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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

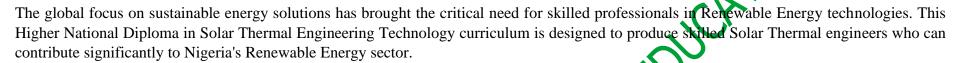


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FOREWORD



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.

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	FEDERAL
Retrofitting & Energy Efficiency Techniques	
MINI – PROJECT ON SOLAR THERMAL SYSTEM	
Solar Thermal Policy, Regulation, and Standards	
Maintenance of Solar Thermal Systems	
Energy Efficiency and Demand Side Management (DSM)	
Engineering ethics and professional practice	
PRACTICAL MANUAL FOR HND SOLAR THERMAL	
LIST OF EQUIPMENT FOR HIGHER NATIONAL DIPLOMA (HND) SOLAR THERMAL ENGINEER	ING LABORATORY
LIST OF EQUIPMENT FOR HIGHER NATIONAL DIPLOMA (HND) SOLAR THERMAL ENGINEER	NG WORKSHOP
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TONALBO	
4 KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES	





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 system
- 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





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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.

STRUCTURE OF PROGRAMME 5.0

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.

EVALUATION SCHEME 6.0

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%.

ACCREDITATION 7.0

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 nimu... candidates should have completed a minimum of 97/20 semester credit units.





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

G OF COURSES: Courses s		
MARKED RANGE	LETTER GRADE	WEIGHTING
75% and above	А	4.00
70% - 74%	AB	3.50
65% - 69%	В	5.25
60% - 64%	BC	3.00
55% - 59%	С	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 QUALIFICATION OF THE TEACHERS:
- 9.1 Holders of BSc / HND and Higher Degrees in:
- Renewable Energy Engineerit
- Chemical Engineering
- Mechanical Engineering





9.0

IN

- Electrical/ Electronic Engineering
- Mechatronics Engineering
- EDUCATION In addition, teachers of this programme should have been trained and certified by: 9.2
 - (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.

GUIDANCE NOTES FOR TEACHERS OF THE PROGRAMME 10.0

The new curriculum is drawn in unit courses. This is in keeping with the provisions of the National Policy on Education which stresses 10.1 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,

In designing the units, the principle of the modular system by product has been adopted; thus, making each of the professional modules, 10.2 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.

Our aim is to continue to see to it that a solid internal evaluation system exists in each institution for ensuring minimum standard and 10.3 quality of education in the programmes offered throughout the Technical and Vocational Education (TVE) system.





The teaching of the theory and practical work should as much as possible be integrated. Practical exercises, especially those in 10.4 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 SIW

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

See Guidelines for the Implementation of MSQ in Polytechnics in Nigeria ics.





CURRICULUM TABLE FOR HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY

YEAR I SEMESTER I

S/N	COURSE CODE	COURSE TITLE		Р	CU	СН
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
5	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







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YEAI	R I SEMESTER II					
S/N	COURSE CODE	COURSE TITLE	L	P	CU	СН
1	GNS 302	Communication in English III		-	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 & JoT 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







3 ENT 416 4 EEC 324 5 STE 411	Communication in English IV Numerical Methods Practice of Entrepreneurship II Control Engineering Solar Thermal Heating and Cooling Technologies	2 2 2 1	0 2	2 2 4
3 ENT 416 4 EEC 324 5 STE 411	Practice of Entrepreneurship II Control Engineering	•	2	
4 EEC 324 5 STE 411	Control Engineering	•		4
5 STE 411		1		
	Solar Thermal Heating and Cooling Technologies		2	3
6 STE 412		1	2	3
	Modelling and Simulation of Solar Thermal Systems	1	2	3
7 STE 413	Hybrid Thermal Systems and Grid Integration in power generation	2	1	3
9 STE 414	Retrofitting & Energy Efficiency Techniques	1	2	3
10 STE 415	Mini-Project on Solar Thermal Technology	0	0	3
11 STE 416	Seminar	0	0	2
	TOTAL	12	11	28
	ronne Bor			





YEAR II SEMESTER II

S/N	COURSE CODE	COURSE TITLE	L		CU	СН
1	MTH 422	Statistical Methods in Engineering			2	2
2	SPE 424	Applications of AI for Energy Trading		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
		14				



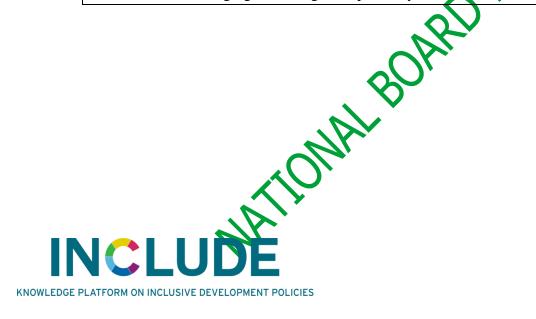


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Fundamental	s of Electrical power systems and machines
PROGRAMME: HIGHER NATIONAL DIPLOMA SO	LAR THERMAL ENGINEERING TECHNOLOGY
COURSE TITLE : Fundamentals of Electrical power	COURSE CODE: STE 311 CONTACT HOURS: 3
systems and machines	OGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY URSE TITLE: Fundamentals of Electrical power ems and machines CREDIT UNIT: 3 THEORETICAL: 2
YEAR: I SEMESTER: I	PRE-REQUISITE: NIL
GOAL: This course is designed to equip the students with	h knowledge and skills of electrical power systems and machines
GENERAL OBJECTIVES: On completion of this course	se, 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 transform
- 5.0 Understand emerging technologies in power systems and machines.







	MME: HIGHER NATION TITLE: Fundamentals of I		COURSE COD		TACT HOURS: 3	
and machines			CREDIT UNIT:	3 TH	EORETICAL: 2	
ZEAR:	I SEMESTER: I		PRE-REQUISIT FICAL	'E: PR	ACTICAL: 1	
	This course is designed to equal to the construction of the constr				ind machines	
	ETICAL CONTENT	the fundamentals of cice	inear power syste.	PRACTICAL CONTEN	T	
WEEK	SPECIFIC LEARNING OUTCOME	TEACHER'S ACTIVITIES	RESOURCES	SPECIFIC LÉARNING OUTCOME	TEACHER'S ACTIVITIES	RESOURCE
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 Electri circuit Pen Paper Graph Sheet Calculator Sample circuit Power system model Rheostat Cell





	TransmissionDistribution	Explain power system			all.	
	1.3 Explain power system stability relating to generation and load	stability relating to generation and load connected				
	connected 1.4 Explain how to calculate current, voltage and power from a simple circuit	Explain how to calculate current, voltage and power from a simple circuit		HMICALED		
ENER	AL OBJECTIVE 2.0: Know	w the components of electr	ical power system	25		
-7	 2.1 Explain power system components. •Generators •Transformers •Circuit breakers •Isolators 	Explain power system components. •Generators •Transformers •Circuit breakers •Isolators	Textbooks Journals Internet Computer Projector White Board	Identify power system components Identify overhead lines	Guide students to; Identify different power system components Identify overhead	Power systen model Power systen simulator (OpenDSS,
	•Lines •Cables, etc.	•Lines •Cables, etc.	Marker Animations Charts	Identify underground cables	lines Identify underground cables	PSAT
	2.2 Describe the functions of basic power system components	Explain the functions of basic power system components				
	2.3 Explain the interconnection of					





	power system					
	components	Explain the			× ×	
	2.4 Explain overhead lines and underground cables in power system	interconnection of power system components			CA	
		Explain overhead lines				
		and underground cables				
		in power system				
ENER	RAL OBJECTIVE 3.0: Unde	rstand the principles of ele	ectrical machines			
-10	3.1 Define basic	Explain basic electrical	Textbooks			
	electrical machine	machine concepts and	Journals			
	concepts and	terminologies	Internet			
	terminologies	• electromagnetic induction,	Computer			
	• Electromagnetic	• torque,	Projector			
	induction	• commutation.	White Board			
	• Torque		Marker			
	• Commutation.		Animations			
	3.2 Explain the working principles of DC machines	Explain the working principles of DC machines	Charts			
	3.3 Explain the working	Explain the working				
	principles of AC	principles of AC				
	machines	machines				
	3.4 Describe the	Explain the construction				
		of common electrical				
	CLUDE	L	18	1	1	I







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	construction of	machines				
	common electrical					
	machines 3.5 Explain the role of electrical machines in power: • Generation	Discuss the role of electrical machines in power: Generation Transmission Distribution			SCA.	
	• Transmission	• Utilization				
	DistributionUtilization			10.		
NFR	AL OBJECTIVE 4.0: Know	the operating principles a	and applications (oftransformer		
-12	4.1 Define a transformer	Explain a transformer	Textbooks Journals	Identify components of transformer	Guide students to; Identify basic	Transformer
	4.2 Explain the working principles of a transformer	Explain the working principles of a transformer	Internet Computer Projector White Board	Identify transformer types	transformer parts Identify transformer	Power system simulator (OpenDSS, PSAT,
	4.3 Explain components of transformers	Explain types of transformers	Marker Animations		parts	rsai,
	• Core	• Core	Charts			
	• Windings	Windings				
	• Insulation and cooling medium	Insulation and cooling medium				
	• Tap changer, etc.	Tap changer, etc.				
	4.4 Explain types of	Explain types of				







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	transformers and their	transformers and their				
	functions	functions				
	• Power and distribution transformers (step-	Power and distribution transformers			ACA	
	 up & step-down) Instrument transformers 	(step-up & step- down)Instrument				
	• Auto-transformers	transformersAuto-transformers				
ENER	AL OBJECTIVE 5.0: Unde			ems and machines		
3-15	5.1 Explain smart grids as emerging technology	Explain smart grids as emerging technology	Textbooks Journals Internet	ÇĽ.		
	5.2 Explain High-Voltage Direct Current (HVDC) Transmission technology	Explain HVDC Transmission technology	Marker			
	 5.3 Describe advancements in electrical machines and their control system: Variable frequency drives (VFDs) Brushless DC motors Energy-efficient motors, etc. 	 Explain advancements in electrical machines and their control system: Variable frequency drives (VFDs) Brushless DC motors Energy-efficient motors 	Charts			
N	CLUDE		20	<u> </u>		





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	COURSE CODE: STR 312	CONTACT HOURS: 3
Energy	CREDIT UNIT: 3	THEORETICAL: 2
YEAR: I SEMESTER: I	PRE-REQUISITE: NIL	PRACTICAL: 1
GOAL: This course is designed to acquaint students w	vith basic knowledge and skills in Sola	ar Thermal Systems
GENERAL OBJECTIVES: On completion of this c	ourse, the students should be able to:	
 2.0 Understand the principles of Solar Thermal System 3.0 Know the components and design of Solar Therma 4.0 Understand the benefits and limitations of Solar Therma 	al Systems	
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MAN		
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E PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES		





	AMME: HIGHER NATION E TITLE: Introduction to So		COURSE CODE			ACT HOURS: 3	
			CREDIT UNIT:	3	THE	ORETICAL: 2	
YEAR:	I SEMESTER: I		PRE-REQUISIT			CTICAL: 1	
COURSE	E SPECIFICATION: THE	ORETICAL AND PRAC	CTICAL		V		
GOAL: 7	This course is designed to acc	quaint students with basic	c knowledge and sk	ills in Solar Therma	al Systems	\$	
GENERA	AL OBJECTIVE 1.0: Under	erstand the concept of So	lar Thermal System	IS			
THEOR	RETICAL CONTENT			PRACTICAL CO	ONTENT	1	
WEEK	SPECIFIC LEARNING	TEACHER'S	RESOURCES	SPECIFIC LEAD	RNING	TEACHER'S	RESOURCES
	OUTCOME	ACTIVITIES		OUTCOME		ACTIVITIES	
-3	1.1 Define Energy	Explain Energy	Textbooks	,			
			Journals				
	1.2 Explain sources of	Explain sources of	Internet				
	renewable energy:	renewable energy:	Computer				
	• Solar	• Solar	Projector				
	• Wind	Wind	White Board				
	• Hydro	• Hydro	Marker				
	• Bio-mass	Bio-mass	Animations				
	• Tidal	• Tidal	Charts				
	Ocean waves	Ocean waves					
	• Ocean thermal	Ocean thermal					
	• Geothermal, etc.	Geothermal, etc.					
	1.3 Define solar thermat	Explain solar thermal					
	system	system					





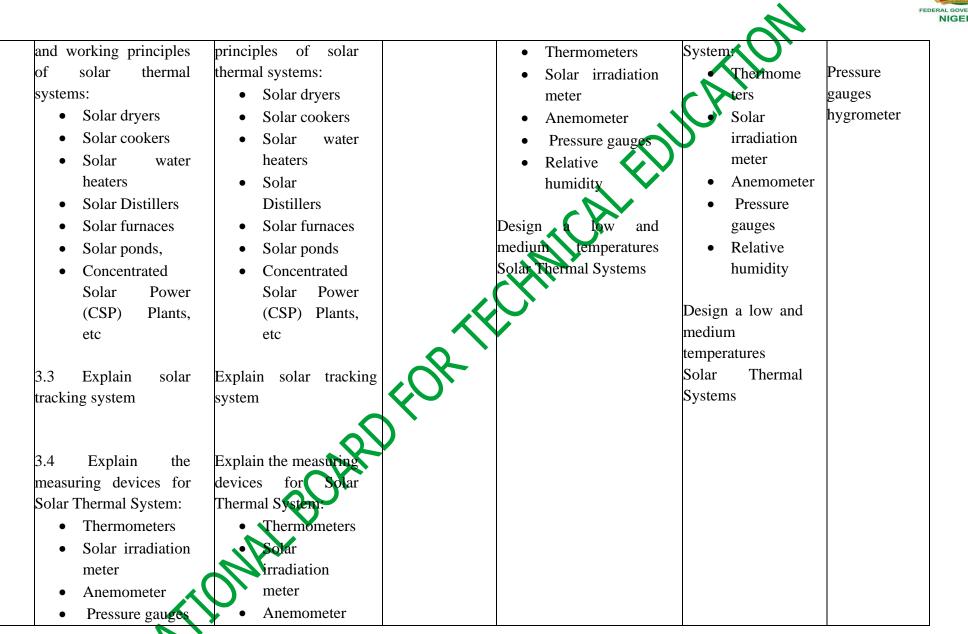
	1.4 List types of solar	Explain types of solar				
	thermal systems:	thermal systems:				
	• Active	Active				
	Passive	Passive			J	
	RAL OBJECTIVE 2.0: Unde		-		1	I
-7	2.1 Explain the basic	Explain the basic working		Identify the types of solar	Guide students to:	flat plate,
	working principle of	principle of solar thermal		collectors and their	J J1	evacuated
	solar thermal energy	energy conversion	Internet	operating characteristics:	solar collectors and	tube,
	conversion		Computer		their operating	Line focus
			Projector	- Non concentrating types	characteristics:	Point focus
	2.2 List the key	Explain the key	White Board	Hot alots	Non conceptuation	
	components in a solar thermal system:	components in a solar t.hermal system:	Marker Animations	Plat plate Evacuated tube	- Non concentrating types	
	•Collectors	•Collectors	Charts		types	
	•Absorbers	•Absorbers	Churtis		• Flat plate	
	•Heat transfer fluid	•Heat transfer fluid		- Concentrating types	Evacuated tube	
	•Storage units	•Storage units.	X	• Line focus		
	•Insulation materials,	•Insulation materials		Point focus		
	etc.	• Instration matchars			- Concentrating types	
	0.00				• Line focus	
	2.3 Explain the heat	Discuss the beat transfer			• Point focus	
	transfer mechanisms	mechanisms involved in				
	involved in solar thermal	solar thermal systems:				
	systems:	Conduction				
	Conduction	Convection				
	Convection	Radiation				





S	2.4 Explain applications of					
S		Explain applications of				
	Solar Thermal Systems	Solar Thermal Systems				
4	2.5 Explain differences	Explain differences				
t	between active and passive	between active and				
s	solar thermal systems in	passive solar thermal				
ť	erms of:	systems in terms of:				
	• Design	• Design				
	• Efficiency, and	• Efficiency, and				
	• Application.	• Application.				
NERA	L OBJECTIVE 3.0: Know	v the components and desi	ign of Solar Ther	mal Systems		
10 3	3.1 Explain solar	Explain solar thermal	Textbooks	Identify components of	Guide students to:	Solar
ť	hermal components:	components:	Journals	solar thermal systems	Identify components	collectors
	• Solar collectors	• Solar	Internet		of solar thermal	Heat
	• Heat exchangers	collectors	Computer		systems	exchanger
	• Heat transfer	• Heat	Projector			
	media	exchangers	White Board	Demonstrate the use of	Demonstrate the use	Heat transfer
	• Thermal storage	• Heat transfer	Marker	solar tracking system	of solar tracking	medium
	systems, etc.	media	Animations		system	Thermal
		• Thermal	Charts			storage
		storage				storage
		systems, etc.		Demonstrate the use of the	Demonstrate the use	Thermometer
	~			following measuring	of the following	
3	3.2 Explain the types	Explain the working		devices for Solar Thermal	measuring devices	Pyrheliomete
	· / / .			System:	for Solar Thermal	Anemometer













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						4	FEC
	Relative	Pressure				$\sqrt{\mathbf{O}}$	
	humidity	gauges					
		• Relative					
		humidity					
	3.5 Explain the basic	Explain the basic					
	design principles of	design principles of					
	Solar Thermal Systems	Solar Thermal					
	5	Systems			×		
GENER	AL OBJECTIVE 4.0: Unde	-	nitations of Solar 7	Thermal Systems			
11-14	4.1 Explain the	Explain the	Textbooks				
	environmental and	environmental and	Journals				
	economic benefits of	economic benefits of	Internet	N.			
	solar thermal energy	solar thermal energy	Computer				
			Projector				
	4.2 Explain differences	Discuss differences	White Board				
	between types of solar	between types of solar	Marker				
	thermal systems in	thermal systems in terms	Animations				
	terms of efficiency and		Oharts				
	applicability	applicability	ľ				ļ
							ļ
	4.3 Explain site and climate						
	considerations that	considerations that					
	influence effectiveness:	influence effectiveness:					
	Geographic factors	e Geographic					ļ
	Climatic factors	factors					l
		Climatic factors					l



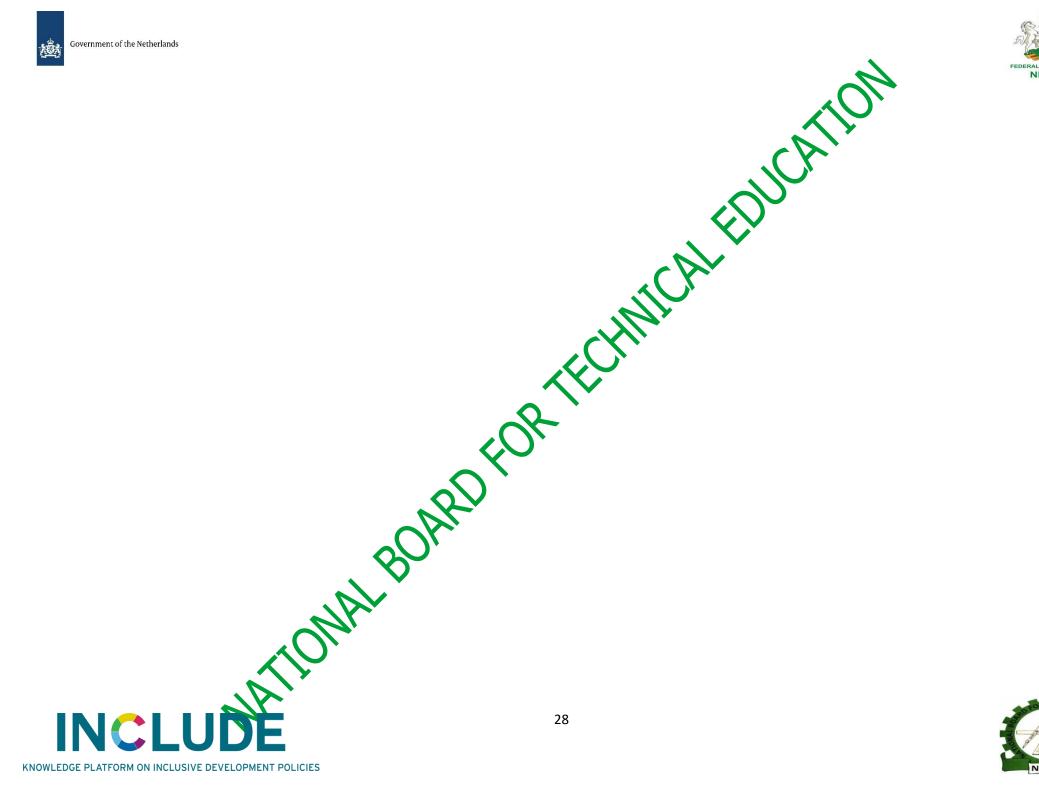




		4
 4.4 Describe common technical and economic Ex limitations of the Solar te thermal systems: lin Heat loss Storage limitations. 		
ASSESSMENT:		
Continuous Assessment (CA): 60%		
Examination: 40%		
	ABOARDFOR	
INCLUDE		











PROGRAMME: HIGHER NATIONAL DIPLOMA S COURSE TITLE: Heat Transfer Analysis in Solar	Course Code: STE 313	Contact Hourse 3
Thermal Systems	Credit Unit: 3	Theoretical: 2
Year: I Semester: I	Pre-requisite: Nil	Practical: 1 Hour/week
GOAL: This course is designed to acquaint students w	ith basic knowledge and skills in l	leat transfer of Solar Thermal System
GENERAL OBJECTIVES: On completion of this cour	rse, the students should be able to:	
1.0 Understand the concept of heat transfer in Solar Th	ermal Systems	
1.0 Understand the concept of heat transfer in Solar The 2.0 Know the working principles of heat transfer in Sol		
_		
2.0 Know the working principles of heat transfer in Sol		
2.0 Know the working principles of heat transfer in Sol 3.0 Know the functions of heat transfer equipment		
2.0 Know the working principles of heat transfer in Sol 3.0 Know the functions of heat transfer equipment		
2.0 Know the working principles of heat transfer in Sol 3.0 Know the functions of heat transfer equipment		
2.0 Know the working principles of heat transfer in Sol		





	SE TITLE: Heat Transfer	COURSE CODE: STE 3	313	Con	tact Hours: 3		
Analysi	is in Solar Thermal Systems	Credit Unit: 3			Theoretical: 2		
Year:	I Semester: I	Pre-requisite: NIL		Riac	tical: 1		
COUR	SE SPECIFICATION: THEO	RETICAL AND PRACTIC	AL	, V			
GOAL	: This course is designed to acq	uaint students with basic kn	owledge and ski	lls in heat transfer of So	olar Thermal System	S	
GENEI	RAL OBJECTIVE 1.0: Under	stand the concept of heat tra	ansfer in Solar T	hermal Systems			
THEOR	RETICAL CONTENT			PRACTICAL CONTI	ENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning	Teacher's	Resource	
				Outcome	Activities		
-5	1.1 Define heat transfer	Explain heat transfer	Textbooks				
			Journals Internet				
	1.2 Define heat transfer by:	Explain heat transfer by:	Computer Projector				
	ConductionConvection	 Conduction 	White board				
	Radiation	Convection	Marker Animation				
		Radiation	Charts				
	1.3 Explain the heat transfer behavior in materials		Tables				
	behavior in materials	behavior in materials					
	1.4 List the properties of	Explain the properties of materials used in Solar					
	materials used in Solar	materials used in Solar					







2

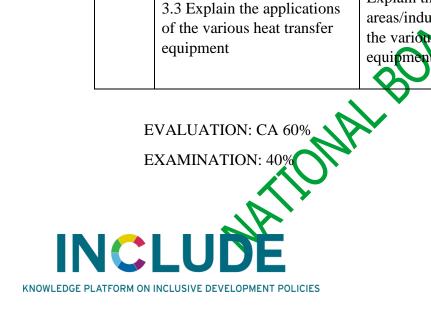
	1.5 Explain the heat transfer coefficient of different materials	Thermal Systems Discuss the heat transfer coefficient of different materials				
General	Objective 2.0: Know the working	ng principles of heat transfe	r in Solar Thern	nal Systems		
6-10	 2.1 State the following laws governing heat transfer: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





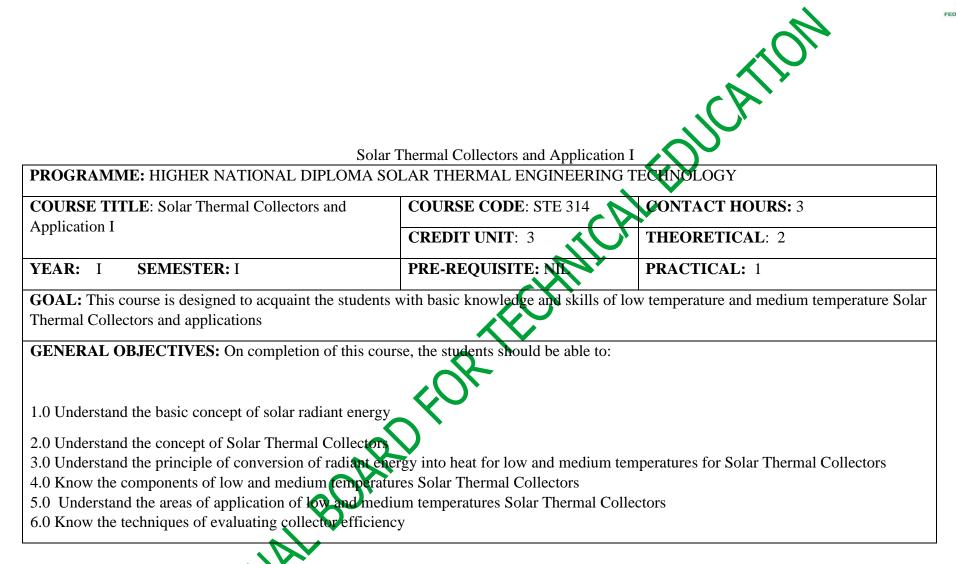


General	Objective 3.0: Know the function	ons of heat transfer equipme	ent			
11-15	 3.1 List heat transfer equipment: Heat exchangers Heaters Boilers Blowers Refrigerators/ Air conditioners etc. 3.2 Explain the working principle of the various heat transfer equipment 3.3 Explain the applications of the 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: Neat 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 s etc. Demonstrate the use of heat transfer equipment	Heat exchanger Heaters Boilers Blowers Refrigerat ors Air conditione rs Heat exchanger Test rig











