, airways, collectors and sliding

PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY						
COURSE: SOLAR ENERGY AND PV		**COURSE CODE: SET 113**		**CONTACT HOURS:** 4 hrs/wk (L =2, P = 2)		
YEAR 1 SEMESTER 1						
Goal: The course is intended to provide the students with the knowledge and skills in the principles and Operations of Solar Collectors and PV Array						
Course Specification: : Theoretical Content:				Practical Content		
Week	**General Objective: 1.0: Know the terminologies in Solar thermal and PV Energy**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
1-2	1.1 Explain the following: ▪ Solar Terminologies ▪ Solar Intensity/power ▪ Solar Radiations ▪ Solar Irradiance ▪ Solar Constant ▪ Black body as it relates to solar energy 1.2 Define the following terms: ▪ Air Mass ▪ Solar Insulations ▪ Solar Time ▪ Solar Azimuth angle ▪ Solar declination ▪ Array and collector kit	• Explain the fundamentals of solar energy, thermalogies with diagrams and sketches • Define in simple terms with demonstrations of sketches	• Textbooks, • Lecture notes, and Solar Modules	• Demonstration on sites with relevant tools and instruments • Classify Terminologies in Solar thermal and PV energy	• Guide students on how to measure and understand the terminology	• Models and instruments for measurement
Week	**General Objective: 2.0: Know the Empirical and Computer based Design Systems**					
	Specific Learning Outcome	**Teachers activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
3-4	2.1 Explain the rules of Thumb, empirical, and computer system design for PV and solar thermal system	▪ Explain the rules of Thumb, empirical, and computer system	▪ Textbooks, ▪ Lecture Notes ▪ Internet	▪ Compare empirical and computer	▪ Guide students on how to compare practical data	• Measuring Instruments, • Tools • ABS amp

	2.2 Explain the basic methods of comparing practical and theoretical data for Array and solar thermal system			based design systems	and theoretical ones	• Modules
Week	**General Objective: 3.0: : Know the factors that reduce or enhance the amount of solar energy collected by a PV Array**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
5	3.1 Explain in details, the following solar thermal systems: ▪ Solar water heater ▪ Solar dissoliller ▪ Solar Cooler ▪ Solar thermal 3.2 Explain in details the following solar operated PV systems ▪ Standalone solar PV system ▪ Solar water pumping system ▪ Solar PV powered vaccine system 3.3 Explain the factors that enhance or reduce collection.	• Explain the basic operations of each of the mentioned solar thermal and PV systems storage system • Explain the factors that enhance or reduce collection	• Hand booms and manuals, • Journals • Textbooks, • Lecture notes • Solar thermal and PV system	• Provide clear illustrations working primary of major solar thermal and PV system • Draw Solar thermal system • Draw Solar PV system	• Guide the students on how to draw/label and simulate on the working principles of solar thermal and PV system	• Drawing Board • Plastic Materials • Glasses, • Biba-glass • Computer • PV and solar thermal systems
Week	**General Objective: 4.0: : Understand Collector Parameters, Shading and Method of Solar Powered Shading**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
9- 12	4.1 Explain use of standard compass in determining geographical location 4.2 Discuss on different types of collectors for medium higher and concentrating solar powered	▪ Using relevant instrumentation and flat form ▪ Explain in details how collector/array are installed,	▪ Hand books material, note journals and text books	To provide to students on learning by doing through translation of theory to practical	Guide students on the installation, operation and maintenance of Collector	Existing Building roof surface and experiment set up for array and collector

	collectors for electricity generation 4.3 Explain how collectors and arrays are mounted on roof of buildings 4.4 Explain the procedure required on the installation, operation and maintenance of solar collectors for heat generation	operated and maintained		▪ Install, Operate and maintain a Collector		
Week	**General Objective: 5.0: Understand the sun's apparent movement and the solar window**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
3 - 4	5.1 Explain the sun apparent movement across the sky over any given day and over entire year at any given latitudes 5.2 Define diffuse direct and total solar radiations. 5.3 Explain absorption and reflection of solar radiation. 5.5 Explain the area of application of diffuse direct and total/global solar radiation	• Explain the concept of physics of solar energy with relevant instruments and model	• Text books, • Journals, • Lecture note & model for demonstration	• Demonstrate absorption and reflection of solar radiation	• Guide students to demonstrate absorption and reflection of solar radiation	• Tools and basic on solar and PV Technologies • Solar Atlas • Model equipment • Relevant sites and measurements
Week	**General Objective: 6.0: Understand Collector Parameters, Measurement and description of Collector Components**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
4-6	6.1 Explain with relevant illustrations on solar measurement equipment such as pyrometer, silarmeter, etc	• Explain with aid of diagram the	• Text books, • Lecture notes, • Journals	• Measure internal cell	• Guide the students to draw,	• Wooden glass, paint and

	6.2 Explain Collector system 6.3 Explain the following: - Flat plate collectors terms (i) Tilt angle (ii) Heat semol factor (iii) Heat exchange factor (iv) Collector useful energy (v) Collector systems efficiency	fundamentals of collector systems	• Procedures, and other relevant material on internet	temperature and Radiation	construct and analyse collector systems efficiency	insulating materials • Measuring equipment
Week	**General Objective: 7.0: Understand Solar orientation, airways, collectors and sliding**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
6 -7	7.1 Explain action of collector and array generating parameters 7.2 Explain array and collector shading of generating parameters 7.2 Explain how collector array orientation affects the system efficiency 7.4 Define the following terms: • Peak sun hour, • solar insolation and Peak sun	• Explain solar orientation, arrays, collectors and shading	• Textbooks, • Lecture notes, • Journals and Internet materials	• Measure solar insolation • Determine the effect of orientation on system efficiency	• Provide clear direction and unalersting on collector and array operating parameters • Guide students to measure and determine solar insolation and orientation	• Books on datas, • Collectors, • Arrays and other components • Computer software and equipment for shadding
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	SCIENCE OF SOLAR ENERGY SYSTEMS
COURSE CODE	SET 112
YEAR:	YEAR 1, SEMESTER 1
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	This Course is designed to acquaint the students on the concepts and applications of semiconductor to solar energy.

GENERAL OBJECTIVES:

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

1.0 Understand the basic concepts of semiconductors

2.0 Understand the construction, operation and simple application of p-n junction diodes and the Solar cells

3.0 Understand the basic concepts and operation of Solar Cells.

4.0 Understand the Construction of Solar Cells and Fabrication of Solar Modules

5.0 Understand the applications of Solar Cells and Solar Modules

6.0 Understand the fundamentals of chemical energy conversion and storage

7.0 Understand Mechanical Support Structure for Solar System application

PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY						
	Course: SCIENCE OF RENEWABLE ENERGY SYSTEMS	**Course Code: SET 112**			**Contact Hours: 3**	
					Theoretical: hours/week: 2	
	Year: 1 Semester: 1	**Pre-requisite:**			**Practical: hours /week: 1**	
	Goal: The Course is designed to acquaint the students on the concept and applications of semiconductor to solar energy					
	Course Specification: Theoretical Content			**Practical Content**		
	General Objective 1.0: Understand the basic concepts of semiconductors					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1-2	1.1 Explain electronic structure of elements 1.2 Explain covalent bonds, valency band, conduction band and energy gap for forbidden energy band. 1.3 1.3 Explain discrete energy levels in atoms 1.4 Explain semiconductors, doping, types of doping and the properties of a semiconductor in relation to conductors and insulators. 1.5 1.6 State the two common types of semiconductor materials, silicon and germanium. 1.6 1.7 Explain qualitatively the structure of intrinsic n- type and p-type semiconductors.	1.1 Explain the activities in 1.1, 1.3-1.8 1.2 Explain current carrier concentration in n-or-p type materials 1.3 Explain why Silicon and Germanium are the most important Semiconductor Materials. 1.4 Explain the electrical properties of	• White board, recommended textbooks etc. • Internet	1.1 Identify sources of conductors 1.2 Draw the energy band structure for a conductor, a semi-conductor and an insulator. 1.3 Illustrate with diagrams the activity in 1.2. 1.4 Make a list of insulators, conductors and semiconductors and ask the students to group them under the heading	• Guide students to draw the energy band structure for a conductor, a semi-conductor and an insulator	• Semi-Conductors • Insulators • Charts • Conductors

	1.7 1.8 Explain electrical conduction as apparent movement of holes in p-type semiconductor material and movement of electrons in n-type semiconductor material. 1.8 State the effect of temperature change on intrinsic conduction in semiconductors.	Silicon and Germanium.		insulator, semiconductors and conductors. 1.5 Illustrate using band diagram the differences amongst Insulator, Semiconductor and a Conductor.		
	General Objective 2.0: Understand the basic concepts p-n junction diode and their characteristics					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
3-4	2.1 Explain the formation of the depletion region and the junction potential when a p-type and an n-type semiconductors are brought in contact. 2.2 Explain the action of a p-n junction diode in the forward bias mode and reverse bias mode 2.3 Explain with aid of diagram construction of a diode. 2.4 State the diode equation for the current flowing at a given applied voltage and temperature and define the symbols used. 2.5 Explain the dynamic (or a.c.) resistance of a diode at a given d.c. voltage.	2.1 Explain the activities in 2.1,2.3 2.7, 2.8 2.2	• White board, • Recommended textbooks etc. • Internet	2.1 Know p-n junction and their characteristics 2.2 Know a p-n junction connected in the: -forward bias mode and reverse bias mode, indicating for each case the current flow in the diode and external circuit. 2.3 Illustrate using band diagram the	3 Guide Students to identify a p-n junction 4 Guide students to draw different diagrams 5 Guide students to perform the tasks	6 Conductors 7 Semi-conductors 8 Insulators 9 Solar Cells 10 Waters 11 Voltmeters

	2.6 Explain reverse saturation current, breakdown voltage and the importance of considering the peak inverse voltage of the diode.			differences amongst 2.4 Illustrate using band diagram the differences amongst Insulator, Semiconductor and a Conductor. 2.5 Compare the typical static characteristics for germanium and silicon diodes to illustrate different in forward voltage drop and reverse current. 2.6 Illustrate using band diagram the operation of the LED, Solar Cell and photo diode		
	General Objective 3.0: Understand the basic concepts and operation of Solar Cells					
	3.1 Define Solar of Cell 3.2 Explain the concepts on Solar Cells.	3.1 Explain activities in 3.1 – 3.4	• White board, • Recommended textbooks etc. • Internet	3.1 Identify Solar Cells and PV modules	• Show students solar Cells	• Solar cells • PV Modules

	3.3 Explain types of Solar Cells 3.4 Explain photo-voltaic effects 3.5 Explain Generation of power from solar cells			3.2 Illustrate with diagram the activities in 3.1 – 3.4	and PV modules	
	General Objective 4: Understand the Construction of Solar Cells and Fabrication of Solar Modules					
Week/s	Specific Learning Outcomes	Teacher's activities	Resources	Specific Learning Outcomes	Teacher's activities	Resources
6	4.1 Explain the production of pure Silicon 4.2 Explain Solar cell fabrication techniques 4.3 Explain Solar Module fabrication 4.4 Explain various types of solar modules	4.1 Explain the activities in 4.1-4.2 Explain the activities in 4.3- 4.4 Assess the students	• White board, • Recommended textbooks etc. • Internet	4.1 Assemble Solar Cells 4.2 Fabricate solar cells using Thin Films or any other materials 4.3 Illustrate with diagrams the activities in 4.1-4.2 4.4 Illustrate with diagrams the activities in 4.3-4.4	• Guide students to fabricate solar cells and assemble them	• Glass Soxlitor • Chemicals • Sealant • Oven, etc. • Solar Cells
	General Objective 5.0: Understand the Applications of Solar Cells and Solar Modules					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
7	5.1 Explain the applications of Solar cells giving various examples 5.2 Explain the applications of Solar Modules giving practical	5.1 Explain the activities in 5.1-5.2 5.2 Assess the students	• Chalk board, • Recommended textbooks etc.	5.1 Assemble cells to module	• Guide students to assemble cells to module	• Cells Frame • Tempered Glass

	examples		• Internet			• Water proof
	General Objective 6: Understand the fundamentals of chemical energy conversion and storage					
12 13-15	6.1Define battery 6.2 State the different types of batteries • Primary batteries (zinc carbon cells, alkaline batteries, silver oxide batteries, zinc air, lithium batteries, etc) • Secondary batteries (Lead acid batteries, Nickel Cadmium batteries, Lithium ion batteries and lithium polymer batteries) 6.3 State the properties of Primary and secondary batteries and their uses 6.4 Explain Reduction and Oxidation reaction using equation (REDOX) 6.5 State the difference between super capacitor and capacitor 6.6 Define fuel cell 6.6 Describe different types of fuel cells • Proton exchange membrane fuel cell (PEMFC)	6.1 Explain the activities in details in 5.1 to 5.10 6.2 Assess the students	• Textbooks, • Lecture notes, • Related journals, • Materials, • Internet	6.1 Identify different types of bacterial 6.2 Demonstrate Electrolytes 6.3 construct primary and secondary batteries	• Guide students to identify types of bacterial • Guide students to demonstrate electrolytes	• Bacterial • Electrodes • Acids • Base • Electrolysis bath • Hydrometers • PH meters •

