NATIONAL BOARD FOR TECHNICAL EDUCATION

HIGHER NATIONAL DIPLOMA (HND)

SOLAR THERMAL ENGINEERING TECHNOLOGY

CURRICULUM AND COURSE SPECIFICATIONS

PLOT B, BIDA ROAD, P.M.B. 2239, KADUNA –NIGERIA

APRIL, 2025

FOREWORD

The global focus on sustainable energy solutions has brought the critical need for skilled professionals in Renewable Energy technologies. This Higher National Diploma in Solar Thermal Engineering Technology curriculum is designed to produce skilled Solar Thermal engineers who can contribute significantly to Nigeria's Renewable Energy sector.

This curriculum is developed to address the demands of skilled Renewable Energy professionals and align with international best practices, It is meticulously structured to equip students with the essential skills necessary to deliver high-quality solar thermal energy solutions.

I would like to express my sincere gratitude to the African Studies Center, Leiden (ASCL), Netherlands, under their INCLUDE KNOWLEDGE PLATFORM, for their sponsorship and invaluable contribution to the development of this vital curriculum. Their commitment to enhancing skills acquisition in relevant sectors has been instrumental in shaping this programme.

It is my firm belief that the effective implementation of this curriculum will produce a cadre of competent Solar Thermal engineers who will play a pivotal role in harnessing Nigeria's solar energy potential, thereby contributing to a sustainable energy future and economic growth.

Prof. Idris M. Bugaje
EXECUTIVE SECRETARY
NBTE, KADUNA

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GENERAL INFORMATION:

1.0 TITLE OF THE PROGRAMME: Higher National Diploma Solar Thermal Engineering Technology.

2.0 GOAL AND OBJECTIVES:

2.1 GOAL: The Programme is designed to equip students with the knowledge and skills required in Solar Thermal Engineering

2.2 OBJECTIVES OF THE PROGRAMME

A Diplomate of HND Solar Thermal Engineering Technology should be able to:

A Diplomate of HND Solar Thermal Engineering Technology should be able to:

1. Install, test, operate, commission and maintain power systems and machines for solar thermal.
2. Retrofit Solar Thermal Systems
3. Comply with Policy, Regulation and Standards for Solar Thermal Systems
4. Carryout Demand Side Management (DSM) in Solar Thermal Systems
5. Carryout advanced thermal system troubleshooting and maintenance
6. Carryout heat transfer analysis of solar thermal systems.
7. Support in the design of solar thermal systems.
8. Manage solar thermal systems life cycle.
9. Model and simulate Solar Thermal Systems.
10. Install, Operate and Maintain Smart Grid Thermal Systems in power generation
11. Install, Operate and Maintain Hybrid Thermal Systems in power generation
12. Maintain low and medium temperatures solar thermal Collectors.
13. Evaluate economic values of solar thermal systems.
14. Test, operate, and maintain solar thermal heating and cooling systems.
15. Manage projects in solar thermal systems.
16. Write technical reports.
17. Apply AI to achieve Energy security and trading
18. Register, Manage and Own Business in Solar Thermal
19. Comply with engineering ethics and professional practices

3.*0* *ENTRY* REQUIREMENTS*:*

The general entry requirements for the HND Solar Thermal Engineering Technology Programme are:

(a) In addition to the basic entry requirements for National Diploma in Renewable Energy Engineering, Chemical Engineering, Mechanical Engineering, Electrical/ Electronic Engineering, Mechatronics Engineering, Agric and Bio-environmental Engineering, Petroleum and Gas Processing Engineering and Railway Engineering

(b) Candidate most possess a National Diploma from any of the above mentioned Engineering programmes.

(c) Compulsory Industrial Training.

(d) Diplomate with a Lower Credit pass in the ND examination with one or more years of cognate experience in the specific field listed in (a) above may be considered.

4.*0* ***CURRICULLUM***

4.1 The curriculum of the HND programme consists of four main components. These are:

I. General studies/education
II. Foundation courses
III. Professional courses
IV. SIWES

4.2 The General Education component shall include courses in
English Language
Communication
Mathematics
Citizenship (the Nigerian Constitution),
Entrepreneurship

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

4.4 Foundation Courses include courses in Mathematics, and Statistics etc. The number of hours will vary with the programmes and may account for about 10 –15% of the total contact hours.

4.5 Professional Courses are courses, which give the student the theory and practical skills he needs to practice his field of calling at the technical/technologists level.

5.0 *STRUCTURE* OF PROGRAMME

This is a two-year Programme, i.e. four semesters of classroom, laboratory, field and workshop activities in the institution. Each semester shall be of 17 weeks duration made up as follows: 15 Contact weeks of teaching, i.e. recitation, practical exercises, quiz, tests, etc. and 2 weeks for examination and registration.

6.0 EVALUATION SCHEME

The HND Solar Thermal Engineering Technology Examination must be externally moderated. In grading the students, theory shall constitute 40% while practical and project are 60%.

7.0 ACCREDITATION

Each Programme offered at the HND level shall be accredited by the NBTE before the Diplomates can be awarded the Higher National Diploma Certificates. Details about the process of accrediting a Programme for the award of the HND are available from the office of the Executive Secretary, National Board for Technical Education, Plot B, Bida Road, P.M.B. 2239, Kaduna, Nigeria.

8.0 CONDITIONS FOR THE AWARD OF HND SOLAR THERMAL ENGINEERING TECHNOLOGY:

Institutions offering this Programme will award the HND certificate to candidates who successfully complete the Programme after passing prescribed course work, examinations, Project and must have been certified by an ICT industrial organization as approved by NBTE. Such candidates should have completed a minimum of 97-120 semester credit units.

8.1 GRADING OF COURSES: Courses shall be graded as follows:

MARKED RANGE	LETTER GRADE	WEIGHTING
75% and above	A	4.00
70% – 74%	AB	3.50
65% – 69%	B	3.25
60% – 64%	BC	3.00
55% – 59%	C	2.75
50% – 54%	CD	2.50
45% – 49%	D	2.25
40% – 44%	E	2.00

8.2 CLASSIFICATION OF DIPLOMAS: Higher National Diploma Certificates shall be awarded based on the following classifications:

Distinction - CGPA 3.50-4.00

Upper Credit - CGPA 3.00-3.49

Lower Credit - CGPA 2.50-2.99

Pass - CGPA 2.00-2.49

9.0 QUALIFICATION OF THE TEACHERS:

9.1 Holders of BSc / HND and Higher Degrees in:

- Renewable Energy Engineering
- Chemical Engineering
- Mechanical Engineering

- Electrical/ Electronic Engineering
- Mechatronics Engineering

9.2 In addition, teachers of this programme should have been trained and certified by:

(a) Council for the Regulation of Engineering in Nigeria (COREN)

(b) Industrial certifications in Engineering.

9.3 Headship of the Department:

Holders of HND/Bachelor's degree in any of the Engineering listed in 9.1 above and Higher degrees in Renewable energy and Energy Engineering. Who must not be below the rank of a Senior Lecturer.

10.0 GUIDANCE NOTES FOR TEACHERS OF THE PROGRAMME

10.1 The new curriculum is drawn in unit courses. This is in keeping with the provisions of the National Policy on Education which stresses the need to introduce the semester credit units. This will enable a student who wishes to transfer the units already completed in an institution of similar standard,

10.2 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.

As the success of the credit unit system depends on the articulation of Programme between the institutions and industry, the curriculum content has been written in behavioral objectives, so that it is clear to all the expected performances of the student who successfully completed some of the courses or the diplomates of the Programme. There is a slight departure in the presentation of the performance-based curriculum which requires the conditions under which the performance is 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 the institution under which the performance can take place and to follow that with the criteria for defining an acceptable level of performance. Departmental submission on the final curriculum may be vetted by the Academic Board of the institution.

10.3 Our 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 Technical and Vocational Education (TVE) system.

10.4 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 most courses, there should be a balance of theory to practice in the ratio of 40:60 or the reverse.

10.5 Internship: Internship should be carried out in year I semester II at a relevant industry for a period of 6-8 Weeks. Student placement should be done by the department with assigned logbooks whose grade score of 3CU has been provided in the curriculum table.

Note that this internship is not funded by ITF because only ND students are to take part in the SIWES.

11.0 **Mandatory Skills Qualification (MSQ) for Higher National Diploma (HND) Programmes.**

See Guidelines for the Implementation of MSQ in Polytechnics in Nigeria

CURRICULUM TABLE FOR HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY

YEAR I SEMESTER I

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH
1	GNS 301	Use of English III	2	-	2	2
2	MEC 311	Engineer and Society	2	0	2	2
3	MSQ 311	Quality Assurance Assessor (QAA)	0	0	0	2
4	MTH 311	Advanced Algebra	1	1	2	2
5	MEC 323	Advanced Fluid Mechanics	2	2	3	4
6	SPE 312	Principles of Renewable Energy	2	0	2	2
7	SPE 314	Solar Resource Assessment	1	2	3	3
8	SPE 315	Workshop Practice and Safety Procedures	1	1	2	2
9	STE 311	Fundamentals of Power System and Machines	2	1	3	3
10	STE 312	Introduction to Solar Thermal Energy	2	1	3	3
11	STE 313	Heat Transfer analysis in Solar Thermal Systems	2	1	3	3
12	STE 314	Solar Thermal Collectors and Applications I	2	1	3	3
		TOTAL	**19**	**10**	**28**	**31**

YEAR I SEMESTER II

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH
1	GNS 302	Communication in English III	2	-	2	2
2	MTH 312	Advanced Calculus	2	0	2	2
3	ENT 326	Practice of Entrepreneurship I	2	2	2	4
4	MSQ 321	Quality Assurance Assessor (QAA)	0	0	0	2
5	CTE 323	Python Programming	1	2	3	3
6	MEA 321	Applied Thermodynamics	2	2	3	4
7	STE 321	Techno-Economic analysis for Solar Thermal	1	1	2	2
8	STE 322	Installation and Commissioning of Solar Thermal System	1	2	3	3
9	STE 323	Advanced Thermal System Performance and Troubleshooting	1	1	2	2
10	STE 324	Solar Thermal Collectors and Applications II	2	1	2	3
11	STE 325	Research Methodology in Solar Thermal Energy	1	1	2	2
12	STE 326	Smart Grids & IoT in Solar Thermal System	1	2	2	3
13	STE 327	Thermal Project Management & Tendering Process	1	1	2	2
14	STE 328	Internship (6-8 Weeks)	0	0	3	3
		TOTAL	**17**	**14**	**30**	**37**

YEAR II SEMESTER I

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH
1	GNS 401	Communication in English IV	2	-	2	2
2	MTH 412	Numerical Methods	2	0	2	2
3	ENT 416	Practice of Entrepreneurship II	2	2	4	4
4	EEC 324	Control Engineering	1	2	3	3
5	STE 411	Solar Thermal Heating and Cooling Technologies	1	2	3	3
6	STE 412	Modelling and Simulation of Solar Thermal Systems	1	2	3	3
7	STE 413	Hybrid Thermal Systems and Grid Integration in power generation	2	1	3	3
9	STE 414	Retrofitting & Energy Efficiency Techniques	1	2	3	3
10	STE 415	Mini-Project on Solar Thermal Technology	0	0	3	3
11	STE 416	Seminar	0	0	2	2
		TOTAL	**12**	**11**	**28**	**28**

YEAR II SEMESTER II

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH
1	MTH 422	Statistical Methods in Engineering	1	1	2	2
2	SPE 424	Applications of AI for Energy Trading	1	2	3	3
3	STE 421	Solar Thermal Policy, Regulation, and Standards	2	0	2	2
4	STE 422	Maintenance of Solar Thermal Systems	1	2	3	3
5	STE 423	Energy Efficiency and Demand-Side Management	1	1	2	2
6	STE 424	Engineering Ethics and Professional practice	2	0	2	2
7	STE 425	Project	0	0	6	6
		TOTAL	**8**	**6**	**20**	**20**

YEAR I SEMESTER I COURSES

Fundamentals of Electrical power systems and machines

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Fundamentals of Electrical power systems and machines	**COURSE CODE**: STE 311	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 2
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
GOAL: This course is designed to equip the students with knowledge and skills of electrical power systems and machines		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the fundamentals of electrical power systems. 2.0 Know the components of electrical power systems. 3.0 Understand the principles of electrical machines. 4.0 Know the operating principles and applications of transformer. 5.0 Understand emerging technologies in power systems and machines.		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Fundamentals of Electrical power systems and machines	**COURSE CODE**: STE 311	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 2
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to equip the students with knowledge and skills of electrical power systems and machines		
GENERAL OBJECTIVE 1.0: Know the fundamentals of electrical power systems.		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-3	1.1 Define terms and concepts related to electrical power systems • Voltage • Current • Power • Energy • Frequency • Load 1.2 Explain the basic structure and function of electrical power systems: • Generation	Explain terms and concepts related to electrical power systems • Voltage • Current • Power • Energy • Frequency • Load Explain the basic structure and function of electrical power system • Generation • Transmission • Distribution	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Identify the basic structure and function of electrical power system • Generation • Transmission • Distribution Measure current and voltage in a simple circuit Calculate power from a simple circuit	Guide students to: Identify the basic structure and function of electrical power system • Generation • Transmission • Distribution Measure current and voltage in a simple circuit Calculate power from a simple circuit	Multimeter Simple Electric circuit Pen Paper Graph Sheet Calculator Sample circuit Power system model Rheostat Cell

	• Transmission • Distribution 1.3 Explain power system stability relating to generation and load connected 1.4 Explain how to calculate current, voltage and power from a simple circuit	Explain power system stability relating to generation and load connected Explain how to calculate current, voltage and power from a simple circuit				
GENERAL OBJECTIVE 2.0: Know the components of electrical power systems						
4-7	2.1 Explain power system components. •Generators •Transformers •Circuit breakers •Isolators •Lines •Cables, etc. 2.2 Describe the functions of basic power system components 2.3 Explain the interconnection of	Explain power system components. •Generators •Transformers •Circuit breakers •Isolators •Lines •Cables, etc. Explain the functions of basic power system components	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Identify power system components Identify overhead lines Identify underground cables	Guide students to; Identify different power system components Identify overhead lines Identify underground cables	Power system model Power system simulator (OpenDSS, PSAT

	power system components 2.4 Explain overhead lines and underground cables in power system	Explain the interconnection of power system components Explain overhead lines and underground cables in power system				
GENERAL OBJECTIVE 3.0: Understand the principles of electrical machines						
8-10	3.1 Define basic electrical machine concepts and terminologies • Electromagnetic induction • Torque • Commutation. 3.2 Explain the working principles of DC machines 3.3 Explain the working principles of AC machines 3.4 Describe the	Explain basic electrical machine concepts and terminologies • electromagnetic induction, • torque, • commutation. Explain the working principles of DC machines Explain the working principles of AC machines Explain the construction of common electrical	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	construction of common electrical machines 3.5 Explain the role of electrical machines in power: • Generation • Transmission • Distribution • Utilization	machines Discuss the role of electrical machines in power: • Generation • Transmission • Distribution • Utilization				
GENERAL OBJECTIVE 4.0: Know the operating principles and applications of transformer						
11-12	4.1 Define a transformer 4.2 Explain the working principles of a transformer 4.3 Explain components of transformers • Core • Windings • Insulation and cooling medium • Tap changer, etc. 4.4 Explain types of	Explain a transformer Explain the working principles of a transformer Explain types of transformers • Core • Windings • Insulation and cooling medium • Tap changer, etc. Explain types of	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Identify components of transformer Identify transformer types	Guide students to; Identify basic transformer parts Identify transformer parts	Transformer Power system simulator (OpenDSS, PSAT,

	transformers and their functions • Power and distribution transformers (step-up & step-down) • Instrument transformers • Auto-transformers	transformers and their functions • Power and distribution transformers (step-up & step-down) • Instrument transformers • Auto-transformers				
GENERAL OBJECTIVE 5.0: Understand emerging technologies in power systems and machines						
13-15	5.1 Explain smart grids as emerging technology 5.2 Explain High-Voltage Direct Current (HVDC) Transmission technology 5.3 Describe advancements in electrical machines and their control system: • Variable frequency drives (VFDs) • Brushless DC motors • Energy-efficient motors, etc.	Explain smart grids as emerging technology Explain HVDC Transmission technology Explain advancements in electrical machines and their control system: • Variable frequency drives (VFDs) • Brushless DC motors • Energy-efficient motors	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

ASSESSMENT:
Continuous Assessment (CA): 60%
Examination: 40%

Introduction to Solar Thermal Energy

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Introduction to Solar Thermal Energy	**COURSE CODE**: STE 312	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 2
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
GOAL: This course is designed to acquaint students with basic knowledge and skills in Solar Thermal Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the concept of Solar Thermal Systems 2.0 Understand the principles of Solar Thermal Systems 3.0 Know the components and design of Solar Thermal Systems 4.0 Understand the benefits and limitations of Solar Thermal Systems		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Introduction to Solar Thermal Energy	**COURSE CODE**: STE 312	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 2
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to acquaint students with basic knowledge and skills in Solar Thermal Systems		
GENERAL OBJECTIVE 1.0: Understand the concept of Solar Thermal Systems		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-3	1.1 Define Energy 1.2 Explain sources of renewable energy: • Solar • Wind • Hydro • Bio-mass • Tidal • Ocean waves • Ocean thermal • Geothermal, etc. 1.3 Define solar thermal system	Explain Energy Explain sources of renewable energy: • Solar • Wind • Hydro • Bio-mass • Tidal • Ocean waves • Ocean thermal • Geothermal, etc. Explain solar thermal system	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	1.4 List types of solar thermal systems: • Active • Passive	Explain types of solar thermal systems: • Active • Passive				
GENERAL OBJECTIVE 2.0: Understand the principles of solar thermal systems						
4-7	2.1 Explain the basic working principle of solar thermal energy conversion 2.2 List the key components in a solar thermal system: •Collectors •Absorbers •Heat transfer fluid •Storage units •Insulation materials, etc. 2.3 Explain the heat transfer mechanisms involved in solar thermal systems: • Conduction • Convection	Explain the basic working principle of solar thermal energy conversion Explain the key components in a solar t.hermal system: •Collectors •Absorbers •Heat transfer fluid •Storage units. •Insulation materials Discuss the heat transfer mechanisms involved in solar thermal systems: • Conduction • Convection • Radiation	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Identify the types of solar collectors and their operating characteristics: - Non concentrating types • Flat plate • Evacuated tube - Concentrating types • Line focus • Point focus	Guide students to: Identify the types of solar collectors and their operating characteristics: - Non concentrating types • Flat plate • Evacuated tube - Concentrating types • Line focus • Point focus	flat plate, evacuated tube, Line focus Point focus