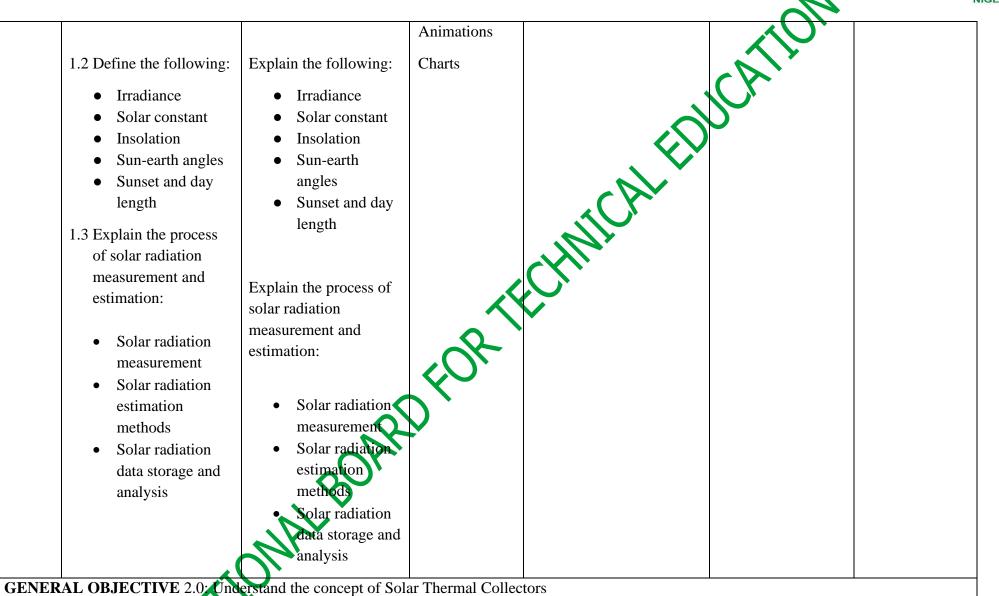


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	SE TITLE: Solar Thermal C	collectors and	COURSE COD	E : STE 314	CONT	CT HOURS:	3
Applica	tion I		CREDIT UNIT	: 3	THE	RETICAL:	2
YEAR:	I SEMESTER: I		PRE-REQUISI	ГЕ:	PRAC	TICAL: 1	
COURS	SE SPECIFICATION: TH	EORETICAL AND PRAC	CTICAL				
GOAL:	This course is designed to a	equaint the students with	basic knowledge a	nd skills of low ten	nperature and	medium tempe	rature Solar Therma
	ors and applications		-	"Why		-	
GENEF	RAL OBJECTIVE 1.0: Un	derstand the basic concept	of solar radiant er	nergy			
THEO	RETICAL CONTENT			PRACTICAL	CONTENT		
THEO Week		Teacher's Activities	Resources			Teacher's	Resources
	ORETICAL CONTENT Specific Learning Outcome	Teacher's Activities	Resources	Specific Learni Outcome	ng	Teacher's Activities	Resources
Week	Specific Learning	Explain the basic	Resources Textbooks	Specific Learn	ng		Resources
Week	Specific Learning Outcome		40x	Specific Learn	ng		Resources
Week	Specific Learning Outcome1.1 Explain the basic concepts in solar radiant energy:	Explain the basic concepts in solar radiant energy:	Textbooks	Specific Learn	ng		Resources
Week	Specific Learning Outcome1.1 Explain the basic concepts in solar radiant	Explain the basic concepts in solar	Textbooks Journals	Specific Learn	ng		Resources
Week	Specific Learning Outcome1.1 Explain the basic concepts in solar radiant energy:• Solar radiation	Explain the basic concepts in solar radiant energy: • Solar radiation	Textbooks Journals Internet	Specific Learn	ng		Resources
	Specific Learning Outcome1.1 Explain the basic concepts in solar radiant energy:• Solar radiation • Extraterrestrial radiation	Explain the basic concepts in solar radiant energy: • Solar radiation • Extraterrestrial radiation	Textbooks Journals Internet Computer	Specific Learn	ng		Resources













					A	FEDERA N
3-4	2.1 Define Solar Thermal	Define Solar Thermal	Textbooks	Construct the following	Guide students to:	Mirror
	Collectors	Collectors	Journals	Solar Thermal	Construct the	
			Internet	Collectors:	following Solar	Sheet metal
	2.2 Explain the different	Explain the different	Computer	• Flat plate solar collector	Thermal	plate
	classifications of	classifications of solar	Projector	Parabolic trough	Collectors:	Glazing material
	Solar Thermal	thermal collectors	White Board	type with line focu	Flat plate	Shazing inatorial
	Collectors	• Low	Marker		solar	insulation
		Temperature	Animations		collector	material
	Low Temperature	• Medium	Charts		Parabolic	
	Medium	Temperature	•		trough type	Galvanized steel
	Temperature	• High			with line	/copper Pipes
	High Temperature	Temperature			focus	1 1903
						Plumbing
	2.3 List types of low and	Explain types of low				fittings
	medium Solar Thermal	and medium Solar				~
	Collectors:	Thermal Collectors:				Support
	• Flat plate solar	• Flat plate solar				structure
	collector	collector				Coating
	• Evacuated tube	• Evacuated tube	\mathbf{D}			couting
	collector	collector	•			
	Integral collector	• Integral				
	Parabolic trough	collector				
	type with line	• Parabolic trough				
	focus	type with line				
	• Parabolic trough	focus				
	type with line	Parabolic trough				
	focus and tracker	type with line				
		focus and				





		tracker			CATIO	
GENEI Collecto	RAL OBJECTIVE 3.0: Under ors	erstand the principle of cor	version of radiant ener	gy into heat for low-an	d medium temperatur	e for Solar
5-6	 3.1 Explain the working principle of Solar Thermal power plant systems: Transmissivity Absorptivity Reflectivity of radiant heat within the solar thermal 	Explain the working principle of Solar Thermal power plant systems: • Transmissivity • Absorptivity • Reflectivity of radiant heat within the solar	Textbooks Journals Internet Computer Projector White Board Marker	MCAL		
	collector 3.2 Explain the Mechanism of converting radiant energy to heat in Solar Thermal Collectors	thermal collector Explain the Mechanism of converting radiant energy to heat in Solar Thermal Collectors Explain the Mechanism	Ammations			
	3.3 Explain the Mechanism of heat transfer within the	of heat transfer within the solar thermal collector				





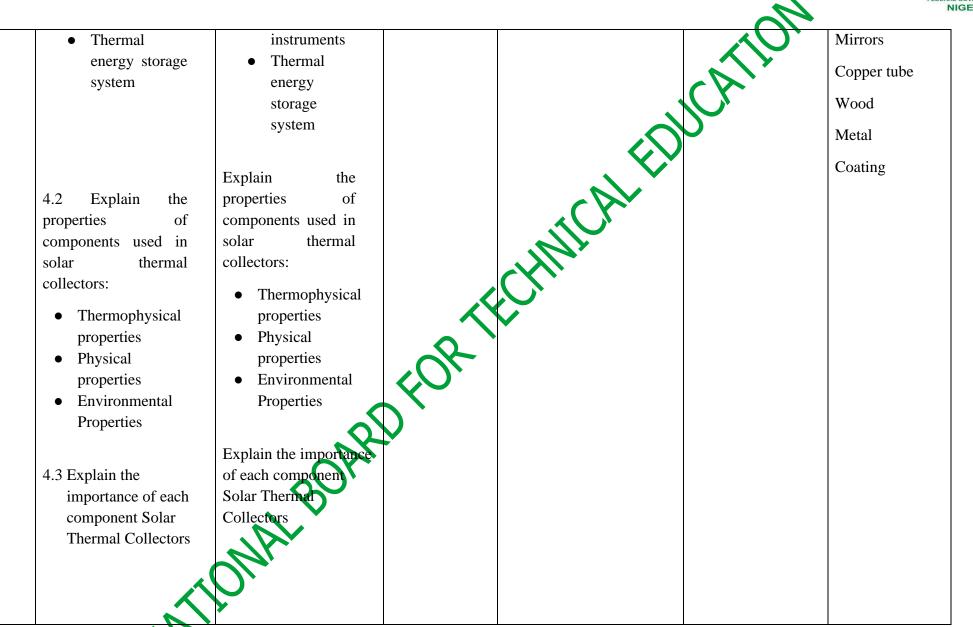


CENER	solar thermal collector 3.4 Explain Storage of heat content and circulation of working fluid	Explain Storage of heat content and circulation of working fluid	temperature and p	nedium temperature Solar Th		
GENER	AL ODJECTIVE 4.0. KIIO					
7-8	4.1 Explain the	Explain the working	Textbooks	Identify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















						^b u	
	RAL OBJECTIVE 5.0: Und		_	erature and medium	temperature solar th	nermal collectors	
-11	5.1 Explain the function of Solar Thermal Collector	Explain the function of Solar Thermal Collector Explain the application	Textbooks Journals Internet	HNICA			
	5.2 Explain the application of low and medium temperature Solar Thermal Collector:	of low and medium temperature Solar Thermal Collector:	Computer Projector White Board				
	 Water heating Space heating and cooling Solar Cooking Power generation Drying Solar water disinfection or Desalination (SODIS) etc. 	 Water heating Space heating and cooling Solar Cooking Power generation Drying Solar water disinfection or Desalination (SODIS) etc. 	Marker Animations Charts				
	5.3 Explain limitations of						







					A	FEDERA
	low and medium temperature Solar Thermal Collectors	Explain limitations of low and medium temperature Solar Thermal Collectors			CAIL	
GENER	RAEL OBJECTIVE 6.0: Kn	now techniques of evaluation	ng solar thermal c	collector efficiency		
12-14	6.1 Define Solar Thermal	Explain solar thermal	Textbooks	Demonstrate the use of	Guide students to:	Pyranometer or
	Collector efficiency	collector efficiency	Journals Internet	measuring devices in evaluating efficiency of Solar Thermal Collector	Identify measuring instrument used in	pyrheliometer
	6.2 Explain the techniques for obtaining	Explain the techniques for obtaining the	Computer	Solar Thermal Conector	evaluating efficiency of solar	UV-VIS-NIR spectrometers or
	the following parameters:	following parameters:	Projector		thermal collector	double beam
	• Useful heat	Useful heat	White Board	Demonstrate the use of		spectral photometer



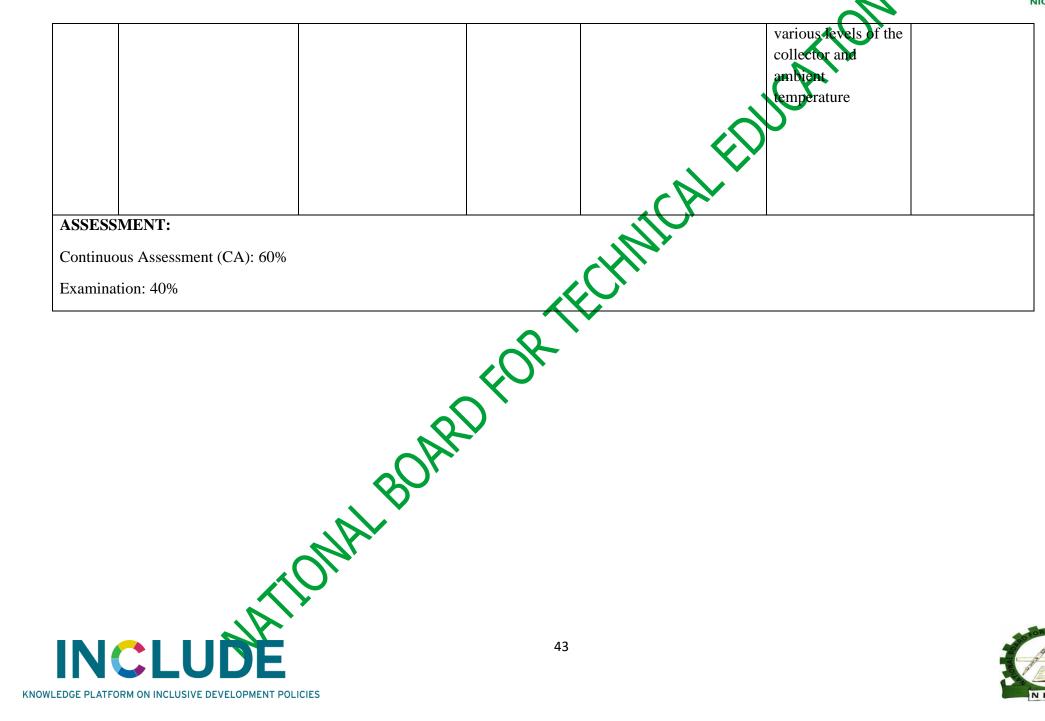


area	surface area	Animations	radiation	device	
• Intensity of solar	• Intensity of	Charts		to measure beam	Flow meter or
radiation on	solar radiation			and diffuse	flow sensor and
collector surface	on collector		Demonstrate the use of	component of solar	
• Transmissivity	surface		measuring device to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













YEAR I SEMESTER II COURSES

Techno-Economic Analysis for Solar Thermal Systems

COURSE TITLE : Techno-Economic Analysis for	COURSE CODE: STE 321	CONTACT HOURS: 2
Solar Thermal Systems	CREDIT UNIT: 2	THEORETICAL: 1
YEAR: I SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 1
GOAL: This course is designed to acquaint the student Thermal Systems	s with basic knowledge and skills in	Techno-Economic Analysis (TEA) in Solar
GENERAL OBJECTIVES: On completion of this con	urse, the students should be able to:	
1.0 Understand the technical and economic principles o	f Solar Thermal Systems	
2.0 Understand the methodology of Techno-Economic	Analysis (THA) in Solar Thermal Sy	stems
3.0 Know the modelling techniques used in Techno-Eco	phomic Analysis (TEA) of Solar The	rmal Systems
	bility of Solar Thermal Systems	
4.0 Know the techniques of analyzing the economic via	onity of Solar Therman Systems	



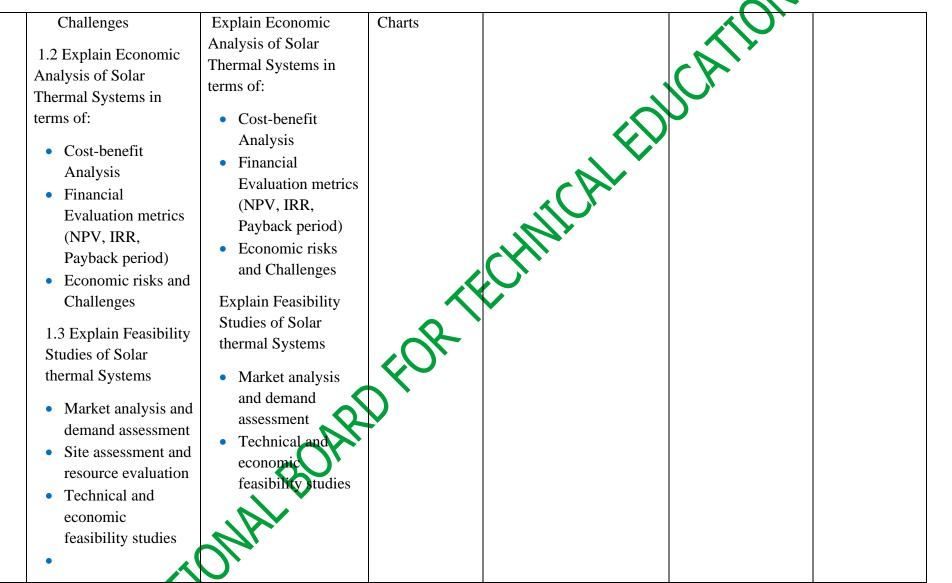




COURS	E TITLE: Techno-Econor	nic Analysis for Solar	COURSE CODE: STE 312		CONTACT HOURS: 2	2
Thermal	Systems		CREDIT UNIT	: 2	THEOREFICAL: 1	
YEAR:	I SEMESTER: I		PRE-REQUISI	ГЕ:	PRACTICAL: 1	
COURS	E SPECIFICATION: TH	HEORETICAL AND PRAC	CTICAL		\mathbf{C}	
GOAL:	This course is designed to	acquaint the students with	basic knowledge a	nd skills in Teehno-Eco	nomic Analysis (TEA) ir	n Solar Thermal
Systems	6	1			, , , , , , , , , , , , , , , , , , ,	
GENER	AL OBJECTIVE 1.0 Und	derstand the technical and e	economic principle	s of Solar Thermal Sys	tems	
	RETICAL CONTENT		r • r	PRACTICAL CON		
	-					
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning	Teacher's Activities	Resources
	Outcome			Outcome	Activities	
1-2	1.1 Explain technical	Explain technical	Textbooks			
	analysis of Solar	analysis of Solar	Journals			
	Thermal System in terms of :	Thermal System in terms of :	Internet			
	• System design and performance	• System design and performance	Computer			
	evaluation	Energy Yield and	Projector			
	• Energy Yield and	Efficiency	White Board			
	Efficiency	• Technical Risk and	Marker			
	• Technical Risk and	Challenges	Animations			



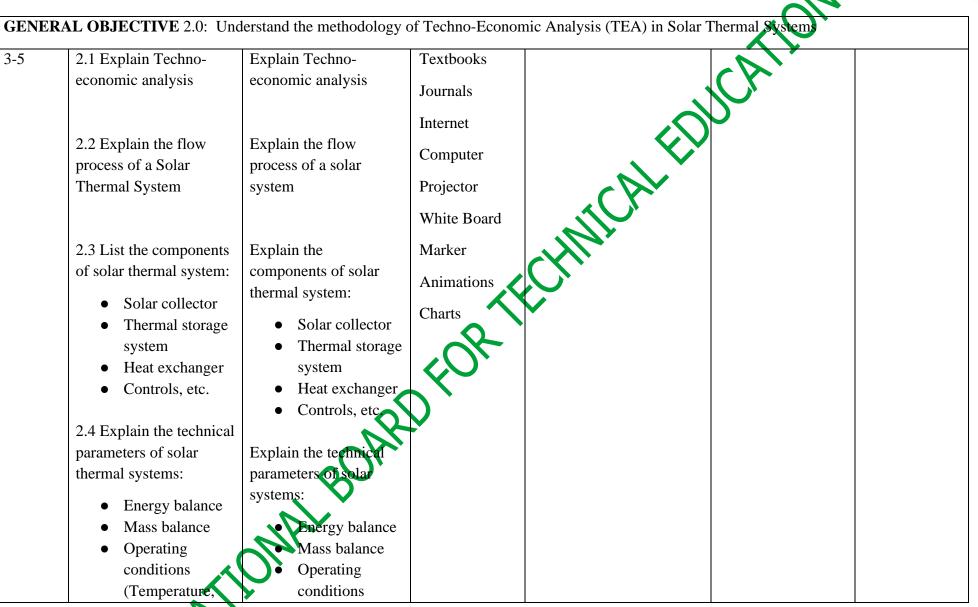


















	pressure, flow	(Temperature,				
	rate, etc)	pressure, flow				
	• Efficiency	rate, etc)				
	• Plant capacity	• Efficiency				
		• Plant capacity				
ENER	AL OBJECTIVE 3.0: Knov	w the modelling technique	s used in Techno	-Economic Analysis (TE	A) of Solar Thermal Syster	ns
-8	3.1 Explain process	Explain process	Textbooks	Demonstrate how to	Guide the student	MS Excel
	modelling	modelling	Journals	perform modelling	on how to:	RETScreen
	3.2 Explain types of	Discuss types of	Internet		Perform modelling	
	Modelling process	Modelling process			Solar Thermal	
	01		Computer		System using	System
	Visual economic model	• Visual economic model	Projector		software	Advisor Model (SAM)
	Mathematical	Mathematical	White Board			
	model	model	Marker			
	• Empirical models	• Empirical	IVIAIIKEI			
	• Simulation	models	Animations			
	models	Simulation	Charts			
		models				
	3.3 Explain the	°O,				
	simulation aspect of	Explain the simulation				
	solar thermal system					
	process, including	thermal system				
	material flow,	process, including				
	energy consumption	material flow,				
	and equipment	▼				
	CLUDE	1	48			

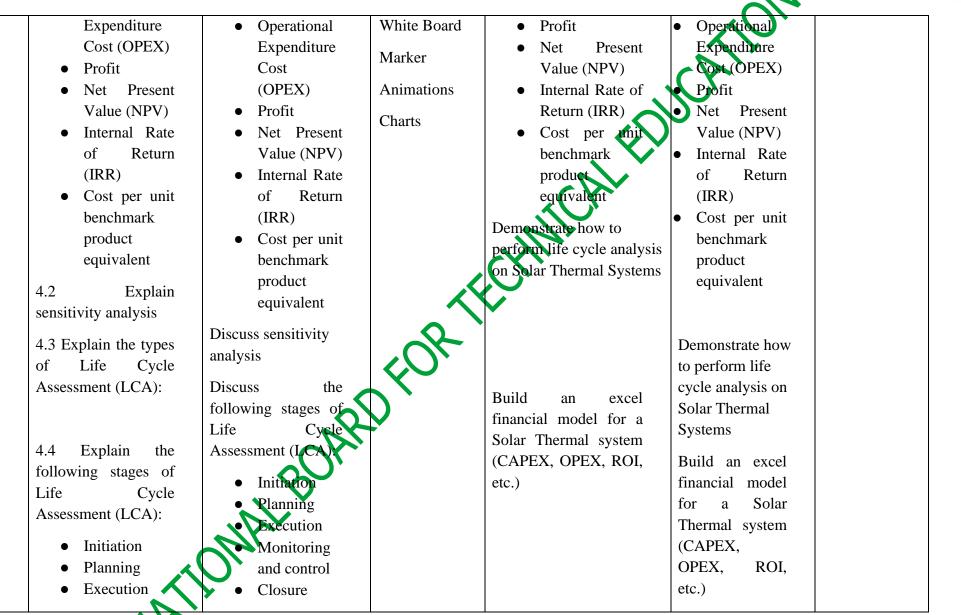




	 performance 3.4 Explain the methods for the evaluation of the following: Component sizing parameters Utility requirement of components of Solar Thermal System 	energy consumption and equipment performance Explain the methods for the evaluation of the following: • Component sizing parameters • Utility requirement of components of Solar Thermal System	F08-		JUNI	
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	 c viability of Solar Thermal 3 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/Sim ulink software MS Excel









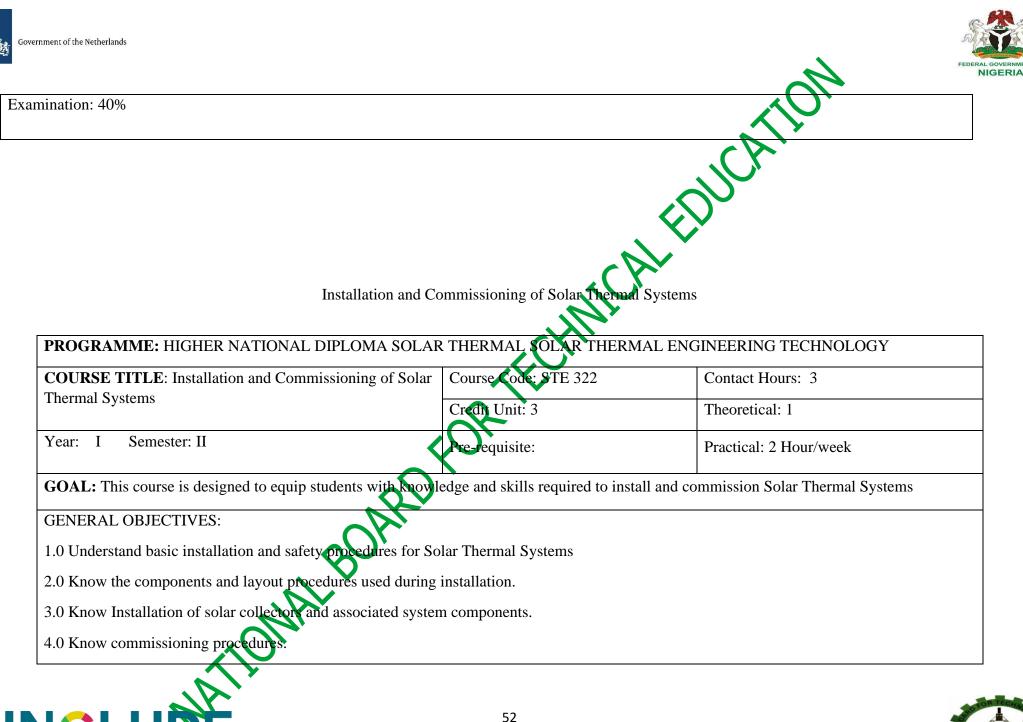




Monitoring and control Closure ENERAL OBJECTIVE 5.0 Und	lengtond Dick Accompany i	n Solon Thormol		CATIO	
 13-15 5.1 Explain the principles of risk assessment in solar thermal systems 5.2 Explain risks analysis procedures in Solar Thermal System 5.3 Explain strategies for risk mitigation 5.4 Explain the effectiveness of risk management plan 	Explaintheprinciplesofriskassessmentinsolarthermal systemsExplainrisksanalysisproceduresinSolarThermalSystemDiscussstrategiesforriskmitigationExplaintheeffectivenessofmanagementplan	TextbooksJournalsInternetComputerProjectorWhite BoardMarkerAnimationsCharts	Analyse risks in Sølar Thermal System Develop strategies for risk mitigation Evaluate the effectiveness of risk management plan	Guidestudentsto:IdentifyanalyserisksinSolarThermalSystemDevelopstrategiesforriskmitigationEvaluatetheeffectivenessofriskmanagementplan	Microsoft Project System Advisor Mode (SAM) RiskMatrix RETScreen MS Excel Sample risk management plan