	• Direct methanol fuel cells (DMFC) • Phosphoric acid fuel cells (PAFC) • Solid oxide fuel cells (SOFC) • Molten carbonate fuel cells (MCFC) 6.7 Differentiate between batteries \and fuel cells 6.9 Define solar energy 6.10 Describe the types of Solar cells • Crystalline silicon (Poly silicon or mono silicon) • Thin film solar cell • Organic photovoltaic cell					
General Objective 7.0: Understand Mechanical Support Structure for Solar System application						
	7.1 Explain mechanical structure for solar system application 7.3 Explain dynamics and orientation of solar support structure 7.3	7.1 Explain 7.1 – 7.2	• Textbooks • Structural designs • Charts • Diagrams	7.1 Construct different mechanical support structure with different orientation for solar system	• Guide students to construct different mechanical supports • Guide students to construct different orientation for solar system.	• Angle irons • Bolts and Nuts • Welding kits • Plumbs and Indinoments
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

YEAR 1 SECOND SEMESTER

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	ENERGY AND ENVIRONMENTAL
COURSE CODE	SET 122
YEAR:	YEAR 1, SEMESTER 2
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	This course is designed to acquaint the students with the knowledge of different types of omission and Pollution, their environmental health effects, control and prevention

GENERAL OBJECTIVES:

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

1.0 Understand the concept of environment and environmental health

2.0 Understand the concepts of pollution, pollutant and different types of pollution

3.0 Understand the composition of the atmosphere and the units of measuring air pollution

4.0 Understand the classification of water-related diseases, methods of control and prevention

5.0 Understand the management of solid wastes and their effects on the environment

6.0 Understand the basic principles of environmental impact assessment (EIA)

PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY						
COURSE: ENERGY AND ENVIRONMENT			**Course Code:** SET 122		**Contact Hours:** 2HRS/WK L = 2 P =	
Goal: The student should be able to know the different types of pollution, their environmental health effects, control and prevention						
Course Specification: THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**General Objective: 1.0. . Understand the concept of environment and environmental health**					
	Specific Learning Outcome:	**Teachers Activities**	**Resources**	**Specific Learning Outcome:**	**Teacher Activities**	**Resources**
1	1.1 Define Environment 1.2 Explain the concept of Health 1.3 Explain the concept of Environmental health 1.4 Explain with examples the different types of environment; • Physical environment • Biotic environment • Social or cultural environment	• Explain in details the activities in 1.1 to 1.4 • Use questions and answers techniques • Give assignments	• Charts, • Textbooks, • Lecture notes, • Related journals, • Materials, • Internet, • Pictures, • Photos • Images, • Power point projectors	• Appreciate Environment and its health issues • Classify Environment	• Guide students to appreciate environment and its health issues • Guide students to classify environment.	• Pictures • Charts • Images
	General Objective 2.0 Understand the concepts of pollution , pollutant and different types of pollution					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
2-3	2.1 Define pollution 2.2 Define the different types of pollution with examples • Air pollution • Land pollution • Water pollution • Light pollution • Noise pollution	• Explain in details the activities in 2.1 to 2.4 • Use questions and answers techniques • Give assignments	• Charts, • Textbooks, • Lecture notes, • Related journals, • Materials, • Internet, • Pictures, • Photos,	• Carry out test for outdoor and indoor air pollution • Test for water pollution • Measure noise pollution in	• Arrange a visit to the airport for the students to witness noise pollution • Allow a generator to run in a class room	• Conductivity meter • Pit meter • Spector photometer/colon meter • Calorimeter • Soil samples • Air quality sensors e.g. ingress, etc.

	• Visual pollution • Thermal pollution 2.3 Define pollutant 2.4 Explain examples of pollutants as well as sources for specific types of pollution		• Images, • Power point projectors	your area of operation. • Test soil pollution	• Guide students to carryout tests	
	General Objective 3.0: Understand the composition of the atmosphere and the units of measuring air pollution					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
4	3.1 Explain the composition of the atmosphere ; • Nitrogen • Oxygen • Argon • Carbon dioxide • Water vapour • Trace elements 3.2 Explain indoor air pollution 3.3 Explain the units of measurement of air Pollution; • air pollution index (API), • reparable suspended particulate (RSP)	• Explain in details activities in 3.1 to 3..2 • Give assignments	• Text books, • Lecture notes, • Related journals • Materials, • Images and • Picture	• Identify air pollution measuring instrument • Use air pollution measuring instrument	• Guide students to identify air pollution measuring instrument • Guide students to use air pollution measuring instruments • Excursion	• API • RSP •
	General Objective: 4.0. Understand the classification of water-related diseases , methods of control and prevention					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**

3	4.1 Explain with examples water-borne disease, water-based disease, water-washed disease and water Related diseases. 4.2 Explain the classes/types of these under listed water-related diseases; • Schistosommiasis, Filariasis, Malaria, Diarrhoea , Cholera, Typhoid, Amoebic dysentery, Bacillary dysentery, Scabies, Dracunculiasis 4.3 Explain the life cycle and methods of control of the diseases in 4.1 above 4.4 Differentiate between epidemics and endemic diseases. 4.5 Explain the motive of WHO drinking water and sanitation laws.	4.1 Explain the activities in details in 4.1 to 4..6 4.2 Use questions and answer techniques 4.3 Give assignments	• Textbooks, • Journals, • Related materials, • Internet, • Power point projector, • Charts, • Drawings, • Pictures/ videos	• Identify water related diseases • Identify control measures in water related diseases	• Guide students to identify water related diseases • Guide students to identify control measures in water related diseases • Excursion	• Charts • Pictures • Projectors • Films • Water purifiers etc.

	4.6 Propose measures to curb water related diseases.					
	General Objective 5.0: Understand the management of solid wastes and their effects on the environment					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
10-12	5.1 Explain the environmental effects of solid waste management. 5.2 5.3 Explain the general principles of sanitary land fill. 5.4 Explain the general principles of: a. High temperature incineration. b. Pulverization and bailing. 5.5 Describe the general principles of material recovery and conversion from solid wastes	• Explain the activities in details in 5.1 to 5.5 • Use questions and answer techniques • Give assignments	• Textbooks, • Journals, • Related materials, • Internet, • Power point projector, • Charts, • Drawings, • Pictures/ videos	• Design refuse disposal unit at your state of operation • Undertake the construction of refuse disposal unit using the principles on 5.4 • Identify the different methods of solid waste, waste collection treatment and disposal e.g., sanitary landfill, incineration. • Appreciate the effects of solid wastes management on the environment.	• Guide the students on how to design the refuse/ waste disposal unit by showing them an already produced one • Show the students how to construct the refuse/ waste disposal unit and pulverizer used for grinding wastes into dusts	• Ductile metals(mild steel), • Oxy acetylene, • Welding torch, • Gas cylinder

	General Objective 6.0:. Understand the basic principles of environmental impact assessment (EIA)					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teachers Activities**	**Resources**
14	6.1 Define Environmental impact assessment (EIA) 6.2 Outline the basic steps in EIA 6.3 Explain environmental impact statements. 6.4 Explain environmental audits.	• Explain the activities in details in 6.1 to 6.4 • Use questions and answer techniques • Give assignments	• Textbooks, • Journals • Related materials, • Internet, • Power point projector, • Charts, • Drawings, • Pictures/ videos	• Identify problem in the environment brought about by development projects by visual observation • Carry out visit to specific industrial development sites at different stages of completion to assess probable and possible environmental impacts of the developments, both positive and negative. • Visit already commissioned and Operating development sites to evaluate/audit the project vis-à-vis their impact (positive and negative), on the lives and health of the adjacent population	• Guide Students to locate the sites to visit to cover a fairly broad and different types of projects and industrial activity. • Guide students on the site visits • Guide students on site discussions • Guide students to provide instruments and materials for testing	• Vehicles to facilitate transportation • Spectrophotometer • Noise detector equipment • Radiation detector • Conductivity meter

				• Prepare EIA, EIS for two different projects (e.g. oil and textile industries)		
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	MEASUREMENT AND INSTRUMENTATION I
COURSE CODE	SET 123
YEAR:	YEAR 1, SEMESTER 2
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	This course is designed to acquaint the students with the basic knowledge of measurement and instrumentation

GENERAL OBJECTIVES:

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

1.0 Understand classification of measuring instruments

2.0 Know measuring instruments for length

3.0 Understand the concept of area and volume

4.0 Understand the techniques of measuring solar radiation

5.0 Know the various instruments for measuring temperature

6.0 Understand the techniques of pressure measurement

7.0 Understand the techniques of measuring some meteorological parameters

8.0 Understand principles of density and its measurement

PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY						
COURSE: Measurement and Instrumentation I		**COURSE CODE: SET 123**		**CONTACT HOURS:** 4 hrs/wk (L =2, P = 2)		
Goal: The course is design to acquaint the student to acquire basic knowledge of measurement and instrumentation						
Course Specification: : Theoretical Content:				Practical Content		
Week	**General Objective: 1.0: Understand classification of instruments**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
1-2	1.3 Differentiate between measuring and testing. 1.4 Classify instruments into indicating and recording instruments 1.5 Classify instruments into analog and digital 1.6 Classify instruments into direct measurement and indirect measurement instruments	• Explain in details difference between measuring and testing • Illustrate with examples the classifications 1.2-1.4 • Ask students to give more examples on each of the classification • Asses the students	• Textbooks, • Internet	• Identify measuring instruments	• Guide students to differentiate between measuring and testing • Guide students to classify 1.2 – 1.4	• Caliphus • Micrometer • Parameters • Sorometers • Pressure guages • Hydrometers • Thermometer • etc
Week	**General Objective: 2.0: Know measuring instruments for length**					
	Specific Learning Outcome	**Teachers activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
3-4	2.1 Explain SI units of length: metre 2.2 Explain some sub-divisions and sub-multiples of units of length and their symbols: • Micro- :µ	• Explain in details the SI and non SI units	Chalkboard textbooks, notes micrometres vernier calipers steel rule	• Identify the instruments used for measuring length • Use the instruments	• Show each of the instrument to the students	• micrometers • vernier calipers • steel rule • metre rule

	• milli-,: m • centi-,: c • kilo- : k 2.3 Explain some non SI units of length: • inch • feet • yard 2.4 Explain how to convert from non-SI units to SI units 2.5 Explain some measuring instruments for length • micrometres • vernier calipers • steel rule • metre rule • tape 2.6 Explain how to use the instruments in 2.5 2.7 Explain factors to be considered in selecting instrument to be used • range • accuracy • precision 2.8 Explain the advantages and disadvantages of each of the measuring instrument	• Explain how to convert from one unit to another. Give examples • Explain how to use each instrument • Explain the factors to be considered in selecting instruments • Explain the advantages and disadvantages of each instrument • Asses the students	metre rule tape rule	• Illustrate the length of a metre and its sub-divisions and sub multiples • Identify the factors to be considered in selecting instruments to be used • Illustrate the length of an inch, feet and yard	• Guide the students on how each of the instrument is being used • Guide the students on selecting instrument • Guide the students to make some measurement : • Length and breadth of a book, a table, classroom etc • Guide the students to make some measurement : thickness of a paper, diameter of a wire etc	• tape • piece of wire etc
Week	**General Objective: 3.0: :Understand the concept of Area and Volume**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**

5	3.1 Derive the units of area: cm^2, m^2, km^2, Hector, etc. 3.2 Explain how to convert from one unit to another 4.5 Explain how to measure area of different shapes: • rectangular, • triangular, • Circular, etc	• Explain in details the units of area • Explain the conversions from one unit to another • Give examples • Explain how to measure area of various shapes:	• Chalkboard • textbooks, • notes • tape rule	• Demonstrate how to measure areas of different shapes objects	• Guide the students to measure the areas of different objects e.g book, field, coin, etc.	• tape rule • objects of various shapes
6	3.4 Derive the units of volume: cm^3, m^3, litre, centilitre, millilitre, etc 3.5 Explain how to convert from one unit to another 3.6 Explain how to measure the volume of liquids using beaker	• Explain in details the units of volume • Explain the conversions from one unit to another • Give examples • Explain how to measure volume of various objects:	• Chalkboard • textbooks, • notes • beaker	• Demonstrate how to measure volumes of different objects	• Guide the students to measure the volume of different objects using a beaker eg bottle, gallon, etc	• tape rule • beaker • bottle • gallon etc
Week	**General Objective: 4.0: : Understand the concept and measurement of solar radiation**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
7	4.1 Explain the concept of solar radiation or Insolation 4.2 Outline the instruments used in measuring solar radiation: pyranometer, pyrgeometers etc.	• Explain the concept of solar radiation • Demonstrate the measurement of solar radiation using	• Chalkboard • textbooks, • notes • pyranometer • phygeometers	• Demonstrate how to measure solar radiation	• Guide the students to demonstrate how to measure solar radiation	pyranometer phygeometers

	4.3 Explain various units for measuring solar radiation 4.4 Explain the conversion from one unit to another	pyranometer and phrgeometers • Explain various units used for solar radiation and conversion from one form to another • Asses the students			• Guide the students to measure solar radiation at different times of the day and observe its variability	
Week	**General Objective: 5.0: : Know the various instruments for measuring temperature**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
8-9	5.1 Define Units of Temperature e.g. Kelvin, Fareinheit, Absolute Centigrade etc. 5.2 Covert from one Unit of temperature to another 5.3 Explain temperature measuring systems e.g. filled system, thermocouples, resistance, themometry, Thermiostors, bimetalic, pyrometers, Quarts Crystal 5.4 Explain the different types of the temperature measuring systems 5.5 Explain the Principles of Operation and the Constructional features of each type	• Explain in details various units of temperature • Explain how to convert from one unit to another • Give examples • Explain various temperature measuring instruments • Explain how to use each instrument • Explain the factors to be considered in selecting instruments • Explain the advantages and	• Chalkboard • textbooks, • notes • thermocouples, • resistance, themometry, • Thermiostors, • bimetalic, • pyrometers, • Quarts Crystal • Data logger	• Identify the instruments used for measuring temperature • know how to use the instruments • Identify the factors to be considered in selecting instruments to be used	• Show each of the instrument to the students • Guide the students on how each of the instrument is being used • Guide the students on selecting instrument • Guide the students to make some measurement • Length and breadth of a	• filled system, • thermocouples, • resistance, themometry, • Thermiostors, • bimetalic, • pyrometers, • Quarts Crystal • Data logger