	• Radiation 2.4 Explain applications of Solar Thermal Systems 2.5 Explain differences between active and passive solar thermal systems in terms of: • Design • Efficiency, and • Application.	Explain applications of Solar Thermal Systems Explain differences between active and passive solar thermal systems in terms of: • Design • Efficiency, and • Application.				
GENERAL OBJECTIVE 3.0: Know the components and design of Solar Thermal Systems						
8-10	3.1 Explain solar thermal components: • Solar collectors • Heat exchangers • Heat transfer media • Thermal storage systems, etc. 3.2 Explain the types	Explain solar thermal components: • Solar collectors • Heat exchangers • Heat transfer media • Thermal storage systems, etc. Explain the working	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Identify components of solar thermal systems Demonstrate the use of solar tracking system Demonstrate the use of the following measuring devices for Solar Thermal System:	Guide students to: Identify components of solar thermal systems Demonstrate the use of solar tracking system Demonstrate the use of the following measuring devices for Solar Thermal	Solar collectors Heat exchanger Heat transfer medium Thermal storage Thermometer Pyrheliometer Anemometer

	and working principles of solar thermal systems: • Solar dryers • Solar cookers • Solar water heaters • Solar Distillers • Solar furnaces • Solar ponds, • Concentrated Solar Power (CSP) Plants, etc 3.3 Explain solar tracking system 3.4 Explain the measuring devices for Solar Thermal System: • Thermometers • Solar irradiation meter • Anemometer • Pressure gauges	principles of solar thermal systems: • Solar dryers • Solar cookers • Solar water heaters • Solar Distillers • Solar furnaces • Solar ponds • Concentrated Solar Power (CSP) Plants, etc Explain solar tracking system Explain the measuring devices for Solar Thermal System: • Thermometers • Solar irradiation meter • Anemometer		• Thermometers • Solar irradiation meter • Anemometer • Pressure gauges • Relative humidity Design a low and medium temperatures Solar Thermal Systems	System: • Thermometers • Solar irradiation meter • Anemometer • Pressure gauges • Relative humidity Design a low and medium temperatures Solar Thermal Systems	Pressure gauges hygrometer

	• Relative humidity 3.5 Explain the basic design principles of Solar Thermal Systems	• Pressure gauges • Relative humidity Explain the basic design principles of Solar Thermal Systems				
GENERAL OBJECTIVE 4.0: Understand the benefits and limitations of Solar Thermal Systems						
11-14	4.1 Explain the environmental and economic benefits of solar thermal energy 4.2 Explain differences between types of solar thermal systems in terms of efficiency and applicability 4.3 Explain site and climate considerations that influence effectiveness: • Geographic factors • Climatic factors	Explain the environmental and economic benefits of solar thermal energy Discuss differences between types of solar thermal systems in terms of efficiency and applicability Discuss site and climate considerations that influence effectiveness: • Geographic factors • Climatic factors	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	4.4 Describe common technical and economic limitations of the Solar thermal systems: • Heat loss • Storage limitations.	Explain common technical and economic limitations of the systems. • Heat loss • Storage limitations.				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Heat Transfer Analysis in Solar Thermal Systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Heat Transfer Analysis in Solar Thermal Systems	Course Code: STE 313	Contact Hours: 3
	Credit Unit: 3	Theoretical: 2
Year: I Semester: I	Pre-requisite: Nil	Practical: 1 Hour/week
GOAL: This course is designed to acquaint students with basic knowledge and skills in heat transfer of Solar Thermal Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the concept of heat transfer in Solar Thermal Systems 2.0 Know the working principles of heat transfer in Solar Thermal Systems 3.0 Know the functions of heat transfer equipment		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY						
COURSE TITLE: Heat Transfer Analysis in Solar Thermal Systems		**COURSE CODE**: STE 313		Contact Hours: 3		
		Credit Unit: 3		Theoretical: 2		
Year: I Semester: I		Pre-requisite: NIL		Practical: 1		
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to acquaint students with basic knowledge and skills in heat transfer of Solar Thermal Systems						
GENERAL OBJECTIVE 1.0: Understand the concept of heat transfer in Solar Thermal Systems						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-5	1.1 Define heat transfer 1.2 Define heat transfer by: • Conduction • Convection • Radiation 1.3 Explain the heat transfer behavior in materials 1.4 List the properties of materials used in Solar Thermal Systems	Explain heat transfer Explain heat transfer by: • Conduction • Convection • Radiation Explain the heat transfer behavior in materials Explain the properties of materials used in Solar	Textbooks Journals Internet Computer Projector White board Marker Animation Charts Tables			

	1.5 Explain the heat transfer coefficient of different materials	Thermal Systems Discuss the heat transfer coefficient of different materials				
General Objective 2.0: Know the working principles of heat transfer in Solar Thermal Systems						
6-10	2.1 State the following laws governing heat transfer: • Fourier's law • Newton's law of cooling • Stefan-Boltzman law 2.2 Explain how to derive the equation for: • Fourier's law • Newton's law of cooling • Stefan-Boltzman law 2.3 Explain how to analyze heat transfer modes in a solar thermal collector	Explain the following laws governing heat transfer: • Fourier's law • Newton's law of cooling • Stefan-Boltzman law Derive the equation for: • Fourier's law • Newton's law of cooling • Stefan-Boltzman law Explain heat transfer modes in a solar thermal collector	Textbooks Journals Internet Computer Projector White board Marker Animation Charts Tables	Demonstrate measurement of temperature to analyze modes of heat transfer using Solar thermal system models Derive the equation for: • Fourier's law • Newton's law of cooling • Stefan-Boltzman law Analyze heat transfer modes in a solar thermal collector	Guide students to: Demonstrate measurement of temperature to analyze modes of heat transfer using Solar thermal system models	Solar thermal system models

General Objective 3.0: Know the functions of heat transfer equipment						
11-15	3.1 List heat transfer equipment: • Heat exchangers • Heaters • Boilers • Blowers • Refrigerators/ Air conditioners etc. 3.2 Explain the working principle of the various heat transfer equipment 3.3 Explain the applications of the various heat transfer equipment	Explain heat transfer equipment: • Heat exchangers • Heaters • Boilers • Blowers • Refrigerators/ Air conditioners etc. Explain the working principles of heat exchangers, heaters, boilers etc. Explain the areas/industries where the various heat transfer equipment are applied.	Textbooks Journals Internet Computer Projector White board Marker Animation Charts Tables	Identify heat transfer equipment: • Heat exchangers • Heaters • Boilers • Blowers • Refrigerators / Air conditioners etc. Demonstrate the use of heat transfer equipment	Guide students to: Identify heat transfer equipment: • Heat exchangers • Heaters • Boilers • Blowers • Refrigerator / Air conditioners etc. Demonstrate the use of heat transfer equipment	Heat exchangers Heaters Boilers Blowers Refrigerators Air conditioners Heat exchanger Test rig

EVALUATION: CA 60%

EXAMINATION: 40%

Solar Thermal Collectors and Application I

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Thermal Collectors and Application I	**COURSE CODE**: STE 314	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 2
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
GOAL: This course is designed to acquaint the students with basic knowledge and skills of low temperature and medium temperature Solar Thermal Collectors and applications		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the basic concept of solar radiant energy 2.0 Understand the concept of Solar Thermal Collectors 3.0 Understand the principle of conversion of radiant energy into heat for low and medium temperatures for Solar Thermal Collectors 4.0 Know the components of low and medium temperatures Solar Thermal Collectors 5.0 Understand the areas of application of low and medium temperatures Solar Thermal Collectors 6.0 Know the techniques of evaluating collector efficiency		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Thermal Collectors and Application I	**COURSE CODE**: STE 314	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 2
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to acquaint the students with basic knowledge and skills of low temperature and medium temperature Solar Thermal Collectors and applications		
GENERAL OBJECTIVE 1.0: Understand the basic concept of solar radiant energy		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1-2	1.1 Explain the basic concepts in solar radiant energy: • Solar radiation • Extraterrestrial radiation • Solar radiation on inclined surface	Explain the basic concepts in solar radiant energy: • Solar radiation • Extraterrestrial radiation • Solar radiation on inclined surface	Textbooks Journals Internet Computer Projector White Board Marker			

	1.2 Define the following: • Irradiance • Solar constant • Insolation • Sun-earth angles • Sunset and day length 1.3 Explain the process of solar radiation measurement and estimation: • Solar radiation measurement • Solar radiation estimation methods • Solar radiation data storage and analysis	Explain the following: • Irradiance • Solar constant • Insolation • Sun-earth angles • Sunset and day length Explain the process of solar radiation measurement and estimation: • Solar radiation measurement • Solar radiation estimation methods • Solar radiation data storage and analysis	Animations Charts			
• **GENERAL OBJECTIVE** 2.0: Understand the concept of Solar Thermal Collectors						

3-4	2.1 Define Solar Thermal Collectors 2.2 Explain the different classifications of Solar Thermal Collectors • Low Temperature • Medium Temperature • High Temperature 2.3 List types of low and medium Solar Thermal Collectors: • Flat plate solar collector • Evacuated tube collector • Integral collector • Parabolic trough type with line focus • Parabolic trough type with line focus and tracker	Define Solar Thermal Collectors Explain the different classifications of solar thermal collectors • Low Temperature • Medium Temperature • High Temperature Explain types of low and medium Solar Thermal Collectors: • Flat plate solar collector • Evacuated tube collector • Integral collector • Parabolic trough type with line focus • Parabolic trough type with line focus and	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts •	Construct the following Solar Thermal Collectors: • Flat plate solar collector • Parabolic trough type with line focus	Guide students to: Construct the following Solar Thermal Collectors: • Flat plate solar collector • Parabolic trough type with line focus	Mirror Sheet metal plate Glazing material insulation material Galvanized steel /copper Pipes Plumbing fittings Support structure Coating

		tracker				
GENERAL OBJECTIVE 3.0: Understand the principle of conversion of radiant energy into heat for low and medium temperature for Solar Thermal Collectors						
5-6	3.1 Explain the working principle of Solar Thermal power plant systems: • Transmissivity • Absorptivity • Reflectivity of radiant heat within the solar thermal collector 3.2 Explain the Mechanism of converting radiant energy to heat in Solar Thermal Collectors 3.3 Explain the Mechanism of heat transfer within the	Explain the working principle of Solar Thermal power plant systems: • Transmissivity • Absorptivity • Reflectivity of radiant heat within the solar thermal collector Explain the Mechanism of converting radiant energy to heat in Solar Thermal Collectors Explain the Mechanism of heat transfer within the solar thermal collector	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	solar thermal collector 3.4 Explain Storage of heat content and circulation of working fluid	Explain Storage of heat content and circulation of working fluid				
GENERAL OBJECTIVE 4.0: Know the components of low temperature and medium temperature Solar Thermal Collectors						
7-8	4.1 Explain the working principles of solar thermal collector components: • Absorber Plate • Transparent cover (glazing) • Thermal insulation • Casing • Working fluid • Connectors • Pumps • Auxiliary motors • Measuring instruments	Explain the working principles of solar thermal collector components: • Absorber Plate • Transparent cover (glazing) • Thermal insulation • Casing • Working fluid • Connectors • Pumps • Auxiliary motors • Measuring	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Identify components of solar thermal collectors Demonstrate the use of low and medium temperature solar thermal collectors Identify the properties of Solar Thermal Collector components	Guide students to: Identify components of solar thermal collectors Demonstrate the use of low and medium temperature solar thermal collectors Identify the properties of Solar Thermal Collectors components	Absorber Plate Transparent cover (glazing) Thermal insulation Casing Working fluids Thermal energy storage system Glass

	• Thermal energy storage system 4.2 Explain the properties of components used in solar thermal collectors: • Thermophysical properties • Physical properties • Environmental Properties 4.3 Explain the importance of each component Solar Thermal Collectors	instruments • Thermal energy storage system Explain the properties of components used in solar thermal collectors: • Thermophysical properties • Physical properties • Environmental Properties Explain the importance of each component Solar Thermal Collectors				Mirrors Copper tube Wood Metal Coating

GENERAL OBJECTIVE 5.0: Understand the areas of application of low temperature and medium temperature solar thermal collectors						
9-11	5.1 Explain the function of Solar Thermal Collector 5.2 Explain the application of low and medium temperature Solar Thermal Collector: • Water heating • Space heating and cooling • Solar Cooking • Power generation • Drying • Solar water disinfection or Desalination (SODIS) etc. 5.3 Explain limitations of	Explain the function of Solar Thermal Collector Explain the application of low and medium temperature Solar Thermal Collector: • Water heating • Space heating and cooling • Solar Cooking • Power generation • Drying • Solar water disinfection or Desalination (SODIS) etc.	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	low and medium temperature Solar Thermal Collectors	Explain limitations of low and medium temperature Solar Thermal Collectors				
GENERAEL OBJECTIVE 6.0: Know techniques of evaluating solar thermal collector efficiency						
12-14	6.1 Define Solar Thermal Collector efficiency 6.2 Explain the techniques for obtaining the following parameters: • Useful heat output of the collector • Collector surface	Explain solar thermal collector efficiency Explain the techniques for obtaining the following parameters: • Useful heat output of the collector • Collector	Textbooks Journals Internet Computer Projector White Board Marker	Demonstrate the use of measuring devices in evaluating efficiency of Solar Thermal Collector Demonstrate the use of measuring device to measure beam and diffuse component of solar	Guide students to: Identify measuring instrument used in evaluating efficiency of solar thermal collector Demonstrate the use of measuring	Pyranometer or pyrheliometer UV-VIS-NIR spectrometers or double beam spectral photometer

	area • Intensity of solar radiation on collector surface • Transmissivity • Absorptivity • Overall heat loss coefficient of collector • Working fluid temperature at various level within the collector • Mass flow rate of working fluid • Ambient temperature 6.3 Explain the methods of improving efficiency of Solar Thermal Collectors	surface area • Intensity of solar radiation on collector surface • Transmissivity • Absorptivity • Overall heat loss coefficient of collector • Working fluid temperature at various level within the collector • Mass flow rate of working fluid • Ambient temperature Explain the methods of improving efficiency of Solar Thermal Collectors	Animations Charts	radiation Demonstrate the use of measuring device to measure transmissivity and absorptivity of a glass Demonstrate the use of flow meter to measure the flow rate of a working fluid across the solar thermal collector Measure temperatures at various levels of the collector and ambient temperature	device to measure beam and diffuse component of solar radiation Demonstrate the use to measuring device to measure transmissivity and absorptivity of a glass Demonstrate the use of flow meter to measure the flow rate of a working fluid across the solar thermal collector Measure temperatures at	Flow meter or flow sensor and Mass flow meter Thermometers: • Thermocouples • Infrared Thermometers • Digital/Analog thermometers

					various levels of the collector and ambient temperature	

ASSESSMENT:

Continuous Assessment (CA): 60%

Examination: 40%

YEAR I SEMESTER II COURSES

Techno-Economic Analysis for Solar Thermal Systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Techno-Economic Analysis for Solar Thermal Systems	**COURSE CODE**: STE 321	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: I **SEMESTER:** II	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
GOAL: This course is designed to acquaint the students with basic knowledge and skills in Techno-Economic Analysis (TEA) in Solar Thermal Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the technical and economic principles of Solar Thermal Systems 2.0 Understand the methodology of Techno-Economic Analysis (TEA) in Solar Thermal Systems 3.0 Know the modelling techniques used in Techno-Economic Analysis (TEA) of Solar Thermal Systems 4.0 Know the techniques of analyzing the economic viability of Solar Thermal Systems 5.0 Understand Risk Assessment in Solar Thermal Systems		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Techno-Economic Analysis for Solar Thermal Systems	**COURSE CODE**: STE 312	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to acquaint the students with basic knowledge and skills in Techno-Economic Analysis (TEA) in Solar Thermal Systems		
GENERAL OBJECTIVE 1.0 Understand the technical and economic principles of Solar Thermal Systems		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1-2	1.1 Explain technical analysis of Solar Thermal System in terms of : • System design and performance evaluation • Energy Yield and Efficiency • Technical Risk and	Explain technical analysis of Solar Thermal System in terms of : • System design and performance • Energy Yield and Efficiency • Technical Risk and Challenges	Textbooks Journals Internet Computer Projector White Board Marker Animations			

	Challenges 1.2 Explain Economic Analysis of Solar Thermal Systems in terms of: • Cost-benefit Analysis • Financial Evaluation metrics (NPV, IRR, Payback period) • Economic risks and Challenges 1.3 Explain Feasibility Studies of Solar thermal Systems • Market analysis and demand assessment • Site assessment and resource evaluation • Technical and economic feasibility studies •	Explain Economic Analysis of Solar Thermal Systems in terms of: • Cost-benefit Analysis • Financial Evaluation metrics (NPV, IRR, Payback period) • Economic risks and Challenges Explain Feasibility Studies of Solar thermal Systems • Market analysis and demand assessment • Technical and economic feasibility studies	Charts			

GENERAL OBJECTIVE 2.0: Understand the methodology of Techno-Economic Analysis (TEA) in Solar Thermal Systems						
3-5	2.1 Explain Techno-economic analysis 2.2 Explain the flow process of a Solar Thermal System 2.3 List the components of solar thermal system: • Solar collector • Thermal storage system • Heat exchanger • Controls, etc. 2.4 Explain the technical parameters of solar thermal systems: • Energy balance • Mass balance • Operating conditions (Temperature,	Explain Techno-economic analysis Explain the flow process of a solar system Explain the components of solar thermal system: • Solar collector • Thermal storage system • Heat exchanger • Controls, etc. Explain the technical parameters of solar systems: • Energy balance • Mass balance • Operating conditions	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	pressure, flow rate, etc) • Efficiency • Plant capacity	(Temperature, pressure, flow rate, etc) • Efficiency • Plant capacity				
GENERAL OBJECTIVE 3.0: Know the modelling techniques used in Techno-Economic Analysis (TEA) of Solar Thermal Systems						
6-8	3.1 Explain process modelling 3.2 Explain types of Modelling process • Visual economic model • Mathematical model • Empirical models • Simulation models 3.3 Explain the simulation aspect of solar thermal system process, including material flow, energy consumption and equipment	Explain process modelling Discuss types of Modelling process • Visual economic model • Mathematical model • Empirical models • Simulation models Explain the simulation aspect of solar thermal system process, including material flow,	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts .	Demonstrate how to perform modelling	Guide the student on how to: Perform modelling Solar Thermal System using software	MS Excel RETScreen System Advisor Model (SAM)

	performance 3.4 Explain the methods for the evaluation of the following: • Component sizing parameters • Utility requirement of components of Solar Thermal System	energy consumption and equipment performance Explain the methods for the evaluation of the following: • Component sizing parameters • Utility requirement of components of Solar Thermal System				
GENERAL OBJECTIVE 4.0: Know the techniques of analysing the economic viability of Solar Thermal Systems						
9-12	4.1 Explain the following economics of solar energy: • Capital Expenditure Cost (CAPEX) • Operational	Discuss the following economics of solar energy: • Capital Expenditure Cost (CAPEX)	Textbooks Journals Internet Computer Projector	Demonstrate how to evaluate: • Capital Expenditure Cost (CAPEX) • Operational Expenditure Cost (OPEX)	Guide students to: Demonstrate how to evaluate: • Capital Expenditure Cost (CAPEX)	RETScreen software MATLAB/Simulink software MS Excel

	Expenditure Cost (OPEX) • Profit • Net Present Value (NPV) • Internal Rate of Return (IRR) • Cost per unit benchmark product equivalent 4.2 Explain sensitivity analysis 4.3 Explain the types of Life Cycle Assessment (LCA): 4.4 Explain the following stages of Life Cycle Assessment (LCA): • Initiation • Planning • Execution	• Operational Expenditure Cost (OPEX) • Profit • Net Present Value (NPV) • Internal Rate of Return (IRR) • Cost per unit benchmark product equivalent Discuss sensitivity analysis Discuss the following stages of Life Cycle Assessment (LCA): • Initiation • Planning • Execution • Monitoring and control • Closure	White Board Marker Animations Charts	• Profit • Net Present Value (NPV) • Internal Rate of Return (IRR) • Cost per unit benchmark product equivalent Demonstrate how to perform life cycle analysis on Solar Thermal Systems Build an excel financial model for a Solar Thermal system (CAPEX, OPEX, ROI, etc.)	• Operational Expenditure Cost (OPEX) • Profit • Net Present Value (NPV) • Internal Rate of Return (IRR) • Cost per unit benchmark product equivalent Demonstrate how to perform life cycle analysis on Solar Thermal Systems Build an excel financial model for a Solar Thermal system (CAPEX, OPEX, ROI, etc.)	