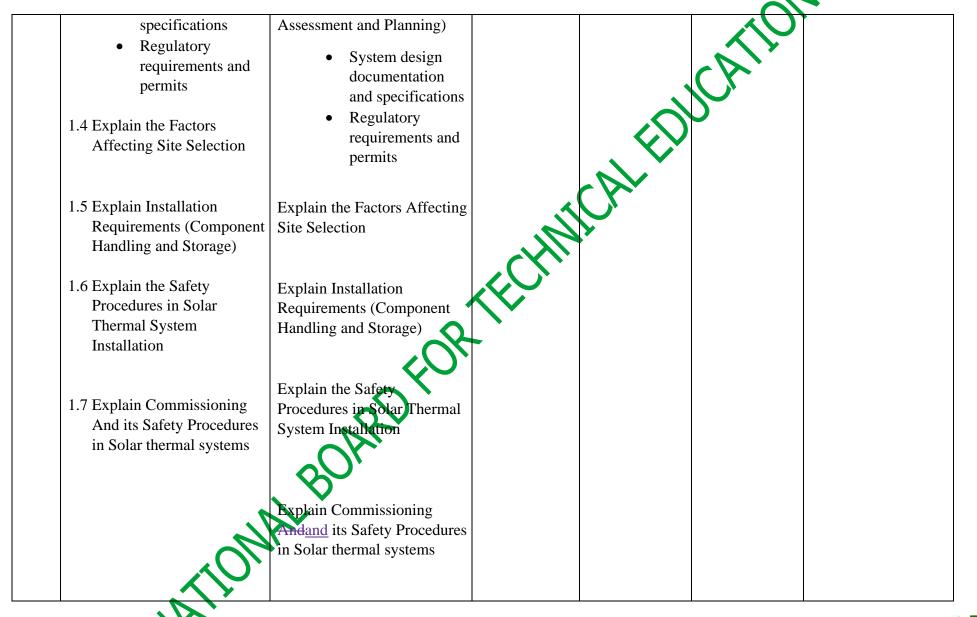




PRO	GRAMME: HIGHER NATION	AL DIPLOMA SOLAR THEF	RMAL SOLAR T	HERMAL ENC	JINEERING TEC	HNOLOGY
	RSE TITLE : Installation and	Course Code: STE 322			Contact Hour	s: 3
Comn Syster	nissioning of Solar Thermal ns	Credit Unit: 3		5	Theoretical: 1	
Year:	I Semester: II	Pre-requisite:			Practical: 2 H	lour/week
COU	RSE SPECIFICATION: THE	DRETICAL AND PRACTICAL	L	$\overline{\mathbf{O}}$	1	
GOA	L: This course is designed to eq	uip students with knowledge ar	nd skills required t	to install and co	mmission Solar T	hermal Systems
GENI	ERAL OBJECTIVE 1.0: Under	erstand basic installation and sa	fety procedures for	or Solar Therma	al Systems	
THEC	DRETICAL CONTENT		XV.	PRACTICAL	L 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	Explain Solar Thermal System Installation	Textbooks			
	1.2 Explain Solar Thermal System Installation procedures	Explam Solar Thermal System Installation	Internet Computer			
	1.3 Explain Assessment (Site Assessment and Planning)	procédures	Projector White Board			
	• System design	Explain Assessment (Site	8			









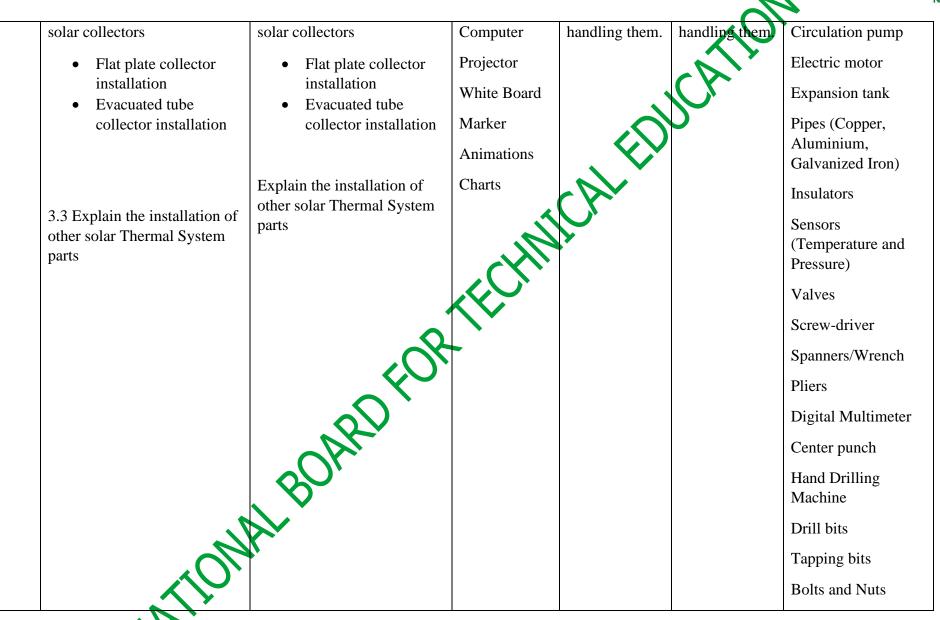




4-7	2.1 Explain the tools and	Explain the tools and	Textbooks	Develop a solar		Auto-cad softwar
	equipment in solar thermal installation.	equipment in solar thermal installation.	Journals	thermal system layout drawing	thermal system layout drawing	Pencil and Sketch
	2.2 Explain the physical	Explain the physical	Internet	from an existing design	from an existing design	pad Mathematical set
	attributes of Solar Thermal	attributes of Solar Thermal	Computer	existing design	existing design	
	components	components	Projector			Measuring tape
			White Board	Apply	Apply	Pencil
	2.3 Explain the layout	Explain the layout		measuring and	measuring and	Ruler
	procedures during installation	procedures during installation	Marker	marking tools to accurately	marking tools to accurately	Sminit lawal
	• System layout	• System layout	Animations	position and	position and	Spirit level
	drawings and	drawings and	Charts	install solar	install solar	Inclinometer
	schematics	schematics		thermal	thermal	Magnetic Compa
	• Planning, Marking and	Planning, Marking	-	components based on a	components based on a	
	Measuring for component placement	and Measuring for component placement		prepared layout	prepared layout	
	 Fixing of system 	component placement		diagram	diagram	
	components using				-	
	different techniques	Ar				
Gener	ral Objective 3.0: Know installation	on of solar collectors and associ	ated system com	ponents		
8-11	3.1 Explain site preparation	Explain the steps required in	Textbooks	Identify the	Identify the	Solar collector (F
	-	preparing for the installation	Journals	components in	components in	plate)
	prior to installing solar	of solar collectors		a solar thermal	a solar thermal	Storage tank
	thermal collectors		Internet	system and the tools used in	system and the tools used in	Heat exchanger
	3.2 Explain the installation of	Explain the installation of			10015 4504 III	ricat excitatiget
	LUDE	•	55			







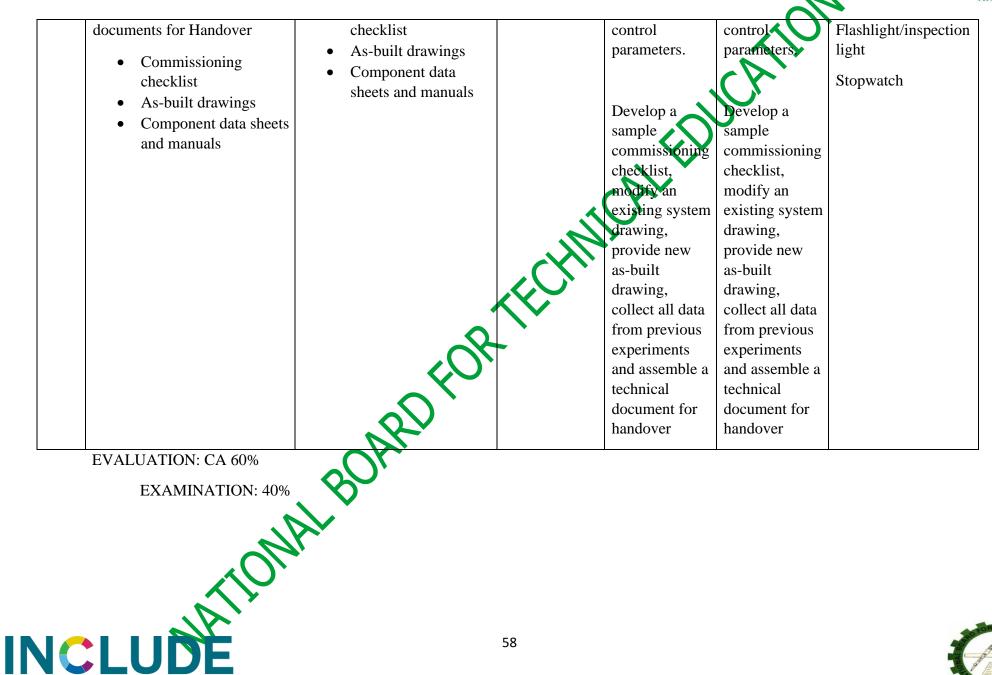




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						Plumbing Fittings
Genera	al Objective 4.0: Know commiss	ioning procedures			CA.	
12-15	4.1 Define pre- commissioning,	Explain pre-commissioning, commissioning and testing.	Textbooks Journals	Conduct visual checks in a	Conduct visual checks in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











Advanced	Thermal System Performance and T	roubleshooting
PROGRAMME: HIGHER NATIONAL DIPLOMA		
COURSE TITLE: Advanced Thermal System	Course Code: STE 323	Contact Hours 2
Performance and Troubleshooting	Credit Unit: 2	Theoretical: 1
Year: I Semester: II	Pre-requisite: Nil	Practical: 1 Hour/week
GOAL: This course is designed to acquaint students troubleshooting	with the knowledge and skills in ad	wanced thermal system performance and
GENERAL OBJECTIVES: On completion of this co	ourse, the students should be able to:	X
1.0 Know the performance principles for advanced th	nermal systems	
2.0 Know troubleshooting techniques for advanced the		
3.0 Know the performance of advanced thermal syste	ems.	
4.0 Know the safety measures and regulations in adv		
5.0 Know the maintenance procedures for advanced to	thermal systems.	
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ICLUDE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES	59	



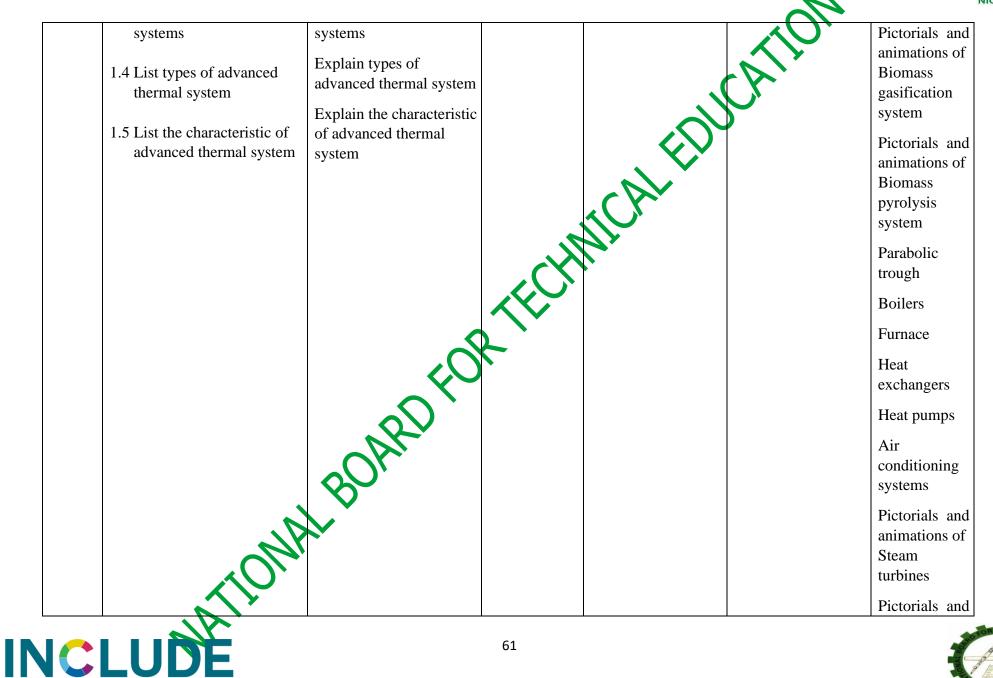


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PROG	RAMME HIGHER NATIONAL	L DIPLOMA SOLAR THE	RMAL ENGIN	EERING TECHNOL	OGX	
	SE TITLE: Advanced Thermal	COURSE CODE: STE 3	23	G	ontact Hours: 2	
-	Performance and eshooting	Credit Unit: 2			eoretical: 1	
Year: I Semester: II Pre-requisite: Nil				Pra	actical: 1	
COUR	SE SPECIFICATION: THEOR	ETICAL AND PRACTICA	AL			
troubles	: This course is designed to acqua shooting RAL OBJECTIVE 1.0: Know t				F	
THEOF	RETICAL CONTENT			PRACTICAL CON	TENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Define thermal system1.2 Define advanced thermal system	Explain thermal system Explain advanced thermal system	Textbooks Journals Internet Computer Projector White board Marker	Identify advanced thermal systems Demonstrate the uses of advanced	Guide students to: Identify advanced thermal systems Demonstrate the uses of advanced	Pictorials and animations of small modular reactors Pictorials and animations of
	1.3 List the differences between thermal systems and advanced thermal	Explain the differences between thermal systems and advanced thermal	Animation	thermal systems	thermal systems	Supercritical Heat Exchangers













					4	FED
					10	animations of Gas turbines
Genera	al Objective 2.0: Know troublesho	poting techniques for advan	ced thermal sys	tems	\mathbf{C}	
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 	Explain trouble shooting in advanced thermal system Explain how troubleshooting is carried out with respect to advanced thermal	Textbooks Journals Internet Computer Projector White board Marker Animation	Troubleshoor 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
	2.3 List the benefits derived from troubleshooting of advanced thermal system.	system Explain the benefits derived from troubleshooting of advanced thermal system.				Supercritical Heat Exchangers Pictorials and animations of Biomass gasification system
	Ala	BOAR				Pictorials and animations of Biomass pyrolysis system
						Parabolic trough







7_9	3.1 Define performance of	Explain performance of	Textbooks	Demonstrate how	(mide students to:	Pictorials and
-9	 a.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 response time 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:	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	 Heat transfer rate Energy efficiency Coefficient of performance Thermal 	Pictorials and animations of Small modular reactors Pictorials and animations of Supercritical Heat Exchangers Pictorials and animations of Biomass gasification
		 Heat transfer rate Energy efficiency Coefficient of performance Thermal conductivity Specific heat capacity System efficiency System response time System capacity 		 capacity System efficiency System response time System capacity System stability 	 Specific heat capacity System efficiency System response time System capacity System stability 	system Pictorials and animations of Biomass pyrolysis system Parabolic trough



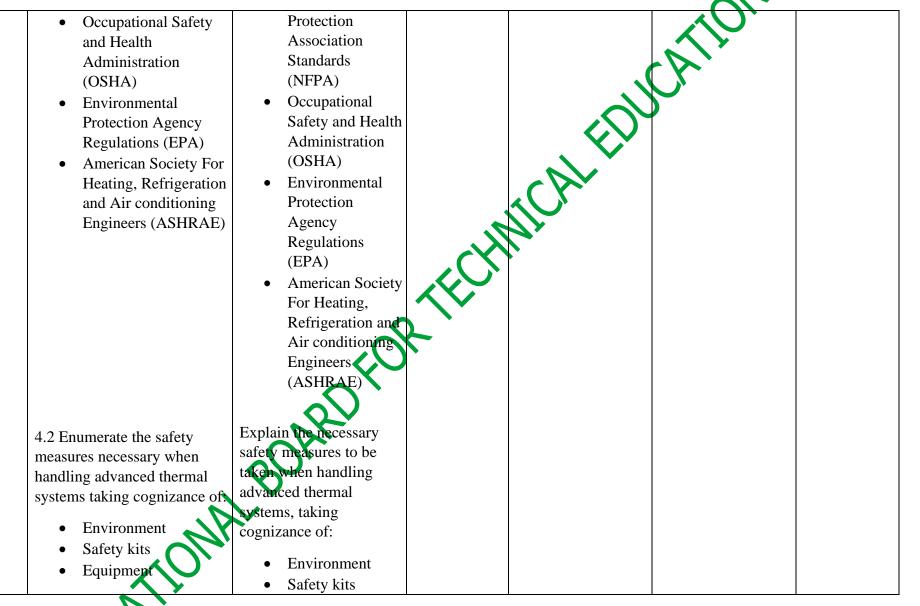


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	3.4 Explain how to determine the performance of advance thermal systems3.5 Explain how advanced thermal system are modeled.	 System stability Explain how to determine the performance of advance thermal systems Explain how advanced thermal system are 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 a	hAdvanced The	ermal Systems	1	
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











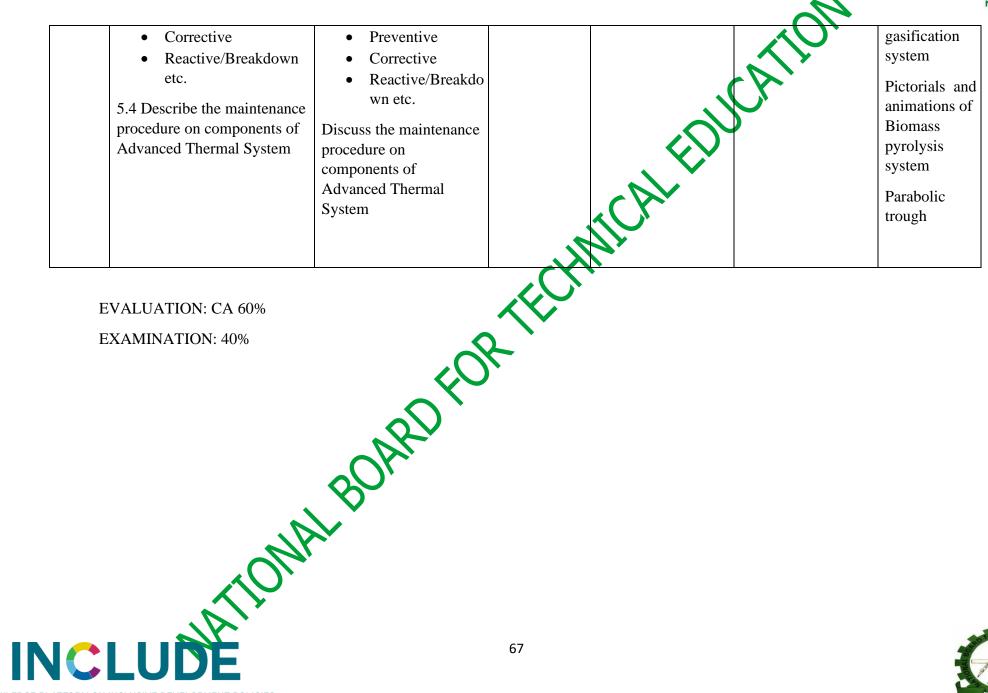




		Equipment			10	
	4.3 List the safety kits necessary when working on advanced thermal systems	Explain the necessary safety kits and gadgets to be used when working on advanced thermal		ED!	Ch.	
	4.4 Describe the first aid measures to be taken in case of accident when handling advanced thermal systems	systems Explain first aid measures to be taken in case of accident when handling advanced thermal systems		NCALED.		
enera	l Objective 5.0: Know the mainte	1	, i i i i i i i i i i i i i i i i i i i	stems		
2-15	5.1 Explain maintenance in relation to advanced thermal systems	Explain maintenance in relation to advanced thermal systems	Textbooks Journals Internet Computer	Carry out preventive maintenance on	Guide students to: Carry out preventive maintenance on	Pictorials and animations of Small modular
	5.2 State the Importance of maintenance to Advanced Thermal Systems	Explain the Importance of maintenance to Advanced Thermal Systems	Projector White board Marker Animation	Heat Exchanger	Heat Exchanger	reactors Pictorials an animations of
	5.3 Explain the different types of maintenance namely	Explain the different types of maintenance namely:				Supercritical Heat Exchangers
	PredictiveCondition -based	Predictive				Pictorials an animations of









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COURSE TITLE: Solar Thermal Collectors and	COURSE CODE: STE 324	CONTACT HOURS: 3
Application II	CREDIT UNIT : 3	THEORETICAL: 2
YEAR: I SEMESTER: II	PRE-REQUISITE: Nil	PRACTICAL: 1
GOAL: This course is designed to acquaint the student	ts with basic knowledge and skills in	Solar Thermal Power Plants
.0 Understand the concept of Solar Thermal Collector .0 Understand the principles of Solar Thermal Collect .0 Know the components of Solar Thermal Collectors .0 Know the efficiency of Solar Thermal Power Plants .0 Know the components of Thermal energy storage	ors in Power Plants in Power Plants	
6.0 Understand the applications of Solar Thermal Pove	et Plants	

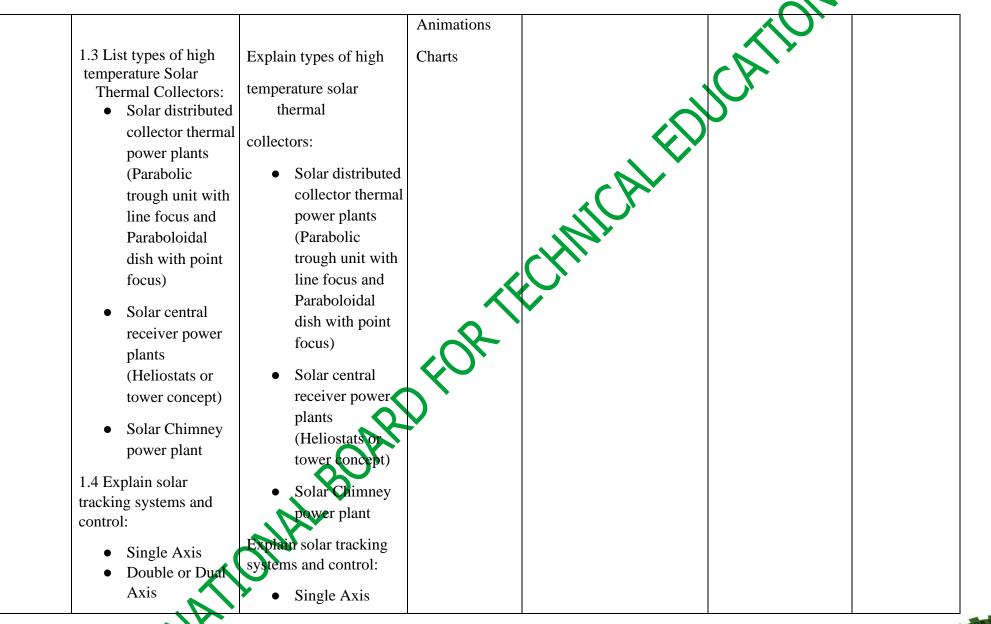




	OURSE TITLE: Solar Thermal Collectors and		COURSE COD	E: STE 324	CONTACT HOURS: 3	3
Applicati	on II		CREDIT UNIT:	3	THEORETICAL:	2
YEAR:	I SEMESTER: II		PRE-REQUISIT	E: Nil	PRACTICAL: 1	
COURSI	E SPECIFICATION: THE	EORETICAL AND PRAC	TICAL			
GOAL: 7	This course is designed to a	cquaint the students with	basic knowledge an	d skills in Solar Therma	l Power Plants	
	AL OBJECTIVE 1.0: Und					
	RETICAL CONTENT			PRACTICAL CONT	FNT	
						D
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-2	1.1 Explain solar	Explain solar thermal	Textbooks			
	thermal power systems	power systems	Journals			
			Internet			
	1.2Explain high temperature solar	Explain high temperature yolar	Computer			
	thermal collectors	thermal collectors	Projector			
		NAN	White Board			
		O_{r}	Marker			













		• Double or Dual Axis)
GENER A	AL OBJECTIVE 2.0: Und	erstand the principles of S	olar Thermal Collectors in Po	wer Plant	
3-4	2.1 Explain the working	Explain the working	Textbooks		•
	principle of Solar Thermal Power	principle of Solar Thermal Power Plants:	Journals		
	Plants:	• Transmissivity,	Internet		
	• Transmissivity,	absorptivity and	Computer	CV.	
	absorptivity and reflectivity of	reflectivity of radiant heat	Projector	CAL	
	radiant heat	within the	White Board		
	within the collector	collector	Marker		
		Explain the Mechanism	Animations		
	2.2 Explain the	of converting radiant			
	Mechanism of converting radiant	energy to heat	Charts		
	energy to heat	Explain the mechanism			
		of heat transfer within			
	2.3 Explain the	the solar thermal			
	mechanism of heat	collector			
	transfer within the solar				
	thermal collector	Explain the storage of			
		heat content and			
	2.4 Explain the storage	circulation of working			
	of heat content and	fluid			







	circulation of working fluid					
	IIulu					
GENER	RAL OBJECTIVE 3.0 Kno	w the components of Solar	Thermal Collector	ors 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 	 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 	TextbooksJournalsInternetComputerProjectorWhite BoardMarkerAnimationsCharts	Identify components of solar thermal power plant Demonstrate the use of high solar thermal collector	 Quide 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
	 Heat transfer fluids condenser Fresnel lenses 3.2 Explain the working principles 	 condenser Fresnel lenses Explain the working principles of solar 				