	5.6 State the advantages and disadvantages of each system	disadvantages of each instrument • Asses the students			book, a table, classroom etc • Guide the students to make some measurements	
Week	**General Objective: 6.0: Understand the techniques of pressure measurement**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
10-11	**6.1** Define pressure as force/Unit area 6.2 Define the units of measurement of Pressure e.g. N/m^2, atmosphere, Pascal etc 6.3 Convert from one Pressure Unit to the other 6.4 Define the following terms used in pressure measurements – atmospheric, guage, absolute, differential, vacuum pressures 6.5 Explain fluid pressure with the following: a. Common gauge, b. Peizometer c. Pitot tube d. U-tube manometer e. Bourdon gauge and f. Aneroid Barometer 6.6 State the advantages and	• Explain the term "pressure" • Explain in details various units of pressure • Explain how to convert from one unit to another • Give examples • Explain the common terms used in pressure measurement • Show various instruments used in measuring pressure • Explain how to use each instrument	• Chalkboard • textbooks, • notes • Common gauge, • Peizometer • Pitot tube • U-tube manometer • Bourdon gauge, and • Aneroid Barometer	• Identify the instruments used for measuring pressure • Demonstrate how to use the instruments • Identify the factors to be considered in selecting instruments to be used • Measure pressure	• Demonstrate each of the instrument to the students • Guide the students on how each of the instrument is being used • Guide the students on selecting instrument • Guide the students to make some measurements using the instruments	• Common gauge, • Peizometer • Pitot tube • U-tube manometer • Bourdon gauge, • Aneroid • Barometer

	disadvantages of each measuring Instruments	• Explain the factors to be considered in selecting instruments • Explain the advantages and disadvantages of each instrument • Asses the students			• Guide the students to make some measurements	
Week	**General Objective: 7.0: : Understand the techniques of measuring some meteorological parameters**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**
12-13	7.1 Explain the concept of wind Speed 7.2 Explain the instrument used in measuring wind speed 7.4 Explain the concept of wind Direction 7.5 List the instrument used in measuring wind direction 7.6 Explain the concept of humidity, absolute humidity and relative humidity 7.7 Explain the instrument used in measuring humidity: Hygrometer psychrometer	• Explain the concepts of wind speed and wind direction • Explain how to use the instruments to measure wind speed and wind direction • Explain the concept of absolute humidity and relative humidity • Explain how to use the instruments to measure humidity	• **A**nemometer • Wind vane • Psychrometer • hygrometer	• Measure wind speed • Identify instrument used in measuring wind • Demonstrate how to measure wind direction • Measure humidity	• Guide the students to measure wind speed and wind directions after some intervals • Guide the students to measure relative humidity for some days	• Anemometer • Wind vane • Psychrometer • hygrometer
Week	**General Objective: 8.0: : Understand principles of density and its measurement**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Objective**	**Teacher Activities**	**Resources**

14-15	8.1 Define density as mass/volume 8.2 Define unit of density: g/cm^3 , kg/m^3 8.3 Explain density of water as 1 g/cm^3 , or 1000kg/m^3 8.4 Define relative density as density of substance/density of water 8.5 Explain relative density as dimensionless quantity 8.6 Explain use of hydrometer to determine the relative density of different liquids. 8.7 Explain Archimedes principle	• Explain the term "density" • Derives its units from the definition • Explain how to convert from one unit to another • Give examples • Explain density of water • Define relative density • Show that relative density is dimensionless quantity • Explain how to use hydrometer to find density of liquids • Explain how to convert density to relative density and vice versa • State Archimedes principle	• Chalkboard • textbooks, • notes • hydrometer • relative density bottle	• Use hydrometer to measure density • Demonstrate how to use relative density bottle	• Guide the students to use hydrometer to measure density of some liquids: kerosene • Guide the students to make some measurements using the instruments • Guide the students to Carry out simple experiment using Archimedes apparatus to determine density of substances. • make some measurements	hydrometer relative density bottle

		• Explain how to use hydrometer to measure densities • Asses the students				
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	SOLAR ENERGY COMPONENT I
COURSE CODE	SET 124
YEAR:	YEAR 1, SEMESTER 2
DURATION:	2HOURS/2 CREDIT UNITS
GOAL:	This course is intended to expose the students to the working principles of a Solar System Components

GENERAL OBJECTIVES:

(Based on NABCEP PV Entry Level)
On completion of this course, the students should be able to:

1.0 Understand how a solar cell converts sunlight into electrical power.

2.0 Know the difference between PV cells, modules, panels and arrays.

3.0 Know the five key electrical output parameters for PV modules using manufacturers' literature (Voc, Isc, Vmp, Imp and Pmp), and label these points on a current-voltage (I-V) curve.

4.0 Understand the effects of varying incident solar irradiance and cell temperature on PV module electrical output.

5.0 Know the operating point on a given I-V curve given the electrical load.

6.0 Understand why PV modules make excellent battery chargers based on their I-V characteristics.

7.0 Understand the effects of connecting similar and dissimilar PV modules in series and in parallel on electrical output.

8.0 Know various performance rating and measurement conditions for PV modules and arrays, including STC, SOC, NOCT, and PTC.

9.0 Know the fabrication of solar cells from various manufacturing processes.

10.0 Understand the components and the construction for a typical flat-plate PV module made from crystalline silicon solar cells, and compare to thin-film modules.

11.0 Know the surface area, incident solar irradiance and electrical power output for a PV cell, module or array.

12.0 Understand the significance and consequences of PV modules being limited current sources.

13.0 Know the purpose and operation of bypass diodes.

14.0 Know the standards and design qualification testing and reliability of PV modules.

	PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY					
	Course: SOLAR ENERGY COMPONENT I	**Course Code: SET 124**		**Contact Hours: 2HRS/WK L = 2**		
	GOAL: This course is intended to expose the students to the working principles of a Solar System Components					
	Year: I Semester: II	**Pre-requisite:**		**Theory: 2hours /week**		
	Course Specification Theoretical Content			**Practical Content**		
	General Objective 1.0: Understand how a solar cell converts, sunlight into electrical power					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1 - 2	1.1 Define Semi-conductor Materials 1.2 Explain the operation of Semi-Conductor 1.3 Define solar cell 1.4 Explain photoelectric effect 1.5 Explain direct, diffuse, and reflective sun radiation 1.6 Explain types of solar cells 1.7 Explain how photon energy is used in generating electricity from solar cell	1.1 Explain the concept of silicon as a semi-conductor materials 1.2 Explain how photon energy is used in generating electricity from solar cell	Chalkboard, Textbooks, Lecture Notes, Markers, Dusters, Internet	• Identify semi-conductor materials • Demonstrate how solar cell convert sunlight into electricity	• Guide student on how to connect sunlight into electricity	Solar cells Measuring equipment Capacitor
	General Objective 2.0 : Know the difference between PV cells, modules, panels and arrays					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**

3 - 4	2.1 Explain the common types of PV cells 2.2 Explain PV cells efficiency 2.3 Explain the solar cells 2.4 Explain the solar module 2.5 Explain the solar arrays	2.1 Explain the difference between PV cells, modules, panels and arrays	Chalkboard Textbooks Note, Marker, Solar Cells	• Identify PV cells, modules, panels and arrays • Measure PV cells efficiency	• Guide students to identify PV cells, modules, panels and arrays	Solar cells, Modules Measuring Equipment
	General Objective 3.0: Know the five key electrical output parameters for PV modules using manufacturers" literature (Voc, Isc, Vmp, Imp and Pmp) and label these points on a current-voltage (I-V) curve					
Week/s	Specific Learning Outcomes	Teacher's activities	Resources	Specific Learning Outcomes	Teacher's activities	Resources
5	3.1 Explain the PV electrical parameters 3.2 Explain I – V curve 3.3 Explain how to label these parameters in I – V curve	3.1 List 5 key electrical parameters 3.2 Explain 1-V curve 3.3 Describe how to label an I-V curve.	Chalkboard Markers Textbooks Internet Charts	• Plot I-V curve • Label PV electrical Parameters	• Guide the students to plot the parameter on the I-V curve	I-V Curve graph Oscilloscope Drawing equipment
	General Objective 4.0: Understand the effects of varying incident solar irradiance and cell temperature on PV module electrical output.					
Week/s	Specific Learning Outcomes	Teacher's activities	Resources	Specific Learning Outcomes	Teacher's activities	Resources
7 -8	4.1 Explain the effect of varying incident solar irradiation 4.2 Describe the cell temp effect on PV module and power on I–V curve	4.1 Explain the differences in changing angle of incidence	I-V Curve Textbooks Chalkboard	• Indicate change in current, voltage and power on IV curve.	• Guide the student to use graph in plotting I-V curve	I-V Curve graph Pyrometer

				• Measure Cells temperature on PV module		
	General Objective 5.0 : Know the operating point on a given I-V curve given the electrical load.					
Week/s	Specific Learning Outcomes	Teacher's activities	Resources	Specific Learning Outcomes	Teacher's activities	Resources
9-10	5.1 Explain the operating point on a given I-V curve 5.2 Explain the standard rating condition used in PV modules 5.3 Describe the maximum power output.	5.1 Explain the standard rating condition used in PV modules	Textbooks I-V Curve graph Whiteboard	• Plot I-V Curve • Measure maximum power output of a PV module	• Guide students to plot I-V curve and take measurement	PV Installation tester Drawing equipment
	General Objective 6.0: Understand why PV modules make excellent battery chargers based on their I-V characteristics.					
Week/s	Specific Learning Outcomes	Teacher's activities	Learning Resources	Specific Learning Outcomes	Teacher's activities	Resources
11 - 12	6.1 Explain maximum power tracking 6.2 Describe three stages of battery charging 6.3 Differentiate between pulse width modulation and maximum power point tracking	6.1 Explain the PV modules charging stages	Whiteboard Textbooks Modules	• Track maximum power point • Charge battery • Check pulse with modular	• Guide Students to track and charge battery power point	Oscilloscope Battery Battery Charger Tracker
	General Objective 7.0: Understand the effects of connecting similar and dissimilar PV modules in series and in parallel on Electrical Output..					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	7.1 Explain the effect of current PV modules in : • series, • parallel	7.1 Discuss the effect of PV modules in series Parallel	I-V curve Computer Whiteboard Modules	• Connect to show the effect of PV module for series and parallel	• Guide students to connect PV modules for	I-V curve Computer Whiteboard Modules

	7.2 Describe the resulting I-V Curves above	7.2 Explain the resulting I-V curve		• Show the I-V curve above	series and parallel • Show the resulting I-curve.	Oscilloscope
	General Objective 8.0: Know various performance rating and measurement conditions for PV modules and arrays, including STC, SOC, NOCT, and PTC.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	8.1 Explain the terms STC, SOC, NOCT and PTC 8.2 Explain the performance rate of PV modules and arrays	8.1 Discuss the difference between STC, SOC, NOCT & PTC	Modules Computer PV Simulator	• Connect to show SOC and PTC • Check the performance rate of PV modules and arrays	• Guide students to show the state of charge.	PV installation tester, Modules Arrays
	General Objective 9.0: Know the fabrication of solar cells from various manufacturing processes.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	9.1 Explain the solar cell fabrication 9.2 Describe major fabrication process 9.3 Estimate the cost of solar cell fabrication	9.1 Explain the manufacturing process of a solar cell	Video documentary Textbooks Computer online	• Fabricate thin films	• Show the students the manufacturing processes/fabrication of thin films	Dye-Synthesis Chemicals FTC Glass Substrate Electrode Cement
	General Objective 10.0: Understand the components and the construction for a typical flat-plate PV module made from crystalline Silicon, Solar cells, and compare to thin-film modules.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	10.1 Explain flat-plate PV modules construction components	10.1 Explain the PV Components and their differences	Video documentary Textbooks	• Carry out Solar cell fabrication	• Guide the students on how to construct the	Dye-Synthesis Chemicals

	10.2 List the difference between silicon and thin film Modules construction.		Computer online	using local materials	Silicon and thin-film modules	Silicon Water FTC Glass Substrate Electrode Cement
	General Objective 11.0: Know for a given the surface area, incident solar irradiance and electrical power output for a PV cell, module or array..					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	11.1 Explain how to calculate the PV efficiency 11.2 Explain the power output per unit area of a PV cell	11.1 Explain how to calculate the PV efficiency and power output	Irradiance meter Thermometer	• Compute the PV cell power output and the solar efficiency	• Guide the students on how to calculate the PV output and Solar efficiency	Irradiance meters Pyrometer
	General Objective 12.0: Understand the significance and consequences of PV modules being limited current sources.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	12.1 Explain the lack of current sources in PV Modules 12.2 Explain the consequences of PV not receiving enough sun resources	12.1 Discuss the effect of PV shading in relation to power output.	Textbook Computers Simulation board PV Module	• Demonstrate the effect of shading on the PV Module	• Guide the student on how to demonstrate shading a PV module	Simulation board PV Module Opaque Materials
	General Objective 13.0: Know the purpose and operation of bypass diodes.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	13.1 Explain bypass diode 13.2 Describe forward bias and Reverse bias of a bypass diode	13.1 Explain how to test for bypass diode continuity	Bypass diode PV Modules Multimeters	• Determine the functionality of the diode	• Guide the student on how to measure forward and reverse bias diode	Bypass diode Multimeter PV Modules