	• Monitoring and control • Closure					
GENERAL OBJECTIVE 5.0 Understand Risk Assessment in Solar Thermal Systems						
13-15	5.1 Explain the principles of risk assessment in solar thermal systems 5.2 Explain risks analysis procedures in Solar Thermal System 5.3 Explain strategies for risk mitigation 5.4 Explain the effectiveness of risk management plan	Explain the principles of risk assessment in solar thermal systems Explain risks analysis procedures in Solar Thermal System Discuss strategies for risk mitigation Explain the effectiveness of risk management plan	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Analyse risks in Solar Thermal System Develop strategies for risk mitigation Evaluate the effectiveness of risk management plan	Guide students to: Identify and analyse risks in Solar Thermal System Develop strategies for risk mitigation Evaluate the effectiveness of risk management plan	Microsoft Project System Advisor Model (SAM) RiskMatrix RETScreen MS Excel Sample risk management plan
ASSESSMENT: Continuous Assessment (CA): 60%						

Examination: 40%

Installation and Commissioning of Solar Thermal Systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Installation and Commissioning of Solar Thermal Systems	Course Code: STE 322	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: I Semester: II	Pre-requisite:	Practical: 2 Hour/week
GOAL: This course is designed to equip students with knowledge and skills required to install and commission Solar Thermal Systems		
GENERAL OBJECTIVES: 1.0 Understand basic installation and safety procedures for Solar Thermal Systems 2.0 Know the components and layout procedures used during installation. 3.0 Know Installation of solar collectors and associated system components. 4.0 Know commissioning procedures.		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL SOLAR THERMAL ENGINEERING TECHNOLOGY						
COURSE TITLE: Installation and Commissioning of Solar Thermal Systems		Course Code: STE 322		Contact Hours: 3		
		Credit Unit: 3		Theoretical: 1		
Year: I Semester: II		Pre-requisite:		Practical: 2 Hour/week		
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills required to install and commission Solar Thermal Systems						
GENERAL OBJECTIVE 1.0: Understand basic installation and safety procedures for Solar Thermal Systems						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain Solar Thermal System Installation 1.2 Explain Solar Thermal System Installation procedures 1.3 Explain Assessment (Site Assessment and Planning) • System design documentation and	Explain Solar Thermal System Installation Explain Solar Thermal System Installation procedures Explain Assessment (Site	Textbooks Journals Internet Computer Projector White Board 8			

	specifications • Regulatory requirements and permits 1.4 Explain the Factors Affecting Site Selection 1.5 Explain Installation Requirements (Component Handling and Storage) 1.6 Explain the Safety Procedures in Solar Thermal System Installation 1.7 Explain Commissioning And its Safety Procedures in Solar thermal systems	Assessment and Planning) • System design documentation and specifications • Regulatory requirements and permits Explain the Factors Affecting Site Selection Explain Installation Requirements (Component Handling and Storage) Explain the Safety Procedures in Solar Thermal System Installation Explain Commissioning ~~And~~and its Safety Procedures in Solar thermal systems				

General Objective 2.0: Know the components and layout procedures used during installation.						
4-7	2.1 Explain the tools and equipment in solar thermal installation. 2.2 Explain the physical attributes of Solar Thermal components 2.3 Explain the layout procedures during installation • System layout drawings and schematics • Planning, Marking and Measuring for component placement • Fixing of system components using different techniques	Explain the tools and equipment in solar thermal installation. Explain the physical attributes of Solar Thermal components Explain the layout procedures during installation • System layout drawings and schematics • Planning, Marking and Measuring for component placement	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Develop a solar thermal system layout drawing from an existing design Apply measuring and marking tools to accurately position and install solar thermal components based on a prepared layout diagram	Develop a solar thermal system layout drawing from an existing design Apply measuring and marking tools to accurately position and install solar thermal components based on a prepared layout diagram	Auto-cad software Pencil and Sketch pad Mathematical set Measuring tape Pencil Ruler Spirit level Inclinometer Magnetic Compass
General Objective 3.0: Know installation of solar collectors and associated system components						
8-11	3.1 Explain site preparation procedures and requirements prior to installing solar thermal collectors 3.2 Explain the installation of	Explain the steps required in preparing for the installation of solar collectors Explain the installation of	Textbooks Journals Internet	Identify the components in a solar thermal system and the tools used in	Identify the components in a solar thermal system and the tools used in	Solar collector (Flat plate) Storage tank Heat exchanger

	solar collectors • Flat plate collector installation • Evacuated tube collector installation 3.3 Explain the installation of other solar Thermal System parts	solar collectors • Flat plate collector installation • Evacuated tube collector installation Explain the installation of other solar Thermal System parts	Computer Projector White Board Marker Animations Charts	handling them.	handling them.	Circulation pump Electric motor Expansion tank Pipes (Copper, Aluminium, Galvanized Iron) Insulators Sensors (Temperature and Pressure) Valves Screw-driver Spanners/Wrench Pliers Digital Multimeter Center punch Hand Drilling Machine Drill bits Tapping bits Bolts and Nuts

						Plumbing Fittings
General Objective 4.0: Know commissioning procedures						
12-15	4.1 Define pre-commissioning, commissioning and testing. 4.2 Explain the procedures in pre-commissioning checks • Visual inspection • System settings verification • Fluid levels and pressure checks • Pump operation and flow direction 4.3 Explain the commissioning procedures • System Startup Procedure • Flow rate verification, etc 4.4 Explain the concept of Performance Testing 4.5 Explain the preparation of	Explain pre-commissioning, commissioning and testing. Explain the procedures in pre-commissioning checks • Visual inspection • System settings verification • Fluid levels and pressure checks • Pump operation and flow direction Explain the commissioning procedures • System Startup Procedure • Flow rate verification, etc Explain the concept of Performance Testing Explain the preparation of documents for Handover • Commissioning	Textbooks Journals Internet Computer Projector White Board Marker Charts	Conduct visual checks in a solar thermal system identifying installation faults, system failures and poor workmanship Check fluid levels, system pressure and temperatures, measure flow rates at different levels, and calculate the thermal power output to verify system settings and	Conduct visual checks in a solar thermal system identifying installation faults, system failures and poor workmanship Check fluid levels, system pressure and temperatures, measure flow rates at different levels, and calculate the thermal power output to verify system settings and	Pressure gauge Pressure sensor Temperature gauge Temperature Sensor Thermometer Thermocouple Expansion vessel/tank Actuator Pressure relief valves Heat transfer fluid. PPE (Hand gloves, safety goggles etc) Spirit level Measuring Tape Sample photos of good and bad installations

	documents for Handover • Commissioning checklist • As-built drawings • Component data sheets and manuals	checklist • As-built drawings • Component data sheets and manuals		control parameters. Develop a sample commissioning checklist, modify an existing system drawing, provide new as-built drawing, collect all data from previous experiments and assemble a technical document for handover	control parameters. Develop a sample commissioning checklist, modify an existing system drawing, provide new as-built drawing, collect all data from previous experiments and assemble a technical document for handover	Flashlight/inspection light Stopwatch

EVALUATION: CA 60%

EXAMINATION: 40%

Advanced Thermal System Performance and Troubleshooting

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Advanced Thermal System Performance and Troubleshooting	Course Code: STE 323	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: I Semester: II	Pre-requisite: Nil	Practical: 1 Hour/week
GOAL: This course is designed to acquaint students with the knowledge and skills in advanced thermal system performance and troubleshooting		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the performance principles for advanced thermal systems 2.0 Know troubleshooting techniques for advanced thermal systems 3.0 Know the performance of advanced thermal systems. 4.0 Know the safety measures and regulations in advanced thermal systems 5.0 Know the maintenance procedures for advanced thermal systems.		

PROGRAMME HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY					
COURSE TITLE: Advanced Thermal System Performance and Troubleshooting	**COURSE CODE**: STE 323		Contact Hours: 2		
	Credit Unit: 2		Theoretical: 1		
Year: I Semester: II	Pre-requisite: Nil		Practical: 1		
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL					
GOAL: This course is designed to acquaint students with the knowledge and skills in advanced thermal system performance and troubleshooting					
GENERAL OBJECTIVE 1.0: Know the performance principles for advanced thermal systems					
THEORETICAL CONTENT				PRACTICAL CONTENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Define thermal system 1.2 Define advanced thermal system 1.3 List the differences between thermal systems and advanced thermal	Explain thermal system Explain advanced thermal system Explain the differences between thermal systems and advanced thermal	Textbooks Journals Internet Computer Projector White board Marker Animation	Identify advanced thermal systems Demonstrate the uses of advanced thermal systems	Guide students to: Identify advanced thermal systems Demonstrate the uses of advanced thermal systems	Pictorials and animations of small modular reactors Pictorials and animations of Supercritical Heat Exchangers

	systems 1.4 List types of advanced thermal system 1.5 List the characteristic of advanced thermal system	systems Explain types of advanced thermal system Explain the characteristic of advanced thermal system				Pictorials and animations of Biomass gasification system Pictorials and animations of Biomass pyrolysis system Parabolic trough Boilers Furnace Heat exchangers Heat pumps Air conditioning systems Pictorials and animations of Steam turbines Pictorials and

						animations of Gas turbines
General Objective 2.0: Know troubleshooting techniques for advanced thermal systems						
4-6	2.1 Define trouble shooting in advanced thermal system. 2.2 Explain how troubleshooting is carried out with respect to advanced thermal system 2.3 List the benefits derived from troubleshooting of advanced thermal system.	Explain trouble shooting in advanced thermal system Explain how troubleshooting is carried out with respect to advanced thermal system Explain the benefits derived from troubleshooting of advanced thermal system.	Textbooks Journals Internet Computer Projector White board Marker Animation	Troubleshoot some specific advanced thermal systems	Guide students to: Troubleshoot some specific advanced thermal systems	Pictorials and animations of Small modular reactors Pictorials and animations of Supercritical Heat Exchangers Pictorials and animations of Biomass gasification system Pictorials and animations of Biomass pyrolysis system Parabolic trough

General Objective 3.0: Know the performance of Advanced Thermal Systems.						
7-9	3.1 Define performance of Advance Thermal Systems 3.2 List the relevant parameters to be determined when carrying out the performance analysis of Advanced Thermal Systems 3.3 Explain how key parameters can be determined. These include: • Heat transfer rate • Energy efficiency • Coefficient of performance • Thermal conductivity • Specific heat capacity • System efficiency • System response time • System capacity • System stability	Explain performance of advance Thermal Systems Explain the relevant parameters to be determined when carrying out the performance analysis of Advanced Thermal Systems Explain how key parameters can be determined. These include: • Heat transfer rate • Energy efficiency • Coefficient of performance • Thermal conductivity • Specific heat capacity • System efficiency • System response time • System capacity	Textbooks Journals Internet Computer Projector White board Marker Animation	Demonstrate how key parameters can be determined. These include: • Heat transfer rate • Energy efficiency • Coefficient of performance • Thermal conductivity • Specific heat capacity • System efficiency • System response time • System capacity • System stability	Guide students to: Demonstrate how key parameters can be determined. These include: • Heat transfer rate • Energy efficiency • Coefficient of performance • Thermal conductivity • Specific heat capacity • System efficiency • System response time • System capacity • System stability Illustrate how to	Pictorials and animations of Small modular reactors Pictorials and animations of Supercritical Heat Exchangers Pictorials and animations of Biomass gasification system Pictorials and animations of Biomass pyrolysis system Parabolic trough

	3.4 Explain how to determine the performance of advance thermal systems 3.5 Explain how advanced thermal system are modeled.	• System stability Explain how to determine the performance of advance thermal systems Explain how advanced thermal system are modeled.		Illustrate how to determine the performance of advance thermal systems Demonstrate how advanced thermal system are modeled	determine the performance of advance thermal systems Demonstrate how advanced thermal system are modeled	
General Objective 4.0: Know the safety measures and regulations in Advanced Thermal Systems						
10-11	4.1Enumerate the safety regulations associated with advanced Thermal Systems including: • American Society of Mechanical Engineers (ASME) • American Petroleum Institute (API) • National Free Protection Association Standards (NFPA)	Explain the safety regulations associated with Advanced Thermal Systems including: • American Society of Mechanical Engineers (ASME) • American Petroleum Institute (API) • National Free	Textbooks Journals Internet Computer Projector White board Marker Animation	Use of the safety kits and gadgets relevant to Advanced Thermal Systems	Guide students to: Use of the safety kits and gadgets relevant to advanced thermal systems	Safety kit

	• Occupational Safety and Health Administration (OSHA) • Environmental Protection Agency Regulations (EPA) • American Society For Heating, Refrigeration and Air conditioning Engineers (ASHRAE) 4.2 Enumerate the safety measures necessary when handling advanced thermal systems taking cognizance of: • Environment • Safety kits • Equipment	Protection Association Standards (NFPA) • Occupational Safety and Health Administration (OSHA) • Environmental Protection Agency Regulations (EPA) • American Society For Heating, Refrigeration and Air conditioning Engineers (ASHRAE) Explain the necessary safety measures to be taken when handling advanced thermal systems, taking cognizance of: • Environment • Safety kits				

	4.3 List the safety kits necessary when working on advanced thermal systems 4.4 Describe the first aid measures to be taken in case of accident when handling advanced thermal systems	• Equipment Explain the necessary safety kits and gadgets to be used when working on advanced thermal systems Explain first aid measures to be taken in case of accident when handling advanced thermal systems				
General Objective 5.0: Know the maintenance procedures for advanced thermal systems						
12-15	5.1 Explain maintenance in relation to advanced thermal systems 5.2 State the Importance of maintenance to Advanced Thermal Systems 5.3 Explain the different types of maintenance namely: • Predictive • Condition -based • Preventive	Explain maintenance in relation to advanced thermal systems Explain the Importance of maintenance to Advanced Thermal Systems Explain the different types of maintenance namely: • Predictive • Condition -based	Textbooks Journals Internet Computer Projector White board Marker Animation	Carry out preventive maintenance on Heat Exchanger	Guide students to: Carry out preventive maintenance on Heat Exchanger	Pictorials and animations of Small modular reactors Pictorials and animations of Supercritical Heat Exchangers Pictorials and animations of Biomass

	• Corrective • Reactive/Breakdown etc. 5.4 Describe the maintenance procedure on components of Advanced Thermal System	• Preventive • Corrective • Reactive/Breakdown etc. Discuss the maintenance procedure on components of Advanced Thermal System				gasification system Pictorials and animations of Biomass pyrolysis system Parabolic trough

EVALUATION: CA 60%

EXAMINATION: 40%

Solar Thermal Collectors and Application II

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Thermal Collectors and Application II	**COURSE CODE**: STE 324	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 2
YEAR: I **SEMESTER:** II	**PRE-REQUISITE:** Nil	**PRACTICAL:** 1
GOAL: This course is designed to acquaint the students with basic knowledge and skills in Solar Thermal Power Plants		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the concept of Solar Thermal Collectors in Power Plants 2.0 Understand the principles of Solar Thermal Collectors in Power Plants 3.0 Know the components of Solar Thermal Collectors in Power Plants 4.0 Know the efficiency of Solar Thermal Power Plants 5.0 Know the components of Thermal energy storage 6.0 Understand the applications of Solar Thermal Power Plants		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Thermal Collectors and Application II	**COURSE CODE**: STE 324	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 2
YEAR: I **SEMESTER:** II	**PRE-REQUISITE:** Nil	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to acquaint the students with basic knowledge and skills in Solar Thermal Power Plants		
GENERAL OBJECTIVE 1.0: Understand the concept of solar thermal collectors in Power Plants		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1-2	1.1 Explain solar thermal power systems 1.2Explain high temperature solar thermal collectors	Explain solar thermal power systems Explain high temperature solar thermal collectors	Textbooks Journals Internet Computer Projector White Board Marker			

	1.3 List types of high temperature Solar Thermal Collectors: • Solar distributed collector thermal power plants (Parabolic trough unit with line focus and Paraboloidal dish with point focus) • Solar central receiver power plants (Heliostats or tower concept) • Solar Chimney power plant 1.4 Explain solar tracking systems and control: • Single Axis • Double or Dual Axis	Explain types of high temperature solar thermal collectors: • Solar distributed collector thermal power plants (Parabolic trough unit with line focus and Paraboloidal dish with point focus) • Solar central receiver power plants (Heliostats or tower concept) • Solar Chimney power plant Explain solar tracking systems and control: • Single Axis	Animations Charts			