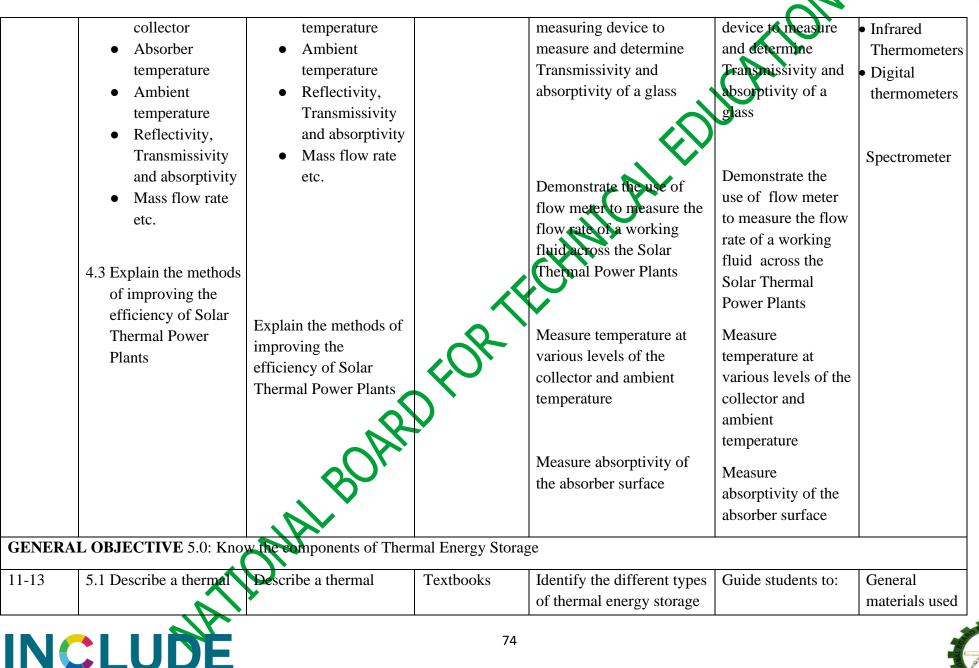


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	of solar thermal power plant components	thermal power plant components			CATIO.	
	3.3 Explain merits and demerits of solar tracking systems	Explain merits and demerits of solar tracking systems			5	
GENERA	AL OBJECTIVE 4.0 Know	w the efficiency of Solar Tl	nermal Power Pla	ints		
8-10	4.1 Define efficiency of	Explain efficiency of	Textbooks	Demonstrate the use of	Guide students to:	Pyranometer
	Solar Thermal Power plant system	Solar Thermal Power plant system	Journals	measuring devices in evaluating efficiency of	Identify measuring instrument used in	or pyrheliometer
		Explain the following	Internet	Sotar Thermal Power Plants	evaluating	
	4.2 Explain the following energy parameters within the	energy parameters within the solar thermal power plant:	Computer Projector White Board		efficiency of solar thermal collector	UV-VIS-NIR spectrometers or double
 Solar Thermal Power Plants: Solar irradiation absorbed by absorber Beam solar 		• Solar irradiation absorbed by	Marker		Demonstrate the use of measuring	beam spectral photometer
		absorber • Beam solar	Animations	Demonstrate the use of measuring devices to	device to measure	
	irradiation intensity Aperture area	Charts	measure beam and diffuse component of solar irradiation	beam and diffuse component of solar irradiation	Flow meter or flow sensor and	
	irradiation intensity	parabolic trough collector				Thermometer
	• Aperture area parabolic trough	Absorber		Demonstrate the use of	Demonstrate the use of measuring	• Thermocoupl









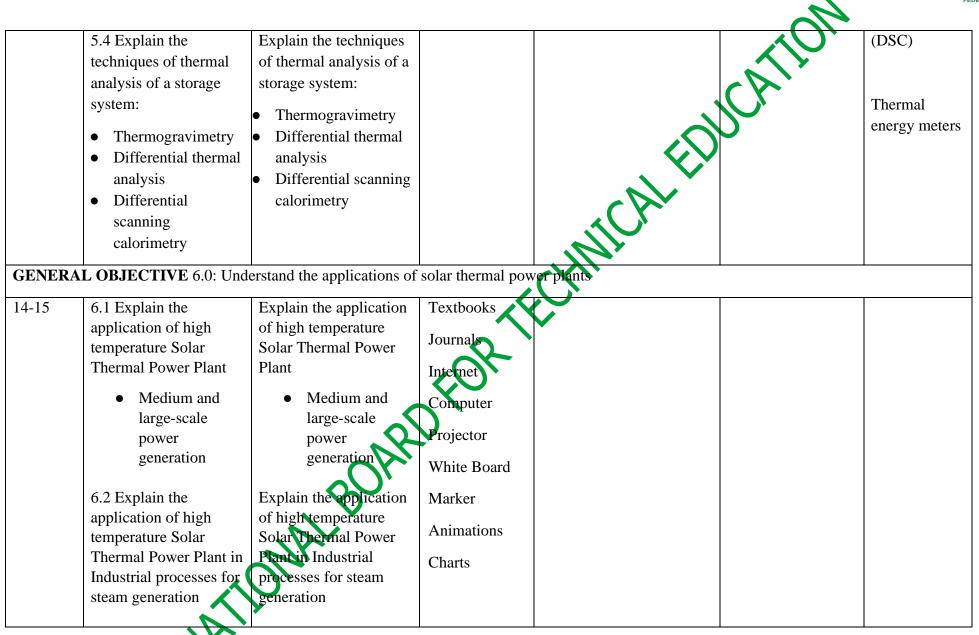




	1	1			Γ
energy storage system.	energy storage system.	Journals	systems and materials	Identify the	in Thermal
		Internet		different types of	energy
				thermal energy	storage
5.2 Explain the	Explain the	Computer	Demonstrate the mode of	storage systems and	system:
classification of	classification of	Projector	operation of thermal	materials	Rock
thermal storage system:	thermal storage system:		energy storage systems	Demonstrate the	Concrete
• Single tank	• Single tank	White Board		mode of operation	Sand
storage	storage	Marker		of thermal energy	Iron
• Double tank	• Double tank			storage systems	Iron oxide
storage	storage	Animations			Water
		Charts			WaterThermal
5.3Explain the types of	Explain the types of		Demonstrate the use of	Demonstrate the	Oil
solar thermal energy	solar thermal energy		thermal energy storage	use of thermal	Sodium
storage:	storage:		system to measure	energy storage	and
• Sensible heat	• Sensible heat	0	 physical property of material as it is subjected 	system to measure	potassium
energy storage	energy storage		to change in temperature	physical property of	nitrate
• Latent heat	• Latent heat		to change in temperature	material as it is	Animal fa
energy storage	energy storage			subjected to change	Paraffin
• Water storage	Water storage	M		in temperature	wax
Packed bed	Packed bed				wax
exchange	exchange				
storage	storage				Calorimeter
• Thermo-	Thermo-				
chemical	chemical				
storage	storage				Differential
	N° storage				scanning
					calorimeters



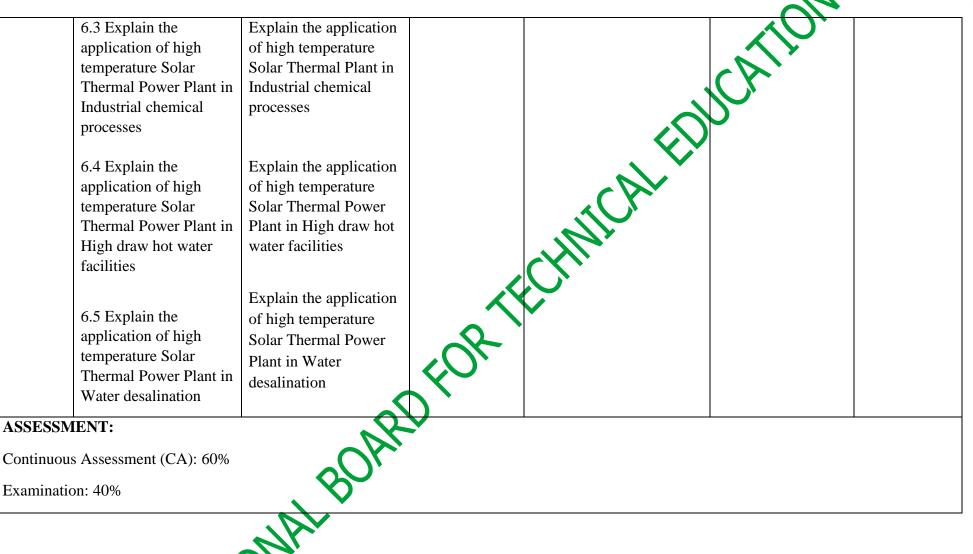














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Research Methodology in Solar Thermal Energy

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOG

COURSE TITLE: Research Methodology in Solar	COURSE CODE: STE 325	CONTACT HOURS: 2
Thermal Energy	CREDIT UNIT: 2	THEORETICAL: 1
YEAR: I SEMESTER: II	PRE-REOUISITE:	PRACINCAL: 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





COURSE	TITLE : Research Method	ology in Solar Thermal	COURSE CODE	CON CON CON	TACT HOURS: 2	
Energy		CREDIT UNIT : 2	2 TH	THEORETICAL: 1		
EAR:	I SEMESTER: II		PRE-REQUISIT	E: PR	ACTICAL: 1	
	SPECIFICATION: THE					
	This course is designed to account to accoun	E			elation to Solar Ther	mal Systems
	L OBJECTIVE 1.0: Unde	erstand the fundamental c	oncepts of research			
THEOR	ETICAL CONTENT			PRACTICAL CONTEN		
WEEK	SPECIFIC LEARNING		RESOURCES	SPECIFIC LÉARNING		RESOURCES
	OUTCOME	ACTIVITIES		OUTCOME	ACTIVITIES	
	1.1 Define Research	Explain Research	Textbooks			
1-2			Journals			
	1.2 Explain the importance of Research	of Research	Internet			
	of Research	of Research	Computer Projector			
	1.3 Describe types of	Explain types of	White Board			
	Research:	Research:	Marker			
			Animations			
	• Experimental	• Experimental	Charts			
	• Descriptive	• Descriptive				
	• Applied research	Applied research				
	1.4 Explain Literature					
	review in research	Explain Literature review	W			
	1.5 Explain ethical issues.	inresearch				
	• Plagiarism and					

NBTE



	consent					
	• Data falsification,	Discuss Ethical issues				
		relating to Research:				
		• Plagiarism and				
		consent			5	
		• Data falsification				
GENERA	L OBJECTIVE 2.0: Know	w the process of formulating	g research proble	ms, hypotheses, and objectiv	es for solar thermal app	olications.
3-4	2.1 Enumerate the essential	Explain the essential parts	Textbooks	Write a concise and clear	Guide students to:	Journals
	parts of research:	of research:	Journals	title along with background		Internet
	•Title,	•Title,	Internet	information relevant to	clear title along with	Research
	 Background 	 Background 	Computer	solar thermal energy	background information relevant	papers on solar
	 Problem statement, 	• Problem statement,	Projector		to solar thermal	thermal
	• Goal and Objectives,	• Goal and Objectives,	White Board 🧹		energy	
	etc.	etc.	Marker			
	2.2 Explain problem statement, objectives and Research questions	Explain problem statement, objectives and Research questions	Animations Charts	Formulate a research problem relating to solar thermal and derive appropriate objectives for it Create precise and	objectives for it	
	-	Discuss Literature Review		researchable problem statements	Create precise and researchable problem statements	
				Draft a literature review section of a Research	Draft a literature	
				proposal	review section of a	
				proposa	Research proposal	
	. (Summarize relevant studies	Proposal	
				and highlight research gaps	Summarize relevant	
				in solar thermal energy	studies and highlight	







OBJECTIVE 3.0: Kno Define research ectives for berimental or field dy Explain appropriate earch design and thodology selection Outline the steps instruments needed carry out the study on ar Thermal Systems	ow the design and conduct of 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	of experiments/five Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	eld studies in solar thermal sys 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	Journals Internet Research papers on sola thermal Relevant Software for simulation if applicable
Define research ectives for perimental or field dy Explain appropriate earch design and thodology selection Outline the steps l instruments needed carry out the study on	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	Textbooks Journals Internet Computer Projector White Board Marker Animations	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	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	Internet Research papers on sola thermal Relevant Software for simulation if
ectives for berimental or field dy Explain appropriate earch design and thodology selection Outline the steps l instruments needed carry out the study on	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	Journals Internet Computer Projector White Board Marker Animations	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	Select appropriate research design and methodology. Develop experimental or field procedure for the research on any area of your choice on Solar Thermal Systems	Internet Research papers on sola thermal Relevant Software for simulation if
erimental or field dy Explain appropriate earch design and thodology selection Outline the steps l instruments needed carry out the study on	experimental or field study Explain appropriate research design and methodology selection Explain the steps and instruments needed to carry out the study on	Internet Computer Projector White Board Marker Animations	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	research design and methodology. Develop experimental or field procedure for the research on any area of your choice on Solar Thermal Systems	Research papers on sola thermal Relevant Software for simulation if
dy Explain appropriate earch design and thodology selection Outline the steps l instruments needed carry out the study on	study Explain appropriate research design and methodology selection Explain the steps and instruments needed to carry out the study on	Computer Projector White Board Marker Animations	field procedure for the research on any area of your choice on Solar Thermal Systems Conduct the study using tools and techniques in real	methodology. Develop experimental or field procedure for the research on any area of your choice on Solar Thermal Systems	Research papers on sola thermal Relevant Software for simulation if
Explain appropriate earch design and thodology selection Outline the steps l instruments needed carry out the study on	Explain appropriate research design and methodology selection Explain the steps and instruments needed to carry out the study on	Projector White Board Marker Animations	field procedure for the research on any area of your choice on Solar Thermal Systems Conduct the study using tools and techniques in real	Develop experimental or field procedure for the research on any area of your choice on Solar Thermal Systems	papers on sola thermal Relevant Software for simulation if
earch design and thodology selection Outline the steps l instruments needed carry out the study on	research design and methodology selection Explain the steps and instruments needed to carry out the study on	White Board Marker Animations	field procedure for the research on any area of your choice on Solar Thermal Systems Conduct the study using tools and techniques in real	experimental or field procedure for the research on any area of your choice on Solar Thermal Systems	thermal Relevant Software for simulation if
earch design and thodology selection Outline the steps l instruments needed carry out the study on	research design and methodology selection Explain the steps and instruments needed to carry out the study on	Marker Animations	research on any area of your choice on Solar Thermal Systems Conduct the study using tools and techniques in real	experimental or field procedure for the research on any area of your choice on Solar Thermal Systems	Relevant Software for simulation if
thodology selection Outline the steps l instruments needed carry out the study on	research design and methodology selection Explain the steps and instruments needed to carry out the study on	Animations	choice on Solar Thermal Systems Conduct the study using tools and techniques in real	procedure for the research on any area of your choice on Solar Thermal Systems	Software for simulation if
Outline the steps l instruments needed carry out the study on	Explain the steps and instruments needed to carry out the study on		Systems Conduct the study using tools and techniques in real	research on any area of your choice on Solar Thermal Systems	Software for simulation if
l instruments needed carry out the study on	instruments needed to carry out the study on	Charts	Conduct the study using tools and techniques in real	of your choice on Solar Thermal Systems	simulation if
l instruments needed carry out the study on	instruments needed to carry out the study on	OP 1	tools and techniques in real	Solar Thermal Systems	
carry out the study on	instruments needed to carry out the study on	CR	tools and techniques in real	Systems	apprease
• •	carry out the study on	08	tools and techniques in real		
ar Thermal Systems		10×	-		
			or simulated environments	~	
			or simulated environments	Conduct the study	
				using tools and	
				techniques in real or	
				simulated	
				environments	
OBJECTIVE 4.0: Und		nniques and analy	ysis tools in solar thermal resea	urch.	
Explain different data	Explain different data	Textbooks	Analyze data sets using	Analyze data sets	Data logger
collection methods:	collection methods (e.g.	Journals	appropriate software tools	using appropriate	
Surveys	surveys, experiments,	Internet		software tools	Appropriate
Experiments	sensor data collection)	Computer			analysis
Sensor data collection	$\mathbf{\mathcal{P}}$	Projector			software
í n	Explain data analysis	White Board			tool (Exce
LUDE		81			
]	Experiments	Experiments Sensor data collection) Sensor data collection	ExperimentsSensor data collection)ComputerSensor data collectionProjector	ExperimentsSensor data collection)ComputerSensor data collectionProjector	ExperimentsSensor data collection)ComputerSensor data collectionProjector





2					4	FE
	4.2 Explain data analysis methods	methods	Marker Animations Charts		101	MATLAB, Python)
	4.3 Describe data analysis software tools:	Explain data analysis software tools:			<u>Cr</u>	
	ExcelMATLABPython, etc.	ExcelMATLABPython, etc.		CHNICALED		
	4.4 Explain the Interpretation of results from data analysis in the context of solar thermal energy systems	analysis in the context of solar thermal energy systems				
GENER 9-10	AL OBJECTIVE 5.0: Know 5.1 Explain the structure of			tation of research findings in the Compile research data and	_	
7-10	a technical report	technical report	Journals Internet	analysis into coherent	<i>,</i>	Papers Computer Printer
	5.2 Explain how to Compile research data and analysis into coherent sections	Discuss how to compile research data and analysis into coherent sections	Computer Projector White Board Marker Animations Charts	Interpret the implications of research results Apply correct citation and	coherent sections Interpret the implications of research results	
	5.3 Explain the implications of Research, results	Discuss the implications of Research results		referencing styles in a technical report	Apply correct citation and referencing styles	
					in a technical report	







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	5.4 Explain referencing	Explain referencing and			
	and citation in Research	citation in Research			
	report	report			
GENER.	AL OBJECTIVE 6.0: Under	-	RE and engineer	ing fields	
11-12	7.1 Explain the	Explain the importance	Textbooks		
	importance of	of technical reporting in	Journals		
	technical reporting in	engineering and RE	Internet	1	
	engineering and RE	projects	Computer		
	projects		Projector		
	7.2 Evaluin the role of	Explain the role of	White Board Marker		
	7.2 Explain the role of communication,	communication, documentation and	Animations		
	documentation and	decision making derived	Charts		
	decision making	from technical reports in			
		RE /engineering reports		Y	
	reports in	Feasibility reports			
	RE/engineering	 Progress/Interim 			
	reports	reports			
	• Feasibility reports	Research/project			
	Progress/Interim	reports			
	reports	Incident or			
	• Research/project	troubleshooting			
	reports	reports			
	• Incident or	Close out reports			
	troubleshooting				
	reports	Explain the parts of			
	Close-out reports	technical report writing			
		in engineering and			
		thermal project			
		• Title page			







6.3 Explain the parts of Abstract/Executiv ٠ Recharcher technical report writing in e summary engineering and RE project Introduction ٠ Title page Methodology Abstract/Executive Results/Findings/ Budget summary Introduction Discussions and • Methodology conclusions Results/Findings/B References • udget Appendices Discussions and conclusions Explain the structure and References components of a standard report Appendices ٠ Explain the difference 6.4 Explain the structure between technical and and components of a non-technical readers standard report Explain ethical and 6.5 Explain the difference professional practice in between technical and nontechnical reporting. technical readers 6.6 Explain ethical and Explain the steps involved in planning and professional practice in writing a technical report technical reporting. Discuss how report 6.7 Describe the steps structure supports clarity involved in planning and and readability writing a technical report Explain content tailoring 6.8 Describe how report to suit different report



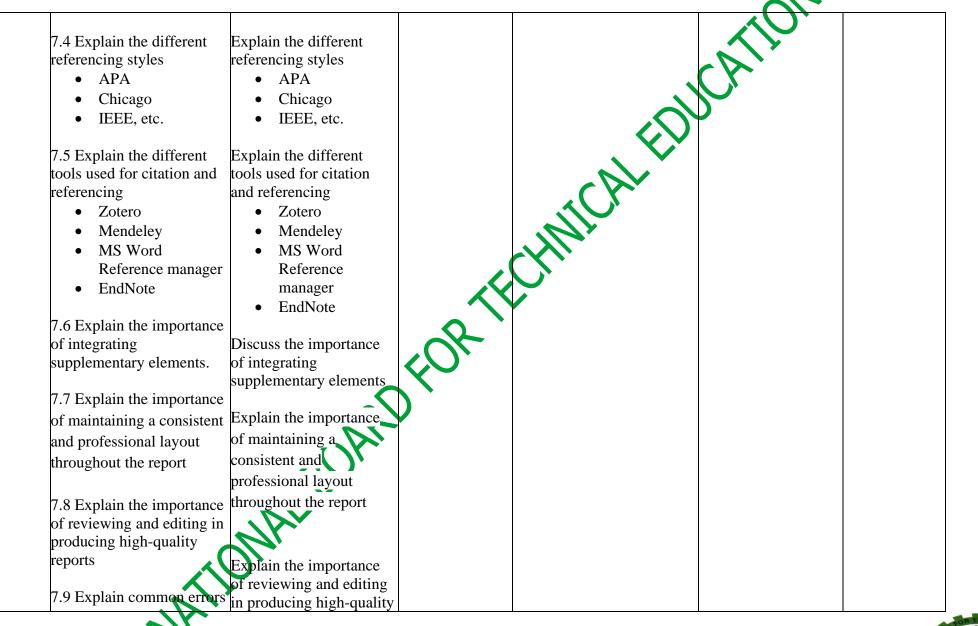




	structure supports clarity and readability	types and purposes			10.	
	6.9 Explain content tailoring to suit different report types and purposes	Explain the importance of coherence, flow, and technical language in report writing			CA.	
	6.10 Explain the importance of coherence, flow, and technical language in report writing	Explain the common errors in report writing and how to avoid them		TCALE		
	6.11 Explain the common errors in report writing and how to avoid them			CHIM		
ENER	AL OBJECTIVE 7.0: Unders	stand Supplementary elementary	ents, reviewing,	editing, and presenting technic	al reports	
-15	 7.1 Explain the types of supplementary elements commonly used in technical reports 7.2 Explain when and how to use visuals charts, 	Explain the types of supplementary elements commonly used in technical reports Explain when and how to use visuals • charts	Marker Animations	 Write a/an: Progress/Interim report Feasibility report Incident or troubleshooting report Demonstrate the use of citation and referencing tools 	 Guide students to write a/an: Progress/Interim report Feasibility report Incident or troubleshooting report 	Sample report Zotero Mendeley
	 tables, diagram 7.3 Explain the importance of source citation and referencing 	• tables, • diagram	Charts	ZoteroMendeley	Demonstrate the use of citation and referencing tools • Zotero Mendeley	













in to shared non-out working			
in technical report writing and how to correct them	reports		
and now to correct them	Explain common errors		× I
7.10 List the key elements	-	r Y	
of a professional	writing and how to		
presentation of reports	correct them		
presentation of reports			
7.11 Explain best practices	Explain key elements of		
C	a professional		
delivering technical report	presentation of reports		
	8		
in academic or workplace	Explain best practices for		
settings	submitting or delivering		
	technical reports in		
	academic or workplace		
	settings		
SSESSMENT:			
Continuous Assessment (CA): 60%			
xamination: 40%			
	` ``		
	Alt		
	NALBU		
NCLUDE	Nr.		