	General Objective 14.0: Know the standards and design qualification testing safety and reliability of PV Modules					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	14.1 Explain the standards to ensure PV Modules Safety. 14.2 Explain the design qualification testing for PV modules	14.1 Explain each PV modules standard	PV Modules Multimeters Journals Internet	• Conduct PV Module Safety Standard •	• Guide students to conduct PV Module Safety Standard	PV Installation Tester PV Modules
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

YEAR 2 SEMESTER 1

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	ELECTRICAL INSTALLATION
COURSE CODE	EEC 129
YEAR:	YEAR 1, SEMESTER 2
DURATION:	3HOURS/3 CREDIT UNITS
GOAL:	This course is designed to acquaint the students with the skills in Electrical Installation

GENERAL OBJECTIVES:

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

1.0 Understand electrical/electronic graphical symbols

2.0 Know various wiring diagrams

3.0 Understand various architectural drawings and symbols

4.0 Know different sizes and applications of cables

5.0 Understand estimation procedure in electrical/electronic installation

6.0 Understand the installation of various different Solar operated appliances

7.0 Understand installation of various electrical/electronic systems

	PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY					
	Course: ELECTRICAL INSTALLATION			**Course Code: SET**	**Contact Hours: 3HRS/WK L = 1**	
	GOAL: This course is designed to acquaint the students with the skills in Electrical Installation					
	Year: I	**Semester: 2**	**Pre-requisite:**		**Practical: 2hours /week**	
	Course Specification		**Theoretical Content**		**Practical Content**	
	General Objective 1.0: Understand electrical/electronic graphical symbols					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1 2-3 4-5 6-7 8-9 10 11 12	1.1 Explain electrical/electronic graphical symbols 1.2 Explain various electrical/electronic schematic diagrams 1.3 Explain various electrical installation/wiring diagrams 1.4 Explain architectural drawings of simple buildings e.g. 3-bedroom flat etc. 1.5 Explain elevation drawings for architectural drawings 1.6 Explain electrical services for a residential building e.g. 3-bedroom flat 1.7 Explain electrical supply for a 3-bedroom building 1.8 Explain the installation diagram for a single phase and three-	1.1 Explain activities in 1.1 – 1.8	Graphical keys and symbols, Charts Drawing Sets	• Draw electrical/electronic graphical symbol • Interpret electrical installation wiring charges • Produce electrical drawings for architectural drawings	• Guide students to interpret electrical/electronic graphical symbols	Graphical keys and symbols, Charts Drawing Sets

	phase energy meters in domestic and commercial/industrial premises.					
	General Objective 2.0 : Know and draft various wiring diagrams					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
2 - 4	**Graphic Symbols** 2.1 Explain electrical/electronic graphical symbols a. Resistor b. Capacitor c. Inductor d. Diodes e. Thyristor f. Diac g. Triac h. Operational amplifier i. Logic gates j. Linear IC k. Power Switches l. Sockets m. Isolator Switch n. Sockets o. Isolator Switch p. Breakers q. Motors r. Fans s. ELCB 2.2 Explain symbols in 2.1 above using appropriate instruments	• Explain the activities in 2.1 – 2.16 • The teacher should draft various schematic diagram for electrical/electronic circuits and	Charts Electrical Drawing Codes Keys and Symbols Drawing instrument and drawing boards Typical samples of	• Identify electrical/electronic graphical symbols • Administer First Aids • Interpret wiring diagrams/drawings	• Guide students to identify electrical/electronic graphical symbols	First Aid Boxes Charts Keys and symbols

	Schematic and Wiring Diagrams 2.3 Explain schematic and Wiring Diagrams 2.4 State the merits and demerits of schematic diagrams 2.5 Explain various schematic diagrams e.g. Transistor Circuits Panel, etc 2.6 Explain wiring diagram 2.7 State the merits and demerits of wiring diagrams 2.8 Explain measures involved in electrical wiring 2.9 Define earth continuity conductor, earth electrode, consumer's earth terminal 2.10 Explain the necessity for earthing and state the relevant regulations concerning earthing 2.11 Explain the protection of an installation by fuse and by ELCB 2.12 Distinguish between solid earthing practice and earth	panel to the students. • Teacher to draft various wiring diagrams to students	architectural drawings must be available in the Laboratory and workshops.	• Detect and rectify faults		

	leakage and circuit breaker protection 2.13 State a number of problems associated with earth leakage circuit breakers 2.14 Describe how the human body can become part of an electric circuit 2.15 Explain how to prevent electric shock 2.16 Explain artificial respiration a) Mouth resuscitation b) Revised Holger Nelson resuscitation c) External cardio compression/cardio-pulmonary resuscitation					
	General Objective 3.0: Understand various architectural drawings and symbols					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
5	**Sectional and Architectural Drawing** 3.1 Explain architectural drawings and symbols	Teacher to explain architectural drawings of simple building e.g. 3-bedroom flat	Chalk and Board Textbooks	• Draft Architectural Drawings • Interpret architectural drawings	• Guide students to draft and interpret architectural drawings	Architectural Drawings Equipment CAD

	3.2 Explain architectural drawings of simple buildings e.g. 3 bedroom flat 3.3 Distinguish elevation drawings from architectural drawings			• Produce elevation drawings from architectural drawing		
	General Objective 4.0: Know different sizes and applications of cables					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
7 -8	4.1 Define the following diversity factor ambient temperature, class of excess current protection, and disposition of cable 4.2 Explain the use of relevant IEE tables for cable selection 4.3 Calculate the total load current for a final sub circuit in the building 4.4 List the main types of insulating and conducting materials 4.5 Distinguish between conductors and insulators 4.6 Describe, the construction of different types of cables 4.7 State the advantages and disadvantages when using: a. PVE-Insulated, PVC – sheathed cables	• The teacher should show to the student various cable sizes used in wiring and services building • Draw typical electrical supply systems for building	Film Computers to aid drafting (Auto CAD)	• Determine Cable and sizes • Apply 4.1 and 4.2 for close selection • Design an external supply system for a 3-bedroom building • Draft electrical services for a simple 3-bedroom building • Sketch the internal structure of different cables	• Guide students to determine sizes of cables and their application	Various Cable Charts Drawing CAD Soft Wires Pictures Drawing Equipment

	b. Mineral – Insulated metal – sheathed cables c. Amoured PVC – insulted, PVC – sheathed cables d. Steel and PVC conducts e. Steel and PVC trunking f. Flexible cabled and cord etc. 4.8 Explain the general I.E.E. Regulation related to cables and their uses 4.9 Explain the cable colour coding.			• Identify Cable colour coding • Demonstrate various types of joints using PVC and flexible cables		
	General Objective 5.0 : Understand estimation procedure in electrical/electronic installation					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
11 - 12	**Estimating Procedure** 5.1 Explain estimation procedure 5.2 Explain preparation of bill of Quantities 5.4 Explain bill of engineering measurement and materials for an electrical installation	• Prepare typical bills of quantities for electrical installations • Give students practices and mark them.	Textbooks Charts Whiteboard Multimedia	• Produce item quantities from drawings • Assess cost of materials • Prepare typical bills of engineering measurements and materials for an electrical installation	• Guide students to prepare bills of quantities, equipment measurement and materials	Sample Bills of Quantities CAD Softwares

	General Objective 6.0: Understand the installation of different Solar operated appliances					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
13-15	**Electrical/electronic Installation** 6.1 Describe the general basics of electrical installation 6.2 Describe various solar systems (solar operated appliances) 6.3 Describe ways of installing solar Systems such as: i. Solar water heater ii. Solar street light iii. Solar water pump, etc. 6.4 Explain Electrical services of residential and commercial/industrial premises 6.5 Explain Installation of single phase and three-phase energy meters in domestic and commercial/industrial premises	6.1 Explain items 6.1 to 6.5	Charts Whiteboard Multimedia Textbooks	• Carry out the installation of each of the following: i Solar water heater ii. solar street light iii solar water pump etc. • Install single and three-phase energy meters in domestic, commercial and industrial premises	Guide students to carry out the installation of: i. solar water heater ii. Solar Street light iii. Solar water pump. iv. Single phase v. Three phase	- solar Street light - solar water Heater - solar water pump, etc. - Energy Materials - Tools and Equipment
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	SYSTEM COMPONENTS II
COURSE CODE	SET 211
YEAR:	YEAR 1, SEMESTER 2
DURATION:	3HOURS/3 CREDIT UNITS
GOAL:	This course is designed to acquaint the students with working principles and operations of System components

GENERAL OBJECTIVES:

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

1.0 Understand the purpose and principles of operation for a basic major PV system components, (classify/outline including PV modules and arrays, inverters and chargers, charge controllers, energy storage and other sources).

2.0 Know the types of PV system balance of system components, (and describe their functions and specifications, including conductors, conduit and raceway systems, overcurrent protection, switchgear, junction and combiner boxes, terminations and connectors).

3.0 Know PV system power processing equipment.

	PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY					
	Course: SYSTEM COMPONENTS II	**Course Code: SET 211**		**Contact Hours: 2HRS/WK L = 2**		
	GOAL: This course is designed to acquaint the students with working principles and operations of System components					
	Year: I Semester: III	**Pre-requisite:**		**Practical: 1hour /week**		
	Course Specification	**Theoretical Content**		**Practical Content**		
	General Objective 1.0: Understand the purpose and principles of operation for major PV system components.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1 - 2	1.1 Explain the basic components of a PV system, Panels, Charge controllers, inverters and battery banks 1.2 Explain basic connection principles of a PV system 1.3 Explain the role of each component in energy supply 1.4 Explain the PV cell, module, array. 1.5 Differentiate PV cells into 3 types: • Monocrystaline • polycrystaline, and • Armophones 1.6 Define charge controllers and its basic functions. 1.7 Explain types of charge controllers	1.1 Explain the function of each system component 1.2 Explain the factors considered when selecting PV system components 1.3 Explain factors considered when arranging PV panels 1.4 Explain factors considered when selecting a charge controller - Voltage selection - Current capacity	White Board Textbooks Charts	• Identify the components by name and physical structure • Assemble the components of the PV system • Arrange batteries in series and parallels • Test for DOD (Depth of Discharged) using the battery tester • Demonstrate the features of the types of inverters including the quasi-sine wave/modified sine wave and pure sine wave inverter	• Guide the student in the arrangement process • Guide the student in testing of batteries • Guide the student in testing from AC and DC outputs, the response of the inverter. • Guide the student in steps in selecting an inverter	• Equipment panels, • Charge controllers, • Inverters, Batteries, • Combiner boxes, • Switch breakers, • Circuit breakers • Battery Tester • Modified Sine wave and Pure sine wave inverters, • AC and DC outlets

	1.8 Define Battery and list the types relative to solar energy 1.9 List terms and terminologies associated with batteries 1.10 Define Inverters and explain their functions 1.11 List terms and terminologies associated with inverters.	1.5 Explain arrangement of batteries for increased output of current/voltage 1.6 Explain factors to consider when selecting an inverter 1.7 Explain battery and inverters terms and terminologies.				
	General Objective 2.0 : Know balance of system components.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
3 - 4	2.1 Define the term "Balance of System' (BOS) 2.2 List all the components of a BOS which includes wiring, switches, mounting system, inverters, battery bank, charge controller. 2.3 Explain the role of each components for optimal production of energy and protection against surge.	2.1 Describe the concept of the use of raceways, conducts in wiring 2.2 Explain the use of circuit breakers for over current protection 2.3 Explain the role of each components for optimal production of energy and	White Board Textbooks	• Demonstrate the use of conduits, raceways, switches in the wiring process • Demonstrate the use of combiner boxes with an array of PV panels to optimize output.	• Guide the student in simple wiring process. • Instruct the student in proper switch connection process. • Guide the student on testing for optimal output from the PV combiner	• Conduits, • raceways, combiner boxes • PV arrays • Circuit breaker • Disconnect switches • Inverter • Charger • Controller switches

		protection against surge 2.4 Explain the different types of connectors and terminations used in solar installation				
	General Objective 3.0: Know PV system power processing equipment.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
9-10	3.1 Explain the types of charge, controllers, inverters, etc. 6.2 List features of types of charge controllers and inverters 6.3 Highlight the performance indicators associated with charge controllers and inverters. 6.4 Explain the purpose of indicators in system components	3.1 Explain the factors of a charge controller selection. 3.2 Explain the differences between MPPT & PWM charge Controller 3.3 Explain the differences and similarities between the types of inverters.	White Board Textbooks	• Observe performance indicators in charge controllers and inverters. • Test output features of modified sine wave & pure sine wave inverters using AC and DC outputs	• Guide the students to identify the indicator colors (of the charge controller), the performance of the component	• Charge controllers, • Inverters • MSW and PSW, • AC and DC outlets. • Oscilloscope
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	MEASUREMENT AND INSTRUMENTATION II
COURSE CODE	SET 213
YEAR:	YEAR 1, SEMESTER 2
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	This course is designed to acquaint the students with the basic knowledge of measurement and instrumentation

GENERAL OBJECTIVES:

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

Goal: The Course is designed to acquaint the students with concept of measurement and instrumentation