		• Double or Dual Axis				
GENERAL OBJECTIVE 2.0: Understand the principles of Solar Thermal Collectors in Power Plant						
3-4	2.1 Explain the working principle of Solar Thermal Power Plants: • Transmissivity, absorptivity and reflectivity of radiant heat within the collector 2.2 Explain the Mechanism of converting radiant energy to heat 2.3 Explain the mechanism of heat transfer within the solar thermal collector 2.4 Explain the storage of heat content and	Explain the working principle of Solar Thermal Power Plants: • Transmissivity, absorptivity and reflectivity of radiant heat within the collector Explain the Mechanism of converting radiant energy to heat Explain the mechanism of heat transfer within the solar thermal collector Explain the storage of heat content and circulation of working fluid	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			•

	circulation of working fluid					
GENERAL OBJECTIVE 3.0 Know the components of Solar Thermal Collectors in Power Plants						
5-7	3.1 Explain components of Solar Thermal Power Plants: • Parabolic collectors (central receiver) • Single or Double/Dual Axis sun tracker • Heliostats • Storage tank • Boiler • Turbine • Heat transfer fluids • condenser • Fresnel lenses 3.2 Explain the working principles	Explain components of solar thermal power plants: • Parabolic collectors (central receiver) • Single or two-plane sun tracker • Heliostats • Storage tank • Boiler • Turbine • Heat transfer fluids • condenser • Fresnel lenses Explain the working principles of solar	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Identify components of solar thermal power plants Demonstrate the use of high solar thermal collector	Guide students to: Identify components of solar thermal collectors Demonstrate the use of high temperature solar thermal collectors	Parabolic collectors Single and double plane sun tracker Storage tank Boiler Fresnel lenses Pictorials and animations of Turbine

	of solar thermal power plant components 3.3 Explain merits and demerits of solar tracking systems	thermal power plant components Explain merits and demerits of solar tracking systems				
GENERAL OBJECTIVE 4.0 Know the efficiency of Solar Thermal Power Plants						
8-10	4.1 Define efficiency of Solar Thermal Power plant system 4.2 Explain the following energy parameters within the Solar Thermal Power Plants: • Solar irradiation absorbed by absorber • Beam solar irradiation intensity • Aperture area parabolic trough	Explain efficiency of Solar Thermal Power plant system Explain the following energy parameters within the solar thermal power plant: • Solar irradiation absorbed by absorber • Beam solar irradiation intensity • Aperture area parabolic trough collector • Absorber	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Demonstrate the use of measuring devices in evaluating efficiency of Solar Thermal Power Plants Demonstrate the use of measuring devices to measure beam and diffuse component of solar irradiation Demonstrate the use of	Guide students to: Identify measuring instrument used in evaluating efficiency of solar thermal collector Demonstrate the use of measuring device to measure beam and diffuse component of solar irradiation Demonstrate the use of measuring	Pyranometer or pyrheliometer UV-VIS-NIR spectrometers or double beam spectral photometer Flow meter or flow sensor and Thermometers • Thermocouples

	collector • Absorber temperature • Ambient temperature • Reflectivity, Transmissivity and absorptivity • Mass flow rate etc. 4.3 Explain the methods of improving the efficiency of Solar Thermal Power Plants	temperature • Ambient temperature • Reflectivity, Transmissivity and absorptivity • Mass flow rate etc. Explain the methods of improving the efficiency of Solar Thermal Power Plants		measuring device to measure and determine Transmissivity and absorptivity of a glass Demonstrate the use of flow meter to measure the flow rate of a working fluid across the Solar Thermal Power Plants Measure temperature at various levels of the collector and ambient temperature Measure absorptivity of the absorber surface	device to measure and determine Transmissivity and absorptivity of a glass Demonstrate the use of flow meter to measure the flow rate of a working fluid across the Solar Thermal Power Plants Measure temperature at various levels of the collector and ambient temperature Measure absorptivity of the absorber surface	• Infrared Thermometers • Digital thermometers Spectrometer
GENERAL OBJECTIVE 5.0: Know the components of Thermal Energy Storage						
11-13	5.1 Describe a thermal	Describe a thermal	Textbooks	Identify the different types of thermal energy storage	Guide students to:	General materials used

	energy storage system. 5.2 Explain the classification of thermal storage system: • Single tank storage • Double tank storage 5.3Explain the types of solar thermal energy storage: • Sensible heat energy storage • Latent heat energy storage • Water storage • Packed bed exchange storage • Thermo-chemical storage	energy storage system. Explain the classification of thermal storage system: • Single tank storage • Double tank storage Explain the types of solar thermal energy storage: • Sensible heat energy storage • Latent heat energy storage • Water storage • Packed bed exchange storage • Thermo-chemical storage	Journals Internet Computer Projector White Board Marker Animations Charts	systems and materials Demonstrate the mode of operation of thermal energy storage systems Demonstrate the use of thermal energy storage system to measure physical property of material as it is subjected to change in temperature	Identify the different types of thermal energy storage systems and materials Demonstrate the mode of operation of thermal energy storage systems Demonstrate the use of thermal energy storage system to measure physical property of material as it is subjected to change in temperature	in Thermal energy storage system: • Rock • Concrete • Sand • Iron • Iron oxide • Water • Thermal Oil • Sodium and potassium nitrate • Animal fat • Paraffin wax Calorimeter Differential scanning calorimeters

	5.4 Explain the techniques of thermal analysis of a storage system: • Thermogravimetry • Differential thermal analysis • Differential scanning calorimetry	Explain the techniques of thermal analysis of a storage system: • Thermogravimetry • Differential thermal analysis • Differential scanning calorimetry				(DSC) Thermal energy meters
GENERAL OBJECTIVE 6.0: Understand the applications of solar thermal power plants						
14-15	6.1 Explain the application of high temperature Solar Thermal Power Plant • Medium and large-scale power generation 6.2 Explain the application of high temperature Solar Thermal Power Plant in Industrial processes for steam generation	Explain the application of high temperature Solar Thermal Power Plant • Medium and large-scale power generation Explain the application of high temperature Solar Thermal Power Plant in Industrial processes for steam generation	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	6.3 Explain the application of high temperature Solar Thermal Power Plant in Industrial chemical processes 6.4 Explain the application of high temperature Solar Thermal Power Plant in High draw hot water facilities 6.5 Explain the application of high temperature Solar Thermal Power Plant in Water desalination	Explain the application of high temperature Solar Thermal Plant in Industrial chemical processes Explain the application of high temperature Solar Thermal Power Plant in High draw hot water facilities Explain the application of high temperature Solar Thermal Power Plant in Water desalination				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Research Methodology in Solar Thermal Energy

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Research Methodology in Solar Thermal Energy	**COURSE CODE**: STE 325	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: I **SEMESTER:** II	**PRE-REQUISITE:**	**PRACTICAL:** 1
GOAL: This course is designed to acquaint students with knowledge and skills in Research methodology and technical report writing in relation to Solar Thermal Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the fundamental concepts of research in solar thermal energy. 2.0 Know the process of formulating research problems, hypotheses, and objectives for solar thermal applications. 3.0 Know the design and conduct of experiments/field studies in solar thermal systems. 4.0 Understand data collection techniques and analysis tools in solar thermal research. 5.0 Know the compilation, presentation, and interpretation of research findings in technical report format. 6.0 Understand technical reporting in RE and engineering fields 7.0 Understand Supplementary elements, reviewing, editing, and presenting technical reports		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Research Methodology in Solar Thermal Energy	**COURSE CODE**: STE 325	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: I **SEMESTER:** II	**PRE-REQUISITE:**	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to acquaint students with knowledge and skills in Research methodology in relation to Solar Thermal Systems		
GENERAL OBJECTIVE 1.0: Understand the fundamental concepts of research in solar thermal energy		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-2	1.1 Define Research 1.2 Explain the importance of Research 1.3 Describe types of Research: • Experimental • Descriptive • Applied research 1.4 Explain Literature review in research 1.5 Explain ethical issues: • Plagiarism and	Explain Research Explain the importance of Research Explain types of Research: • Experimental • Descriptive • Applied research Explain Literature review in research	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	consent • Data falsification,	Discuss Ethical issues relating to Research: • Plagiarism and consent • Data falsification				
GENERAL OBJECTIVE 2.0: **Know** the process of formulating research problems, hypotheses, and objectives for solar thermal applications.						
3-4	2.1 Enumerate the essential parts of research: ▪ Title, ▪ Background ▪ Problem statement, ▪ Goal and Objectives, etc. 2.2 Explain problem statement, objectives and Research questions 2.3 Explain Literature Review	Explain the essential parts of research: ▪ Title, ▪ Background ▪ Problem statement, ▪ Goal and Objectives, etc. Explain problem statement, objectives and Research questions Discuss Literature Review	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Write a concise and clear title along with background information relevant to solar thermal energy Formulate a research problem relating to solar thermal and derive appropriate objectives for it Create precise and researchable problem statements Draft a literature review section of a Research proposal Summarize relevant studies and highlight research gaps in solar thermal energy	Guide students to: Write a concise and clear title along with background information relevant to solar thermal energy Formulate a research problem relating to solar thermal and derive appropriate objectives for it Create precise and researchable problem statements Draft a literature review section of a Research proposal Summarize relevant studies and highlight	Journals Internet Research papers on solar thermal

					research gaps in solar thermal energy	
GENERAL OBJECTIVE 3.0: Know the design and conduct of experiments/field studies in solar thermal systems						
5-6	3.1 Define research objectives for experimental or field study 3.2 Explain appropriate research design and methodology selection 3.3 Outline the steps and instruments needed to carry out the study on Solar Thermal Systems	Explain research objectives for experimental or field study Explain appropriate research design and methodology selection Explain the steps and instruments needed to carry out the study on Solar Thermal Systems	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Select appropriate research design and methodology Develop experimental or field procedure for the research on any area of your choice on Solar Thermal Systems Conduct the study using tools and techniques in real or simulated environments	Guide students to: Select appropriate research design and methodology. Develop experimental or field procedure for the research on any area of your choice on Solar Thermal Systems Conduct the study using tools and techniques in real or simulated environments	Journals Internet Research papers on solar thermal Relevant Software for simulation if applicable
GENERAL OBJECTIVE 4.0: Understand data collection techniques and analysis tools in solar thermal research.						
7-8	4.1 Explain different data collection methods: ▪ Surveys ▪ Experiments ▪ Sensor data collection	Explain different data collection methods (e.g. surveys, experiments, sensor data collection) Explain data analysis	Textbooks Journals Internet Computer Projector White Board	Analyze data sets using appropriate software tools	Analyze data sets using appropriate software tools	Data logger Appropriate analysis software tool (Excel,

	4.2 Explain data analysis methods 4.3 Describe data analysis software tools: • Excel • MATLAB • Python, etc. 4.4 Explain the Interpretation of results from data analysis in the context of solar thermal energy systems	methods Explain data analysis software tools: • Excel • MATLAB • Python, etc. Explain the Interpretation of results from data analysis in the context of solar thermal energy systems	Marker Animations Charts			MATLAB, Python)
GENERAL OBJECTIVE 5.0: Know the compilation, presentation, and interpretation of research findings in technical report format.						
9-10	5.1 Explain the structure of a technical report 5.2 Explain how to Compile research data and analysis into coherent sections 5.3 Explain the implications of Research results	Explain the structure of a technical report Discuss how to compile research data and analysis into coherent sections Discuss the implications of Research results	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Compile research data and analysis into coherent sections Interpret the implications of research results Apply correct citation and referencing styles in a technical report	Guide students to; Compile research data and analysis into coherent sections Interpret the implications of research results Apply correct citation and referencing styles in a technical report	Papers Computer Printer

	5.4 Explain referencing and citation in Research report	Explain referencing and citation in Research report				
GENERAL OBJECTIVE 6.0: Understand technical reporting in RE and engineering fields						
11-12	7.1 Explain the importance of technical reporting in engineering and RE projects 7.2 Explain the role of communication, documentation and decision making derived from technical reports in RE/engineering reports • Feasibility reports • Progress/Interim reports • Research/project reports • Incident or troubleshooting reports • Close-out reports	Explain the importance of technical reporting in engineering and RE projects Explain the role of communication, documentation and decision making derived from technical reports in RE /engineering reports • Feasibility reports • Progress/Interim reports • Research/project reports • Incident or troubleshooting reports • Close-out reports Explain the parts of technical report writing in engineering and thermal project • Title page	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	6.3 Explain the parts of technical report writing in engineering and RE project • Title page • Abstract/Executive summary • Introduction • Methodology • Results/Findings/Budget • Discussions and conclusions • References • Appendices 6.4 Explain the structure and components of a standard report 6.5 Explain the difference between technical and non-technical readers 6.6 Explain ethical and professional practice in technical reporting. 6.7 Describe the steps involved in planning and writing a technical report 6.8 Describe how report	• Abstract/Executive summary • Introduction • Methodology • Results/Findings/ Budget • Discussions and conclusions • References • Appendices Explain the structure and components of a standard report Explain the difference between technical and non-technical readers Explain ethical and professional practice in technical reporting. Explain the steps involved in planning and writing a technical report Discuss how report structure supports clarity and readability Explain content tailoring to suit different report				

	structure supports clarity and readability 6.9 Explain content tailoring to suit different report types and purposes 6.10 Explain the importance of coherence, flow, and technical language in report writing 6.11 Explain the common errors in report writing and how to avoid them	types and purposes Explain the importance of coherence, flow, and technical language in report writing Explain the common errors in report writing and how to avoid them				
GENERAL OBJECTIVE 7.0: Understand Supplementary elements, reviewing, editing, and presenting technical reports						
13-15	7.1 Explain the types of supplementary elements commonly used in technical reports 7.2 Explain when and how to use visuals • charts, • tables, • diagram 7.3 Explain the importance of source citation and referencing	Explain the types of supplementary elements commonly used in technical reports Explain when and how to use visuals • charts, • tables, • diagram Explain the importance of source citation and referencing	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Write a/an: • Progress/Interim report • Feasibility report • Incident or troubleshooting report Demonstrate the use of citation and referencing tools • Zotero • Mendeley	Guide students to write a/an: • Progress/Interim report • Feasibility report • Incident or troubleshooting report Demonstrate the use of citation and referencing tools • Zotero Mendeley	Sample reports Zotero Mendeley

	7.4 Explain the different referencing styles • APA • Chicago • IEEE, etc. 7.5 Explain the different tools used for citation and referencing • Zotero • Mendeley • MS Word Reference manager • EndNote 7.6 Explain the importance of integrating supplementary elements. 7.7 Explain the importance of maintaining a consistent and professional layout throughout the report 7.8 Explain the importance of reviewing and editing in producing high-quality reports 7.9 Explain common errors	Explain the different referencing styles • APA • Chicago • IEEE, etc. Explain the different tools used for citation and referencing • Zotero • Mendeley • MS Word Reference manager • EndNote Discuss the importance of integrating supplementary elements Explain the importance of maintaining a consistent and professional layout throughout the report Explain the importance of reviewing and editing in producing high-quality				

	in technical report writing and how to correct them 7.10 List the key elements of a professional presentation of reports 7.11 Explain best practices for submitting or delivering technical reports in academic or workplace settings	reports Explain common errors in technical report writing and how to correct them Explain key elements of a professional presentation of reports Explain best practices for submitting or delivering technical reports in academic or workplace settings				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Smart Grids & IoT in Solar Thermal Systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Smart Grids & IoT in Solar Thermal Systems	Course Code: STE 326	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: I Semester: II	Pre-requisite: Nil	Practical: 2 Hour/week
GOAL: This course is designed to acquaint students with knowledge and skills in Smart Grid and IoT for Solar Thermal Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the smart grid & IoT principles 2.0 Understand the design and development of smart grid systems 3.0 Know the development of IoT applications for smart grids 4.0 Know the modelling and simulation of IoT solutions to smart grid problems. 5.0 Know the equipment used in smart grid & IoT applications		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY						
COURSE TITLE: Smart Grids & IoT in Solar Thermal Systems	**COURSE CODE**: STE 326			Contact Hours: 3		
	Credit Unit: 3			Theoretical: 1		
Year: I Semester: II	Pre-requisite: Nil			Practical: 2		
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to acquaint students with knowledge and skills in Smart Grid and IoT for Solar Thermal Systems						
GENERAL OBJECTIVE 1.0: Understand the smart grid & IoT principles						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Define Smart Grid 1.2 Explain the principles of Smart Grid. 1.3 Enumerate the key Smart Grid components with their respective examples in the following order: • Advanced metering infrastructure • Grid management systems • Renewable energy	Explain smart grid Explain the principles of smart grid. Explain the key smart grid components with their respective examples in the following order: • Advanced metering infrastructure • Grid management systems	Textbooks Journals Internet Computer Projector White board Marker Animation	Demonstrate the use of smart grid components: • Advanced metering infrastructure • Grid management systems • Renewable energy integration • Grid animation and control	Guide students to: Demonstrate the use of smart grid components: • Advanced metering infrastructure • Grid management systems • Renewable energy integration	Energy meter Arduino Internet Computer MATLAB Simulink Bread board Low

	integration • Grid animation and control • Communication networks • Data analytics and management etc. 1.4 Define Internet of Things (IoT) 1.5 List facilities needed to set up IoT in the following order: • Physical • Technical • Human resources • Infrastructure • Regulatory, etc. 1.6 List the equipment needed to set up IoT in the order: • Sensors and actuators	• Renewable energy integration • Grid animation and control • Communication networks • Data analytics and management etc. Explain Internet of Things (IoT) Explain facilities needed to set up IoT in the following order: • Physical • Technical • Human resources • Infrastructure • Regulatory, etc. Explain the equipment needed to set up IoT in the order:		• Communication networks • Data analytics and management etc. Identify the facilities needed to set up IoT: • Physical • Technical • Human resources • Infrastructure • Regulatory, etc. Identify the equipment needed to set up IoT: • Sensors and actuators • Microcontrollers and processors • Communication modules • Gateways and routers • Power management	• Grid animation and control • Communication networks • Data analytics and management etc. Identify the facilities needed to set up IoT: • Physical • Technical • Human resources • Infrastructure • Regulatory, etc. Identify the equipment needed to set up IoT: • Sensors and actuators • Microcontrollers and processors • Communication modules	voltage Power supply pack

	• Microcontrollers and processors • Communication modules • Gateways and routers • Power management equipment 1.7 Explain the differences between smart grids and other forms of grids such as: • Conventional • Power grids, • Legacy grids, etc. 1.8 Explain the advantages of smart grids with IoT over non- IoT smart grids	• Sensors and actuators • Microcontrollers and processors • Communication modules • Gateways and routers • Power management equipment Explain the differences between smart grids and other forms of grids such as: • Conventional • Power grids, • Legacy grids, etc. Explain the advantages of smart grids with IoT over non- IoT smart grids		equipment	• Gateways and routers • Power management equipment	
General Objective 2.0: Understand the design and development of Smart Grid Systems						
4-5	2.1 Explain the design of smart grid systems	Explain the design of smart grid systems	Textbooks Journals Internet			