Smart C	Grids & IoT in Solar Thermal S	Systems
PROGRAMME: HIGHER NATIONAL DIPLOMA SO		
COURSE TITLE: Smart Grids & IoT in Solar Thermal	Course Code: STE 326	Contact Hours 3
Systems	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 Smar	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 g	grids	
4.0 Know the modelling and simulation of IoT solutions t	o smart grid problems.	
5.0 Know the equipment used in smart grid & IoT applica	itions	
- CONAL-BOAR	>	
PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES	88	





	SE TITLE: Smart Grids & IoT	COURSE CODE: STE 3	26	Contae	t Hours: 3	
in Solai	r Thermal Systems	Credit Unit: 3		Theore	tical: 1	
Year: I	Semester: II	Pre-requisite: Nil		Rraetic	al: 2	
	SE SPECIFICATION : THEOR : This course is designed to acqu			Smart Grid and IoT for So	lar Thermal Systems	
	RAL OBJECTIVE 1.0: Underst RETICAL CONTENT	and the smart grid & IoT p	rinciples	PRACTICAL CONTEN	Т	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resource
-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 Compute MATLA Simulink Bread board Low



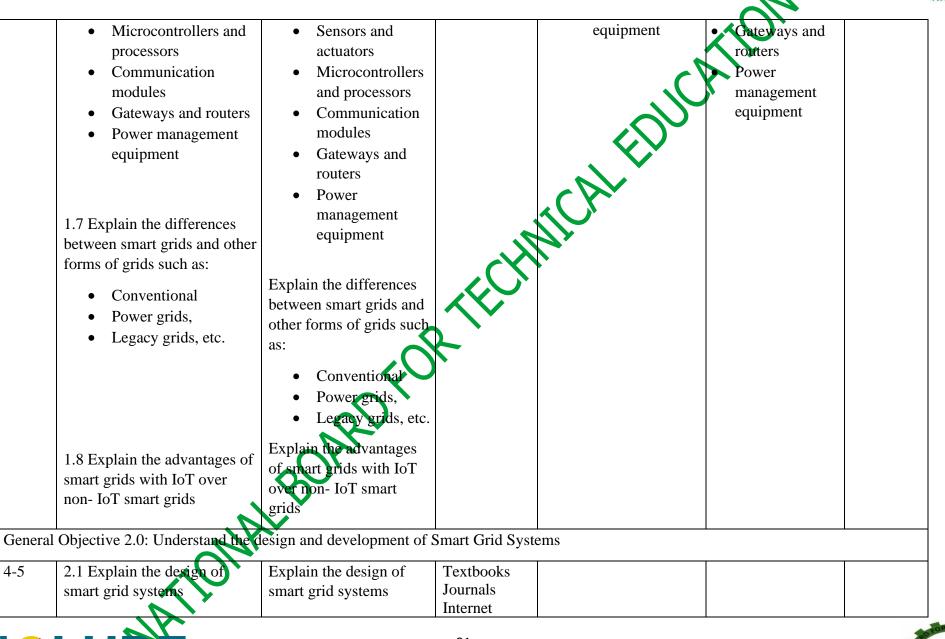


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 integration Grid animation and control Communication networks Data analytics and 	 Renewable energy integration Grid animation and control Communication 	 Communication networks Data analytics and management etc. Identify the facilities 	Grid animation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



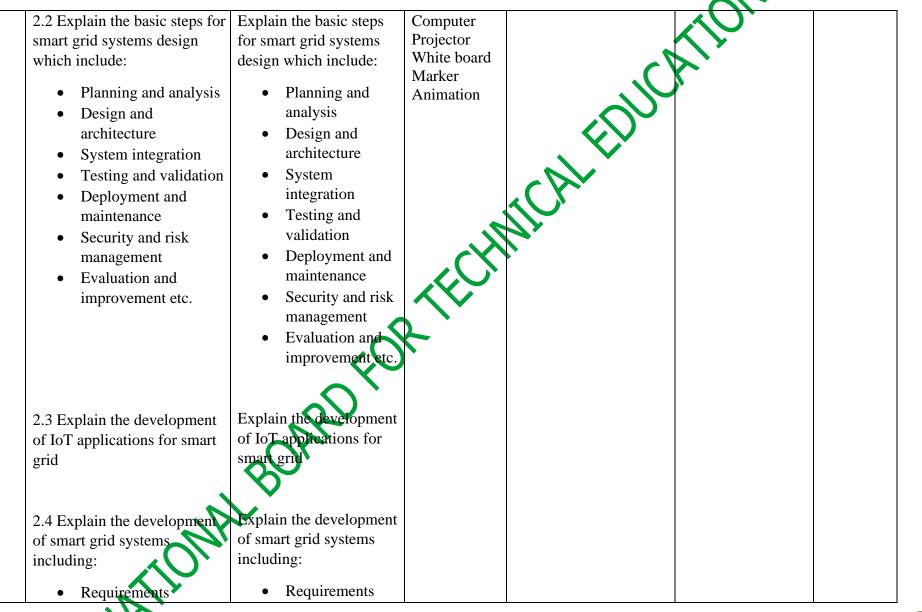


















Genera	gathering Design and Development Testing and validation Development and maintenance Security and risk management Evaluation and improvement 	 gathering Design and Development Testing and validation Development and maintenance Security and risk management Evaluation and improvement 	or smart utils			
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 	Explain the software components needed in the development of applications for smart grid. Explain the use of relevant Software needed	Textbooks Journals Internet Computer Projector White board Marker Animation	Demonstrate the use of relevant Software needed in the development of applications for smart grids.	Guide students to: Demonstrate the use of relevant Software needed in the development of applications for smart grids.	MATL Simulin VS cod LabVie Gatewa
	 applications for Smart Grids: Python Java C++, etc. 3.3 List the hardware components needed in the development of applications 	 in the development of applications for smart grids namely: Python Java C++, etc. List the hardware 		Identify the hardware components needed in the development of applications for smart grid under the category: • Sensors and actuators • Communication	Identify the hardware components needed in the development of applications for smart grid under	RS485 Etherne cables Local server Smart





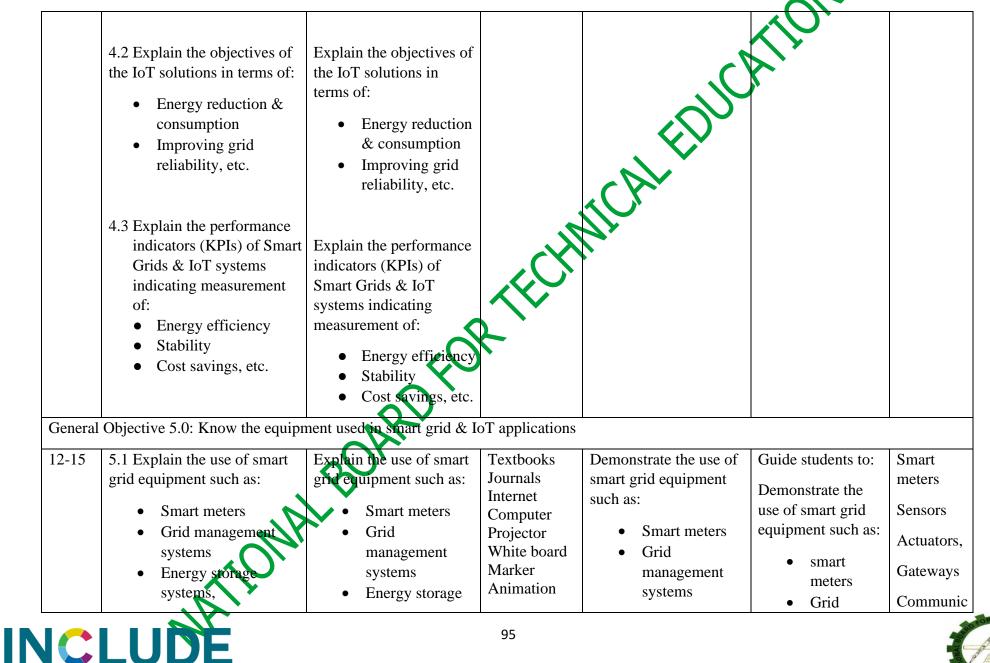
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	for Smart Grid:	components needed in		devices	the category:	meter
	 Sensors and actuators Communication devices Computing devices Energy storage and generation devices Power electronics devices Network devices, etc. 	 the development of applications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













Renewable energy	systems,	• Energy storage	manageme	ation
systems, etc.	• Renewable	systems,	nt systems	modules
 5.2 Enumerate IoT equipment such as: Sensors Actuators, Gateways Communication modules 	energy systems, etc. Explain IoT equipment such as: • Sensors • Actuators, • Gateways • Communication modules	 Renewable energy systems etc. Identify IoT equipment such as: Sensors Actuators, Gateways 	 Energy storage systems, Renewable energy systems etc. Identify IoT equipment such as: 	Energy storage equipment Inverters Rectifiers Circuit breakers Switch
 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 	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	Communication modules Demonstrate the use of IoT equipment	 Sensors Actuators, Gateways Communica tion modules Demonstrate the use of IoT equipment 	gears Switches Routers Servers
SSESSMENT:				
ontinuous Assessment (CA): 60% kamination: 40%				







COURSE TITLE: Thermal Project Management and Fendering 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 procurement processes.	knowledge and skills required to p	anage thermal energy projects, tendering and
GENERAL OBJECTIVES:	, Mr.	
1.0 Understand project management in developing solar the	ermal and hybrid systems	
2.0 Know the tools and techniques used in project manager	ment for planning and management	of thermal energy projects
3.0 Understand project documentation, feasibility studies a	and close-out reports	
4.0 Know tendering processes		
5.0 Understand procurement and contract management.	, Y -	
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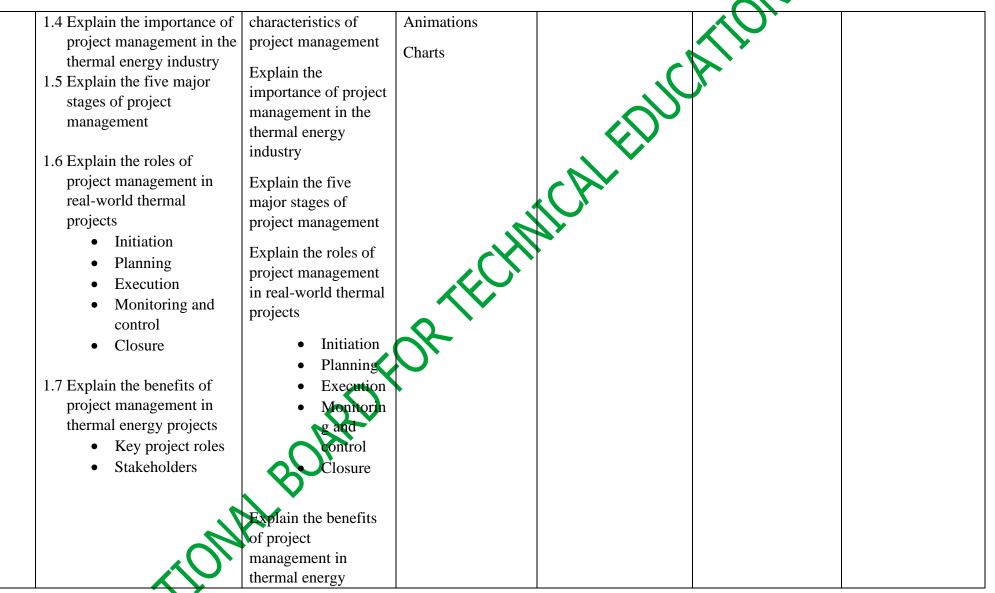




	RSE TITLE : Thermal Project	COURSE CODE: ST	COURSE CODE: STE 327 Contact Hours				
Manag	gement and Tendering Process	Credit Unit: 2	Credit Unit: 2 Theoretical: 1				
Year:	I Semester: 2	Pre-requisite:		Practi	ical: 1		
COUF	RSE SPECIFICATION: THEO	RETICAL AND PRAC	TICAL	ch'			
	: This course is designed to equ	ip students with the know	owledge and skills r	equired to manage therma	l energy projects, tenderi	ing and procurer	
proces				b_{\star}			
GENE	ERAL OBJECTIVE 1.0: Unde	rstand project managem	ent in developing s	plar thermal and hybrid sy	stems		
THEO	RETICAL CONTENT			PRACTICAL CONT	ENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning	Teacher's Activities	Resources	
				Outcome			
1-2	1.1 Define project	Explain project	Textbooks				
	management	management	Journals				
	1.2 Explain its importance in	Explain its importance in	Internet				
	engineering and energy sectors.	engineering and	Computer				
		energy sectors.	Projector				
	1.3 List the characteristics of	K.	White Board				
	project management		Marker				
		Explain the					









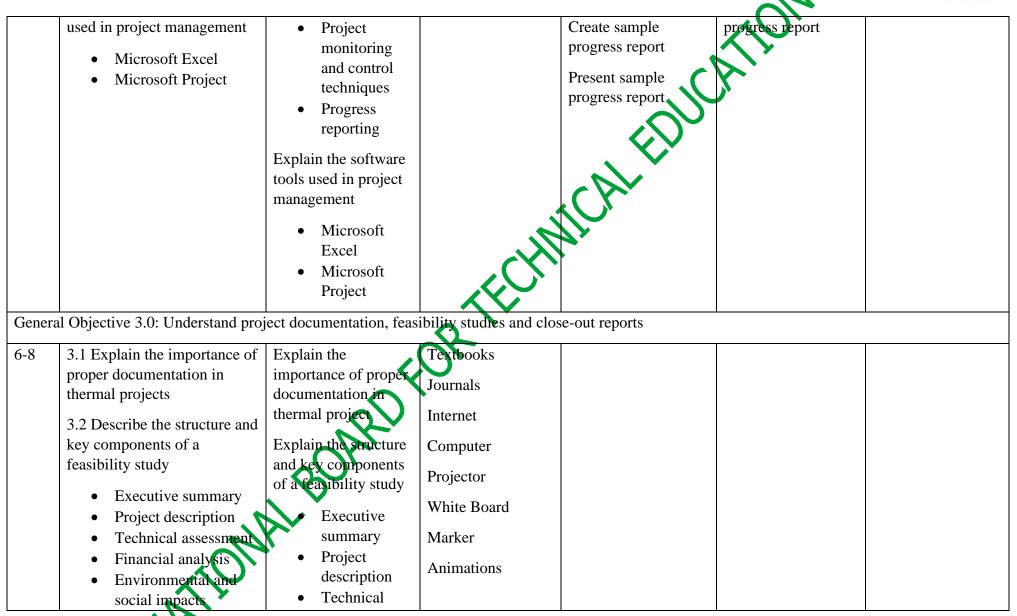




		projects Key project roles Stakeholde rs 		- DUC		
ener	al Objective 2.0: Know the tools	and techniques used in p	project management	for planning and managen	nent of thermal energy	projects
5	2.1 Describe project planning	Explain project	Textbooks	Create a Gantt chart	Guide the student to:	Relevant software
tools and their relev	tools and their relevance in thermal energy projects	planning tools and their relevance in	Journals	for a small thermal project using any	Create a Gantt chart for a small thermal	(Microsoft Excel, Microsoft Project
	2.2 Define Work Breakdown Structure (WBS)	thermal energy projects	Internet Computer	thermal energy source (preferably solar	project using any thermal energy	
	2.3 Explain Linking of WBS to responsibilities and	Explain Work Breakdown Structure (WBS)	Projector	thermal)	source (preferably solar thermal)	
	costing		White Board		(Group Work)	
	2.4 List the type of tools used	Explain Linking of	Marker	(Group Work)	Develop a work	
	in project management such	WBS to responsibilities and	Animations	Develop a work	breakdown structure (WBS) using any	
	as:	costing	Charts	breakdown structure	relevant software and	
	• Resource planning and		Charts	(WBS) using any relevant software and	assign	
	budgeting tools	Explain the type of tools used in project		assign	tasks/responsibilities,	
	 Project monitoring and control techniques 	management such as:		tasks/responsibilities, resources and specify	resources and specify timelines	
	Progress reporting	Resource		timelines,	Create sample	
	2.5 Explain the software tools	planning and budgeting			progress report	
		tools	1		Present sample	



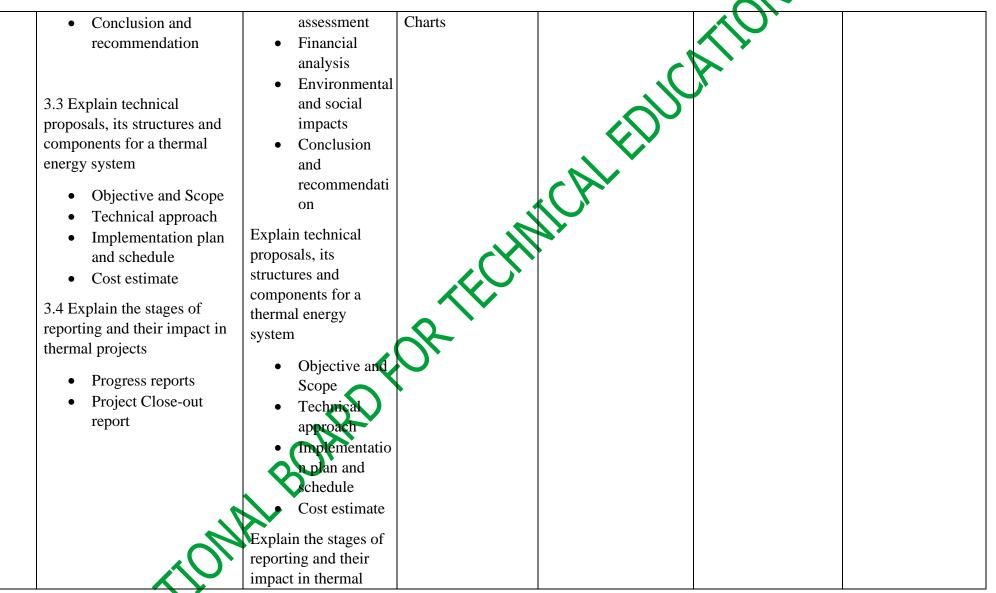
















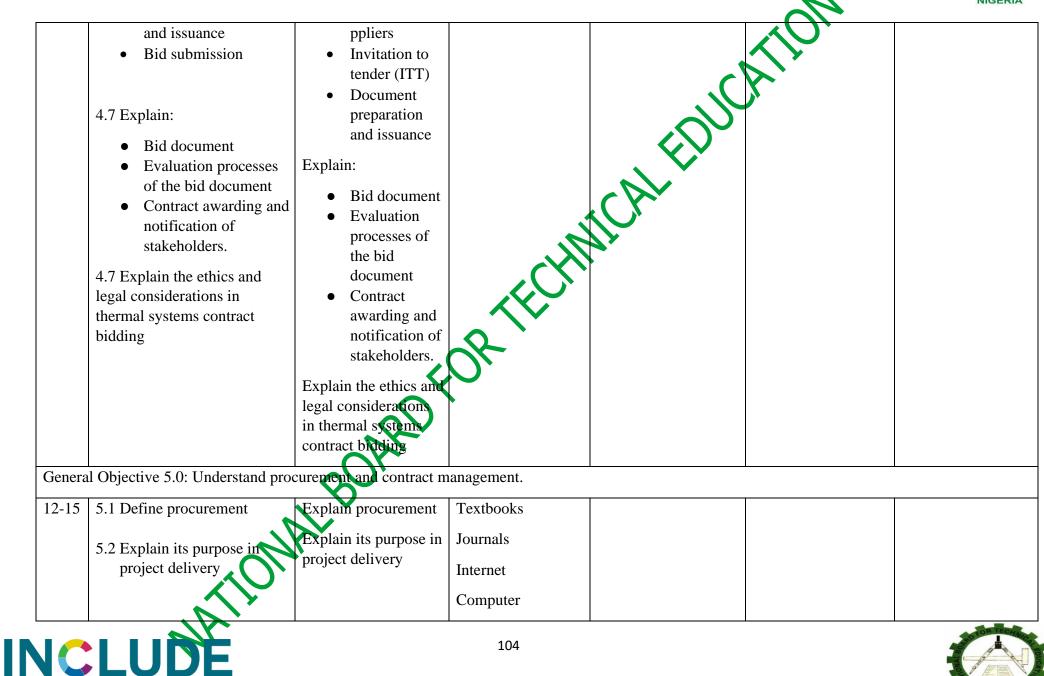


		projects			N.	
		 Progress reports Project Close- out report 				
Gener	al Objective 4.0: Know tendering	, processes				
9-11	4.1 Define a tender	Explain tendering	Textbooks	Prepare a tender	Assign students into	Sample tender
	4.2 Explain tendering process	process	Journals	document	groups	documents
	4.3 Explain the importance of	Explain the importance of	Internet		Guide groups to:	
	tendering in private and public sectors	tendering in private and public sectors	Computer .	Evaluate a tender document	Prepare a tender document	
	4.4 List types of tendering	Explain types of	Projector			
	4.5 List Parties involved in tendering process and their	tendering	White Board Marker		Evaluate a tender document	
	responsibilities 4.6 Explain the steps in the tendering process	Explain Parties involved and their	Animations Charts			
	• Expression of interest (EOI)	responsibilities Explain the steps in the tendering process				
	Prequalification of contractors/suppliers	Expression of				
	• Invitation to tender (ITT)	interest (EOI)Prequalificatio				
	Document preparation	n of contractors/su				
	LUDE		103	1	1	FOR

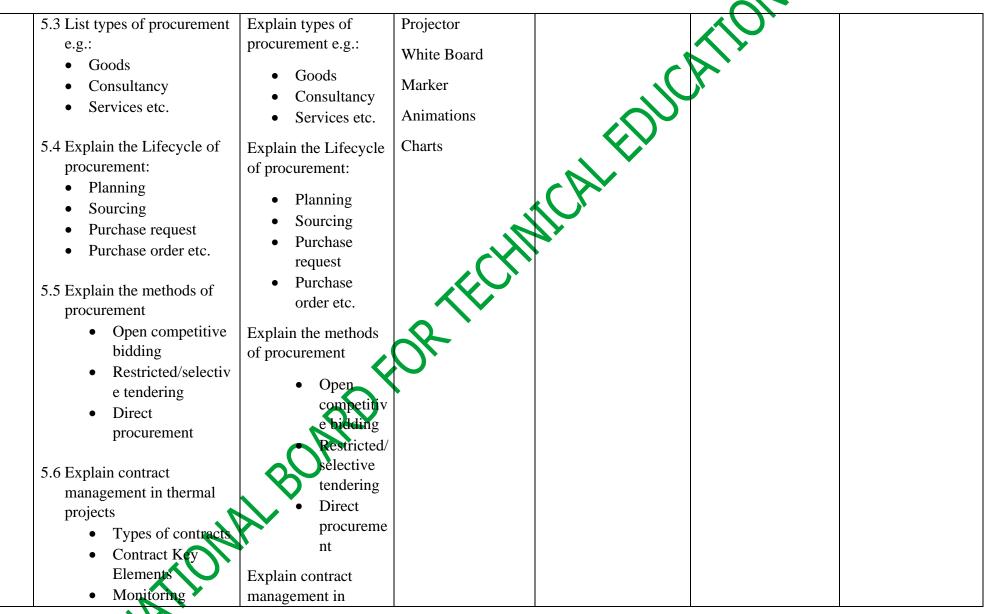








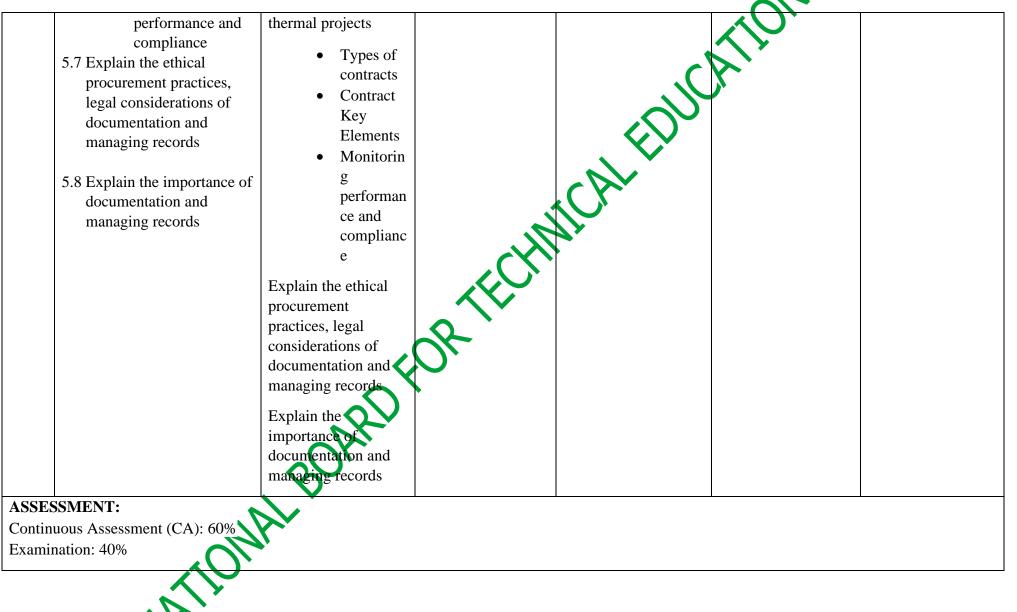














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Solar Thermal Heating and Cooling Technologies

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY

 COURSE TITLE: Solar Thermal Heating and Cooling Technologies
 COURSE CODE: STE 411
 CONTACT HOURS: 3

 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





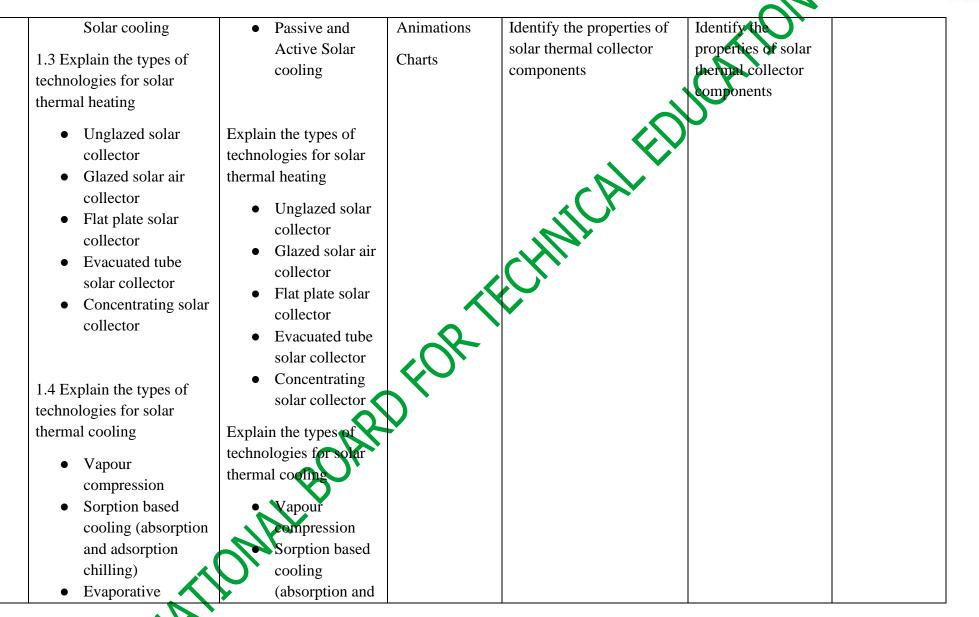


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	SE TITLE: Solar Thermal H	eating and Cooling	COURSE CODE: STE 411 CON		VIACT HOURS: 3	
Technologies		CREDIT UNIT	Г: 3	EORETICAL: 1		
YEAR: II SEMESTER: I			PRE-REQUIS	ITE: PR	ACTICAL: 2	
COUR	SE SPECIFICATION: TH	EORETICAL AND PRA	CTICAL			
GOAL	This course is designed to A	Acquaint students with the	knowledge and s	kills in solar thermal heating	and cooling technologie	s
	-	-	-	.Ny	6	
JENE	RAL OBJECTIVE 1.0: Kno	w the concept of solar the	ermal heating and			
THE	ORETICAL CONTENT			PRACTICAL CONTEN	ЛТ	
Week	Specific Learning Outcome	-	Resources	Specific Learning	Teacher's Activities	Resources
			102	Outcome		
-3	1.1 Explain the following:	Explain the following:	Textbooks	Identify passive and active	e Guide students to:	Solar thermal
	• Solar thermal	• Solar thermal	Journals	thermal systems	Identify passive and	heating mode
	power systemSolar heating	power system	Internet		active thermal	equipped with sensors/meter
	• Solar cooling	Solar heatingSolar booling	Computer		systems	
	1.2 Explain the following		1	Demonstrate how heating		
	Technologies:	Explain the following Technologies:	Projector	and cooling systems work		Solar thermatic cooling mode
	• Passive and active		White Board		heating and cooling systems work	equipped wit
	Solar heatingPassive and Active	Passive and active Solar	Marker		systems work	sensors/meter
		heating				