1.0 Understand various Instrumentation

2.0 Understand the concept and applications of multimeters

3.0 Know the concept and application of electronic voltmeters

4.0 Understand the concept of resistors and measurement of resistance

5.0 Understand the use of oscilloscope

6.0 Understand the concept of crystal diodes and some special purpose diodes

7.0 Understand the application of crystal diodes

PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY						
COURS: MEASUREMENT AND INSTRUMENTATION II			**Course Code SET 213**		**Contact Hours 4HRS/WK L=2 P=2**	
Goal: The Course is designed to acquaint the student with concept of measurement and instrumentation						
Course Specification: THEORETICAL CONTENT			**PRACTICAL CONTENT**			
Week	**General Objective 1.0 Understanding the concept of instruments**					
	Specific Learning Outcome	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teacher Activities**	**Resources**
1-2	1.1 Explain the factors considered in instrument selection e.g. • accuracy, • precision, • resolution • sensitivity, • range, • reliability, • cost, etc. 1.2 Explain the sources of errors in • measurement systems into: • manufacturing errors, • design error, • operating errors, • environmental errors and • application errors. 1.3 Explain the concept of empirical model	• Explain the classification of instruments. • Explain the factors considered in selecting instruments and give examples. • Explain sources of error in measurement. • Asses the students	• White Board • Recommended Text books • Some common instruments	• Discuss some basic safety in the laboratory/ workshop. • Identify some common instruments in the laboratory • Detect errors in instruments • Carry out measurement using different empirical models • Determine precision in two empirical models • Compare measured	• Teach some basic safety required in the workshop • Show to students some common instruments used in the laboratory and their functions	• Practical manual • Some common instruments

				empirical models		
	General Objective 2.0 : Understand the concept and applications of multimeters					
Week	Specific Learning Outcome	Teachers Activities	Resources	Specific Learning Outcome	Teacher Activities	Resources
3-4	2.1 Explain the concept and function of galvanometer 2.2 Explain the concept of multimeter 2.3 Explain the principle of operation of multimeter 2.4 Outline the application of multimeters: • Measuring AC and DC voltage • Measuring AC and DC current • Measuring resistance • Checking the circuit continuity (whether open or short circuit exist) 2.5 State the sensitivity of multimeter 2.6 List the merits and demerits of multimeter	• Explain the working principle of galvanometers and multimeters and the difference between the two. • Explain how multimeters can be used to Perform the functions in 2.4 • Explain sensitivity of multimeters • List the merits and demerits of multimeter	• White Board • Galvanometer • Different types of multimeter • DC and AC Power sources • .DC and AC lamps • Wires	• Identify different types of galvanometers and multimeters • Demonstrate how to use multimeters to measure: • AC and DC voltage, • AC and DC current, • resistance, • continuity of a circuit or wire.	• Show different types of galvanometers and multimeters to students and explain how each is used. • Guide the students to connect some circuits and make measurements using multimeters. • Asses the students	• Galvanometer • Different types of multimeter • DC and AC Power sources • .DC and AC lamps • wires
	General Objective 3.0 : know the concept and application of electronic voltmeters					
Week	Specific Learning Outcome	Teachers Activities	Resources	Specific Learning Outcome	Teacher Activities	Resources

5	3.1 Explain the concept of electronic voltmeters 6.1 List the types of electronic voltmeters: • Vacuum tube voltmeter (VTVM) • Transistor voltmeter • Bridge rectifier voltmeter 6.2 State the advantages of electronic voltmeters over electromagnetic and electrostatic voltmeters in terms of: • Input resistance • Loading effect	• Explain the concept and types of electronic voltmeters • Explain the advantages of electronic voltmeters over electromagnetic and electrostatic voltmeters	• WhiteBoard • Text books • Various types of electronic voltmeters	• Identify electronic voltmeters to make measurements • Know the advantages of electromagnetic voltmeters over other types of galvanometers	• Show different types of electronic voltmeters to students and explain how each is used. • Guide the students to connect some circuits and make some measurement using electronic voltmeters • Guide the students to make the same type of measurement and compare.	• DC and AC power sources • DC and AC loads • Wires • Various types of electronic voltmeters • Electrostatic or electromagnetic voltmeters
	General Objective 4.0 Understand the concept of resistors and measurement of resistance					
Week	Specific Learning Outcome	Teachers Activities	Resources	Specific Learning Outcome	Teacher Activities	Resources
6 -7	4.1 Differentiate resistance from Resistors 4.2 Derive unit of resistance and	• Explain the words “resistance” and “resistors” and differentiate them	• WhiteBoard • Reference text books • Different types of	• Identify different types of resistors • Show how to measure	• Show different types of resistors with	▪ Different types of resistors with

	its sub-multiples: Ω , kΩ, MΩ, etc 4.1 Explain the factors that affect resistance of resistors 4.2 Explain types of resistors 4.3 Explain resistance of resistors from their colour coding 4.4 Explain how to measure resistance using: • Multimeter • Ohm-meter 4.5 Define conductance and conductivity and their units	• Explain the units and sub-units of resistance • Show different types of resistors to students • .Explain how 'length' and 'cross-sectional area' affect resistance • know how to find the resistance of material from their colour coding • Explain how to measure resistance using meters • Explain conductance as reciprocal of resistance and conductivity as reciprocal of resistivity.	resistors with different values • Multimeter • Ohmmeter • .Resistance wires	resistances using meters	different values • Guide the students to measure resistance of some resistors with meter and compare the values obtained with the values indicated by colour bands. • Guide the students to investigate the effect of length and cross sectional area on resistors.	different values ▪ Multimeter ▪ Ohmmeter ▪ .Resistance wires
	General Objective 5.0 Understand the use of oscilloscope					
Week	Specific Learning Outcome	Teachers Activities	Resources	Specific Learning Outcome	Teacher Activities	Resources
8 - 9	5.1 Explain the concept of Oscilloscope 5.2 Explain various types (models) of oscilloscope	▪ Explain the concept and working principle of oscilloscope	▪ White Board ▪ Text book ▪ Various models of oscilloscopes	▪ Identify various types of oscilloscope	▪ Show to students various types of oscilloscopes	. Power source . Signal generator . Oscilloscope

	5.3 State the various controls applied for proper functioning of oscilloscope ▪ Intensity control ▪ Focus control ▪ Horizontal position control ▪ Vertical position control 5.4 Outline the various applications of ▪ oscilloscope ▪ Examination of waveforms ▪ Voltage measurement ▪ Frequency measurement	▪ Explain various models of oscilloscopes ▪ Explain the functions of various controls in oscilloscope ▪ Explain the applications of oscilloscopes ▪ .		▪ Demonstrate how to use oscilloscope for: Examination of waveforms Voltage measurement Frequency measurement	▪ Guide the students to use oscilloscope for the functions listed.	(Analogy and Digital)
	General Objective 6.0 Understand the concept of crystal diodes and some special purpose diodes					
Week	Specific Learning Outcome	Teachers Activities	Resources	Specific Learning Outcome	Teacher Activities	Resources
10 11	6.1 Explain semiconductor diodes (or crystal diode) 6.2 Explain different types of semiconductor diodes 6.3 Explain the terminals of the diode using the paint symbol of the diode 6.4 Explain the terminals of the diode using multimeter 6.5 Explain fault from diodes (open or short) using multimeter 6.6 Explain some special purpose diodes:	▪ Explain different types of diodes to students. ▪ Explain how to identify the terminals (polarity) of diodes using the paint on the diode and by using meter. ▪ Explain how to identify if diodes are functional or faulty.	▪ White Board ▪ Reference text books ▪ Notes ▪ Diodes ▪ Multimeter ▪ Zener diode ▪ Light-Emitting Diode (LED) ▪ Photo diodes ▪ Optoisolator ▪ Tunnel diode ▪ Varactor diode ▪ Shockley diode	▪ Identify different types of diodes ▪ Identify the polarity (terminals) of diode by symbol and by meters ▪ Identify whether a diode is functional or faulty. ▪ Identify terminals of	▪ Show different types of diodes to the students ▪ Guide the students to find the polarity of diodes both by symbols and by using meters. ▪ Guide the students to identify	▪ Diodes ▪ Multimeter ▪ Zener diode ▪ Light-Emitting Diode (LED) ▪ Photo diodes ▪ Optoisolator ▪ Tunnel diode ▪ Varactor diode ▪ Shockley diode

	▪ Zener diode ▪ Light-Emitting Diode (LED) ▪ Photo diodes ▪ Optoisolator ▪ Tunnel diode ▪ Varactor diode ▪ Shockley diode 6.7 State the application of the diodes in	▪ Explain the special diodes listed to the students ▪ Explain the application of each of the special diodes ▪ .Asses the students .		components listed in 6.5 using instruments	whether a diode is short circuited or open circuited or functional. ▪ Show the special diodes to the students and explain their functions. ▪ Guide the students to design a simple circuit using some of the diodes and construct the circuit.	
	General Objective 7.0 Understand the application of crystal diodes					
Week	**Specific Learning Outcome**	**Teachers Activities**		**Specific Learning Outcome**	**Teacher Activities**	**Resources**
12 - 13	7.1 Explain the concept of Regulation 7.2 Outline the types of rectifiers: ▪ Half wave and ▪ Full waves 7.3 Explain how to use crystal diodes to make:	▪ Explain the concept of regulators ▪ Explain full wave and half wave rectifiers	▪ White Board ▪ Crystal diodes ▪ Capacitors ▪ Inductors	▪ Identify the differences between full and have wave rectifier. ▪ Identify polarities of	▪ Demonstrate to the students how to make full wave and half wave rectifiers with the	. AC power source . Diodes . Bread board .Capacitor . wires . load (bulb) . oscilloscope

	▪ Half wave and ▪ Full waves 7.8 Explain the advantages and disadvantages the rectifiers 7.9 Explain the concept of filter 7.10 State various types of filter circuits: ▪ Capacitor filter ▪ Choke input filter ▪ Capacitor input filter or π-filter 7.11 Differentiate regulated power supply from non-regulated.	▪ Explain how to use diodes to make the rectifiers ▪ Explain the advantages and disadvantages of each type ▪ Explain the concept and types of filters ▪ Explain the difference between regulated power supply from un-regulated power supply.		diodes using instruments. ▪ Identify AC and DC terminals of rectifiers using instruments.	help of bread board. ▪ Guide the students to connect the circuit and observe the output wave form using oscilloscope . ▪ Guide the students to add filter circuit and compare the nature of output waveforms. ▪ Asses the students	
	General Objective 8.0 Understand the concept of regulators and their applications					
Week	**Specific Learning Outcome**	**Teachers Activities**	**Resources**	**Specific Learning Outcome**	**Teacher Activities**	**Resources**
14 - 15	8.1 Explain the two basic types of: ▪ Voltage regulators ▪ Series voltage regulator ▪ Shunt voltage regulator 8.2 Explain IC voltage regulators 8.3 Explain the types of voltage regulators	▪ Explain the two basic forms of regulators ▪ Explain the four types of IC regulators ▪ Explain how to identify the polarity	▪ White Board ▪ Various types of IC regulators	▪ Identify some types of regulators ▪ Outline the function of regulators	▪ Show various types of regulators to the students. ▪ Guide the students to connect some simple	▪ AC and DC power sources ▪ Bread board ▪ Wires ▪ Various types of regulators.

	▪ Fixed positive voltage regulators ▪ Fixed negative voltage regulators ▪ Adjustable voltage regulators ▪ Dual tracking voltage regulators 8.4 State the application of each voltage regulators	(terminals) of the regulators. ▪ Explain the function of each type of regulator.			circuits to illustrate the functions of regulators. .	▪ Diodes ▪ Multimeters
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	SOLAR ENERGY SYSTEM DESIGN I (ELECTRICAL AND MECHANICAL) I
COURSE CODE	SET 223
YEAR:	YEAR 1, SEMESTER 2
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	The course is designed to provide students with the knowledge and skills in Solar Energy System Design

GENERAL OBJECTIVES:

On completion of this course, the students should be able to:

1.0 Know how to draw electrical/electromechanical diagrams.
2.0 Understand general support structure for Solar Energy System.
3.0 Understand application of CAD to Solar Energy System Design.
4.0 Understand the importance of nameplate specifications on Solar System Components.
5.0 Understand the requirements for charge control in battery-based Solar Energy systems.
6.0 Know the labeling requirements for electrical equipment in Solar Energy systems.
7.0 Understand the basic principles of Solar Energy system grounding.
8.0 Know how to apply Ohm's Law and conductor properties to calculate voltage drop for simple Solar Energy Systems.
9.0 Understand Regulations for Solar Energy Systems.
10.0 Know the key articles of the National Electrical Code on Solar Energy Systems.

	PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY					
	COURSE: SOLAR ENERGY SYSTEM DESIGN I (ELECTRICAL AND MECHANICAL)			**Course Code: SET 223**	**Contact Hours: 2HRS/WK L = 2**	
	GOAL: The course is designed to provide students with the knowledge and skills in Solar Energy System Design					
	Year: I Semester: IV			**Pre-requisite:**	**Practical: 2hours /week**	
	Course Specification	**Theoretical Content**		**Practical Content**		
	General Objective 1.0 Know how to draw electrical/electromechanical diagrams					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1 - 2	1.1 Define one-line diagrams 1.2 Explain electromechanical Diagrams 1.3 Explain diagrams with symbols used to replaced components including inverters, charge controllers, etc along with other rotational simplifications 1.1 Explain the importance of drawing a one-line diagram of the solar energy system to achieve safe, reliable, durable solar power system	1.1 Describe one-line diagrams using flow-charts, showing direction of flow of energy 1.2 Explain the methods of achieving the objectives in 1.3	White Board Textbooks Diagrams	▪ Draw simple one-line diagrams of an electric circuit, indicating simple components as symbols. ▪ Prepare a complex diagram with mostly all the components	▪ Guide the students in drawing simple and complex diagrams.	Cardboard, Maker, Ruler and Drawing tools
	General Objective 2.0 : Understand general support structure for Solar Energy System.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
3 - 4	2.1 Define support structure 2.2 Explain different orientations of support structure 2.3 List types of support structure: ▪ Roof top	2.1 Explain support Structure, it orientation and types 2.2 Explain advantages and	Textbooks Internet Diagrams	▪ Identify types of Support Structure ▪ Construct a simple Support Structure	▪ Guide the students to construct a simple Support Structure	Tools and Equipment Construction Materials, Indinometer Digital Protector

	▪ Stand alone ▪ Ground mount etc. 2.4 Explain rigidity of support structure 2.5 Explain advantages and disadvantages of support structure	disadvantages				
	General Objective 3.0: Understand application of CAD to Solar Energy System Design					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
5	3.1 Define CAD. 3.2 Explain use of CAD in Solar energy design 3.3 Explain choice of software appropriate for solar energy system design	3.1 Explain CAD, its uses and choice in Solar energy system design	Computer CAD Software Textbooks	▪ Select the appropriate software for use in solar energy system design ▪ Carry out a simple design using CAD	▪ Guide the students to select appropriate software for use in solar energy system design ▪ Guide students to carry out a simple design using CAD	Computers CAD Software Textbooks
	General Objective 4.0: Understand the importance of nameplate specifications on Solar System Components.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
7 -8	4.1 Explain the importance of nameplate specific-actions on Solar energy systems 4.2 Outline specific units attached to Solar energy system components 4.3 Outline specific units attached to	4.1 Explain terms find on systems including; VOC, DOD, Conductance 4.2 Explain how to read Solar Panel	White Board Textbooks	• Test the various inverters for specifications on the name plate.	• Demonstrate using the multimeter to test for the specification outlined on the component of	PV modules Inverter Multimeter

	inverters and other system components.	specifications. 4.3 Explain the electrical characteristics under standard test conditions (STC) including Pmp^2, Prolerance, PmP, max, Pmp, min, Vmp, Imp, Voc, Isc 4.1 Explain the electrical characteristics under standard test conditions (STC) including: Load, Base load, Surge, mining loads, peak power tracking, minimum start voltage, maximum in put current, maximum short-circuit current		• Test the various solar energy modules for specifications on the name plate	the solar system module • Guide the student on testing for the specifications outlined on the inverter	
	General Objective 5.0 : Understand the requirements for charge control in battery-based Solar Energy systems.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**

9-10	5.1 Explain the features of a charge controller 5.2 Explain the three charging stages in charger controller 5.3 State the uses of charge controller in Battery-Based solar energy system.	5.1 Discuss the operating principle of a charge controller 5.2 Discuss the three charging stages in Charger Controller 5.3 List the uses of charge controller in Battery-Based solar energy systems	Charge Controller White Board Multimeter Clamp meter PV Module Wires Model Tool Box Battery	• Connect Battery to charge controller • Connect the solar energy System (module) to charge controller • Measure the following - System voltage - system Circuit - Charging rate	- Show student how to connect the Battery to the Charge Controller - Guide students to the solar energy module to the charge controller - Guide students to measure the following: - System voltage - System Current - Charging rate.	Charge Controller White Board Multimeter Clamp meter PV Module Wires Model Tool Box Battery
	General Objective 6.0: Know the labeling requirements for electrical equipment in Solar Energy systems.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
11 - 12	6.1 Explain the labelling techniques for electrical equipment in solar energy systems e.g. - PV modules - Inverters - Disconnects 6.2 State the importance of labelling of electrical equipment in solar energy system at points of inter connections to other electrical systems on the battery banks. 6.3 State the hazards involved in improper labelling electrical	6.1 Discuss the labelling techniques for electrical equipment in solar energy systems 6.2 List the importance of proper labelling of electrical equipment in solar energy systems 6.2 Ask students questions	- WhiteBoard - Flip Charts - Electrical equipment - Models - Paper tape	- Label various electrical equipment in a solar energy system - Check correctness of label in line standard	- Guide students to label correctly electrical equipment in a PV system - Ask questions	- Model - Real electrical equipment in a solar energy system - Paper tape - Scissor - Tool Box

	equipment					
	General Objective 7.0: Understand the basic principles of Solar Energy system grounding.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	7.1 Explain the various types of electrical grounding 7.2 Explain the basic principles of solar energy system grounding 7.3 Explain the difference between grounded conductors, grounding conductors and grounding electrode conductors 7.4 Explain the following: - purpose of equipment grounding - solar energy system array ground - faults protection - importance of single point grounding	7.1 State types of electrical grounding 7.2 Discuss the basic principles of solar energy system grounding 7.3 State the difference between grounded conductors and grounding electrode conductors 7.4 State the following: - purpose of equipment grounding - solar energy system array ground -faults protection - importance of single point grounding	White Board Flip Charts Tool Box Industrial Salt Models	1. Identify various items used in grounding operations 2. Carry-out a simple grounding operation of solar energy system 3. Test for ground Resisting	▪ Guide students to identify various grounding operations items ▪ Guide students to carry out a simple grounding operations of a solar energy systems ▪ Confirm the effectiveness of the grounding operations using appropriate techniques	- earth rod - copper rod Salt Charcoal Earth ground meter Multimeter Models water
	General Objective 8.0: Know how to apply Ohm's Law and conductor properties to calculate voltage drop for simple solar energy systems					

Week/s	Specific Learning Outcomes	Teacher's activities	Resources	Specific Learning Outcomes	Teacher's activities	Resources
	8.1 Define Ohm's law 8.2 Explain the properties of a Conductor 8.3 Explain how to determine voltage drop for simple solar energy system source circuits.	8.1 Discuss Ohm's law 8.2 Explain the properties of a conductor 8.3 Explain how to calculate voltage drop for a simple solar energy system source circuits	White Board Multimeter Flap Charts Model Real objects	▪ State Ohm's law ▪ State the properties of a conductor ▪ Calculate voltage drop for various solar energy system source circuits	▪ Guide the students to calculate voltage drop of solar energy system source circuits ▪ Ask questions ▪ Guide students to carry out more calculations	Real object Models Wires Multimeters Tool Box Zero Board
	General Objective 9.0: Understand Regulations for Solar Energy Systems					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	9.1 Explain the regulations in relation to solar energy systems	9.1 Explain the regulations in relation to solar energy systems	Textbooks Law of the Federation	▪		
	General Objective 10.0: Know the key articles of the National Electrical Code on Solar Energy Systems.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	10.1 Explain the solar energy of the National Electrical code for solar energy Systems 10.2 Explain the importance of National Electrical code 10.3 State the application of the National Electrical code	10.1 Discuss the Relevant sections of National Electrical code for Solar energy Systems 10.2 State the importance of the National	White Board Journals Flap Chart National electrical Code	▪ Identify the relevant sections of National electrical code for solar energy system ▪ Interpret the relevant	▪ Guide students to identify the relevant sections of National Electrical code for solar energy system	White Board Journals Flap Chart National electrical Code

		Electrical code for PV Systems 10.4 State applications of NCE		sections	▪ Guide students to interpret different sections	
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	INTRODUCTION TO GREEN ECONOMICS
COURSE CODE	SET 222
YEAR:	YEAR 1, SEMESTER 2
DURATION:	3HOURS/3 CREDIT UNITS
GOAL:	The course is designed to acquaint the students with the emerging green economics concept

GENERAL OBJECTIVES:

On completion of this course, the students should be able to:

1.0 Understand the basic concept of green economics

2.0 Understand the different areas of green economics

3.0 Understand the link between development, sustainable development and green economics

4.0 Understand the critical sectors that drives a green economy

5.0 Understand the fundamental role of business development in Green Economy

6.0 Understand business case studies and windows of funding in a green economy

	PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY					
	COURSE: INTRODUCTION TO GREEN ECONOMICS		**Course Code: SET 222**		**Contact Hours: 3HRS/WK L = 2**	
	GOAL: The course is designed to acquaint the students of the emerging green economics concept					
	Year: I Semester: II		**Pre-requisite:**		**Practical: 1hour /week**	
	Course Specification		**Theoretical Content**		**Practical Content**	
	General Objective 1.0: Understand the basic concept of green economics					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1 - 2	1.1 Define green economics 1.2 Explain the basic concepts of green economics 1.3 Outline the benefits of green economics 1.4 Explain the fundamental challenges of green economics	1.1 Explain the activities in details in 1.1 – 1.4 1.2 Assess the students	Textbooks, lecture notes, related journals and materials and internet	▪ Appreciate Green Economics	▪ Guide students to appreciate Green Economics	Audio Visual Aids Documentry
	General Objective 2.0 : Understand the different areas of green economics					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
3 - 4	2.1 Explain the following thematic areas • Ecological/Economic issues • Intellectual and Reality issues • Political and institutional issues • Morality and Poverty issues • Finance and business/issues 2.2 Explain thematic areas as the	2.1 Explain the thematic areas of green economics 2.2 Explain how the thematic areas are building blocs for sustainable development	Textbooks, lecture notes, related journals and materials and internet	▪ Identify the thematic areas in green economics	▪ Guide students to identify thematic areas in green economics	Documentary Audio Video Aids Video Clips

	building bloc of green economics for scientific validation and quality assurance.	2.3 Assess the students				
	7.0 **General Objective 3.0: Understand the link between development, sustainable development and green economics**					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
5	3.1 Explain issues in development 3.2 Explain the history of green economic thought 3.3 Explain the concept of sustainable development	3.1 Explain the activities in details in 3.1 to 3.3 3.2 Assess the students	Textbooks, lecture notes, related journals and materials Internet	▪ Appreciate the green economic thought and its concepts	▪ Guide the students to appreciate the green economic thought and its concept	Charts Pictures Documentary
	General Objective 4.0: Understand the critical sectors that drives a green economy					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
7 -8	4.1 Explain the critical sectors of green economics 4.2 Explain smart Agriculture 4.3 Explain Energy (Renewable and Energy Efficient sources 4.2 Explain green impact assessment from these sectors. 4.3 Explain the opportunities thereto from these sectors	4.1 Explain how these critical sectors drives a green economy 4.2 Explain the opportunities thereto from these sectors 4.3 Assess the students.	Textbooks, lecture notes, related journals and materials and internet	▪ Identify the critical sectors green economy	▪ Guide the students to identify the critical sectors green economy	Charts Pictures Documentary

	General Objective 5.0: Understand the fundamental role of business development in Green Economy					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
5	5.1 Explain the role of the following in business development: o Sales o Marketing o Finance o Production o Human Resources 5.2 Explain green business concept incentives 5.3 Explain the Business Operations in a green economy	5.1 Explain the activities in details in 51 – 5.3 5.2 Assess the Students	Textbooks, lecture notes, related journals and materials and internet	▪ Identify business areas in relation to green economics	▪ Guide students to identify business areas in relation to green economics	Charts Pictures Documentary
	General Objective 6.0: Understand business case studies and windows of funding in a green economy					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
6	6.1 Explain the economies of green economics 6.3 Explain the following case studies: ▪ Integrated Farming ▪ National Green Campus ▪ Urban Mass Transit 6.4 Explain Windows of funding: Green bonds, Sovereign Wealth Fund, Pension Funds, remittances, Foreign reserves	6.1 Explain the activities in details in 6.1 – 6.3 6.2 Assess the students	Textbooks, lecture notes, related journals and materials and internet	▪ Demonstrate how PAYGO, NCGI, Integrated Farming, Urban Mass Train works ▪ Assess business opportunities	▪ Guide students in participatory facilitation methodologies	Group Discussions, Case Studies Documentary

				▪ Identify sources of funding		
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

YEAR 2 SECOND SEMESTER

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	SOLAR ENERGY TECHNOLOGY AND APPLICATION II
COURSE CODE	SET 222
YEAR:	YEAR 2, SEMESTER 2
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	This course is designed to equip the students with the principles and practice of energy technology

GENERAL OBJECTIVES:

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

1.0 Understand the classification of solar energy

2.0 Understand various photovoltaic systems and their components

3.0 Understand Battery classifications

4.0 Understand types and features of Charge Controllers

5.0 Understand the types and operation of inverters

6.0 Understand sizing of stand-alone PV system

7.0 Understand principle of Solar PV pumping systems

8.0 Understand Solar Thermal Systems and other components

	PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY					
	COURSE: SOLAR ENERGYTECHNOLOGY AND APPLICATION II			**Course Code: SET 222**		**Contact Hours: 4HRS/WK L = 2 P = 2**
	GOAL: The course is designed to equip the students with the principles and practice of solar energy technology					
	Year: II Semester: 2		**Pre-requisite:**			**Practical: 2 hours /week**
	Course Specification	**Theoretical Content**		**Practical Content**		
	General Objective 1.0: Understand classification of solar energy					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1 - 2	1.2 Explain the concept of solar energy 1.3 Differentiate solar photovoltaic from solar thermal 1.4 List the advantages and disadvantages of photovoltaic technology	▪ Explain the concept of solar energy ▪ Explain the difference between solar photovoltaic and solar thermal ▪ Explain the advantages of solar energy such as: ▪ it has no need for fuel, it is easily available, ▪ it has low maintenance cost ▪ it is modular in nature ▪ Explain the disadvantages of photovoltaic technology such as: ▪ high initial cost ▪ Variability of available solar radiation ▪ need for storage	▪ Textbooks, Lecture notes, ▪ Board, ▪ Markers, ▪ Duster etc.	▪ Identify Solar PV and Thermal Systems components	▪ Guide the students to identify Solar PV and Thermal Systems components.	Solar Panel Multi- meter Cables Solar thermal Systems etc.