	2.2 Explain the basic steps for smart grid systems design which include: • Planning and analysis • Design and architecture • System integration • Testing and validation • Deployment and maintenance • Security and risk management • Evaluation and improvement etc.	Explain the basic steps for smart grid systems design which include: • Planning and analysis • Design and architecture • System integration • Testing and validation • Deployment and maintenance • Security and risk management • Evaluation and improvement etc.	Computer Projector White board Marker Animation			
	2.3 Explain the development of IoT applications for smart grid	Explain the development of IoT applications for smart grid				
	2.4 Explain the development of smart grid systems including: • Requirements	Explain the development of smart grid systems including: • Requirements				

	gathering • Design and Development • Testing and validation • Development and maintenance • Security and risk management • Evaluation and improvement	gathering • Design and Development • Testing and validation • Development and maintenance • Security and risk management • Evaluation and improvement				
General Objective 3.0: Know the development of IoT applications for smart grids						
6-8	3.1Enumerate the software components needed in the development of applications for Smart Grid. 3.2 Explain the use of relevant Software needed in the development of applications for Smart Grids: • Python • Java • C++, etc. 3.3 List the hardware components needed in the development of applications	Explain the software components needed in the development of applications for smart grid. Explain the use of relevant Software needed in the development of applications for smart grids namely: • Python • Java • C++, etc. List the hardware	Textbooks Journals Internet Computer Projector White board Marker Animation	Demonstrate the use of relevant Software needed in the development of applications for smart grids. Identify the hardware components needed in the development of applications for smart grid under the category: • Sensors and actuators • Communication	Guide students to: Demonstrate the use of relevant Software needed in the development of applications for smart grids. Identify the hardware components needed in the development of applications for smart grid under	MATLAB Simulink VS code LabView Gateway RS485 Ethernet cables Local server Smart

	for Smart Grid: • Sensors and actuators • Communication devices • Computing devices • Energy storage and generation devices • Power electronics devices • Network devices, etc. .	components needed in the development of applications for Smart Grids: • Sensors and actuators • Communication devices • Computing devices • Energy storage and generation devices • Power electronics devices • Network devices, etc.		devices • Computing devices • Energy storage and generation devices • Power electronics devices • Network devices, etc.	the category: • Sensors and actuators • Communication devices • Computing devices • Energy storage and generation devices • Power electronics devices • Network devices, etc.	meter Smart grid model Spreadsheet Battery Solar panels Wind turbine model
General Objective 4.0: Understand the modelling and simulation of IoT solutions to Smart Grid problems.						
9-11	4.1 Enumerate problems associated with smart grids in terms of: • Demand response • Grid stability, • Energy efficiency etc.	Enumerate problems associated with smart grids in terms of: • Demand response • Grid stability, • Energy efficiency etc.	Textbooks Journals Internet Computer Projector White board Marker Animation			

	4.2 Explain the objectives of the IoT solutions in terms of: • Energy reduction & consumption • Improving grid reliability, etc. 4.3 Explain the performance indicators (KPIs) of Smart Grids & IoT systems indicating measurement of: • Energy efficiency • Stability • Cost savings, etc.	Explain the objectives of the IoT solutions in terms of: • Energy reduction & consumption • Improving grid reliability, etc. Explain the performance indicators (KPIs) of Smart Grids & IoT systems indicating measurement of: • Energy efficiency • Stability • Cost savings, etc.				
General Objective 5.0: Know the equipment used in smart grid & IoT applications						
12-15	5.1 Explain the use of smart grid equipment such as: • Smart meters • Grid management systems • Energy storage systems,	Explain the use of smart grid equipment such as: • Smart meters • Grid management systems • Energy storage	Textbooks Journals Internet Computer Projector White board Marker Animation	Demonstrate the use of smart grid equipment such as: • Smart meters • Grid management systems	Guide students to: Demonstrate the use of smart grid equipment such as: • smart meters • Grid	Smart meters Sensors Actuators, Gateways Communic

	• Renewable energy systems, etc. 5.2 Enumerate IoT equipment such as: • Sensors • Actuators, • Gateways • Communication modules 5.3 Explain the benefits of Smart Grid and IoT applications in Solar Thermal Systems 5.4 Explain the challenges of Smart Grid and IoT applications in Solar Thermal Systems	systems, • Renewable energy systems, etc. Explain IoT equipment such as: • Sensors • Actuators, • Gateways • Communication modules Explain the benefits of Smart Grid and IoT applications in Solar Thermal Systems Explain the challenges of Smart Grid and IoT applications in Solar Thermal Systems		• Energy storage systems, • Renewable energy systems etc. Identify IoT equipment such as: • Sensors • Actuators, • Gateways • Communication modules Demonstrate the use of IoT equipment	management systems • Energy storage systems, • Renewable energy systems etc. Identify IoT equipment such as: • Sensors • Actuators, • Gateways • Communication modules Demonstrate the use of IoT equipment	ation modules Energy storage equipment Inverters Rectifiers Circuit breakers Switch gears Switches Routers Servers
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Thermal Project Management and Tendering Process

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Thermal Project Management and Tendering Process	Course Code: STE 327	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: I Semester: II	Pre-requisite:	Practical: 1 Hour/week
GOAL: This course is designed to equip students with the knowledge and skills required to manage thermal energy projects, tendering and procurement processes.		
GENERAL OBJECTIVES: 1.0 Understand project management in developing solar thermal and hybrid systems 2.0 Know the tools and techniques used in project management for planning and management of thermal energy projects 3.0 Understand project documentation, feasibility studies and close-out reports 4.0 Know tendering processes 5.0 Understand procurement and contract management.		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY					
COURSE TITLE: Thermal Project Management and Tendering Process	**COURSE CODE**: STE 327			Contact Hours: 2	
	Credit Unit: 2			Theoretical: 1	
Year: I Semester: 2	Pre-requisite:			Practical: 1	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL					
GOAL: This course is designed to equip students with the knowledge and skills required to manage thermal energy projects, tendering and procurement processes.					
GENERAL OBJECTIVE 1.0: Understand project management in developing solar thermal and hybrid systems					
THEORETICAL CONTENT				PRACTICAL CONTENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-2	1.1 Define project management 1.2 Explain its importance in engineering and energy sectors. 1.3 List the characteristics of project management	Explain project management Explain its importance in engineering and energy sectors. Explain the	Textbooks Journals Internet Computer Projector White Board Marker			

	1.4 Explain the importance of project management in the thermal energy industry 1.5 Explain the five major stages of project management 1.6 Explain the roles of project management in real-world thermal projects • Initiation • Planning • Execution • Monitoring and control • Closure 1.7 Explain the benefits of project management in thermal energy projects • Key project roles • Stakeholders	characteristics of project management Explain the importance of project management in the thermal energy industry Explain the five major stages of project management Explain the roles of project management in real-world thermal projects • Initiation • Planning • Execution • Monitoring and control • Closure Explain the benefits of project management in thermal energy	Animations Charts			

		projects • Key project roles • Stakeholders				
General Objective 2.0: Know the tools and techniques used in project management for planning and management of thermal energy projects						
3-5	2.1 Describe project planning tools and their relevance in thermal energy projects 2.2 Define Work Breakdown Structure (WBS) 2.3 Explain Linking of WBS to responsibilities and costing 2.4 List the type of tools used in project management such as: • Resource planning and budgeting tools • Project monitoring and control techniques • Progress reporting 2.5 Explain the software tools	Explain project planning tools and their relevance in thermal energy projects Explain Work Breakdown Structure (WBS) Explain Linking of WBS to responsibilities and costing Explain the type of tools used in project management such as: • Resource planning and budgeting tools	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Create a Gantt chart for a small thermal project using any thermal energy source (preferably solar thermal) (Group Work) Develop a work breakdown structure (WBS) using any relevant software and assign tasks/responsibilities, resources and specify timelines,	Guide the student to: Create a Gantt chart for a small thermal project using any thermal energy source (preferably solar thermal) (Group Work) Develop a work breakdown structure (WBS) using any relevant software and assign tasks/responsibilities, resources and specify timelines Create sample progress report Present sample	Relevant software: (Microsoft Excel, Microsoft Project)

	used in project management • Microsoft Excel • Microsoft Project	• Project monitoring and control techniques • Progress reporting Explain the software tools used in project management • Microsoft Excel • Microsoft Project		Create sample progress report Present sample progress report	progress report	
General Objective 3.0: Understand project documentation, feasibility studies and close-out reports						
6-8	3.1 Explain the importance of proper documentation in thermal projects 3.2 Describe the structure and key components of a feasibility study • Executive summary • Project description • Technical assessment • Financial analysis • Environmental and social impacts	Explain the importance of proper documentation in thermal project Explain the structure and key components of a feasibility study • Executive summary • Project description • Technical	Textbooks Journals Internet Computer Projector White Board Marker Animations			

	• Conclusion and recommendation 3.3 Explain technical proposals, its structures and components for a thermal energy system • Objective and Scope • Technical approach • Implementation plan and schedule • Cost estimate 3.4 Explain the stages of reporting and their impact in thermal projects • Progress reports • Project Close-out report	assessment • Financial analysis • Environmental and social impacts • Conclusion and recommendation Explain technical proposals, its structures and components for a thermal energy system • Objective and Scope • Technical approach • Implementation plan and schedule • Cost estimate Explain the stages of reporting and their impact in thermal	Charts			

		projects • Progress reports • Project Close-out report				
General Objective 4.0: Know tendering processes						
9-11	4.1 Define a tender 4.2 Explain tendering process 4.3 Explain the importance of tendering in private and public sectors 4.4 List types of tendering 4.5 List Parties involved in tendering process and their responsibilities 4.6 Explain the steps in the tendering process • Expression of interest (EOI) • Prequalification of contractors/suppliers • Invitation to tender (ITT) • Document preparation	Explain tendering process Explain the importance of tendering in private and public sectors Explain types of tendering Explain Parties involved and their responsibilities Explain the steps in the tendering process • Expression of interest (EOI) • Prequalification of contractors/su	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Prepare a tender document Evaluate a tender document	Assign students into groups Guide groups to: Prepare a tender document Evaluate a tender document	Sample tender documents

	and issuance • Bid submission 4.7 Explain: • Bid document • Evaluation processes of the bid document • Contract awarding and notification of stakeholders. 4.7 Explain the ethics and legal considerations in thermal systems contract bidding	ppliers • Invitation to tender (ITT) • Document preparation and issuance Explain: • Bid document • Evaluation processes of the bid document • Contract awarding and notification of stakeholders. Explain the ethics and legal considerations in thermal systems contract bidding				
General Objective 5.0: Understand procurement and contract management.						
12-15	5.1 Define procurement 5.2 Explain its purpose in project delivery	Explain procurement Explain its purpose in project delivery	Textbooks Journals Internet Computer			

	5.3 List types of procurement e.g.: • Goods • Consultancy • Services etc. 5.4 Explain the Lifecycle of procurement: • Planning • Sourcing • Purchase request • Purchase order etc. 5.5 Explain the methods of procurement • Open competitive bidding • Restricted/selective tendering • Direct procurement 5.6 Explain contract management in thermal projects • Types of contracts • Contract Key Elements • Monitoring	Explain types of procurement e.g.: • Goods • Consultancy • Services etc. Explain the Lifecycle of procurement: • Planning • Sourcing • Purchase request • Purchase order etc. Explain the methods of procurement • Open competitive bidding • Restricted/selective tendering • Direct procurement Explain contract management in	Projector White Board Marker Animations Charts			

	performance and compliance 5.7 Explain the ethical procurement practices, legal considerations of documentation and managing records 5.8 Explain the importance of documentation and managing records	thermal projects • Types of contracts • Contract Key Elements • Monitoring performance and compliance Explain the ethical procurement practices, legal considerations of documentation and managing records Explain the importance of documentation and managing records				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

YEAR II SEMESTER I

Solar Thermal Heating and Cooling Technologies

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Thermal Heating and Cooling Technologies	**COURSE CODE**: STE 411	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: II **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 2
GOAL: This course is designed to acquaint students with the knowledge and skills in solar thermal heating and cooling technologies		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the concept of solar thermal heating and cooling 2.0 Know the components of solar thermal systems for heating and cooling 3.0 Know the principle of operation of solar heating and cooling systems 4.0 Know design consideration in development of solar heating and cooling systems		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Thermal Heating and Cooling Technologies	**COURSE CODE**: STE 411	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: II **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to Acquaint students with the knowledge and skills in solar thermal heating and cooling technologies		
GENERAL OBJECTIVE 1.0: Know the concept of solar thermal heating and cooling		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1-3	1.1 Explain the following: • Solar thermal power system • Solar heating • Solar cooling 1.2 Explain the following Technologies: • Passive and active Solar heating • Passive and Active	Explain the following: • Solar thermal power system • Solar heating • Solar cooling Explain the following Technologies: • Passive and active Solar heating	Textbooks Journals Internet Computer Projector White Board Marker	Identify passive and active thermal systems Demonstrate how heating and cooling systems work	Guide students to: Identify passive and active thermal systems Demonstrate how heating and cooling systems work	Solar thermal heating models equipped with sensors/meters Solar thermal cooling models equipped with sensors/meters

	Solar cooling 1.3 Explain the types of technologies for solar thermal heating • Unglazed solar collector • Glazed solar air collector • Flat plate solar collector • Evacuated tube solar collector • Concentrating solar collector 1.4 Explain the types of technologies for solar thermal cooling • Vapour compression • Sorption based cooling (absorption and adsorption chilling) • Evaporative	• Passive and Active Solar cooling Explain the types of technologies for solar thermal heating • Unglazed solar collector • Glazed solar air collector • Flat plate solar collector • Evacuated tube solar collector • Concentrating solar collector Explain the types of technologies for solar thermal cooling • Vapour compression • Sorption based cooling (absorption and	Animations Charts	Identify the properties of solar thermal collector components	Identify the properties of solar thermal collector components	

	cooling • Solar ejectors	adsorption chilling) • Evaporative cooling • Solar ejectors				
GENERAL OBJECTIVE 2.0: Know the components of solar thermal systems for heating and cooling						
4-6	2.1 Explain the working principles of the following components: • Solar Collector (Flat plate, Evacuated tube and concentrating Collector) • Heat exchanger • Chiller • Cooling tower • Thermal storage • Absorber • Generator • Direct expansion system • Fan (blower)	Explain the working principles of the following components: • Solar Collector (Flat plate, Evacuated tube and concentrating Collector) • Heat exchanger • Chiller • Cooling tower • Thermal storage • Absorber • Generator	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Visit a nearby industry to Identify components of solar thermal heating and cooling systems Demonstrate assembling of components of solar thermal heating and cooling systems Measure temperature and pressure at different levels of the solar thermal system	Guide students to: Visit a nearby industry to Identify components of solar thermal heating and cooling systems Demonstrate assembling of components of solar thermal heating and cooling systems Measure temperature different levels on the solar thermal	Solar collectors Heat exchanger chiller Heat transfer medium Thermal storage material Thermometers Heat pump Samples of: • Ammonia • Zeolite

	• Heat pump 2.2 List the properties of the following liquids and adsorbents used in sorption-based cooling: • Ammonia • Lithium-Bromide • Lithium-Chloride • Zeolite • Silica gel • Activated carbon • Calcium-chloride 2.3 Explain the selection criteria for liquids and adsorbents in sorption based solar	• Direct expansion system • Fan (blower) • Heat pump Explain the properties of the following liquids and adsorbents used in sorption-based cooling: • Ammonia • Lithium-Bromide • Lithium-Chloride • Zeolite • Silica gel • Activated carbon • Calcium-chloride Explain the selection criteria for liquids and adsorbents in			system components	• Silica gel • Activated carbon • Calcium-chloride

	thermal cooling systems 2.4 Explain the applications of liquids and adsorbents in sorption based solar thermal cooling systems	sorption based solar thermal cooling systems Explain the applications of liquids and adsorbents in sorption based solar thermal cooling systems				
GENERAL OBJECTIVE 3.0: Know the principle of operation of solar heating and cooling systems						
7-10	3.1 Explain the principle of operation of the following systems: • Solar air heater • Solar wall • Trombe wall • Hydronic heating and cooling • Solar Mechanical cooling • Absorption cooling • Hybrid cooling with evacuated tubes and concentrating solar	Explain the principle of operation of the following systems: • Solar air heater • Solarwall • Trombe wall • Hydronic heating and cooling • Solar Mechanical cooling • Absorption	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Demonstrate the maintenance procedure of Solar thermal Dryer	Guide students to: Demonstrate the maintenance procedure of Solar thermal Dryer	Solar thermal dryer

	collectors 3.2 Explain the applications of the following solar thermal heating and cooling systems: • Refrigeration • Air-conditioning • Process cooling • Dehydration processes • Drying • Pasteurization process 3.3 Explain the maintenance procedure of Solar thermal heating and cooling systems	cooling • Hybrid cooling with evacuated tubes and concentrating solar collectors Explain the applications of the following solar thermal heating and cooling systems: • Refrigeration • Air-conditioning • Process cooling • Dehydration processes • Drying • Pasteurization process Explain the maintenance procedure of Solar thermal heating				

		and cooling systems				
GENERAL OBJECTIVE 4.0: Know design consideration in development of solar heating and cooling systems						
11-14	4.1 Explain the load calculations and Analysis of a Solar Thermal heating and cooling systems: ● Assessment of site solar radiation ● Estimation of Heating/cooling loads 4.2 Explain system sizing and configuration: ● Estimation of heating/cooling size and capacity ● Solar collector sizing, orientation and materials ● Selection of chiller and working fluid ● Estimation of heat rejection capacity ● Thermal storage design analysis	Explain the load calculations and Analysis of a Solar Thermal heating and cooling systems: ● Assessment of site solar radiation ● Estimation of Heating/cooling loads Explain system sizing and configuration: ● Estimation of heating/cooling size and capacity ● Solar collector sizing, orientation and materials ● Selection of chiller and	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Apply design guidelines in development of solar thermal systems for heating and cooling Select components of the design using standard product charts and manuals Produce layout drawing using standard design software Demonstrate the use of PsyCalc Software	Guide the students to: Apply design guidelines in development of solar thermal systems for heating and cooling Select components of the design using standard product charts and manuals Produce layout drawing using standard design software Demonstrate the use of PsyCalc Software	Solar thermal design software AutoCAD Solid works Manufacturers manual and charts Psychrometric chart ASHRAE Psychrometric chart App PsyCalc

	4.3 Explain component selection and integration	working fluid • Estimation of heat rejection capacity • Thermal storage design analysis Explain component selection and integration				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Modelling and Simulation of Solar Thermal Systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Modelling and Simulation of Solar Thermal Systems	**COURSE CODE**: STE 412	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: II **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 2
GOAL: This course is designed to acquaint students with knowledge and skills in Modelling and Simulation of Solar Thermal Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the design principles of solar thermal systems 2.0 Know the application of mathematical models to simulate solar thermal systems 3.0 Know the software tools and techniques used for simulating solar thermal systems		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Modelling and Simulation of Solar Thermal Systems	**COURSE CODE**: STE 412	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: II **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to acquaint students with knowledge and skills in Modelling and Simulation of Solar Thermal Systems		
GENERAL OBJECTIVE 1.0: Know the design principles of Solar Thermal System		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1-5	1.1 Explain factors influencing thermal system design: • Geographical location • Climate • Load requirements • System orientation 1.2 Explain the principles of solar thermal system design: • Component Sizing • Placement • Integration of components for	Explain factors influencing thermal system design: • Geographical location • Climate • Load requirements • System orientation Explain the principles of solar thermal system design: • Component Sizing	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Identify the factors influencing solar thermal system design Calculate to determine the appropriate sizing of components like collectors, storage tanks, and heat exchangers based on system demands and design parameters. Design the layout of a basic solar thermal system	Guide students to: Identify the factors influencing solar thermal system design. Calculate to determine the appropriate sizing of components like collectors, storage tanks, and heat exchangers based on system demands and design parameters.	Papers Pen Computer Calculator Sample layout design Relevant design software (AutoCAD)

	better efficiency 1.3 Describe sizing requirements	• Placement • Integration of components for better efficiency Explain sizing requirements			Design the layout of a basic solar thermal system.	
GENERAL OBJECTIVE 2.0: Know the application of mathematical models to simulate solar thermal systems						
6-10	2.1 Explain the basic mathematical models used in solar thermal system simulation 2.2 Explain thermal performance equations used to model solar collectors 2.3 Explain the process of validating simulated data using real-world data	Explain the basic mathematical models used in solar thermal system simulation Explain thermal performance equations used to model solar collectors Explain the process of validating simulated data using real-world data	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Apply thermal performance equations to model solar collectors: • Heat transfer • Energy equations Use mathematical models to calculate the behavior of heat storage systems • Heat losses • Charging/discharging cycle	Guide students to: Apply thermal performance equations to model solar collectors: • Heat transfer • Energy equations Use mathematical models to calculate the behavior of heat storage systems • Heat losses • Charging/discharging cycle	Papers Pen Computer Calculator Thermometer
GENERAL OBJECTIVE 3.0: Know the software tools and techniques used for simulating solar thermal systems						
11-14	3.1 Explain commonly used software for solar thermal system simulation:	Explain commonly used software for solar thermal system simulation such as	Textbooks Journals Internet Computer	Identify commonly used software for solar thermal system simulation	Guide students to: Identify commonly used software for solar thermal system	Papers Pen Computer