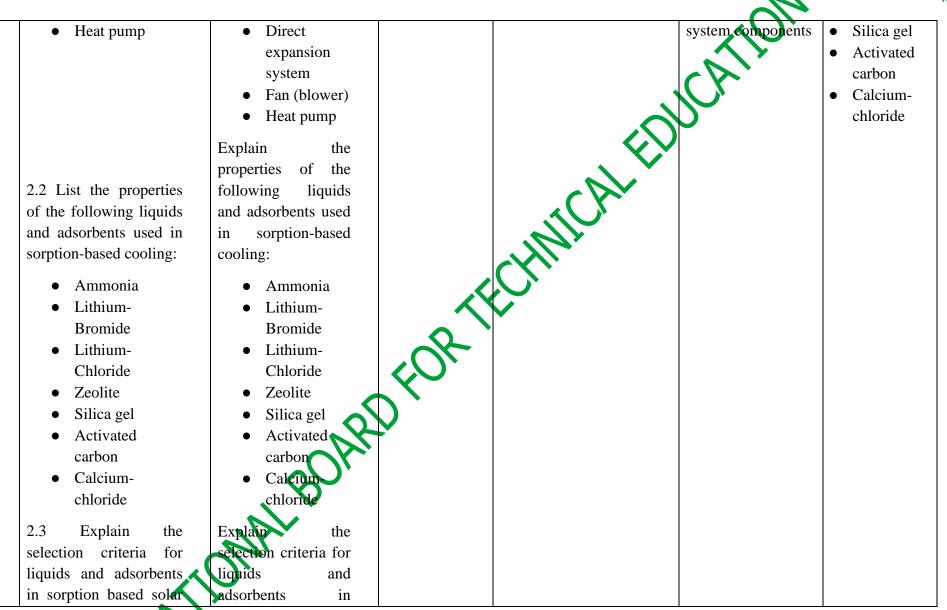


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	cooling	adsorption				
	• Solar ejectors	chilling)				
		• Evaporative				
		cooling				
		• Solar ejectors			5	
ENE	RAL OBJECTIVE 2.0: Know	w the components of solar	thermal systems	for heating and cooling	1	I
4-6	2.1 Explain the working	Explain the working	Textbooks	Visit a nearby industry to	Guide students to:	Solar
	principles of the	principles of the	T 1	Identify components of	X7. 1	collectors
	following components:	following	Journals	solar thermal heating and	Visit a nearby	TT /
		components:	Internet	cooling systems	industry to Identify	Heat
	• Solar Collector	0.1			components of	exchanger
	(Flat plate,	• Solar	Computer	Demonstrate assembling	solar thermal	chiller
	Evacuated tube	Collector	Projector	of components of solar	heating and cooling	
	and	(Flat plate,	White Board	thermal heating and	systems	Heat transfer
	concentrating	Evacuated	White Board	cooling systems	Demonstrate	medium
	Collector)	tube and	Marker		assembling of	Thermal
	• Heat exchanger	concentratin			components of	storage
	• Chiller	g Collector)	Animations		solar thermal	material
	• Cooling tower	• Heat	Charts	Measure temperature and	heating and cooling	
	• Thermal storage	exchanger		pressure at different levels	systems	Thermometers
	Absorber	• Chiller		of the solar thermal		Heat pump
	Generator	Cooling		system		1 1
	• Direct	tower		5	Measure	
	expansion	Thermal			temperature	Samples of:
	system	storage			different levels on	-
	• Fan (blower)	Absorber			the solar thermal	• Ammonia
	Ń N	Generator				• Zeolite
N	CLUDE		110			ą











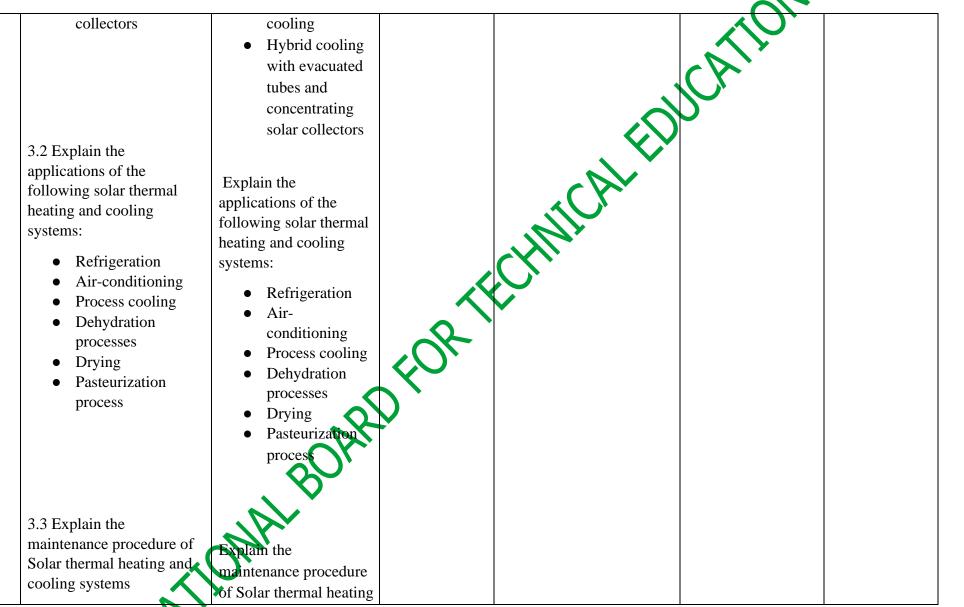


	thermal cooling systems 2.4 Explain the applications of liquids and adsorbents in sorption based solar thermal cooling systems	sorption based solar thermal cooling systems Explain the applications of liquids and adsorbents in sorption based solar thermal cooling systems		CHNI-CALED	CAILO	
	RAL OBJECTIVE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











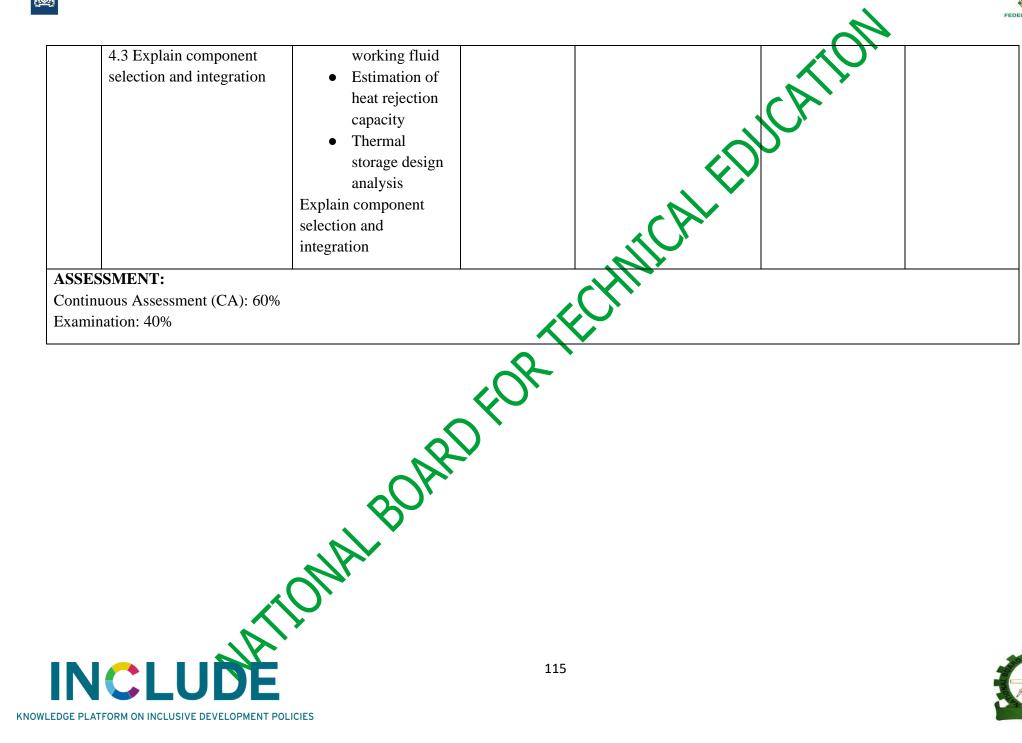




 1-14 4.1 Explain the calculations and of a Solar Therr and cooling system Assessing solar rational cooling rational cooling system and co	A Analysis mal heating tems: nent of site diation ion of ty/cooling diamedia to the solar tems: nent of site diation tion of ty/cooling tems: te	Textbooks Textbooks Journals Internet Computer Projector White Board Nof	solar heating and cooling systemApply design guidelinesin development of solarthermal systems forheating and coolingSelect components of thedesign using standardproduct charts andmanuals	ems Guide the students to: Apply design guidelines in development of solar thermal systems for heating and cooling Select components	Solar thermal design software AutoCAD Solid works Manufacturers manual and charts
 size and Solar consisting, of and material Selection and work Estimaterial Thermaterial 	on: g loads ion of /cooling Explain system siz and configuration: orientation heating/co	DoolinAnimationsAnimationsChartsanof oring-and of of-	Produce layout drawing using standard design software Demonstrate the use of PsyCalc Software	of the design using standard product charts and manuals Produce layout drawing using standard design software Demonstrate the use of PsyCalc Software	Psychrometric chart ASHRAE Psychrometric chart App PsyCalc











Modelling and Simulation of Solar Thermal Systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY

 COURSE TITLE: Modelling and Simulation of Solar
 COURSE CODE: STE 412
 CONTACT HOURS: 3

 Thermal Systems
 CREDIT UNIT: 3
 THEORETICAL: 1

 YEAR: II
 SEMESTER: I
 PRE-REQUISITE:
 PRACNOAL: 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 system



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COURSE TITLE: Modelling and Simulation of Solar			COURSE COI	DE : STE 412 CO	NTACT HOURS: 3	
Thermal	Systems		CREDIT UNIT: 3 THEORETICAL: 1			
YEAR:	II SEMESTER: I		PRE-REQUISI	TE: PR	ACTICAL: 2	
COURS	E SPECIFICATION: THE	ORETICAL AND PRAC	TICAL		V	
GOAL:	This course is designed to ac	quaint students with know	vledge and skills	in Modelling and Simulation	of Solar Thermal System	ms
GENER	AL OBJECTIVE 1.0: Know	w the design principles of	f Solar Thermal S			
THEO	RETICAL CONTENT			PRACTICAL CONTEN	NT	
Week	Specific Learning	Teacher's Activities	Resources	Specific Learning	Teacher's	Resources
	Outcome			Outcome	Activities	
1-5	1.1 Explain factors	Explain factors	Textbooks	Identify the factors	Guide students to:	Papers
	influencing thermal	influencing thermal	Journals	influencing solar thermal		Pen
	system design:	system design:	Internet	system design	Identify the factors	i en
			Computer		influencing solar	Computer
	Geographical	Geographical	Projector		thermal system	Calculator
	location	location	White Board	Calculate to determine the	design.	
	• Climate	Climate	Marker	appropriate sizing of		Sample layou
	• Load requirements	Load	Animations	components like collectors		design
	• System orientation	requirements	Charts	storage tanks, and heat	determine the	Relevant
		• System		exchangers based on syste		design
	1.2 Explain the principles	orientation		demands and design	components like	software
	of solar thermal system			parameters.	collectors, storage	(AutoCAD)
	design:	Explain the principles of			tanks, and heat	
	Component Sizing	solar thermal system		Design the layout of a bas	Ũ	
	• Placement	design:		solar thermal system	system demands and	
	• Integration of	• Component			design parameters.	
	components for	Sizing				



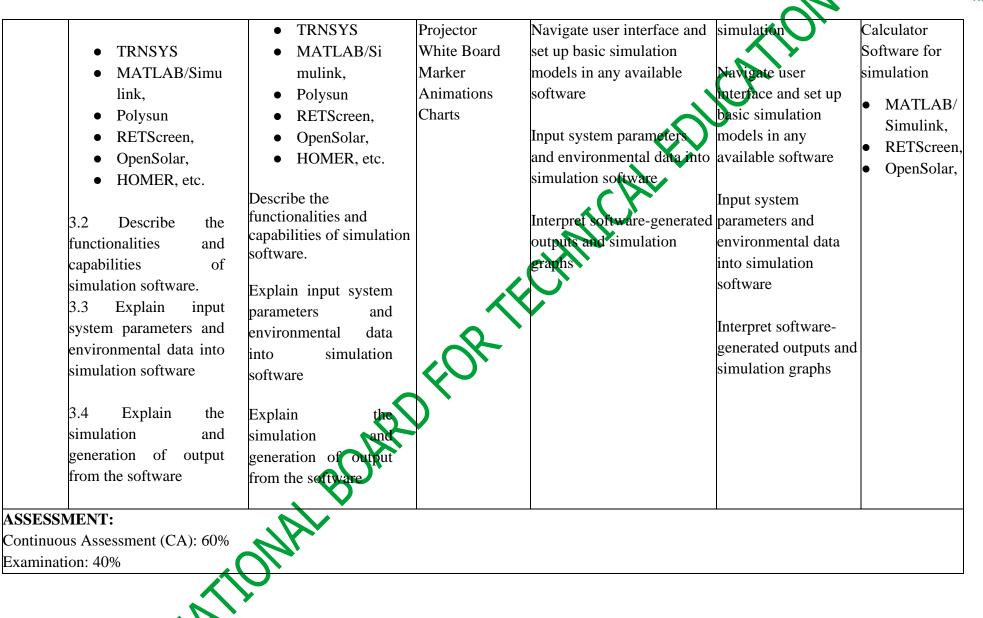




	better efficiency 1.3 Describe sizing requirements	 Placement Integration of components for better efficiency Explain sizing requirements 			Design the layout of a basic solar thermal system.	
ENER 6-10	2.1 Explain the basic mathematical models used in solar thermal system simulation	Explain the basic mathematical models used in solar thermal system simulation Explain thermal	natical models to Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	 simulate solar thermal system 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/dischargin g 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/disc	Papers Pen Computer Calculator Thermomete
ENER 11-14	3.1 Explain commonly used software for solar thermal system	the software tools and teo Explain commonly used software for solar thermal system simulation such as	chniques used for Textbooks Journals Internet Computer	simulating solar thermal system Identify commonly used software for solar thermal system simulation	Guide students to: Identify commonly used software for	Papers Pen Computer









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PROGRAMME: HIGHER NATIONAL DIPLOMA SOL	AR THERMAL ENGINEERING T	ECHNOLOGY
COURSE TITLE: Hybrid Thermal Systems and Grid	Course Code: STE 413	Contact Hours: 3
Integration	Credit Unit: 3	Theoretical: 2
Year: II Semester: I	Pre-requisite:	Practical: 1Hour/week
GOAL: This course is designed to equip students with the renewable energy sources and grid integration.	knowledge and skill required to inte	grate Solar Thermal Systems with othe
GENERAL OBJECTIVES:	, M	
1.0 Understand thermal systems and the principles of therm	nal 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		S
4.0 Know the basic requirements and methods for integrating	ng hybrid systems into the electrical	grid
5.0 Know hybrid thermal system configurations.	<u>Y</u>	
At	•	
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	RSE TITLE : Hybrid Thermal	COURSE CODE: STE 413		Cont	act Hours: 3	
Systen	ns and Grid Integration	Credit Unit: 3	The	oretical: 2		
Year:	II Semester: I	Pre-requisite:		Prac	tical: 1	
COU	RSE SPECIFICATION: THEO	DRETICAL AND PRACTICAL				
energy	sources and grid integration.	uip students with the knowledge	À.		·	th other renew
		erstand thermal systems and the p	orinciples of th			
THEO	RETICAL CONTENT			PRACTICAL CONT	ENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning	Teacher's	Resourc
		<i>'</i> Q ₁		Outcome	Activities	
1-2	1.1 Define thermal energy	Explain thermal energy and	Textbooks			
	and thermal systems	thermal systems	Journals			
	1.2 List types of thermal		Internet			
	energy	Explain types of thermal energy	Computer			
	1.3 Explain the application of		Projector			
	thermal energy 1.4 Explain the basic	Explain the application of thermal energy	White Board			
	principles of Energy	Explain the basic principles of	Marker			



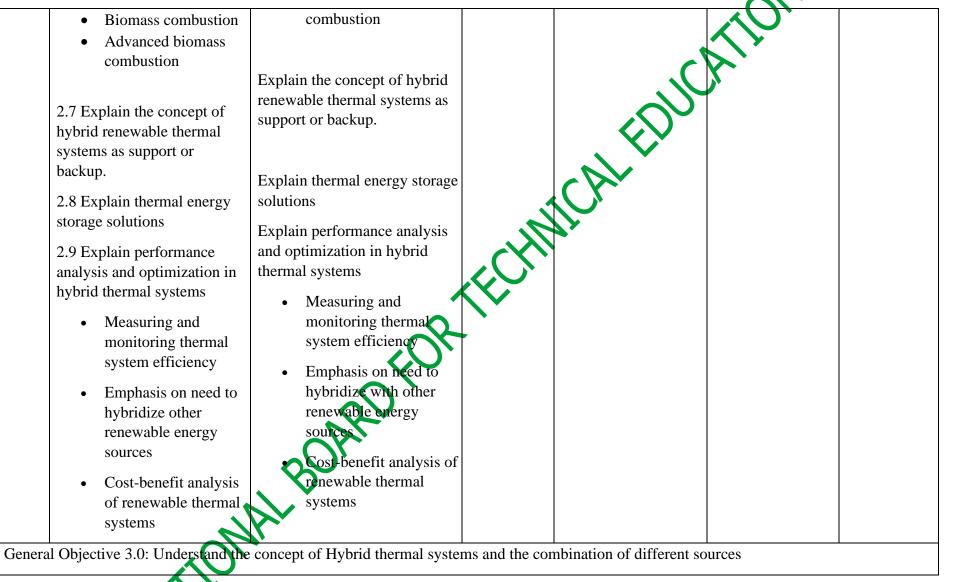


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	Conversion	Energy Conversion	Animations		
	• First and second laws of thermodynamics	• First and second laws	Charts		
	of thermodynamics	of thermodynamics),
Gener	al Objective 2.0: Understand the	renewable sources that can be u	sed for therma	l energ	gy generation
	2.1 Explain renewable and	Explain renewable and non-	Textbooks		$\overline{\mathbf{v}}$
3-4	non-renewable thermal	renewable thermal energy	Journals		
	energy sources	sources		\sim	\sim
	2.2 Explain solar thermal	Explain solar thermal systems	Internet		
	systems and technologies	and technologies	Computer		
	2.3 Explain Wind energy	Explain Wind energy systems	Projector		
	systems for thermal energy	for thermal energy generation	White		
	generation	• Wind-thermal Hybrid	Board		
	• Wind-thermal Hybrid	systems			
	systems	• Wind driven heat	Marker		
	• Wind driven heat	pumps	Animations		
	pumps	Explain Hydroelectric power	Charts		
	2.4 Explain Hydroelectric	and its role in thermal energy			
	power and its role in thermal	generation			
	energy generation	Explain Geothermal Energy			
	2.5 Explain Geothermal	for direct thermal applications			
	Energy for direct thermal	Explain Biomass thermal			
	applications	systems			
	2.6 Explain Biomass thermal				
	systems	Biomass combustion			
		Advanced biomass			





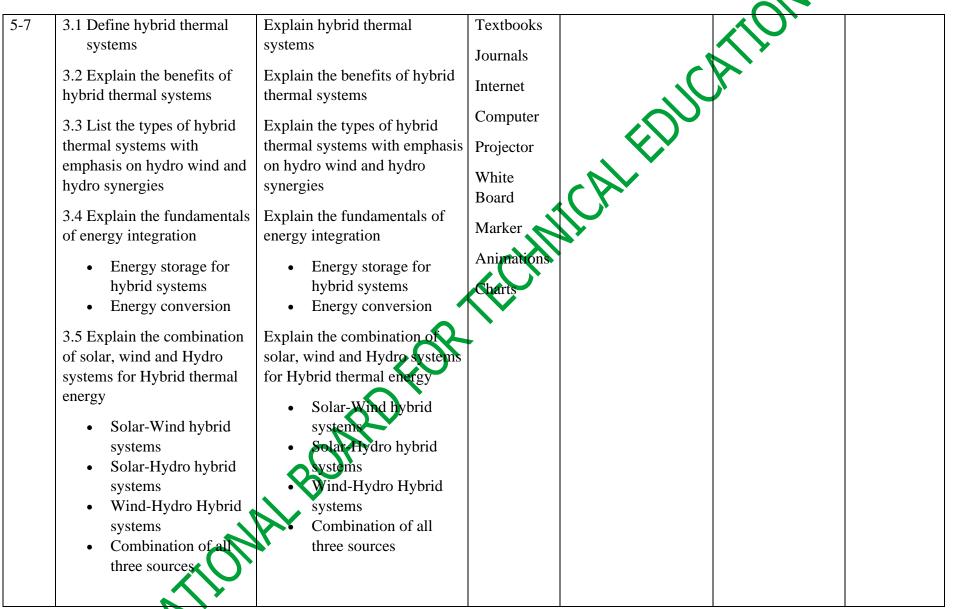








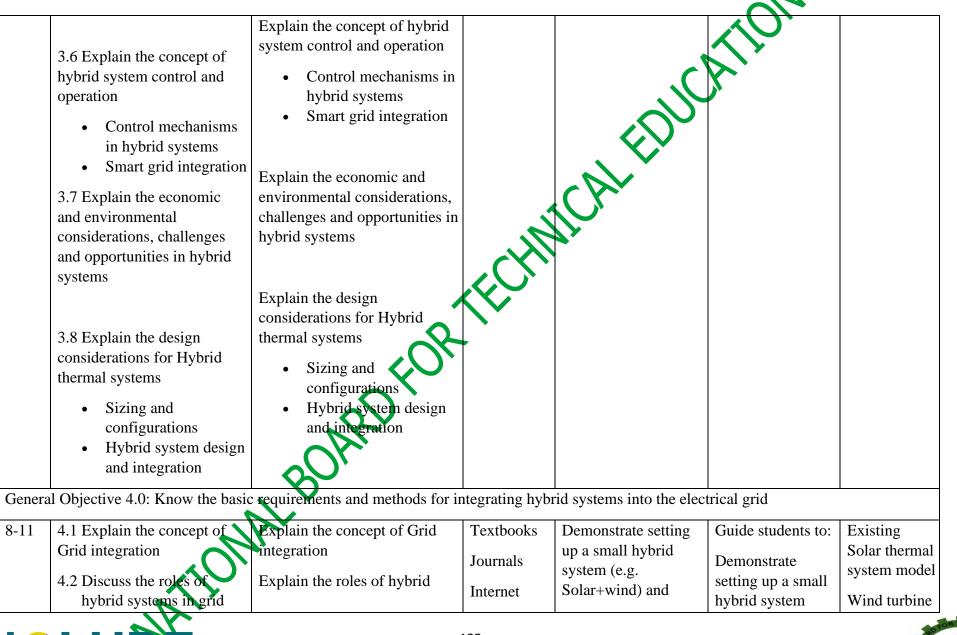


















integration	systems in grid integration	Computer	integrate it with a grid	(e.g. Solar+wind)	model
 4.3 Explain the challenges of grid integration/synchronizati on 4.4 Explain grid connection requirements for hybrid systems Technical requirements Regulatory and standards compliance Safety protocols and 	 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 	Projector White Board Marker Animations Charts	connected inverter.	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	Pyranomete (To measure solar radiation) Battery storage system Storage tanh On-grid inverter Computer
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	 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 		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)	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	Excel SCADA System RETScreen OpenDSS Python for Power System Analysis (PyPSA)