		▪ low efficiency				
	General Objective 2.0 : Understand various photovoltaic systems and their components					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
3 - 6	2.1 Explain photovoltaic system components (i) photovoltaic module (ii) Battery (iii)Charge controller (iv)Inverter 2.2 List some applications of photovoltaic system: (i) electrification (ii) solar water pumping system (iii) solar street light , etc 2.3 List the components required for each system in 2.2 2.4 Explain the principle of solar photovoltaic conversion 2.5 Explain the three types of modules: ▪ Mono-crystalline	▪ Explain the function of each component in 2.1 ▪ Explain the applications of photovoltaic systems in 2.2 ▪ List and explain all the components that make up each system in 2.3 ▪ Explain the principle of solar photovoltaic conversion ▪ Explain the types of modules: ▪ Monocrystalline, ▪ Polycrystalline and ▪ Amorphous ▪ Explain the characteristics of the types solar modules in 2.5 ▪ Explain the I-V curve of module with the aid	Textbooks, Lecture notes, Board, Markers, Duster etc. The Internet. Solar modules, textbooks, lecture notes, board, ,markers, duster etc	▪ Identify the components of photovoltaic system ▪ Identify the differences between the three types of modules, by their features and characteristics	▪ Guide the students to identify the components of photovoltaic system ▪ Guide the students connect a PV module to a rheostat and expose the whole arrangement to sunlight to generate the I-V characteristic curve by ▪ Measuring the following: ▪ Open circuit voltage Voc ▪ Short circuit current Isc ▪ iii) current and voltage at maximum power points ▪	▪ photovoltaic module, Battery, ▪ Charge controller, ▪ Inverter, ▪ DC and AC bulbs, solar water pump, ▪ Cables etc ▪ Solar Modules-one each of Monocrystaline, ▪ Polycrystalline and Amorphous Types ▪ Solar Panel, ▪ Multi- meter, rheostat, thermometer, Cables, etc

	▪ Polycrystalline ▪ Amorphous 6.5 Explain the major ▪ features of the modules listed in 2.2 6.6 Explain the I-V curve of module 6.7 Explain some parameters from the I-V curve: ▪ Maximum power points for voltage and current (Vmp& Imp) ▪ Open circuit voltage Voc ▪ Short circuit current Isc 6.8 Explain the factors that affect the performance output of photovoltaic modules: ▪ Cell material ▪ Sunlight intensity ▪ Cell temperature ▪ Shading 6.9 Explain the effect of the factors in 2.9	of data sheet of the module ▪ Explain how the factors listed in 2.9 affect module performance ▪ Asses the students				

	General Objective 3.0: Understand Battery classifications					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
7 -8	3.1 Explain the principle of operation of battery 3.2 Explain battery as deep cycle and shallow cycle 3.3 Explain battery according to material: lead-acid and alkaline 6.3 Enumerate the methods of measuring state of charge(SoC) of battery by: ▪ specific gravity ▪ voltage label 3.5 Explain battery wiring configuration for the following system voltages: ▪ 12V configuration ▪ 24V ▪ 48V ▪ 96V ▪ 180V 3.6 Explain some battery safety	▪ Explain the principle of operation of battery ▪ Explain the types of battery according to material and depth of discharge ▪ Explain how to measure state of charge of battery through its voltage level or its specific battery ▪ Explain using line drawings to show battery wiring configurations. ▪ Explain some safety measures on battery ▪ Asses the students	▪ Various types of battery, ▪ Textbooks, Lecture notes, Board, Markers, ▪ Duster etc.	▪ Identify classification, state of charge and wiring configuration of batteries.	▪ Guide the students to measure state of charge of battery through specific gravity for floaded lead acid battery or through voltage level for all types of battery. ▪ Guide the students to connect the batteries for various configurations	▪ Various types of batteries, ▪ Hydrometer, multimeter, cables, spanner, pairs of Pliers , etc

	measures					
	General Objective 4.0: Understand the types of operation of inverter					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	General Objective 5.0 : Understand types and features of Charge Controllers					
Week/s	Specific Learning Outcomes	Teacher's activities	Resources	Specific Learning Outcomes	Teacher's activities	Resources
9-10	4.1 Explain the principle of operation of charge controller 4.4 List the types of charge controllers ▪ Shunt controllers ▪ Single-stage series controllers ▪ Diversion controllers ▪ Pulse width modulation (PWM) controllers 4.5 Enumerate some features of controller: ▪ Maximum power point tracking ▪ Voltage step down ▪ LED lights ▪ Meter display ▪ Low voltage disconnect	▪ Explain the principle of operation of charge controller ▪ Explain the various types and features of charge controller	▪ Various types of charge controller, ▪ Textbooks, Lecture notes, ▪ Board, ▪ Markers, ▪ Duster etc.	▪ Identify various types and features of charge controllers	▪ Guide the students to identify the various types of charge controllers ▪ Guide the students to identify the features present in each type of charge controller	▪ Various types of charge controllers with their manuals.

	▪ Low voltage warning beeper ▪ Load circuit breaker ▪ Generator start control ▪ Load timers					
	General Objective 5.0: Understand the types and operation of inverter					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
11 - 12	5.1 Define the term "inverter" 5.2 Explain the working principles of inverter 5.3 Explain the classification of inverter into: ▪ Square wave ▪ Modified square wave ▪ Pure sine wave 5.4 Explain some standard in inverter features: ▪ High efficiency ▪ Low standby losses ▪ Frequency regulation ▪ Low harmonic distortion 5.5 Explain optional inverter features:	▪ Explain the working principles of inverter ▪ Explain the classification of inverters based on the nature of their output wave form ▪ Explain the features, and specification of inverters ▪ Explain classification of inverter as stand alone or hybrid	▪ Various types of inverters, ▪ Textbooks, Lecture notes, Board, Markers, ▪ Duster etc. ▪ Internet	▪ Describe different types and features of inverters	▪ Guide the students to identify different classes and features of inverters	▪ Various types of inverters

	▪ Remote control operation ▪ Load transfer switch ▪ Capability for parallel operation 5.6 Explain inverter as: ▪ Stand alone inverter and ▪ AC Coupled system 5.7 Explain inverter specifications ▪ AC output (watt) ▪ DC input voltage from battery ▪ AC output voltage ▪ Frequency ▪ Waveform type					
	General Objective 6.0 : Understand sizing of stand-alone PV system					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
13-14	6.1 Explain how to make and analyzed load profile 6.2 Explain how to work out inverter sizing 6.3 Explain the significance of days of autonomy 6.4 Explain how to work out battery sizing	▪ Explain how to carryout load analysis ▪ Explain how to carry out sizing of a solar photovoltaic system as shown in 6.2-6.7 ▪ Explain some maintenance measures that can be carried out in PV system	▪ Textbooks, Lecture notes, Board, Markers, ▪ Duster etc.	▪ Determine sizing and connection of system components ▪ Demonstrate how to carry out some basic maintenance of PV systems	▪ Guide the students to work out some simple problems ▪ Guide the students to connect the components ▪ Guide the students to carry	▪ Solar modules, ▪ Batteries, controllers, ▪ Inverters, ▪ Cables, ▪ Multi-meters, ▪ Electrical tool kits, ▪ Bolts ▪ Bulbs, etc,

	6.5 Explain the significance of peak sunshine hours 6.6 Explain how to work out module sizing 6.7 Explain how to work out charge controller sizing 6.8 Explain how to carry out maintenance of solar PV system	▪ Asses the students			out some basic maintenance	
	General Objective 7.0: Understand Solar PV Water Pumping					
Week/s	Specific Learning Outcomes	Teacher's activities	Resources	Specific Learning Outcomes	Teacher's activities	Resources
15	7.1 Explain water pumping System 7.2 Explain the components required for Solar PV water pumping system 7.3 Explain types of pump: ▪ Self-priming pumps ▪ Positive displacement pumps ▪ Centrifugal pumps ▪ Self-priming centrifugal pump ▪ Jet pump ▪ Submersible pump	▪ Explain the components of solar water pumping ▪ Explain types of solar water pumping pumps and their features ▪ Explain the terminologies listed in 7.4	▪ Solar water pumps, ▪ Textbooks, ▪ Lecture notes, ▪ Board, ▪ Markers, ▪ Duster etc. ▪ Internet	▪ Identify the various types and features of Solar PV and water pumps ▪ Categorize Solar PV and Water pumps according their power	▪ Guide the students to identify components of solar water pump ▪ Guide the students to identify types of solar water pumps and their features	▪ Various types of solar water pumps ▪ Solar panels ▪ Reservoir/borehole/well

	7.4 Explain some terminologies relating to water pumping system ▪ Suction head ▪ Discharge head ▪ Static head ▪ Service head ▪ Friction head ▪ Service pressure ▪ Flooded section ▪ Flow					
	General Objective 8.0 : Understand Solar Thermal Systems and their Components					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
	8.1 Explain types of thermal system 8.2 List types of Solar thermal system components 8.3 Explain the function of the components 8.4 Explain the application of Solar thermal system	▪ Explain the types, functions and application of solar thermal system	▪ Textbooks ▪ Internet ▪ Journals	▪ Identify Solar thermal system	▪ Guide students to identify solar thermal system	▪ Various solar systems ▪ Heater ▪ Brooder ▪ Dryer ▪ Distiller, etc.
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	SOLAR ENERGY SYSTEM DESIGN II
COURSE CODE	SET 223
YEAR:	YEAR 1, SEMESTER 2
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	The course is aimed at providing students with the knowledge and skills of mechanical design applications for Solar Energy System

GENERAL OBJECTIVES:

On completion of this course, the students should be able to:

1.0 Know the common ways Solar Energy System components are mechanically secured and installed.

2.0 Know different Solar Energy System array mounting systems and practices.

3.0 Know building-integrated PV architecture and (BIPV) applications.

4.0 Understand material selection for solar energy systems.

5.0 Know the effects of loading on solar energy systems.

6.0 Know mechanical design features that affect the electrical and thermal performance of solar energy systems.

7.0 Understand the importance of manufacturers' instructions and procedures in solar energy system.

	PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY					
	COURSE: SOLAR ENERGY SYSTEM DESIGN II		**Course Code: SET 223**		**Contact Hours: 2HRS/WK L = 2**	
	GOAL: The course is aimed at providing students with the knowledge and skills of mechanical design applications for Solar Energy System					
	Year: I Semester: IV		**Pre-requisite:**		**Practical: 2hours /week**	
	Course Specification	**Theoretical Content**		**Practical Content**		
	General Objective 1.0 Know the common ways Solar Energy System components are mechanically secured and installed.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1 - 2	1.1 Explain the following: ▪ Mechanical support structure ▪ Concrete S.S ▪ Moveable S.S. ▪ Roof mounted S.S ▪ Ground/polar mount structure, etc. 1.2 Explain the best procedure to install solar array and collector on a building inclined at an appropriate angle. 1.4 Explain building integrated PV (BIPV) applications	1.1 Explain 1.1 ▪ Mechanical support structure ▪ Concrete S.S ▪ Moveable S.S. ▪ Roof mounted S.S ▪ Ground/polar mount structure, etc. 1.2 Explain the best procedure to install solar array and collector on a building inclined at an appropriate angle. 1.3 Explain building integrated PV (BIPV) applications	Marker White Board Textbooks	▪ Install solar array and collector on a building at an appropriate angle	▪ Guide the students to install array and collector on a building at at an appropriate angle	T-Square Labels Angle Iron Flat Bar Bolt and nuts Pictures Films Compass Aggregate

	General Objective 2.0 Know different Solar Energy System array mounting systems and practices.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
3 - 4	2.1 Explain the best economical way of mounting solar array and collector 2.2 Explain how to install solar PV and thermal system under restricted condition. 2.3 Explain safety and reliability in making solar energy systems.	2.1 Explain the best economical way of mounting solar array and collector 2.2 Explain how to install solar PV and thermal system under restricted condition	White Board Textbooks	▪ Mount solar array and collector ▪ Demonstrate how to install thermal system under restricted condition	▪ Guide the students to mount array and collector ▪ Guide students on how to install thermal system	T-Square Labels Angle Iron Flat Bar Bolt and nuts Compass Aggregate
	General Objective 3.0: Know building-integrated PV architecture and (BIPV) applications.					
Week/s	Specific Learning Outcomes	Teacher's activities	Learning Resources	Specific Learning Outcomes	Teacher's activities	Resources
5	3.1 Explain various building integrated PV system 3.2 Explain conventional PV array System 3.3 Explain BIPV applications 3.4 Explain the effect of mechanical features of solar energy system	3.1 Discuss 3.1 – 3.4	White Board Textbooks Internet	▪ Compare BIPV and conventional PV array	▪ Guide students to compare BIPV and conventional PV array	Video clips BIPV materials Modules
	General Objective 4.0: Understand material selection for solar energy systems.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
7 -8	4.1 Explain the following: • System roofing expertise	Explain 4.1 – 4.2	White Board	• Select Materials for	• Guide students to	Video clips

	• Preferred structural attachments and weather ceiling method 4.2 Explain the different types of roofing composition and covering as it relate to PV installation		Recommended Textbooks	Solar energy system	select materials for solar energy system	BIPV Materials Models
	General Objective 5.0: Know the effects of loading on Solar Energy Systems.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Learning Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
9-10	5.1 Explain types and magnitude of mechanical load experience by PV modules, arrays and their support structure 5.2 Explain the following terms: • Life and dead loads • Wind Load • Snow load 5.3 Explain the best mechanical design for effective installation and maintenance of solar energy system	5.1 Explain types and magnitude of mechanical load experience by PV modules, arrays and their support structure 5.2 Explain the following terms: • Life and dead loads • Wind load • Snow load 5.3 Discuss 5.3	- White Board - Flip Charts - Electrical equipment - Models - Paper tape	• Determine the effect of various loads	• Guide students to determine the effect of various loads	Industrial Salt Angle Iron Bolt and nut Ply wood Wooding flank Tool Box Models
	General Objective 6.0: Know mechanical design features that affect the electrical and thermal performance of solar energy systems.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
11 - 12	6.1 Explain the importance of manufacturers instruction regarding mounting and installation procedure	6.1 Explain 6.1 - 6.2	Textbooks Manuals Codes	• Interpret Manuals and Instructions	• Guide students to interpret	Manuals Instructions Video Clips