	• TRNSYS • MATLAB/Simulink, • Polysun • RETScreen, • OpenSolar, • HOMER, etc. 3.2 Describe the functionalities and capabilities of simulation software. 3.3 Explain input system parameters and environmental data into simulation software 3.4 Explain the simulation and generation of output from the software	• TRNSYS • MATLAB/Simulink, • Polysun • RETScreen, • OpenSolar, • HOMER, etc. Describe the functionalities and capabilities of simulation software. Explain input system parameters and environmental data into simulation software Explain the simulation and generation of output from the software	Projector White Board Marker Animations Charts	Navigate user interface and set up basic simulation models in any available software Input system parameters and environmental data into simulation software Interpret software-generated outputs and simulation graphs	simulation Navigate user interface and set up basic simulation models in any available software Input system parameters and environmental data into simulation software Interpret software-generated outputs and simulation graphs	Calculator Software for simulation • MATLAB/ Simulink, • RETScreen, • OpenSolar,
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Hybrid Thermal Systems and Grid Integration in power generation

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Hybrid Thermal Systems and Grid Integration	Course Code: STE 413	Contact Hours: 3
	Credit Unit: 3	Theoretical: 2
Year: II Semester: I	Pre-requisite:	Practical: 1Hour/week
GOAL: This course is designed to equip students with the knowledge and skill required to integrate Solar Thermal Systems with other renewable energy sources and grid integration.		
GENERAL OBJECTIVES: 1.0 Understand thermal systems and the principles of thermal energy generation 2.0 Understand the renewable sources that can be used for thermal energy generation 3.0 Understand the concept of Hybrid thermal systems and the combination of different sources 4.0 Know the basic requirements and methods for integrating hybrid systems into the electrical grid 5.0 Know hybrid thermal system configurations.		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY					
COURSE TITLE: Hybrid Thermal Systems and Grid Integration	**COURSE CODE**: STE 413		Contact Hours: 3		
	Credit Unit: 3		Theoretical: 2		
Year: II Semester: I	Pre-requisite:		Practical: 1		
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL					
GOAL: This course is designed to equip students with the knowledge and skill required to integrate solar thermal systems with other renewable energy sources and grid integration.					
GENERAL OBJECTIVE 1.0: Understand thermal systems and the principles of thermal energy generation					
THEORETICAL CONTENT				PRACTICAL CONTENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-2	1.1 Define thermal energy and thermal systems 1.2 List types of thermal energy 1.3 Explain the application of thermal energy 1.4 Explain the basic principles of Energy	Explain thermal energy and thermal systems Explain types of thermal energy Explain the application of thermal energy Explain the basic principles of	Textbooks Journals Internet Computer Projector White Board Marker			

	Conversion • First and second laws of thermodynamics	Energy Conversion • First and second laws of thermodynamics	Animations Charts			
General Objective 2.0: Understand the renewable sources that can be used for thermal energy generation						
3-4	2.1 Explain renewable and non-renewable thermal energy sources 2.2 Explain solar thermal systems and technologies 2.3 Explain Wind energy systems for thermal energy generation • Wind-thermal Hybrid systems • Wind driven heat pumps 2.4 Explain Hydroelectric power and its role in thermal energy generation 2.5 Explain Geothermal Energy for direct thermal applications 2.6 Explain Biomass thermal systems	Explain renewable and non-renewable thermal energy sources Explain solar thermal systems and technologies Explain Wind energy systems for thermal energy generation • Wind-thermal Hybrid systems • Wind driven heat pumps Explain Hydroelectric power and its role in thermal energy generation Explain Geothermal Energy for direct thermal applications Explain Biomass thermal systems • Biomass combustion • Advanced biomass	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	• Biomass combustion • Advanced biomass combustion 2.7 Explain the concept of hybrid renewable thermal systems as support or backup. 2.8 Explain thermal energy storage solutions 2.9 Explain performance analysis and optimization in hybrid thermal systems • Measuring and monitoring thermal system efficiency • Emphasis on need to hybridize other renewable energy sources • Cost-benefit analysis of renewable thermal systems	combustion Explain the concept of hybrid renewable thermal systems as support or backup. Explain thermal energy storage solutions Explain performance analysis and optimization in hybrid thermal systems • Measuring and monitoring thermal system efficiency • Emphasis on need to hybridize with other renewable energy sources • Cost-benefit analysis of renewable thermal systems				
General Objective 3.0: Understand the concept of Hybrid thermal systems and the combination of different sources						

5-7	3.1 Define hybrid thermal systems 3.2 Explain the benefits of hybrid thermal systems 3.3 List the types of hybrid thermal systems with emphasis on hydro wind and hydro synergies 3.4 Explain the fundamentals of energy integration • Energy storage for hybrid systems • Energy conversion 3.5 Explain the combination of solar, wind and Hydro systems for Hybrid thermal energy • Solar-Wind hybrid systems • Solar-Hydro hybrid systems • Wind-Hydro Hybrid systems • Combination of all three sources	Explain hybrid thermal systems Explain the benefits of hybrid thermal systems Explain the types of hybrid thermal systems with emphasis on hydro wind and hydro synergies Explain the fundamentals of energy integration • Energy storage for hybrid systems • Energy conversion Explain the combination of solar, wind and Hydro systems for Hybrid thermal energy • Solar-Wind hybrid systems • Solar-Hydro hybrid systems • Wind-Hydro Hybrid systems • Combination of all three sources	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	3.6 Explain the concept of hybrid system control and operation • Control mechanisms in hybrid systems • Smart grid integration 3.7 Explain the economic and environmental considerations, challenges and opportunities in hybrid systems 3.8 Explain the design considerations for Hybrid thermal systems • Sizing and configurations • Hybrid system design and integration	Explain the concept of hybrid system control and operation • Control mechanisms in hybrid systems • Smart grid integration Explain the economic and environmental considerations, challenges and opportunities in hybrid systems Explain the design considerations for Hybrid thermal systems • Sizing and configurations • Hybrid system design and integration				
General Objective 4.0: Know the basic requirements and methods for integrating hybrid systems into the electrical grid						
8-11	4.1 Explain the concept of Grid integration 4.2 Discuss the roles of hybrid systems in grid	Explain the concept of Grid integration Explain the roles of hybrid	Textbooks Journals Internet	Demonstrate setting up a small hybrid system (e.g. Solar+wind) and	Guide students to: Demonstrate setting up a small hybrid system	Existing Solar thermal system model Wind turbine

	integration 4.3 Explain the challenges of grid integration/synchronization 4.4 Explain grid connection requirements for hybrid systems • Technical requirements • Regulatory and standards compliance • Safety protocols and protection mechanisms 4.5 Explain the different methods of integrating hybrid systems into the Grid • Grid tied systems • Inverters and power conversions • Bi-directional power flow (forward and reverse synchronization) 4.6 Explain Grid-Scale	systems in grid integration Explain the challenges of grid integration/synchronization Explain grid connection requirements for hybrid systems • Technical requirements • Regulatory and standards compliance • Safety protocols and protection mechanisms Explain the different methods of integrating hybrid systems into the Grid • Grid tied systems • Inverters and power conversions • Bi-directional power flow (forward and reverse synchronization) Explain Grid-Scale Hybrid system integration • Microgrids • Smart grids	Computer Projector White Board Marker Animations Charts	integrate it with a grid connected inverter. Measure the energy flow between the hybrid system and the grid Monitor the energy flow between the hybrid system and the grid Demonstrate the use of a control software to monitor the performance of a hybrid system Adjust the control software operation to maintain grid stability and desired output (e.g. changing the energy mix based on weather or/and demand)	(e.g. Solar+wind) and integrate it with a grid connected inverter. Measure the energy flow between the hybrid system and the grid Monitor the energy flow between the hybrid system and the grid Demonstrate the use of a control software to monitor the performance of a hybrid system Adjust its operation to maintain grid stability and desired output (e.g. changing the energy mix based	model Pyranometer (To measure solar radiation) Battery storage system Storage tank On-grid inverter Computer Excel SCADA System RETScreen OpenDSS Python for Power System Analysis (PyPSA)

	Hybrid system integration • Microgrids • Smart grids • Hybrid systems 4.7 Explain Energy storage in Hybrid Grid integration 4.8 Explain Grid balancing and demand response • Load balancing/sharing	• Hybrid systems Explain Energy storage in Hybrid Grid integration Explain Grid balancing and demand response • Load balancing/sharing			on weather or/and demand)	
General Objective 5.0: Know hybrid thermal system configurations						
12-14	5.1 Explain hybrid thermal systems 5.2 Explain the role of hybrid thermal systems in sustainable energy 5.3 Explain the synergy between renewable and other thermal energy sources 5.4 Explain energy demands and geographical factors influencing hybrid systems	Explain hybrid thermal systems Explain the role of hybrid thermal systems in sustainable energy Explain the synergy between renewable and other thermal energy sources Explain energy demands and geographical factors influencing hybrid systems	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Demonstrate system sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a given demand profile. Evaluate various hybrid configurations	Guide students to: Demonstrate system sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a given demand profile. Evaluate various hybrid	Real-world data source Sample design Video clips Animations Thermal hybrid plant (site visit if available)

	5.5 Explain Energy demand Assessment for various applications • Load profiling 5.6 Explain system sizing and optimization for solar, wind and hydropower • Energy production calculation • Hybrid system configuration 5.4 Explain system performance and Cost Analysis • Economic considerations • Return on Investment	Explain Energy demand Assessment for various applications • Load profiling Explain system sizing and optimization for solar, wind and hydropower • Energy production calculation • Hybrid system configuration Explain system performance and Cost Analysis • Economic considerations • Return on Investment		for maximum efficiency and cost effectiveness while considering storage systems as backup and/ or compensators.	configurations for maximum efficiency and cost effectiveness while considering storage systems as backup and/ or compensators.	
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Retrofitting & Energy Efficiency Techniques

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Retrofitting & Energy Efficiency Techniques	**COURSE CODE**: STE 414	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: II **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 2
GOAL: This course is designed to equip students with knowledge and skills on Retrofitting and energy-efficiency relating to Solar Energy Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the principles and benefits of retrofitting in solar energy systems 2.0 Know the assessment of existing systems for energy efficiency opportunities 3.0 Understand the concepts and metrics used in measuring energy efficiency 4.0 Know the application of basic retrofitting techniques to improve system performance		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Retrofitting & Energy Efficiency Techniques	**COURSE CODE**: STE 414	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: II **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to equip students with knowledge and skills on Retrofitting and energy-efficiency relating to Solar Energy Systems		
GENERAL OBJECTIVE 1.0: Understand the principles and benefits of retrofitting in solar energy systems		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1-3	1.1 Define retrofitting in the context of solar energy systems 1.2 Explain the underlying principles of retrofitting technologies. • Thermal performance • Energy conservation • Energy optimization 1.3 Explain the benefits of retrofitting for improving energy efficiency and reducing operational costs	Explain retrofitting in the context of solar thermal systems Explain the underlying principles of retrofitting technologies. • Thermal performance • Energy conservation • Energy optimization Discuss the benefits of retrofitting for improving energy efficiency and reducing operational costs	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

GENERAL OBJECTIVE 2.0: Know the assessment of existing systems for energy efficiency opportunities						
4-8	2.1 Explain common components targeted in solar energy system retrofitting and energy efficiency opportunities: • Collectors/panels • Piping/cabling • Insulation • Storage systems • Controls • Heat exchanger, • Inverters, etc. 2.2 Explain different energy efficiency opportunities based on technical feasibility and cost-effectiveness. 2.3 Explain the effectiveness of current energy-saving technologies used in existing systems	Explain common components targeted in solar energy system retrofitting and energy efficiency opportunities: • Collectors/panels • Piping/cabling • Insulation • Storage systems • Controls • Heat exchanger, • Inverters, etc. Discuss different energy efficiency opportunities based on technical feasibility and cost-effectiveness. Explain the effectiveness of current energy-saving technologies used in existing systems	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Identify common components targeted in solar energy system retrofitting and energy efficiency opportunities: • Collectors/panels • Piping/cabling • Insulation • Storage systems • Controls • Heat exchanger, • Inverters, etc. Conduct energy audits to assess system performance and identify opportunities for energy savings.	Guide students to; Identify common components targeted in solar energy system retrofitting and energy efficiency opportunities: • Collectors/panels • Piping/cabling • Insulation • Storage systems • Controls • Heat exchanger, • Inverters, etc. Conduct energy audits to assess system performance and identify opportunities for energy savings.	Pen Papers Data collection templates Multimeter Thermometers Flow meter Power analyzer Computer Data logger Clamp meter

GENERAL OBJECTIVE 3.0: Understand the concepts and metrics used in measuring energy efficiency						
9-11	3.1 Define energy efficiency in sustainable energy management 3.2 Explain metrics used to measure energy efficiency in building and industrial systems: • Energy productivity • Energy intensity • Coefficient of performance, etc. 3.3 Explain the differences between energy intensity and energy productivity as measures of efficiency. 3.4 Describe the role of benchmarking in evaluating and improving energy efficiency performance.	Explain energy efficiency in sustainable energy management Explain metrics used to measure energy efficiency in building and industrial systems: • Energy productivity • Energy intensity • Coefficient of performance, etc. Explain the differences between energy intensity and energy productivity as measures of efficiency. Describe the role of benchmarking in	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

		evaluating and improving energy efficiency performance.				
GENERAL OBJECTIVE 4.0: Know the application of basic retrofitting techniques to improve system performance						
12-15	4.1 Explain the principles of system optimization and how retrofitting contributes to enhanced performance 4.2 Explain the role of insulation and sealing in retrofitting to reduce heat losses in solar thermal systems 4.3 Explain the role of panel re-configuration and inverter upgrade in retrofitting to increase production in solar photovoltaic systems. 4.4 Describe the types of energy-saving equipment used in retrofitting solar energy systems	Explain the principles of system optimization and how retrofitting contributes to enhanced performance Explain the role of insulation and sealing in retrofitting to reduce heat losses in solar thermal systems. Explain the role of panel re-configuration and inverter upgrade in retrofitting to increase production in solar photovoltaic systems. Explain the types of energy-saving equipment used in retrofitting solar energy systems Explain the environmental and	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Conduct an evaluation of existing systems to determine the need for retrofitting Select appropriate methods for improvement of insulation and sealing Select appropriate methods for improvement of energy production in solar photovoltaic systems. Implement measures for optimizing fluid flow and minimizing heat losses during thermal system retrofitting. Implement measures for reducing energy losses during PV system	Guide students to; Conduct an evaluation of existing systems to determine the need for retrofitting Select appropriate methods for improvement of insulation and sealing Select appropriate methods for improvement of energy production in solar photovoltaic systems. Implement measures for optimizing fluid flow and minimizing heat losses during thermal system	Multimeter Power analyzer Solar thermal model Smart controllers Insulation Sealants Heat exchanger Solar panel Inverter Solar charge controller

	4.5 Describe the environmental and economic benefits of retrofitting systems for energy efficiency improvements	economic benefits of retrofitting systems for energy efficiency improvements		retrofitting Apply basic retrofitting techniques such as upgrading insulation, improving heat exchanger efficiency, and integrating smart controllers, inverter upgrade, panel re-configuration, charge controller upgrade to enhance system performance	retrofitting. Implement measures for reducing energy losses during PV system retrofitting Apply basic retrofitting techniques such as upgrading insulation, improving heat exchanger efficiency, and integrating smart controllers, inverter upgrade, panel re-configuration, charge controller upgrade to enhance system performance	
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

MINI – PROJECT ON SOLAR THERMAL SYSTEM

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: MINI – PROJECT ON SOLAR THERMAL SYSTEM	**COURSE CODE**: STE 415	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 0
YEAR: II **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 0
GOAL: This course is designed to acquaint students with knowledge and skills of Mini – project on Solar Thermal System		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Propose a mini project on Solar Thermal System 2.0 Carryout literature survey on Solar Thermal System 3.0 Design a mini–Solar Thermal System 4.0 Construct the Designed Solar Thermal System 5.0 Test run the Model 6.0 Present a report		