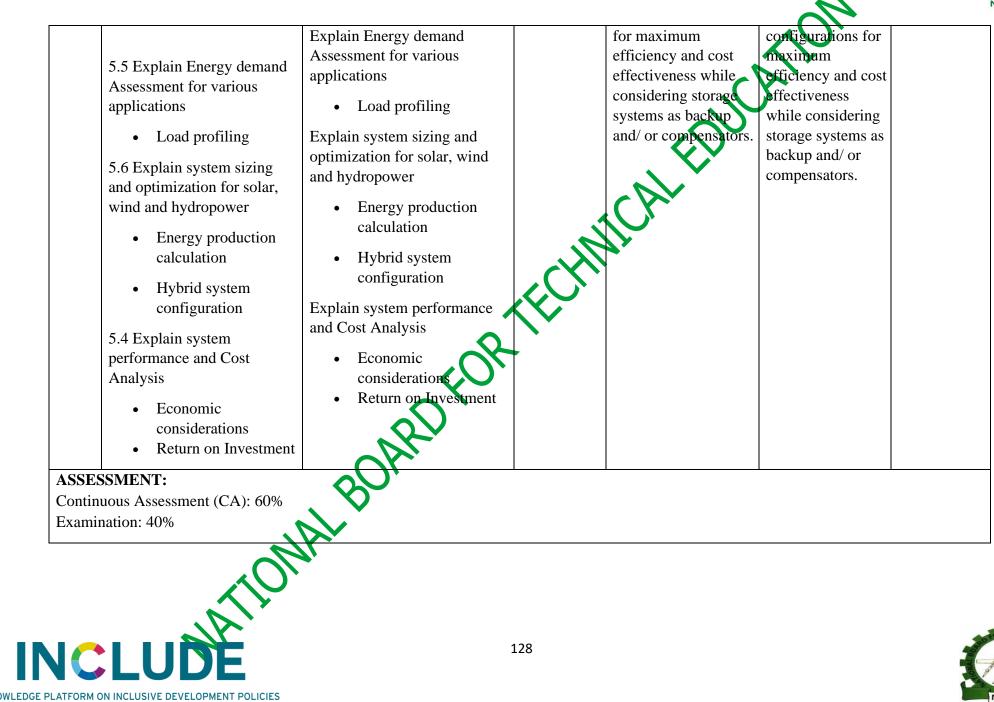


	Hybrid system integration	• Hybrid systems			on-weather or/and	
	 Microgrids Smart grids Hybrid systems 4.7 Explain Energy storage in Hybrid Grid integration 4.8 Explain Grid balancing and demand response Load balancing/sharing 	Explain Energy storage in Hybrid Grid integration Explain Grid balancing and demand response • Load balancing/sharing		CHEDUC	(demand)	
enera	l Objective 5.0: Know hybrid th	hermal system configurations				
14						
2-14	5.1 Explain hybrid thermal	Explain hybrid thermal	Textbooks	Demonstrate system	Guide students to:	Real-world
-14	5.1 Explain hybrid thermal systems	Explain hybrid thermal systems		sizing and		Real-world data source
-14	1 1	systems	Journals	sizing and optimization by using	Guide students to: Demonstrate system sizing and	
-14	systems	systems		sizing and optimization by using real-world data to	Demonstrate	data source
-14	systems 5.2 Explain the role of hybrid	systems Explain the role of hybrid	Journals	sizing and optimization by using real-world data to determine the sizes of	Demonstrate system sizing and optimization by using real-world	data source Sample design
-14	systems 5.2 Explain the role of hybrid thermal systems in sustainable energy	systems Explain the role of hybrid thermal systems in sustainable energy	Journals Internet Computer	sizing and optimization by using real-world data to	Demonstrate system sizing and optimization by using real-world data to determine	data source Sample design Video clips
-14	systems 5.2 Explain the role of hybrid thermal systems in	systems Explain the role of hybrid thermal systems in sustainable	Journals Internet Computer Projector	sizing and optimization by using real-world data to determine the sizes of renewable energy	Demonstrate system sizing and optimization by using real-world data to determine the sizes of	data source Sample design Video clips
-14	systems 5.2 Explain the role of hybrid thermal systems in sustainable energy 5.3 Explain the synergy	systems Explain the role of hybrid thermal systems in sustainable energy Explain the synergy between renewable and other thermal	Journals Internet Computer Projector White	sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a	Demonstrate system sizing and optimization by using real-world data to determine the sizes of renewable energy	data source Sample design Video clips
-14	systems 5.2 Explain the role of hybrid thermal systems in sustainable energy 5.3 Explain the synergy between renewable and	systems Explain the role of hybrid thermal systems in sustainable energy Explain the synergy between	Journals Internet Computer Projector	sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a	Demonstrate system sizing and optimization by using real-world data to determine the sizes of renewable energy components to	data source Sample design Video clips Animation Thermal
-14	systems 5.2 Explain the role of hybrid thermal systems in sustainable energy 5.3 Explain the synergy between renewable and other thermal energy	systems Explain the role of hybrid thermal systems in sustainable energy Explain the synergy between renewable and other thermal	Journals Internet Computer Projector White	sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a	Demonstrate system sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a given	data source Sample design Video clips Animations Thermal hybrid plar
-14	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	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	Journals Internet Computer Projector White Board Marker	sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a	Demonstrate system sizing and optimization by using real-world data to determine the sizes of renewable energy components to	data source Sample design Video clips Animations Thermal hybrid plan
-14	 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 	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	Journals Internet Computer Projector White Board	sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a given demand profile.	Demonstrate system sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a given	data source Sample design Video clips Animations Thermal hybrid plan (site visit if
-14	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	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	Journals Internet Computer Projector White Board Marker	sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a	Demonstrate system sizing and optimization by using real-world data to determine the sizes of renewable energy components to meet a given	data source Sample design Video clips Animations Thermal hybrid plan (site visit if











Retrofitting & Energy Efficiency Techniques PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY **CONTACT HOURS: 3 COURSE TITLE:** Retrofitting & Energy Efficiency COURSE CODE: STE 414 Techniques THEORETICAL: **CREDIT UNIT: 3 PRACTICAL:** YEAR: II **SEMESTER:** I **PRE-REQUISITE:** NIL 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 opportunitie 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 - FOR BORROR



KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES

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NBTE

OURS	E TITLE : Retrofitting & End	ergy Efficiency	COURSE COI	DE : STE 414	CONTACT HOURS: 3	3
Techniqu	les		CREDIT UNIT	: 3	THEORETICAL: 1	
EAR:	II SEMESTER: I		PRE-REQUISI	TE:	PRACTICAL: 2	
	E SPECIFICATION: THE				\sim	
	This course is designed to eq		-	-		lar Energy System
	AL OBJECTIVE 1.0: Unde	erstand the principles and	benefits of retrofi			
THEO	RETICAL CONTENT			PRACTICAL		
Week	Specific Learning	Teacher's Activities	Resources	Specific Learnir	-	Resources
	Outcome			Outcome	Activities	
1-3	 the context of solar energy systems 1.2 Explain the underlying principles of retrofitting technologies. Thermal performance 	Explain retrofitting in the context of solar thermal systems Explain the underlying principles of retrofitting technologies. • Thermal performance • Energy	Journals Internet Computer Projector White Board Marker Animations			
		conservation Energy optimization Discuss the benefits of retrofitting for improving energy efficiency and	Charts			



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



KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES

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



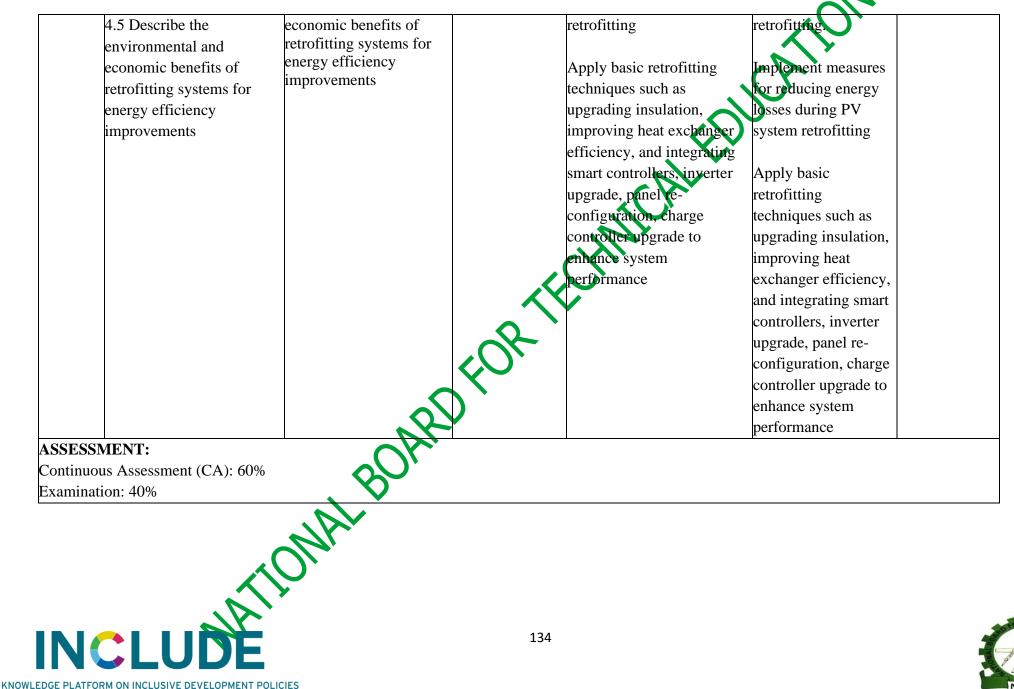




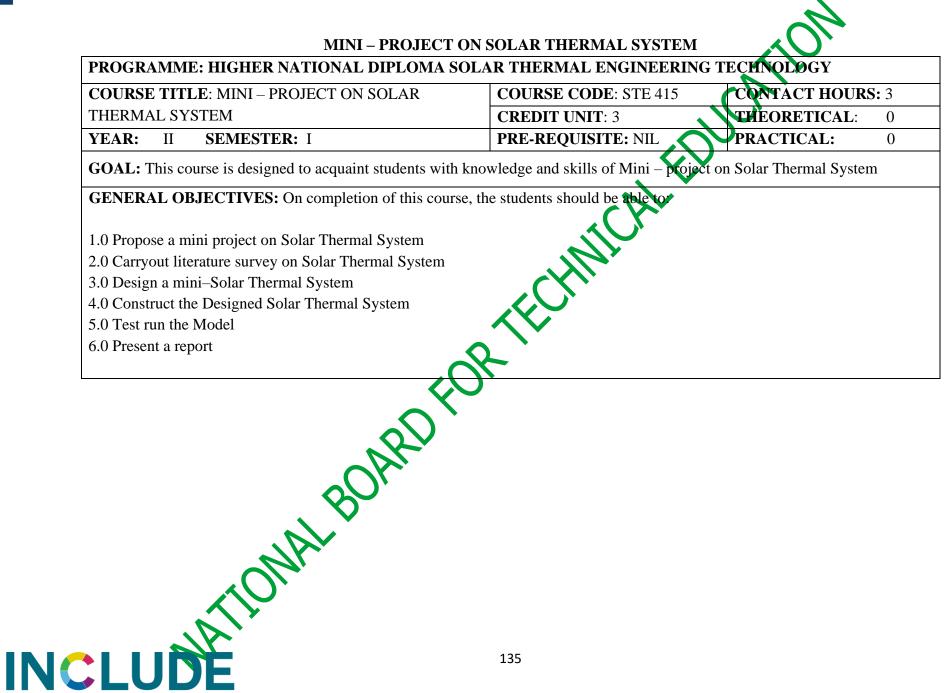
		evaluating and improving energy efficiency performance.			ATU.	
ENER	AL OBJECTIVE 4.0: Know	the application of basic re	etrofitting techn	iques to improve system perfor	mance	·
12-15	4.1 Explain the principles	Explain the principles of	Textbooks	Conduct an evaluation of	Guide students to;	Multimeter
	of system optimization	system optimization and	Journals	existing systems to		Power analyze
	and how retrofitting	how retrofitting	Internet	determine the need for	evaluation of existing	Solar thermal
	contributes to enhanced	contributes to enhanced performance	Computer	retrofitting	systems to determine	model
	performance	periormance	Projector		the need for	Smart
		Explain the role of	White Board		retrofitting	controllers
	4.2 Explain the role of	insulation and sealing in	Marker	Select appropriate methods		Insulation
	insulation and sealing in	retrofitting to reduce heat	Animations	for improvement of	Select appropriate	Sealants
	retrofitting to reduce	losses in solar thermal	Charts	insulation and sealing	methods for	Heat
	heat losses in solar	systems.			improvement of	exchanger
	thermal systems	Evaluin the value of nonal		Select appropriate methods	insulation and sealing	Solar panel
		Explain the role of panel re-configuration and		for improvement of energy		Inverter
		inverter upgrade in		production in solar	Select appropriate	Solar charge
	4.3 Explain the role of	retrofitting to increase	X	photovoltaic systems.	methods for	controller
	panel re-configuration	production in solar			improvement of	
	and inverter upgrade in	photovoltaic systems.		Implement measures for	energy production in	
	retrofitting to increase			optimizing fluid flow and	solar photovoltaic	
	production in solar	Explain the types of		minimizing heat losses	systems.	
	photovoltaic systems.	energy-saving equipment		during thermal system		
	photovoltale systems.	used in retrofitting solar		retrofitting.	Implement measures	
	4.4 Describe the types of	energy systems			for optimizing fluid	
	energy-saving equipment			Implement measures for	flow and minimizing	
		Surlain the		reducing energy losses	heat losses during	
	energy systems	Explain the environmental and		during PV system	thermal system	
	chergy systems		1			1
N	CLUDE		133			













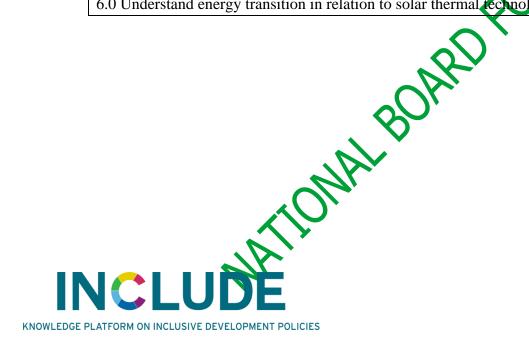


YEAR II SEMESTER II

Solar Th	ermal Policy, Regulation, and Stan	dards
PROGRAMME: HIGHER NATIONAL DIPLOMA SC	DLAR THERMAL ENGINEERING	3 TECHNOLOGY
COURSE TITLE: Solar Thermal Policy, Regulation,	COURSE CODE: STE 421	CONTACT HOURS: 2
and Standards	CREDIT UNIT : 2	THEORETICAL: 2
YEAR: II SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 0
GOAL: This course is designed to equip students with k GENERAL OBJECTIVES: On completion of this course		
1.0 Understand the global and national policy framework	ts guiding solar thermal energy dev	elopment
2.0 Understand the regulatory environment for solar ther	mal energy systems	
3.0 Understand the key standards and codes applicable to solar thermal systems	o the design, installation, commission	oning, maintenance and de-commissioning of
4.0 Understand the role of incentives and fiscal policies i	in promoting solar thermal adoption	1

4.0 Understand the role of incentives and fiscal policies in promoting solar thermal adoption5.0 Understand the environmental and social considerations embedded in solar thermal energy policies

6.0 Understand energy transition in relation to solar thermal technology



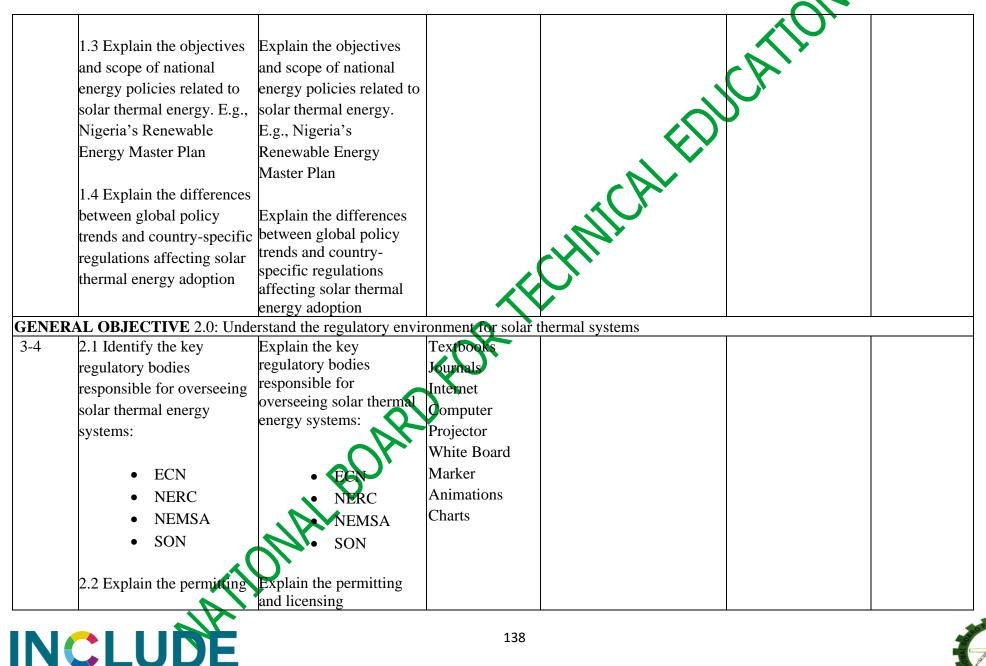




COURS	E TITLE: Solar Thermal Po	licy, Regulation, and	COURSE COI	DE : STE 421	CON	TACT HOURS: 2	
Standard	S		CREDIT UNIT	2:2	TH	EORETICAL: 2	
YEAR:	II SEMESTER: II		PRE-REQUISI	TE:		CFICAL: 0	
COURS	E SPECIFICATION: THE	ORETICAL AND PRAC	ГICAL			5	
	This course is designed to eq			-			
	AL OBJECTIVE 1.0: Unde	erstand the global and natio	onal policy frame				t
THEO	RETICAL CONTENT			PRACTICAL	CONTEN	Г	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learni Outcome	ing	Teacher's Activities	Resources
-2	1.1 Define Policy,	Explain Policy,	Textbooks	Oulcome		Activities	
-2	Regulation and Standard	Regulation and Standard					
			Internet				
	1.2 Explain international	Discuss international	Computer				
	agreements and initiatives that support renewable and	agreements and initiatives that support	Projector				
	solar thermal energy:	renewable and solar	White Board Marker				
	The Paris	thermal energy:	Animations				
	Agreement,	• The Paris	Charts				
	• SDG 7 (Affordable	Agreement,					
	and Clean Energy)	• SDG7					
	• IRENA's role in	(Affordable and					
	promoting solar	Clean Energy) IRENA's role in					
	thermal technologies.	promoting solar					
	teennoiogies.	thermal					
		technologies.					











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	and licensing requirements for solar thermal project development	requirements for solar thermal project development			A)
	2.3 Explain compliance obligations and penalties for violating solar thermal energy regulations	Discuss compliance obligations and penalties for violating solar thermal energy regulations				
GENER	AL OBJECTIVE 3.0: Unde	erstand the key standards an	d codes applicabl	e to the design, instal	llation, commissioning	, maintenance and de-
commiss	ioning of solar thermal syste	ms				
5-7	 3.1 List international and national standards relevant to solar thermal systems: ISO 9806 IEC 62862 NESIS 	national standards relevant to solar thermal systems:	Textbooks Journals Internet Computer Projector White Board Murker Animations			
	3.2 Explain the purpose and application of design and safety standards in solar thermal systems	Explain the purpose and application of design and safety standards in solar thermal systems	Charts			

3.3 Explain various Explain various codes of practice related practice related to the to the installation and anstallation and







	maintenance of solar	maintenance of solar thermal equipment			
	thermal equipment	ulerinai equipilient			
ENER	AL OBJECTIVE 4.0: Und	erstand the role of incentive	s and fiscal polic	cies in promo	ting s
3-10	4.1 List types of financial	Explain types of financial	-		
0 10	• •	r incentives available for	Journals		
	solar thermal energy	solar thermal energy	Internet		
	projects:	projects:	Computer		
	 Tax credits 	• Tax credits	Projector	1	>
	Grants	Grants	White Board		
			Marker		
	• Rebates	Rebates	Animations		
	low-interest loans	low-interest loans	Charts		
	• Feed-in tariffs	• Feed-in tariffs	Ciluito		
		F 1 C 1 1 C		Y	
	4.2 Explain fiscal policies				
	influencing investment and				
	-	r and consumer adoption of			
	thermal technologies:	solar thermal			
	• VAT exemptions	technologies:			
	• Import duty	• VAT exemptions			
	reductions	Import duty			
	• Government	reductions			
	subsidies	 Government 			
		subsidies			
	4.3 Explain the				
	effectiveness of	Discuss the effectiveness			
	selected incentive	of selected incentive			







	programs in	programs in accelerating	
	accelerating solar	solar thermal deployment	
	thermal deployment		
GENER			and social considerations embedded in solar thermal energy policies
1-12	5.1 Describe the	Explain the	Textbooks
	environmental impacts	environmental impacts	Journals
	addressed by solar thermal	addressed by solar	Internet
	energy policies:	thermal energy policies:	Computer Projector
	Reduce greenhouse	• Reduce	White Board
	gas emissions	greenhouse gas	Marker
	Conserve water	emissions	Animations
	resources	Conserve water	Charts
	Minimize	resources	
	ecological	Minimize	
	disruption, etc.	ecological	
		disruption, etc.	
	5.2 Explain the social	Explain the social	
	benefits of integrating solar		
	thermal technologies into	solar thermal	
	energy policy e.g.:	technologies into energy	
	 Job creation 	policy e.g.: V	
	• Energy access in	Job creation	
	rural communities	Energy access in	
	Public health	rural	
	improvements.	communities	







		Public health				D	
		improvements.			A	>	
	5.3 Explain policy	Explain policy measures			all.		
	measures that promote	that promote equity and			$\langle \mathcal{N} \rangle$		
	equity and inclusiveness in						
	solar thermal energy access						
	RAL OBJECTIVE 6.0 - Und			ar thermal technolog	gy		
-15	6.1 Define the concept of	Explain the concept of	Textbooks Journals				
	energy transition in the	energy transition in the	Internet				
	context of global energy systems	context of global energy systems	Computer				
	systems	systems	Projector				
	6.2Explain the role of solar	Explain the role of solar	White Board				
	thermal technology in	thermal technology in	Marker Animations				
	facilitating a low-carbon	facilitating a low-carbon	Charts				
	future	future					
	6.3 Explain national and	Discuss national and					
	international drivers of	international drivers of					
	energy transition policies	energy transition policies					
	such as:	such as:					
	• Net-zero targets	• Net-zero targets					
	SDGs	SDGs					
	Paris Agreement	Paris Agreement					
	6.4 Describe the challenges	Explain the challenges					







and opportunities for solar and opportunities for thermal adoption within solar thermal adoption energy transition strategies within energy transition strategies

ASSESSMENT:

NECCONATIONAL BOARD FOR THICHT Continuous Assessment (CA): 60% Examination: 40%





Μ	aintenance of Solar Thermal Syste	ems
PROGRAMME: HIGHER NATIONAL DIPLOMA S		
COURSE TITLE: Maintenance of Solar Thermal	Course Code: STE 422	Contact Hours 3
Systems	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 main	tenance of Solar Thermal Systems
GENERAL OBJECTIVES: On completion of this cour	rse, the students should be able to:	<u>,</u> ,
1.0 Know the procedures of carrying out routine mainted	enance	
2.0 Know the safety rules and regulations of the Solar		
3.0 Know the optimal performance of the system		
4.0 Know the equipment to be used in carrying out Sol	ar Therman System mannenance	
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COURSE TITLE : Maintenance of Solar Thermal Systems		COURSE CODE: STE	422	Contact	Hours: 3	
		Credit Unit: 3		Theoret	ical: 1	
Year: 1		Pre-requisite: Nil		Practica	l: 2	
	SE SPECIFICATION : THEO : This course is designed to equ			maintertance of solar therr	nal systems	
	RAL OBJECTIVE 1.0: Know RETICAL CONTENT	the procedures of carrying	out routine main	enance PRACTICAL CONTEN	Г	
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: Svaling 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 model





 1.3 Explain the mainter of Solar Thermal Systems: Predictive Condition -bas Preventive Corrective Reactive/Breaketc. 1.4 Explain the benefited rawbacks of types of thermal systems mainter the systems mainter the	ed Explain Maintenance Explain the maintenance of Solar Thermal Systems: • Predictive • Condition -based • Preventive • Corrective • Corrective • Reactive/Breakdown, etc. Explain the benefits and drawbacks of types of solar thermal systems		 Degradation of insulation materials Carryout maintenance on a typical solar thermal system 	 Oprrosion Leaks and fluid loss Control system issues Carryout maintenance on a typical solar thermal system 	
eneral Objective 2.0: Know th 6 2.1 Define hazards in thermal systems	maintenancee safety rules and regulations of thesolarExplain hazards in solarthermal systems	Textbooks Journals	Identify potential hazards with respect to	Guide students to:	First Aid kit PPE
2.2 Explain potential h with respect to solar th systems,2.3 Define accident in plant2.4 Explain accident in	termalwith respect to solarthermal systems,a solarExplain accident in a solar plant	Computer Projector White Board Marker Animations	solar thermal systems Demonstrate the safety measures to be taken when working on solar thermal systems Illustrate the use of safety kits and gadgets	Identify potential hazards with respect to solar thermal systems Demonstrate the safety measures to be taken when	Toolbox