	6.2 Explain the basic skills and competence required for the PV installer				manuals and instructions	
	General Objective 7.0 Understand the importance of manufacturers' instructions and procedures in solar energy system					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

PROGRAMMEE:	NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY
COURSE TITLE:	SOLAR ENERGY SYSTEM EVALUATION
COURSE CODE	SET 224
YEAR:	YEAR 2, SEMESTER 2
DURATION:	4HOURS/4 CREDIT UNITS
GOAL:	The course is designed to expose students with the knowledge and skills involved in Solar Energy Evaluation

GENERAL OBJECTIVES:

On completion of this course, the students should be able to:

1.0 Know the various potential problems related to Solar Energy.

2.0 Understand the use of typical performance parameters monitored in Solar Energy.

3.0 Know typical maintenance requirements for Solar Energy.

4.0 Know the common types of reliability failures in Solar Energy.

5.0 Understand basic troubleshooting principles and progression.

	PROGRAMME: NATIONAL INNOVATION DIPLOMA IN SOLAR ENERGY TECHNOLOGY					
	COURSE: SOLAR ENERGY SYSTEM EVALUATION		**Course Code: SET 224**		**Contact Hours: 2HRS/WK L = 2**	
	GOAL: The course is designed to expose students with the knowledge and skills involved in Solar Energy Evaluation					
	Year: 2 Semester: IV		**Pre-requisite:**		**Practical: 2hours /week**	
	Course Specification		**Theoretical Content**		**Practical Content**	
	General Objective 1.0 Know the various potential problems related to Solar Energy.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1 - 2	1.1 Explain the various problems associated with solar energy system design 1.2 Explain problems related to components installation and operating of solar energy system such as open circuit, short circuit, etc.	1.1 Explain 1.1 – 1.2	Textbooks Internet	• Detect problems associated with solar energy system design	• Guide students to detect problems associated with solar energy system design	PV panels Charge controllers Batteries and Inverters PV Installation Tester
	General Objective 2.0: Understand the use of typical performance parameters monitored in Solar Energy.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
3 - 4	2.1 Define performance parameters 2.2 List various performance parameters in solar energy system 2.3 Explain the importance of the performance parameters.	2.1 Explain 21 – 2.5	Textbooks Internet Sound	• Test for performance parameters	• Guide students to test for performance parameter	PV Installation Tester Oscilloscope PV Panels Charge Controller Batteries Inverter

	2.4 Explain various solar energy system ratings 2.5 Explain different sizes of charge controllers, inverters, batteries, etc.					
	General Objective 3.0: Know typical maintenance requirements for Solar Energy.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
5	3.1 Explain various techniques in Solar energy system Maintenance 3.2 Explain the various safety requirements in operating system 3.3 List out different types of maintenance in solar energy system	3.1 Explain 3.1 – 3.3	Textbooks Internet Resources	• Carry out maintenance • Apply safety measures	• Guide students to carry out maintenance • Guide students to apply safety measures	Tool Box Documentaries PV Installation and Tester Safety Kits box Manuals
	General Objective 4.0: Know the common types of reliability failures in Solar Energy.					
Week/s	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
7 -8	4.1 State the various reliability indices as relate to solar energy system 4.2 List out the causes of failures in Solar energy system 3.5 Explain the factors that enhance reliability	4.1 Explain 4.1 – 4.3	Textbooks Internet Resources	• Determine reliability indices of various solar energy system	• Guide students to reliability indices of various solar energy system	Tool Box PV Installation and Tester Safety Kits box Manuals
	General Objective 5.0 : Understand basic troubleshooting principles and progression.					

Week/s	Specific Learning Outcomes	Teacher's activities	Resources	Specific Learning Outcomes	Teacher's activities	Resources
9-10	5.1 Define troubleshooting in Maintenance 5.2 Explain steps to be followed in troubleshooting in solar energy systems 5.3 Explain the basic troubleshooting principles 5.4 List out the different fault symptoms in solar energy system 5.5 List the operational instructions in solar energy system 5.6 State various methods of diagnosing a fault	5.1 Explain 5.1 – 5.6	Textbooks Internet Resources	• Carry out troubleshooting in solar energy systems	• Guide students to carryout troubleshooting in solar energy systems • Simulate faults	PV Installation and Tester Analysers
ASSESSMENT: The continuous assessment, tests and quizzes will be awarded 40% of the total score. The end of the Semester Examination will make up for the remaining 60% of the total score.						

FINAL YEAR PROJECT
SET 225

MINIMUM EQUIPMENT LIST

Fitting Workshop

1	Work benches for 30 students	10
2	Bench vices	30
3	Marking out table	1
4	Bench Drilling Machine	2
5	Surface plate	1
6	Power hacksaw	1
7	Furnace (Optional)	1
8	Flat rough file (300 mm)	15
9	Round rough file (300 mm)	15
10	Round smooth file (300 mm)	15
11	Source rough file (300 mm)	15
12	Flat smooth file 250 mm)	15
13	Half round rough file (150 mm)	15
14	Triangular rough file (150 mm)	15
15	Half round smooth file (250 mm)	15
16	Triangular smooth file (150 mm)	15
17	Try-square	15
18	Dividers	15
19	Steel rule	15
20	Wallets of warding file	1 set
21	Scribers	15
22	Scribing block	2
23	Centre punches	15
24	Scrapers (set)	1 set
25	Vernier Caliper	10
26	Hacksaw frame	30
25	Stock and dies (set) metric	3 sets
26	Taps and wrenches (set) metric	3 set

27	Hand drill	2
28	Screw extractor (set)	4
29	Screw gauges (assorted)	2 sets
30	Screw driver (set)	4 sets
31	Hammers (assorted weight)	30
32	Wire brush	5
33	Micrometer (assorted)	5
34	Oil can	5
35	Fire extinguisher, water and sand buckets	4 each
36	Measuring tapes	10
37	Feeler gauges	10
38	Rivet gun	6 pairs
39	Goggles	30 pairs
40	Drill set	4 sets
41	Electric hand grinder/sander	5
42	Vernier height gauge	2
43	Dial indicators and stand	5
44	Mallets (rubber, wood and rawhide)	5 each
45	Number stamps	2 sets
46	Letter stamps	2
47	Punches (cold)	4 sets
48	Plier (assorted)	10
49	Hand shear	5
50	Welding chipping hammer (optional)	8
51	Wire brush (bench type)	8
	Welding shield	8
53	Gloves	30
54	Gas bottle keys	4
55	Welding and cutting burner set (optional)	2
56	Gas cylinder truck (optional)	2
57	Brazing rods (optional)	6 tins
58	Flash gas lighter (optional)	4

59	Soldering flux	6 tins
60	Blow lamps	10
61	Stools	30
62	Electrode drying oven (Optional)	1
63	Bending roller	1
64	Assorted cutting snips	10
65	Twist drill sets	2 sets
66	Aprons	30
67	First Aid Box	

DRAWING STUDIO

1	Drawing table complete with drafting machine/stood	30
2	Drawing set complete with pens for ink work	2
3	45o set squares	2
4	60o set squares	2
5	Blue printing machine	1
6	Adjustable set squares	5
7	Desk sharpener	5
8	Triangular scale rule (30 mm)	5
9	Flat scale rule (300 mm)	5
10	Blackboard ruler (1m)	4-1
11	Whiteboard Tee squares	4-1
12	Blackboard set square (45o 60o)	4 each-2
13	Blackboard compasses	4-1
14	Blackboard protractor	4-1
15	French curve set	5
16	Letter stencils (3 mm, 6 mm, 7 mm and 10 mm)	5 each
17	Rubber stencils (3 mm, 6 mm, 7 mm, 6 mm and 10 mm)	5 each
18	Erasing stencils	5 each

19	Drawing rack/shelves for 30 students	
20	Plotter	1
21	Printer to handle A3 size	1

COMPUTER STUDIO

1	Personal Computers (PCs)	15
2	Networked Printer	1
	TYPE OF SOFTWARE (Various)	
1.	CAD/CAM	
2.	Electronic Workbench or Multisim	
3.	Proteus	

BASIC ELECTRICITY, MEASUREMENT AND INSTRUMENTATION LAB

1.	Basic Electricity Trainer (Optional)	1
2.	Ammeters (Various ranges) 0- 25 A DC 0- 25 A AC	2 Each
3.	Milliameter 0- 1000mA DC 0- 1000mA AC	,,
4.	Micrommeter 0- 1000mA DC 0- 1000mA AC	,,
5.	Voltmeter 0- 500V DC 0- 500V AC	,,
6.	Millivoltmeter 0- 1000mV DC	,,

7.	Variac	‘’
8.	Ohmeter 0- 5 ohms 0- 25 ohms 0- 50 ohms (Multirange)	‘’
9.	Galvanometer (triple range) 50-0-50mA 500-0-500mA	,,
10.	Wattmeter Single phase Three phase	‘’
11.	Megger tester	5
12.	Wheastone Bridge	2
13.	Potentiometer	2
14.	Experimental trainer for electronic circuits (Optional)	3
15.	Experimental Trainer for AC and DC	2
16.	Rheostals (Various ranges)	10
18.	Semi conductor Trainer (Optional)	1
19.	Electrical and thermionic fundamentals laboratory kits (Optional)	1
20.	DC power supply out-put 0 - 20V/0-2A	4
21.	Oscilloscopes:	2 each
22	Digital Multimeter	5
23	Fire Extinguisher and Sand bucket	Various

SOLAR ENERGY LABORATORY/WORKSHOP

	PV Unit	
1	Solar panels (Monocrystaline), 12V/50W, 12V/80W, 24V/250W	10 each
2	Solar panels (Polycrystalline) 12V/50W, 12V/80W, 24V/250W	10 each
3	Solar panels (Amorphous) 12V/50W, 12V/80W, 24V/250W	10 each
4	Digital Multimeters	20
5	DC bulbs	Loys
6	DC rechargeable lamps	5
7	Soldering Iron and Lead	5
8	Blowers	5
9	Solar Charge controllers	15 each
10	Solar Charge controllers	15 each
11	Inverters (DC/AC; sinewave, modified sinewave and square wave)	2 each
12	Deep cycle batteries (Assorted)	12
13	Hydrometer	5
14	Oscilloscope (single and dual beam)	1 each
15	Battery terminals	50
16	Wattmeter	5
17	Silicon diodes	100
18	Germanium diodes	100
19	Wiring board	50
20	Submersible pump	1
21	Rheostat	3
22	First Aid Box	
	Solar Thermal Unit	
1	Plain glasses	10
2	Lenses (parabolic and converging) of different focal length	5 each
3	Thermometers (digital and mercury-in-glass - assorted)	10 each
4	Thermocouples (Assorted)	10
5	PVC gums	10
6	Lagging foams (Assorted)	-

7	1", 2", 3" nails	-
8	Sample cooking pots	2 each
9	100 – 250 Litres plastic water tanks for solar water heater	2
	General requirements	
1	Hand drilling machines	
2	Angle iron (Assorted)	
3	Pipes (Assorted)	
4.	Fire Extinguishers and Sand Buckets	Various
5	Bolts and Nuts (Assorted)	
6	Saws (Power Hacksaw, hand-held saw, etc)	3
7	Hammers	20
8	Metal rules	50
9	Galvanized metal sheets (Assorted)	25
10	Complete tool box (Electrical and Mechanical)	2 each
11	Bench drilling machine	1
12	Hand grinders/Pedestal grinder	5
13	Bench Vice	1
14	Rivet gun	2
15	Gas welding equipment	1
16	Arc welding equipment	1
17	Stationary weather station	2
18	Mobile weather station	2
19	Plywood (Assorted)	5 each
20	Personal protective equipment	-
21	Aluminium ladder/Wooden ladder	1
22	Cables (Assorted)	-
23	Power projector	1
24	Laptops	2
25	Pipe Vice	1
26	Plumbing materials PVC (Assorted)	-
27	Plumbing materials GI (Assorted)	-
28	Plumbing tools (Assorted)	-

29	Industrial scale	1
30	Software for Small Hydro and Wind energy	
	SEW	
1.	DC/AC circuit Breakers	
2.	Pyrometer	
3.	Pyranometer	
4.	Solarometer	
5.	PV Installation Tester	
6.	Data logger (Optional)	
7.	Inclinometer	
8.	Compass	
9.	Tracker	
10.	Clampmeter	
11.	Bread Board	
12.	Oxide Pestes and Ink	
13.	Electrolites and Ionic liquids	
14.	Other pastes and Ink	
15.	Substances and Sealants	
16.	Solar Cell Kits	
17.	Perovskite Materials	
18.	Photo-sensitizers and additives	
19	Labware and ccessories	
	CONSUMABLES FOR PRACTICALS	
1.	DC Bulbs	
2.	Plain Glasses	
3.	Lagging Foams	
4.	1”, 2”,3” nails	
5.	Oxides pastes and Inks	
6.	Electrolytes and Lonic Luquids	
7.	Substrates and Sealants	
8.	Perovskite and Additives	

9.	Photo-Sensitizers and Additives	
10.	Labware and Accessories	
11.	Pipes	
12.	Breezing Rods	
13.	Soldering	
14.	Letter Stencils	
15.	Erasing Stencils	
16.	Rubber Stencils	
17.	DC Bulbs	
18.	Soldering Iron and Lead	
19.	PVC Gums	
20.	Plastic Water Tanks	
21.	Plywood	

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