YEAR II SEMESTER II

Solar Thermal Policy, Regulation, and Standards

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Thermal Policy, Regulation, and Standards	**COURSE CODE**: STE 421	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 2
YEAR: II **SEMESTER:** II	**PRE-REQUISITE:** NIL	**PRACTICAL:** 0
GOAL: This course is designed to equip students with knowledge of Policy, Regulation and Standards relating to Solar Thermal Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the global and national policy frameworks guiding solar thermal energy development 2.0 Understand the regulatory environment for solar thermal energy systems 3.0 Understand the key standards and codes applicable to the design, installation, commissioning, maintenance and de-commissioning of solar thermal systems 4.0 Understand the role of incentives and fiscal policies in promoting solar thermal adoption 5.0 Understand the environmental and social considerations embedded in solar thermal energy policies 6.0 Understand energy transition in relation to solar thermal technology		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Thermal Policy, Regulation, and Standards	**COURSE CODE**: STE 421	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 2
YEAR: II **SEMESTER:** II	**PRE-REQUISITE:**	**PRACTICAL:** 0
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to equip students with knowledge of Policy, Regulation and Standards relating to Solar Thermal Systems		
GENERAL OBJECTIVE 1.0: Understand the global and national policy frameworks guiding solar thermal energy development		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1-2	1.1 Define Policy, Regulation and Standard 1.2 Explain international agreements and initiatives that support renewable and solar thermal energy: • The Paris Agreement, • SDG 7 (Affordable and Clean Energy) • IRENA's role in promoting solar thermal technologies.	Explain Policy, Regulation and Standard Discuss international agreements and initiatives that support renewable and solar thermal energy: • The Paris Agreement, • SDG 7 (Affordable and Clean Energy) • IRENA's role in promoting solar thermal technologies.	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	1.3 Explain the objectives and scope of national energy policies related to solar thermal energy. E.g., Nigeria's Renewable Energy Master Plan 1.4 Explain the differences between global policy trends and country-specific regulations affecting solar thermal energy adoption	Explain the objectives and scope of national energy policies related to solar thermal energy. E.g., Nigeria's Renewable Energy Master Plan Explain the differences between global policy trends and country-specific regulations affecting solar thermal energy adoption				
GENERAL OBJECTIVE 2.0: Understand the regulatory environment for solar thermal systems						
3-4	2.1 Identify the key regulatory bodies responsible for overseeing solar thermal energy systems: • ECN • NERC • NEMSA • SON 2.2 Explain the permitting	Explain the key regulatory bodies responsible for overseeing solar thermal energy systems: • ECN • NERC • NEMSA • SON Explain the permitting and licensing	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	and licensing requirements for solar thermal project development 2.3 Explain compliance obligations and penalties for violating solar thermal energy regulations	requirements for solar thermal project development Discuss compliance obligations and penalties for violating solar thermal energy regulations				
GENERAL OBJECTIVE 3.0: Understand the key standards and codes applicable to the design, installation, commissioning, maintenance and de-commissioning of solar thermal systems						
5-7	3.1 List international and national standards relevant to solar thermal systems: • ISO 9806 • IEC 62862 • NESIS 3.2 Explain the purpose and application of design and safety standards in solar thermal systems 3.3 Explain various codes of practice related to the installation and	Explain international and national standards relevant to solar thermal systems: • ISO 9806 • IEC 62862 • NESIS Explain the purpose and application of design and safety standards in solar thermal systems Explain various codes of practice related to the installation and	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	maintenance of solar thermal equipment	maintenance of solar thermal equipment				
GENERAL OBJECTIVE 4.0: Understand the role of incentives and fiscal policies in promoting solar thermal adoption						
8-10	4.1 List types of financial incentives available for solar thermal energy projects: • Tax credits • Grants • Rebates • low-interest loans • Feed-in tariffs 4.2 Explain fiscal policies influencing investment and consumer adoption of solar thermal technologies: • VAT exemptions • Import duty reductions • Government subsidies 4.3 Explain the effectiveness of selected incentive	Explain types of financial incentives available for solar thermal energy projects: • Tax credits • Grants • Rebates • low-interest loans • Feed-in tariffs Explain fiscal policies influencing investment and consumer adoption of solar thermal technologies: • VAT exemptions • Import duty reductions • Government subsidies Discuss the effectiveness of selected incentive	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	programs in accelerating solar thermal deployment	programs in accelerating solar thermal deployment				
GENERAL OBJECTIVE 5.0: Understand the environmental and social considerations embedded in solar thermal energy policies						
11-12	5.1 Describe the environmental impacts addressed by solar thermal energy policies: • Reduce greenhouse gas emissions • Conserve water resources • Minimize ecological disruption, etc. 5.2 Explain the social benefits of integrating solar thermal technologies into energy policy e.g.: • Job creation • Energy access in rural communities • Public health improvements.	Explain the environmental impacts addressed by solar thermal energy policies: • Reduce greenhouse gas emissions • Conserve water resources • Minimize ecological disruption, etc. Explain the social benefits of integrating solar thermal technologies into energy policy e.g.: • Job creation • Energy access in rural communities	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

		• Public health improvements.				
	5.3 Explain policy measures that promote equity and inclusiveness in solar thermal energy access	Explain policy measures that promote equity and inclusiveness in solar thermal energy access				
GENERAL OBJECTIVE 6.0 - Understand Energy Transition as it relates to solar thermal technology						
13-15	6.1 Define the concept of energy transition in the context of global energy systems 6.2Explain the role of solar thermal technology in facilitating a low-carbon future 6.3 Explain national and international drivers of energy transition policies such as: • Net-zero targets • SDGs • Paris Agreement 6.4 Describe the challenges	Explain the concept of energy transition in the context of global energy systems Explain the role of solar thermal technology in facilitating a low-carbon future Discuss national and international drivers of energy transition policies such as: • Net-zero targets • SDGs • Paris Agreement Explain the challenges	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	and opportunities for solar thermal adoption within energy transition strategies	and opportunities for solar thermal adoption within energy transition strategies				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Maintenance of Solar Thermal Systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Maintenance of Solar Thermal Systems	Course Code: STE 422	Contact Hours: 3
	Credit Unit: 3	Theoretical: 2
Year: II Semester: II	Pre-requisite: Nil	Practical: 1 Hour/week
GOAL: This course is designed to equip students with knowledge and skills in the maintenance of Solar Thermal Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the procedures of carrying out routine maintenance 2.0 Know the safety rules and regulations of the Solar Thermal System 3.0 Know the optimal performance of the system 4.0 Know the equipment to be used in carrying out Solar Thermal System maintenance		

PROGRAMME HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY						
COURSE TITLE: Maintenance of Solar Thermal Systems		**COURSE CODE**: STE 422		Contact Hours: 3		
		Credit Unit: 3		Theoretical: 1		
Year: II Semester: II		Pre-requisite: Nil		Practical: 2		
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills in the maintenance of solar thermal systems						
GENERAL OBJECTIVE 1.0: Know the procedures of carrying out routine maintenance						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain common issues associated with Solar Thermal Systems: ● Scaling ● Corrosion ● Leaks and fluid loss ● Control system issues ● Degradation of insulation materials, etc. 1.2 Define Maintenance	Explain common issues associated with Solar Thermal Systems: ● Scaling ● Corrosion ● Leaks and fluid loss ● Control system issues ● Degradation of insulation	Textbooks Journals Internet Computer Projector White Board Marker Animations	Illustrate the maintenance in 1.3 Identify common issues associated with Solar Thermal Systems: ● Scaling ● Corrosion ● Leaks and fluid loss ● Control system issues	Guide students to: Illustrate the maintenance in 1.3 Identify common issues associated with Solar Thermal Systems: ● Scaling	Toolbox Inspection light Multimeter PPE Solar thermal system models

	1.3 Explain the maintenance of Solar Thermal Systems: • Predictive • Condition -based • Preventive • Corrective • Reactive/Breakdown, etc. 1.4 Explain the benefits and drawbacks of types of solar thermal systems maintenance	materials, etc. Explain Maintenance Explain the maintenance of Solar Thermal Systems: • Predictive • Condition -based • Preventive • Corrective • Reactive/Breakdown, etc. Explain the benefits and drawbacks of types of solar thermal systems maintenance		• Degradation of insulation materials Carryout maintenance on a typical solar thermal system	• Corrosion • Leaks and fluid loss • Control system issues Carryout maintenance on a typical solar thermal system	
General Objective 2.0: Know the safety rules and regulations of the Solar Thermal System						
4-6	2.1 Define hazards in solar thermal systems 2.2 Explain potential hazards with respect to solar thermal systems, 2.3 Define accident in a solar plant 2.4 Explain accident in relation to hazards and	Explain hazards in solar thermal systems Explain potential hazards with respect to solar thermal systems, Explain accident in a solar plant Explain accident in relation to hazards and	Textbooks Journals Internet Computer Projector White Board Marker Animations	Identify potential hazards with respect to solar thermal systems Demonstrate the safety measures to be taken when working on solar thermal systems Illustrate the use of safety kits and gadgets	Guide students to: Identify potential hazards with respect to solar thermal systems Demonstrate the safety measures to be taken when	First Aid kit PPE Toolbox

	potential hazards in solar thermal plants 2.5 Define safety in solar thermal systems 2.6 Explain the safety measures to be taken when working on solar thermal systems 2.7 Explain the safety kits and gadgets needed when working in solar thermal plants. 2.8 Define first aid with respect to solar thermal systems	potential hazards in solar thermal plants Explain safety in solar thermal systems Explain the safety measures to be taken when working on solar thermal systems Explain the safety kits and gadgets needed when working in solar thermal plants. Explain first aid with respect to solar thermal systems		in a solar thermal plant. Illustrate first aid measures to be taken when an accident occurs in a solar thermal plant.	working on solar thermal systems Illustrate the use of safety kits and gadgets in a solar thermal plant. Illustrate first aid measures to be taken when an accident occurs in a solar thermal plant	
General Objective 3.0: Know the optimal performance of the Solar Thermal System						
7-9	3.1 Define optimal performance 3.2 Explain optimal performance of a solar thermal system with examples 3.3 Explain the operating conditions of solar thermal	Explain optimal performance Explain optimal performance of a solar thermal system with examples Explain the operating conditions of solar	Textbooks Journals Internet Computer Projector White Board Marker Animations	Illustrate the operating conditions of solar thermal systems with emphasis on the following parameters: • Energy intake • Solar irradiance • System temperature • System pressure	Guide students to: Illustrate the operating conditions of solar thermal systems with emphasis on the following	Pyranometer Pyrheliometer Multimeter Thermometer Pressure gauge Pressure sensor

	systems with emphasis on the following parameters: • Energy intake • Solar irradiance • System temperature • System pressure • Energy output • Efficiency 3.4 Define benchmarking with emphasis on: • Comparison with similar systems • Industrial standards 3.5 Explain the optimization techniques of solar thermal systems taking into cognizance: • Adjustment of system settings • Upgrading system components • Implementation of modern technologies	thermal systems with emphasis on the following parameters: • Energy intake • Solar irradiance • System temperature • System pressure • Energy output • Efficiency Explain benchmarking with emphasis on: • Comparison with similar systems • Industrial standards Explain the optimization techniques of solar thermal systems taking into cognizance: • Adjustment of system settings • Upgrading system components • Implementation		• Energy output • Efficiency Demonstrate benchmarking using simulation software for: • Comparison with similar systems • Industrial standards Demonstrate the optimization techniques of solar thermal systems taking into cognizance: • Adjustment of system settings • Upgrading system components • Implementation of modern technologies	parameters: • Energy intake • Solar irradiance • System temperature • System pressure • Energy output • Efficiency Demonstrate benchmarking using simulation software for: • Comparison with similar systems • Industrial standards Demonstrate the optimization techniques of solar thermal systems taking into cognizance: • Adjustment of	Actuators Valves Flow meters Stop watch Storage tank RETScreen

		of modern technologies			• system settings • Upgrading system components • Implementation of modern technologies	
General Objective 4.0: Know the equipment used in carrying out solar thermal system maintenance						
10-13	4.1Enumerate the various equipment used in carrying out maintenance in solar thermal systems 4.2 Explain the classification of equipment used in solar thermal system maintenance in the following category: • Inspection and testing • Cleaning and flushing • Repair and replacement • Safety • Specialized equipment 4.3 Explain the use of the various equipment/devices in	Explain the various equipment used in carrying out maintenance in solar thermal systems Explain the classification of equipment used in solar thermal system maintenance the following category: • Inspection and testing • Cleaning and flushing • Repair and replacement • Safety • Specialized equipment Explain the use of the	Textbooks Journals Internet Computer Projector White Board Marker Animations	Identify the various equipment used in carrying out maintenance in solar thermal systems Classify equipment used in solar thermal system maintenance in the following category: • Inspection and testing • Cleaning and flushing • Repair and replacement • Safety • Specialized	Guide students to: Identify the various equipment used in carrying out maintenance in solar thermal systems Classify equipment used in solar thermal system maintenance the following category: • Inspection and	Pyranometer Pyrheliometer Multimeter Thermometer Pressure gauge Pressure sensor Actuators Valves Flow meters Brush Blower Stop watch

	each category in 4.2	various equipment/devices in each category in 4.2		equipment Demonstrate the use of the various equipment/devices in each category in 4.2	testing • Cleaning and flushing • Repair and replacement • Safety • Specialized equipment Demonstrate the use of the various equipment/devices in each category in 4.2	Storage tank
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Energy Efficiency and Demand Side Management (DSM)

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Energy Efficiency and Demand Side Management (DSM)	**COURSE CODE**: STE 423	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: II **SEMESTER:** II	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
GOAL: This course is designed to equip students with knowledge and skills on Energy-efficiency and Demand Side Management (DSM) relating to Solar energy Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the principles and procedures of Demand Side Management (DSM) 2.0 Know Energy Auditing 3.0 Know DSM techniques and Energy Efficiency strategies.		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY						
COURSE TITLE: Energy efficiency and Demand Side Management (DSM)		**COURSE CODE**: STE 423		**CONTACT HOURS:** 2		
		CREDIT UNIT: 2		**THEORETICAL**: 1		
YEAR: II **SEMESTER:** II		**PRE-REQUISITE:**		**PRACTICAL:** 1		
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills on Energy-efficiency and Demand Side Management (DSM) relating to solar energy systems						
General Objective 1.0 – Understand the principles and procedures of Demand Side Management (DSM)						
1-5	1.1 Define Demand Side Management (DSM) 1.2 Explain the role of DSM in enhancing energy efficiency. 1.3 Explain the benefits of DSM	Explain Demand Side Management (DSM) Explain the role of DSM in enhancing energy efficiency. Explain the benefits of DSM	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			
General Objective 2.0 Know Energy Auditing						
6-10	2.1 Define Energy Auditing concept 2.2 Explain Energy Auditing tools and techniques: • Pre audit data collection	Define Energy Auditing concept Explain Energy Auditing tools and techniques: • Pre audit data collection • Site visit	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Visit Site for data collection	Guide students to visit Site for data collection	Spreadsheet MS Excel Pen Paper Energy meter Multimeter Data collection template Data logger

	• Site visit • Energy data analysis • Energy Audit Report, etc. 2.3 Explain the benefits of Energy Auditing 2.4 Explain energy optimization techniques	• Energy data analysis • Energy Audit Report, etc. Explain the benefits of Energy Auditing Explain energy optimization techniques				Power analyser RETScreen
General Objective 3.0 Know DSM techniques and Energy Efficiency strategies.						
11-15	3.1 Explain types of DSM strategies: • Load shifting, • Peak shaving, and • Energy conservation, etc. 3.2 Describe the principles of how DSM can be integrated into solar energy systems to optimize energy use 3.3 Explain energy consumption patterns to	Explain types of DSM strategies: • Load shifting, • Peak shaving, and • Energy conservation, etc. Explain the principles of how DSM can be integrated into solar energy systems to optimize energy use Explain energy consumption patterns to	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Illustrate DSM strategies that include Solar Energy System integration for optimal energy usage. Demonstrate load-shifting and peak-shaving techniques in the operation of solar energy systems to improve energy consumption efficiency. Conduct cost-benefit analyses of DSM measures to evaluate their	Guide students to: Illustrate DSM strategies that include Solar Energy System integration for optimal energy usage. Demonstrate load-shifting and peak-shaving techniques in the operation of solar energy systems to improve energy consumption	Power analyzers Energy meter Data logger Multimeters Software • Homer • PVsyst • Energyplus • Odyssey Solar PV System training kit

	identify opportunities for DSM implementation in different types of buildings or industries.	identify opportunities for DSM implementation in different types of buildings or industries.		effectiveness and propose improvements based on performance outcomes Use energy management software tool like Energyplus or Homer to monitor and manage DSM activities effectively	efficiency. Conduct cost-benefit analyses of DSM measures to evaluate their effectiveness and propose improvements based on performance outcomes Use energy management software tool like Energyplus or Homer to monitor and manage DSM activities effectively	Solar thermal System training kit Energy efficient appliances
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Engineering ethics and professional practice

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY		
COURSE TITLE: Engineering ethics and professional practice	**COURSE CODE**: STE 424	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 2
YEAR: II **SEMESTER:** II	**PRE-REQUISITE:** NIL	**PRACTICAL:** Nil
GOAL: The Course is designed to acquaint the students with the knowledge of engineering ethics and professional practice		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the basic concepts of engineering ethics 2.0 Understand the principles of ethics in Renewable energy 3.0 Understand social impacts of Renewable energy 4.0 Understand environmental impacts of Renewable energy 5.0 Understand professional practice in solar energy projects		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY					
COURSE TITLE: Engineering ethics and professional practice		**COURSE CODE**: STE 424		Contact Hours: 2	
		Credit Unit: 2		Theoretical: 2	
Year: II Semester: II		Pre-requisite: NIL		Practical: Nil	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL					
GOAL: The Course is designed to acquaint the students with the knowledge of engineering ethics and professional practice					
GENERAL OBJECTIVE 1.0: Understand the basic concepts of engineering ethics					
THEORETICAL CONTENT				PRACTICAL CONTENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-2	1.1 Define ethics 1.2 Define professional practice 1.3 Explain the role of engineers in society. 1.4 Explain the importance of ethical decision-making.	Discuss ethics Discuss professional practice Explain the role of engineers in society. Explain the importance of ethical decision-making.	Textbooks, Lecture notes, related journals and materials and internet Whiteboard Marker			

General Objective 2.0: Understand the principles of ethics in Renewable energy						
3-5	2.1 Explain theories related to ethics (Utilitarianism, deontology, and virtue ethics) 2.2 Explain the concept of justice and fairness. 2.3 Explain professional codes of conduct relevant to renewable energy. 2.4 Explain concept of ethical decision-making.	Explain theories related to ethics (Utilitarianism, deontology, and virtue ethics) Explain the concept of justice and fairness. Explain professional codes of conduct relevant to renewable energy. Explain concept of ethical decision-making.	Textbooks, Lecture notes, related journals and materials and internet Whiteboard Marker			
General Objective 3.0: Understand social impacts of Renewable Energy						
6-9	3.1 Explain the Social impact of access to energy. 3.2 Explain the social impact of renewable energy on communities.	Explain the Social impact of access to energy. Explain the social impact of renewable energy on communities.	Textbooks, Lecture notes, related journals and materials and internet Whiteboard Marker			

	3.3 Explain the ethical implications of energy pricing and subsidies. 3.4 Explain safety issues in Renewable energy projects	Explain the ethical implications of energy pricing and subsidies. Explain safety issues in Renewable energy projects				
General Objective 4.0: Understand environmental impacts of Renewable Energy						
10-12	4.1 Explain ethics of resource use and depletion. 4.2 Explain the concept of environmental impact assessment and mitigation. 4.3 Explain the role of renewable energy in addressing climate change. 4.4 Explain the environmental impacts of Renewable and non-Renewable Energy projects.	Explain ethics of resource use and depletion. Explain the concept of environmental impact assessment and mitigation. Explain the role of renewable energy in addressing climate change. Explain the environmental impacts of Renewable and non-	Textbooks, Lecture notes, related journals and materials and internet Whiteboard Marker			

	4.5 Explain the social challenges of Renewable and non-Renewable energy production.	Renewable Energy projects. Explain the social challenges of Renewable and non-Renewable energy production.				
General Objective 5.0: Understand professional practice in solar projects						
13-15	5.1 Explain engineer's responsibility (concerning solar energy projects) to the public. 5.2 Explain the concepts of confidentiality, conflicts of interest, and whistleblowing. 5.3 Explain the role of engineers in promoting sustainable practices. 5.4 Explain some ethical dilemmas in solar energy projects.	Explain engineer's responsibility (concerning solar energy projects) to the public. Explain the concepts of confidentiality, conflicts of interest, and whistleblowing. Explain the role of engineers in promoting sustainable practices. Explain some ethical dilemmas in solar energy projects.	Textbooks, Lecture notes, related journals and materials and internet Whiteboard Marker			
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

PRACTICAL MANUAL FOR HND SOLAR THERMAL

S/N	COURSE TITLE / CODE	PRACTICALS
1.	Fundamentals of electrical power systems and machines (STE 311)	1. Identify the basic structure and function of electrical power system • Generation • Transmission • Distribution • Consumption 2. Measure current and voltage in a simple circuit 3. Calculate power from a simple circuit 4. Identify different power system components 5. Identify overhead lines 6. Identify underground cables 7. Identify components of transformer 8. Identify transformer types
2.	Introduction to Solar Thermal Energy (STE 312)	1. Identify the types of solar collectors and their operating characteristics: - - Non concentrating types • Flat plate • Evacuated tube - - Concentrating types

		• Line focus • Point focus 2. Identify components of solar thermal systems 3. Demonstrate the use of solar tracking system 4. Demonstrate the use of the following measuring devices for Solar Thermal System: • Thermometers • Solar irradiation meter • Anemometer • Pressure gauges • Relative humidity 5. Design a low and medium temperatures Solar Thermal Systems
3.	Heat Transfer Analysis in Solar Thermal Systems (STE 313)	1. Demonstrate measurement of temperature to analyze modes of heat transfer using Solar thermal system models 2. Derive the equation for: • Fourier's law • Newton's law of cooling • Stefan-Boltzman law 3. Analyze heat transfer modes in a solar thermal collector 4. Identify heat transfer equipment: • Heat exchangers

		• Heaters • Boilers • Blowers • Refrigerators / Air conditioners etc. 5. Demonstrate the use of heat transfer equipment
4.	Solar Thermal Collectors and Application I (STE 314)	1. Construct the following Solar Thermal Collectors: • Flat plate solar collector • Parabolic trough type with line focus 2. Identify components of solar thermal collectors 3. Demonstrate the use of low and medium temperature solar thermal collectors 4. Identify the properties of Solar Thermal Collector components 5. Demonstrate the use of measuring devices in evaluating efficiency of Solar Thermal Collector 6. Demonstrate the use of measuring device to measure beam and diffuse component of solar radiation 7. Demonstrate the use of measuring device to measure transmissivity and absorptivity of a glass 8. Demonstrate the use of flow meter to measure the flow rate of a working fluid

		across the solar thermal collector 9. Measure temperatures at various levels of the collector and ambient temperature
5.	Techno-Economic Analysis for Solar Thermal Systems (STE 321)	1. Demonstrate how to perform modelling 2. Demonstrate how to evaluate: • Capital Expenditure Cost (CAPEX) • Operational Expenditure Cost (OPEX) • Profit • Net Present Value (NPV) • Internal Rate of Return (IRR) • Cost per unit benchmark product equivalent 3. Demonstrate how to perform life cycle analysis on Solar Thermal Systems 4. Build an excel financial model for a Solar Thermal system (CAPEX, OPEX, ROI, etc.) 5. Analyse risks in Solar Thermal System 6. Develop strategies for risk mitigation 7. Evaluate the effectiveness of risk management plan
6.	Installation and Commissioning of Solar Thermal Systems (STE 322)	1. Develop a solar thermal system layout drawing from an existing design 2. Apply measuring and marking tools to accurately position and install solar thermal components based on a prepared layout diagram 3. Identify the components in a solar thermal

		system and the tools used in handling them. 4. Conduct visual checks in a solar thermal system identifying installation faults, system failures and poor workmanship 5. Check fluid levels, system pressure and temperatures, measure flow rates at different levels, and calculate the thermal power output to verify system settings and control parameters. 6. Develop a sample commissioning checklist, modify an existing system drawing, provide new as-built drawing, collect all data from previous experiments and assemble a technical document for handover
7.	Advanced Thermal System Performance and Troubleshooting (STE 323)	1. Identify advanced thermal systems 2. Demonstrate the uses of advanced thermal systems 3. Troubleshoot in some specific advanced thermal systems 4. Demonstrate how key parameters can be determined. These include: • Heat transfer rate • Energy efficiency • Coefficient of performance • Thermal conductivity • Specific heat capacity • System efficiency • System response time • System capacity • System stability 5. Illustrate how to determine the performance

		of advance thermal systems 6. Demonstrate how advanced thermal system are modeled 7. Use of the safety kits and gadgets relevant to advanced thermal systems Carry out preventive maintenance on Heat Exchanger
8.	Solar Thermal Collectors and Application II (STE 324)	1. Identify components of solar thermal power plants 2. Demonstrate the use of high solar thermal collector 3. Demonstrate the use of measuring devices in evaluating efficiency of Solar Thermal Power Plants 4. Demonstrate the use of measuring device 5. to measure beam and diffuse component of solar radiation 6. Demonstrate the use of measuring device to measure and Determine Transmissivity and absorptivity of a glass 7. Demonstrate the use of flow meter to measure the flow rate of a working fluid across the solar thermal collector 8. Measure temperature at various levels of the collector and ambient temperature 9. Measure absorptivity of absorber surface 10. Identify the different types of thermal energy storage systems and materials 11. Demonstrate the mode of operation of

		thermal energy storage systems 12. Demonstrate the use of thermal energy storage system to measure physical property of material as it is subjected to change in temperature
9.	Research Methodology in Solar Thermal Energy (STE 325)	1. Write a concise and clear title along with background information relevant to solar thermal energy 2. Formulate a research problem relating to solar thermal and derive appropriate objectives for it 3. Create precise and researchable problem statements 4. Draft a literature review section of a Research proposal 5. Summarize relevant studies and highlight research gaps in solar thermal energy 6. Select appropriate research design and methodology 7. Develop experimental or field procedure for the research on any area of your choice on Solar Thermal Systems 8. Conduct the study using tools and techniques in real or simulated environments 9. Analyze data sets using appropriate software tools 10. Compile research data and analysis into coherent sections 11. Interpret the implications of research results 12. Apply correct citation and referencing styles in a technical report

		13. Write a/an: • Progress/Interim report • Feasibility report • Incident or troubleshooting report 14. Demonstrate the use of citation and referencing tools • Zotero
10.	Smart Grids & IoT in Solar Thermal Systems (STE 326)	1. Demonstrate the use of smart grid components: • Advanced metering infrastructure • Grid management systems • Renewable energy integration • Grid animation and control • Communication networks • Data analytics and management etc. 2. Identify the facilities needed to set up IoT: • Physical • Technical • Human resources • Infrastructure • Regulatory, etc. 3. Identify the equipment needed to set up IoT: • Sensors and actuators • Microcontrollers and processors • Communication modules • Gateways and routers • Power management equipment 4. Demonstrate the use of relevant Software

		needed in the development of applications for smart grids. 5. Identify the hardware components needed in the development of applications for smart grid under the category: • Sensors and actuators • Communication devices • Computing devices • Energy storage and generation devices • Power electronics devices • Network devices, etc. 6. Demonstrate the use of smart grid equipment such as: • Smart meters • Grid management systems • Energy storage systems, • Renewable energy systems etc. 7. Identify IoT equipment such as: • Sensors • Actuators, • Gateways • Communication modules 8. Demonstrate the use of IoT equipment
11.	Thermal Project Management and Tendering Process (327)	1. Create a Gantt chart for a small thermal project using any thermal energy source (preferably solar thermal) 2. (Group Work) Develop a work breakdown structure (WBS) using any relevant software and assign tasks/responsibilities, resources and specify timelines,

		3. Create sample progress report 4. Present sample progress report 5. Prepare a tender document 6. Evaluate a tender document
12.	Solar Thermal Heating and Cooling Technologies (STE 411)	1. Identify passive and active thermal systems 2. Demonstrate how heating and cooling systems work 3. Identify the properties of solar thermal collector components 4. Visit a nearby industry to Identify components of solar thermal heating and cooling systems 5. Demonstrate assembling of components of solar thermal heating and cooling systems 6. Measure temperature and pressure at different levels of the solar thermal system 7. Demonstrate the maintenance procedure of Solar thermal Dryer 8. Apply design guidelines in development of solar thermal systems for heating and cooling 9. Select components of the design using standard product charts and manuals 10. Produce layout drawing using standard design software 11. Demonstrate the use of PsyCalc Software
13.	Modelling and Simulation of Solar Thermal Systems (STE 412)	1. Identify the factors influencing solar thermal system design 2. Calculate to determine the appropriate sizing

		of components like collectors, storage tanks, and heat exchangers based on system demands and design parameters. 3. Design the layout of a basic solar thermal system 4. Apply thermal performance equations to model solar collectors: • Heat transfer • Energy equations 5. Use mathematical models to calculate the behavior of heat storage systems • Heat losses • Charging/discharging cycle 6. Identify commonly used software for solar thermal system simulation 7. Navigate user interface and set up basic simulation models in any available software 8. Input system parameters and environmental data into simulation software 9. Interpret software-generated outputs and simulation graphs
14.	Hybrid Thermal Systems (Wind & Hydro Synergies with Solar Thermal, Grid Integration) (STE 413)	1. Demonstrate setting up a small hybrid system (eg. Solar+wind) and integrate it with a grid connected inverter. 2. Measure the energy flow between the hybrid system and the grid 3. Monitor the energy flow between the hybrid system and the grid 4. Demonstrate the use of a control software to

		monitor the performance of a hybrid system 5. Adjust the control software operation to maintain grid stability and desired output (e.g. changing the energy mix based on weather or/and demand) 6. Demonstrate system sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a given demand profile 7. Evaluate various hybrid configurations for maximum efficiency and cost effectiveness while considering storage systems as backup and/ or compensators.
15.	Retrofitting & Energy Efficiency Techniques (STE 414)	1. Identify common components targeted in solar thermal retrofitting and energy efficiency opportunities, such as; • collectors, • piping, • insulation, • storage tanks • controls • Heat exchanger, etc. 2. Conduct energy audits to assess system performance and identify opportunities for energy savings. 3. Conduct an evaluation of existing systems to determine the need for retrofitting 4. Select appropriate methods for improvement of insulation and sealing

		5. Implement measures for optimizing fluid flow and minimizing heat losses during system retrofitting. 6. Apply basic retrofitting techniques such as upgrading insulation, improving heat exchanger efficiency, and integrating smart controllers to enhance system performance
16.	Maintenance of solar thermal systems (STE 422)	1. Illustrate the maintenance in 1.3 2. Identify common issues associated with Solar Thermal Systems: • Scaling • Corrosion • Leaks and fluid loss • Control system issues • Degradation of insulation materials 3. Carryout maintenance on a typical solar thermal system 4. Identify potential hazards with respect to solar thermal systems 5. Demonstrate the safety measures to be taken when working on solar thermal systems 6. Illustrate the use of safety kits and gadgets in a solar thermal plant. 7. Illustrate first aid measures to be taken when an accident occurs in a solar thermal plant 8. Illustrate the operating conditions of solar thermal systems with emphasis on the following parameters: • Energy intake • Solar irradiance • System temperature • System pressure

		• Energy output • Efficiency 9. Demonstrate benchmarking using simulation software for: • Comparison with similar systems • Industrial standards 10. Demonstrate the optimization techniques of solar thermal systems taking into cognizance: • Adjustment of system settings • Upgrading system components • Implementation of modern technologies 11. Identify the various equipment used in carrying out maintenance in solar thermal systems 12. Classify equipment used in solar thermal system maintenance in the following category: • Inspection and testing • Cleaning and flushing • Repair and replacement • Safety • Specialized equipment 13. Demonstrate the use of the various equipment/devices in each category in 4.2
17.	Energy Efficiency and Demand Side Management (DSM) (STE 423)	1. Visit Site for data collection 2. Illustrate DSM strategies that include Solar System integration for optimal energy usage. 3. Demonstrate load-shifting and peak-shaving techniques in the operation of solar systems to improve energy consumption efficiency.

		4. Conduct cost-benefit analyses of DSM measures to evaluate their effectiveness and propose improvements based on performance outcomes 5. Use energy management software tool like energyplus or Hommer to monitor and manage DSM activities effectively

LIST OF EQUIPMENT FOR HIGHER NATIONAL DIPLOMA (HND) SOLAR THERMAL ENGINEERING LABORATORY

S/N	NAME	QUANTITY
1.	Solar thermal system models	2
2.	Heat exchangers	2
3.	Boilers	2
4.	Blowers	10
5.	Heat exchanger test rigs	2
6.	Heaters • Air • Water	1 each

7.	Refrigerator	1
8.	Solar water heater	2
9.	Solar Air-Conditioner	2
10.	Air-Conditioner	1
11.	Multimeter	30
12.	Electric circuit model	30
13.	Power system simulator	1
14.	Electrical Power System Model	2
15.	Digital Power analyzer/ Energy loggers	5
16.	Smart controllers	5
17.	Different efficient bulbs	lot
18.	Solar Panel	5
19.	Digital pyranometer (To measure solar radiation)	1
20.	Pyrheliometer	1
21.	Lithium/tubular Batteries	10
22.	Thermal Storage tank	2
23.	Inverter	2
24.	SCADA System hardware	1
25.	SCADA System software	1
26.	Thermal hybrid plant model with different configuration	5
27.	Flat plate collector	10
28.	Evacuated tube collector	10
29.	Parabolic trough (Line Focus) collector	5
30.	Parabolic Dish (Point Focus)	5
31.	Fresnel lenses (Point Focus)	5
32.	Different Heat transfer media	Variety
33.	Thermometers • Digital • Analogue	 10 10

	• Thermocouples • Infrared	10 5
34.	Sensors • Thermocouple • Pressure	 30 15
35.	Anemometer	2
36.	Pressure gauge	5
37.	Hygrometer	2
38.	Pressure sensor	5
39.	Actuators	5
40.	Flow meters • Volumetric • Mass	5 each
41.	Stopwatch	10
42.	Flashlight/Inspection light	10
43.	Arduino Board	15
44.	Low voltage Power supply pack	5
45.	Bread Board	15
46.	Smart grid model	10
47.	Gateway	1
48.	RS485 cable, plug and port	5 each
49.	Switches and Routers	1 each
50.	Server	1
51.	Ethernet cables	1 roll
52.	Smart meter	3
53.	Rectifiers	5
54.	Moulded case circuit breakers (MCCB)	15
55.	Changeover switch gears	1
56.	Sample risk management plan	Assorted
57.	Mathematical set	15

58.	UV-VIS-NIR spectrometers or double beam spectral photometer	1
59.	Single axis sun tracker	1
60.	Dual axis sun tracker	1
61.	Wind turbine model	3
62.	Spectrometer	1
63.	Calorimeter	1
64.	Thermal conductivity analyzer	1
65.	Differential scanning calorimeters (DSC)	1
66.	Solar thermal heating models equipped with sensors	1
67.	Solar heating cooling models equipped with sensors	1
68.	Chiller	1
69.	Solar thermal dryer	1
70.	Solar thermal design software	1
71.	Thermal energy meter	1
72.	Electric motor	1
73.	Solar System training kit	1
74.	Expansion tank	1
75.	Communication modules	5
76.	Pressure relief valves	1
77.	Sample tender documents	Assorted
78.	Sample reports	Assorted
79.	Data collection templates	Assorted
80.	Data Logger	10
81.	Sample layout design of a solar thermal system	Assorted
82.	Charts	Assorted

	• Manufacturers manual and charts • Psychrometric chart • ASHRAE Psychrometric chart	
Heat Transfer Media		
83.	Rock	Assorted
84.	Concrete	Assorted
85.	Sand	Assorted
86.	Iron	Assorted
87.	Iron oxide	Assorted
88.	Water	Assorted
89.	Paraffin wax	Assorted
90.	Animal Fat	Assorted
91.	Thermal Oil	Assorted
92.	Sodium and potassium nitrate	Assorted
Consumables		
93.	Samples of: • Ammonia • Zeolite • Silica gel • Activated carbon • Calcium-chloride	Assorted

LIST OF EQUIPMENT FOR HIGHER NATIONAL DIPLOMA (HND) SOLAR THERMAL ENGINEERING WORKSHOP

S/N	NAME	QUANTITY
1.	Toolbox • Electrical • Mechanical	6 each
2.	Centre Punch	10
3.	Hammer • Mallet • Claw • Chipping • Club	5 each
4.	Hand Drilling Machine	5
5.	Inspection light	20
6.	PPE kits	30
7.	First Aid kit	1
8.	Flashlight/Inspection light	10
9.	Mathematical set	15
10.	Measuring tape	60
11.	Spirit level	10
12.	Oxy-acetylene welding set	1
13.	Electric arc welding machine	2
14.	Bench vice (6 inches)	6
15.	Wire brush	10
16.	Pipe Brush	10
17.	Furnace	1
18.	Angle grinder	2
19.	PPE	Assorted
	Consumables	
20.	Casing	Assorted

	• Sheet Metal plate • Plywood • Wooden planks	
21.	Glazing Material • Glass • Perspex	Assorted
22.	Insulation material • Rock wool • Fibre glass • Plaster of Paris (POP) • Asbestos • Blanket • Polyurethane	Assorted
23.	Pipes • Copper • Galvanized steel	Assorted
24.	Plumbing fittings • Valves • Elbows • Tees • Socket • Thread tape • PVC gum	Assorted
25.	Support Structures • Angle iron • Square pipes • Round pipes	Assorted
26.	Reflective Surfaces • Mirrors	Assorted

	• Aluminium foil	
27.	Coating	Assorted
28.	Pencil and Sketch pad	Assorted
29.	Drill bits	Assorted
30.	Tapping bits	Assorted
31.	Bolts and Nuts	Assorted
32.	Brazing rod	Assorted
33.	Flux	Assorted
34.	Welding electrodes	Assorted
35.	Sealants	Assorted
36.	Cutting disc	Assorted
37.	Grinding disc	Assorted
38.	Sandpaper	Assorted
39.	Emery cloth	Assorted

LIST OF REQUIRED EQUIPMENT FOR COMPUTER STUDIO

S/N	NAME	QUANTITY
1.	Software (Energyplus or Hommer)	Multi-user
2.	Relevant design software (AutoCAD, Solid works)	1
3.	PVsyst	1
4.	Computers	15
5.	MS Office (Excel)	1
6.	Arduino software (IDE)	1
7.	VS code	1
8.	NI Lab View	1
9.	Local server	1
10.	OpenDSS	1

11.	OpenSolar	1
12.	PsyCalc	1
13.	Odyssey	1
14.	MATLAB Power System Analysis Tool Box (PSAT) Simulink Python Python for Power System Analysis (PyPSA)	1
15.	ASHRAE Psychrometric chart App	1
16.	System Advisor Model (SAM)	1
17.	RiskMatrix	1
18.	RETScreen software	1

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