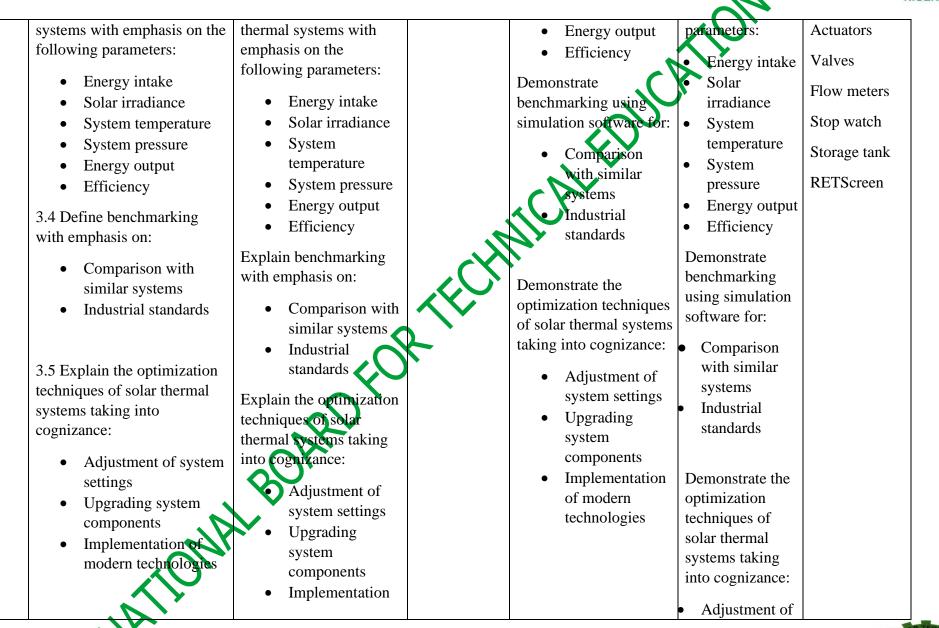


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	potential hazards in solar	potential hazards in solar		in a solar thermal plant.	working on solar	
	thermal plants	thermal plants		Illustrate first aid	thermal systems	
	2.5 Define safety in solar	Explain safety in solar		measures to be taken	Illustrate the use	
	thermal systems	thermal systems		when an accident occurs		
	2.6 Explain the safety measures to be taken when	Explain the safety measures to be taken		in a solar thermakplant.	gadgets in a solar thermal plant.	
	working on solar thermal	when working on solar		ALCAL L	Illustrate first aid measures to be	
	systems	thermal systems			taken when an	
	2.7 Explain the safety kits and	Explain the safety kits			accident occurs	
	gadgets needed when	and gadgets needed			in a solar thermal	
	working in solar thermal	when working in solar			plant	
	plants.	thermal plants.			prunt	
	2.8 Define first aid with	Explain first aid with				
		_				
	respect to solar thermal	respect to solar thermal				
	respect to solar thermal systems	respect to solar thermal systems	5			
	systems I Objective 3.0: Know the optima	systems al performance of the Solar	Thermal Syster			
	systems I Objective 3.0: Know the optima 3.1 Define optimal	systems al performance of the Solar Explain optimal	Thermal Syster Textbooks	Illustrate the operating	Guide students	Pyranometer
Genera 7-9	systems I Objective 3.0: Know the optima	systems al performance of the Solar	Thermal Syster Textbooks Journals	Illustrate the operating conditions of solar	Guide students to:	
	systems I Objective 3.0: Know the optima 3.1 Define optimal performance 3.2 Explain optimal	systems al performance of the Solar Explain optimal performance Explain optimal	Thermal Syster Textbooks Journals Internet	Illustrate the operating conditions of solar thermal systems with		Pyrheliomete
	systems I Objective 3.0: Know the optima 3.1 Define optimal performance 3.2 Explain optimal performance of a solar	systems al performance of the Solar Explain optimal performance Explain optimal performance of a solar	Thermal Syster Textbooks Journals Internet Computer	Illustrate the operating conditions of solar thermal systems with emphasis on the	to: Illustrate the operating	
	systems I Objective 3.0: Know the optima 3.1 Define optimal performance 3.2 Explain optimal performance of a solar thermal system with	systems al performance of the Solar Explain optimal performance Explain optimal performance of a solar thermal system with	Thermal Syster Textbooks Journals Internet Computer Projector	Illustrate the operating conditions of solar thermal systems with	to: Illustrate the operating conditions of	Pyrheliomete Multimeter
	systems I Objective 3.0: Know the optima 3.1 Define optimal performance 3.2 Explain optimal performance of a solar	systems al performance of the Solar Explain optimal performance Explain optimal performance of a solar	Thermal Syster Textbooks Journals Internet Computer Projector White Board Marker	Illustrate the operating conditions of solar thermal systems with emphasis on the	to: Illustrate the operating conditions of solar thermal systems with	Pyrheliomete
	systems I Objective 3.0: Know the optima 3.1 Define optimal performance 3.2 Explain optimal performance of a solar thermal system with examples	systems al performance of the Solar Explain optimal performance Explain optimal performance of a solar thermal system with examples	Thermal Syster Textbooks Journals Internet Computer Projector White Board	Illustrate the operating conditions of solar thermal systems with emphasis on the following parameters: • Energy intake	to: Illustrate the operating conditions of solar thermal systems with emphasis on the	Pyrheliomete Multimeter Thermometer
	systems I Objective 3.0: Know the optima 3.1 Define optimal performance 3.2 Explain optimal performance of a solar thermal system with	systems al performance of the Solar Explain optimal performance Explain optimal performance of a solar thermal system with	Thermal Syster Textbooks Journals Internet Computer Projector White Board Marker	Illustrate the operating conditions of solar thermal systems with emphasis on the following parameters: • Energy intake • Solar irradiance	to: Illustrate the operating conditions of solar thermal systems with	Pyrheliomete Multimeter Thermometer Pressure gaug









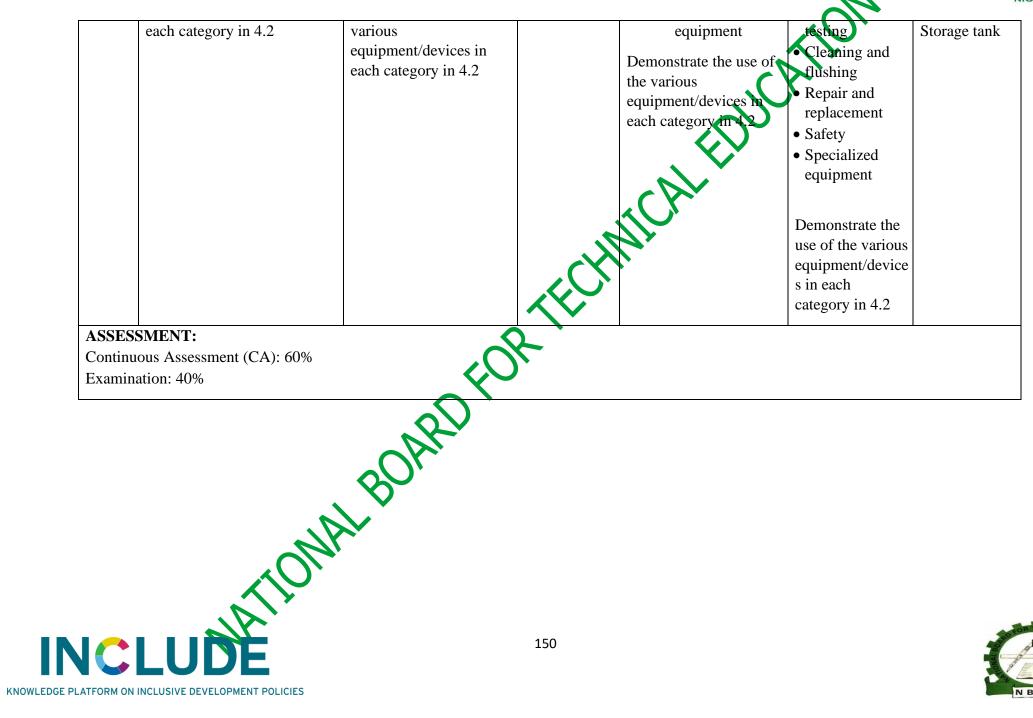




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		of modern technologies			system settings Upgrading system components • Implemen tation of modern technologies	
Jeneral	Objective 4.0: Know the equipm	nent used in carrying out so	lar thermal syst	tem maintenance		
0-13	4.1Enumerate the various	Explain the various	Textbooks	Identify the various	Guide students	Pyranometer
	equipment used in carrying out maintenance in solar	equipment used in carrying out maintenance	Journals	equipment used in	to:	Pyrheliometer
	thermal systems	in solar thermal systems	Internet Computer	carrying out maintenance in solar	Identify the various	Multimeter
	4.2 Explain the classification	Explain the classification	Projector White Board	thermal systems	equipment used	Thermometer
	 of equipment used in solar thermal system maintenance in the following category: Inspection and testing Cleaning and flushing 	maintenance the following category:	Marker Animations	Classify equipment used in solar thermal system maintenance in the following category:	in carrying out maintenance in solar thermal systems	Pressure gauge Pressure sensor
	 Cleaning and flushing Repair and replacement Safety Specialized equipment 	 Inspection and testing Cleaning and flushing Repair and 		 Inspection and testing Cleaning and flushing 	Classify equipment used in solar thermal system	Actuators Valves Flow meters Brush
	4.3 Explain the use of the various equipment/devices in	 replacement Safety Specialized equipment 		 Repair and replacement Safety Specialized 	maintenance the following category:Inspection and	Blower Stop watch









Energy Efficiency and Demand Side Management (DSM)	
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PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR THERMAL ENGINEERING TECHNOLOGY

CONTACT HOURS: 2 **COURSE TITLE**: Energy Efficiency and Demand Side **COURSE CODE:** STE 423 THEORETICAL: Management (DSM) **CREDIT UNIT: 2** PRACTICAL:

SEMESTER: II YEAR: II

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

PRE-REQUISITE: NIL

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. WHILD WHILE BOMPORTOR



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COURS	E TITLE : Energy efficiency	and Demand Side	COURSE COD	E: STE 423 CO	NTACT HOURS: 2	
Manager	ment (DSM)		CREDIT UNIT:	2 T	IEORETICAL: 1	
YEAR:	II SEMESTER: II		PRE-REQUISIT		ACTICAL: 1	
COURS	E SPECIFICATION : THE	ORETICAL AND PRAC	ΓICAL		\mathbf{v}	
GOAL:	This course is designed to eq	uip students with knowled	lge and skills on E	nergy-efficiency and Dem	nd Side Management	(DSM) relating to
solar ene	ergy systems					
General	Objective 1.0 – Understand	the principles and procedu	res of Demand Si	de Management (DSM)		
1-5	1.1 Define Demand Side Management (DSM)	Explain Demand Side Management (DSM)	Textbooks Journals Internet	MIL		
	1.2 Explain the role of DSM in enhancing energy efficiency.	Explain the role of DSM in enhancing energy efficiency.	Computer Projector White Board Marker Animations			
	1.3 Explain the benefits of DSM	Explain the benefits of DSM	Charts			
General	Objective 2.0 Know Energy	Auditing	5			
6-10	2.1 Define Energy Auditing concept	Define Energy Auditing concept	Textbooks Journals Internet	Visit Site for data collecti	on Guide students to visit Site for data collection	Spreadsheet MS Excel Pen
	2.2 Explain Energy Auditing tools and techniques:	Explain Energy Auditing tools and techniques: Pre audit data	Computer Projector White Board Marker Animations			Paper Energy meter Multimeter Data collectio
	• Pre audit data collection	collection Site visit 	Charts			template Data logger



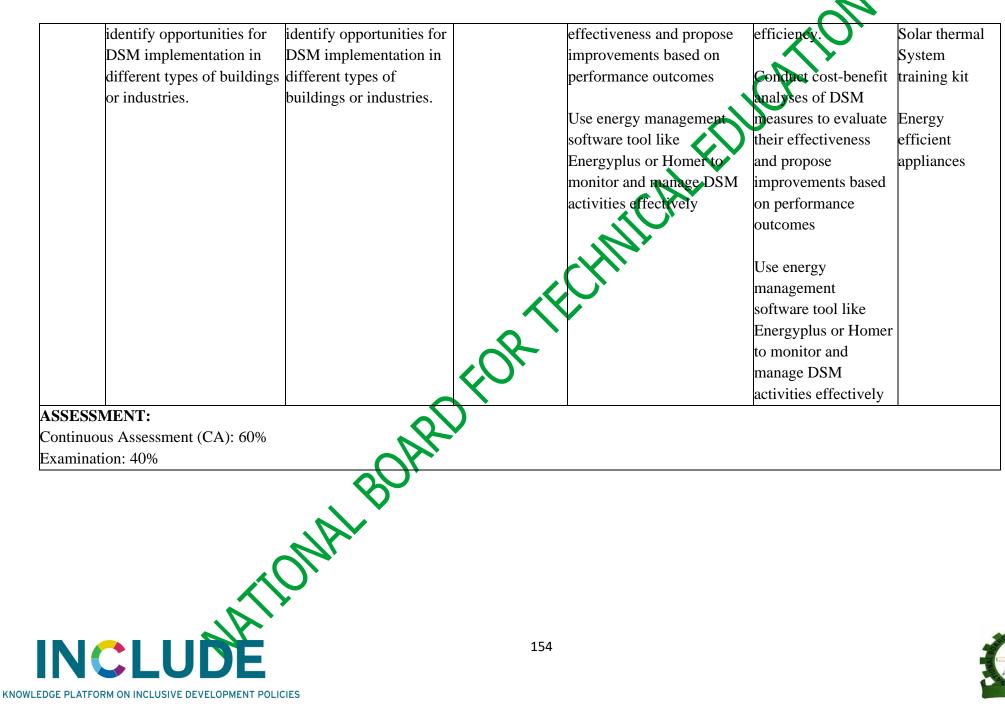


	 Site visit Energy data analysis Energy Audit Report, etc. 	 Energy data analysis Energy Audit Report, etc. 			CATION	Power analyser RETScreen
	2.3 Explain the benefits ofEnergy Auditing2.4 Explain energyoptimization techniques	Explain the benefits of Energy Auditing Explain energy optimization techniques		MALED		
General	Objective 3.0 Know DSM tee	chniques and Energy Efficient	ency strategies.	\mathbf{O}		
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 	how DSM can be integrated into solar	White Board	Utustrate 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.	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	Energy meter Data logger Multimeters Software • Homer • PVsyst • Energyplus













COURSE TITLE : Engineering ethics and professional	COURSE CODE: STE 424	CONTACT HOURS: 2
practice	CREDIT UNIT : 2	THEORETICAL: 2
YEAR: II SEMESTER: II	PRE-REQUISITE: NIL	RRACTICAL: Nil
GOAL: The Course is designed to acquaint the students	with the knowledge of engineering	sethics and professional practice
GENERAL OBJECTIVES: On completion of this cour	rse, the students should be able to:	
1.0 Understand the basic concepts of engineering ethics		
2.0 Understand the principles of ethics in Renewable ene	ergy	
3.0 Understand social impacts of Renewable energy		
4.0 Understand environmental impacts of Renewable end	ergy	
-		
5.0 Understand professional practice in solar energy proj	lects	
5.0 Understand professional practice in solar energy proj	lects	
5.0 Understand professional practice in solar energy proj	lects	
5.0 Understand professional practice in solar energy proj	lects	
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5.0 Understand professional practice in solar energy proj	lects	
	lects	





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	SE TITLE : Engineering ethics	COURSE CODE: STE	424	Conta	ct Hours: 2	
and professional practice		Credit Unit: 2		Theor	retical: 2	
Year:	II Semester: II	Pre-requisite: NIL		Practi	cal: Nil	
COUR	SE SPECIFICATION: THEOF	RETICAL AND PRACTIC	AL			
GOAL	: The Course is designed to acqu	aint the students with the k	nowledge of engin	eering ethics and profe	essional practice	
GENE	RAL OBJECTIVE 1.0: Unders	tand the basic concepts of	engineering ethics			
THEOI	RETICAL CONTENT		<u> </u>	PRACTICAL CONT	TENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning	Teacher's	Resource
			R I	Outcome	Activities	
1-2	1.1 Define ethics	Discuss ethics	Textbooks,			
	1.2 Define professional	Discuss professional	Lecture notes, related journals			
	practice	practice	and materials			
	1.3 Explain the role of	Explain the role of	and internet			
	engineers in society.	engineers in society.	Whiteboard			
	1.4 Explain the importance of	Explain the importance	Marker			
	ethical decision-making.	of ethical decision-				
		making.				







3-5	2.1 Explain theories related to	1	Textbooks,		
	ethics (Utilitarianism,	to ethics (Utilitarianism,	Lecture notes,		
	deontology, and virtue	deontology, and virtue	related journals		
	ethics)	ethics)	and materials and internet		
		Explain the concept of	and internet		
		justice and fairness.	Whiteboard		
	2.2 Explain the concept of	Justice and failless.	Marker		
	justice and fairness.	Explain professional			
		codes of conduct			
		relevant to renewable			
	2.3 Explain professional	energy.			
	codes of conduct relevant	Explain concept of			
	to renewable energy.	ethical decision-making.			
	2.4 Explain concept of ethical				
	decision-making.				
ener	al Objective 3.0: Understand socia	al impacts of Renewable En	ergy		
-9	3.1 Explain the Social impact	Explain the Social	Textbooks,		
	of access to energy.	impact of access to	Lecture notes,		
	3.2 Explain the social impact	energy.	related journals		
	of renewable energy on		and materials		
	communities.	Explain the social impact	and internet		
	N	of renewable energy on communities.	Whiteboard		
		communities.	Marker		
			11101 KOI		







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







	1				
	4.5 Explain the social	Renewable Energy			
	challenges of Renewable and	projects.			
	non-Renewable energy	Explain the social			
	production.	challenges of Renewable			
		and non-Renewable			
		energy production.	•		
Jeneral	Objective 5.0: Understand profe	essional practice in solar pro	ojects		
3-15	5.1 Explain engineer's	Explain engineer's	Textbooks,		
	responsibility (concerning	responsibility	Lecture notes,	\mathbf{O}	
	solar energy projects) to	(concerning solar energy	related journals		
	the public.	projects) to the public.	and materials and internet		
	5.2 E-alain the second of	Explain the concepts of			
	5.2 Explain the concepts of	confidentiality, conflicts	Whiteboard		
	confidentiality, conflicts of interest, and	of interest, and	Marker		
	,	whistleblowing.			
	whistleblowing.				
	5.3 Explain the role of	\sim			
	engineers in promoting	Explain the role of			
	sustainable practices.	engineers in promoting			
	-	sustainable practices.			
	5.4 Explain some ethical	Explain some ethical			
	dilemmas in solar energy	dilemmas in solar energy			
	projects.	projects.			

Examination: 40%





PRACTICAL MANUAL FOR HND SOLAR THERMAL

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		DLAR THERMAL
PRA	CTICAL MANUAL FOR HND S	DLAR THERMAL
S/N	COURSE TITLE / CODE	PRACTICALS
1.	Fundamentals of electrical power systems and machines (STE 311)	 Identify the basic structure and function of electrical power system Generation Transmission Distribution Consumption Measure current and voltage in a simple circuit Calculate power from a simple circuit Identify different power system components Identify overhead lines Identify underground cables Identify components of transformer
2.	Introduction to Solar Thermal Energy (STE 312)	 8. Identify transformer types 1. Identify the types of solar collectors and their operating characteristics: - Non concentrating types Flat plate Evacuated tube - Concentrating types
		160







		• Line focus
		Point focus
		 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: Thermometers Solar irradiation meter Anemometer
		 Pressure gauges Relative humidity 5. Design a low and medium temperatures Solar
3.	Heat Transfer Analysis in Solar Thermal Systems (STE 313)	Thermal Systems 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
	TION	 Analyze heat transfer modes in a solar thermal collector Identify heat transfer equipment: Heat exchangers
	CLUDE	161





		 Heaters Boilers Blowers Refrigerators / Air conditioners etc. 5. Demonstrate the use of heat transfer equipment	ינ
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	
		 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	
	'Ux	8. Demonstrate the use of flow meter to	
		measure the flow rate of a working fluid	
	CLUDE	162	





Solar Thermal Systems (STE 322) 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	5.	Techno-Economic Analysis for Solar Thermal Systems (STE 321)	 across the solar thermal collector 9. Measure temperatures at various levels of the collector and ambient temperature 1. Demonstrate how to perform modelling 2. Demonstrate how to evaluate: Capital Expenditure Cost (CAPEX) Operational Expenditure Cost (OPEX) 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 	
5. Identify the components in a solar thermal	6.		 5. Analyse risks in Solar Thermal System 6. Develop strategies for risk mitigation 7. Evaluate the effectiveness of risk management plan 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 	





 systems 3. Troubleshoot in some specific advanced thermal systems 4. Demonstrate how key parameters can be determined. These include: Neat 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
		 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
		are modeled
		7. Use of the safety kits and gadgets relevant to
		advanced thermal systems
		Carry out preventive maintenance on Heat
0	Calar Thermal Calls do no and	Exchanger
8.	Solar Thermal Collectors and Application II (STE 324)	1. Identify components of solar thermal power
	Application II (STE 524)	plants
		2. Demonstrate the use of high solar thermal collector
		3. Demonstrate the use of measuring devices
		in evaluating efficiency of Solar Thernal
		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. Neasure 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
		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
0	Desearch Mathedale av in Salar	temperature 1. Write a concise and clear title along with
9.	Research Methodology in Solar	, and the second s
	Thermal Energy (STE 325)	background information relevant to solar
		thermal energy2. 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
		echniques in real or simulated
		environments
		9. Analyze data sets using appropriate software
		tools
		NO. 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
_		
	LUDE	166
	JUDE	

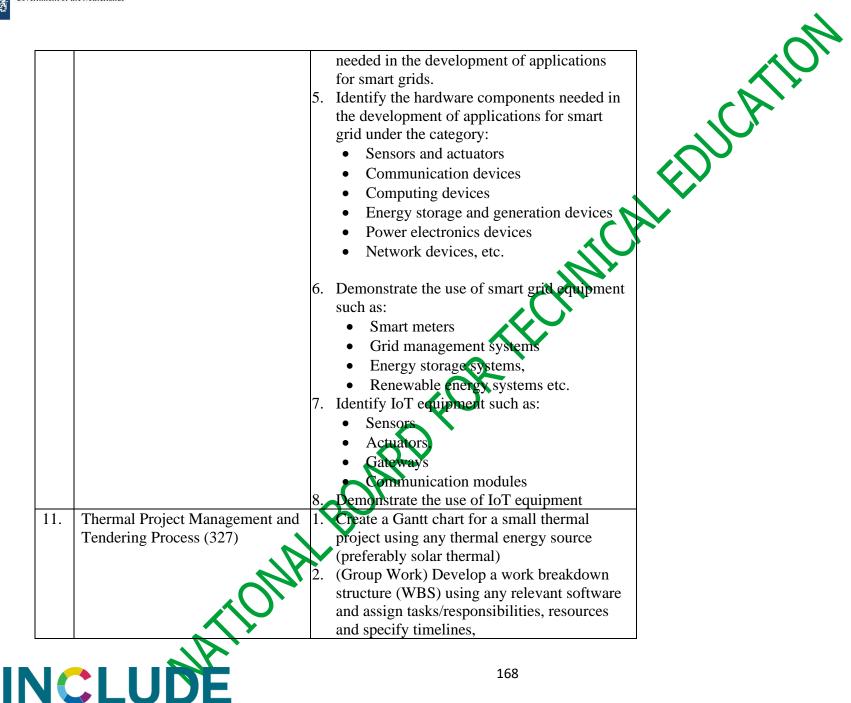




overnment of the Netherlands	
	 13. Write a/an: Progress/Interim report Feasibility report Incident or troubleshooting report 14. Demonstrate the use of citation and referencing tools Zotero
10. Smart Grids & IoT in Solar Thermal Systems (STE 326)	 Demonstrate the use of smart grid components: Advanced metering infrastructure Grid management systems Renewable energy integration Grid animation and control Communication networks Data analytics and management etc. Identify the facilities needed to set up IoT: Physical Technical Human recorrees Infrastructure Regulatory, etc. Identify the equipment needed to set up IoT: Schsors and actuators Microcontrollers and processors Communication modules Gateways and routers Power management equipment
NCLUDE	4. Demonstrate the use of relevant Software 167











		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	 3. Create sample progress report 4. Present sample progress report 5. Prepare a tender document 6. Evaluate a tender document 1. Identify passive and active thermal systems 2. Demonstrate how heating and cooling systems work
	Cooling Technologies (STE 411)	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
		M. Demonstrate the use of PsyCalc Software
13.	Modelling and Simulation of	1. Identify the factors influencing solar thermal
	Solar Thermal Systems (STE 412)	system design
		2. Calculate to determine the appropriate sizing







413)	 Measure the energy flow between the hybrid system and the grid Monitor the energy flow between the hybrid 	
Hybrid Thermal Systems (Wind & Hydro Synergies with Solar Thermal, Grid Integration) (STE	1. Demonstrate setting up a small hybrid system (eg. Solar+wind) and integrate it with a grid connected inverter.	
	 Interpret software-generated outputs and simulation graphs 	
	thermal system simulation	
	6. Identify commonly used software for solar	
	Charging/discharging cycle	
	Heat losses	
	• Energy equations 5 Use mathematical models to calculate the	
	Heat transfer	
	model solar collectors:	
	-	
	and heat exchangers based on system	
	& Hydro Synergies with Solar Thermal, Grid Integration) (STE	demands and design parameters.3. Design the layout of a basic solar thermal system4. Apply thermal performance equations to model solar collectors:• Heat transfer • Energy equations5. Use mathematical models to calculate the behavior of heat storage systems• Heat losses • Charging/discharging cycle6. Identify commonly used software for solar thermal system simulation models in any available software7. Navigate user interface and set up basic simulation models in any available software8. Input system parameters and environmental data into intulation software9. Interpret software-generated outputs and simulation graphsHybrid Thermal Systems (Wind & Hydro Synergies with Solar Thermal, Grid Integration) (STE 413)1. Denestrate setting up a small hybrid system (bg. Solar+wind) and integrate it with a grid connected inverter.2. Measure the energy flow between the hybrid





		 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) 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 for maximum efficiency and cost effectiveness while considering storage systems as backup and/ or compensators.
15.	Retrofitting & Energy Efficiency Techniques (STE 414)	 Identify common components targeted in solar thermal retrofitting and energy efficiency opportunities; such as; collectors, piping, insulation, storage tanks controls Heaterchanger, etc. Conduct energy audits to assess system performance and identify opportunities for energy savings. Conduct an evaluation of existing systems to determine the need for retrofitting Select appropriate methods for improvement of insulation and sealing
	LUDE	171





		 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)	 Illustrate the maintenance in 1.3 Identify common issues associated with Solar Thermal Systems: Scaling Corrosion Leaks and fluid loss Control system issues Degradation of insulation materials Carryout maintenance on typical solar thermal system 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 in a solar thermal plant. Illustrate the operating conditions of solar thermal systems with emphasis on the following parameters: Energy intake Solar irradiance System temperature System temperature System temperature
	LUDE	172





		 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 systems 12. Classify equipment used in solar thermal systems 12. Classify equipment used in solar thermal systems 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)	 Visit Site for data collection Illustrate DSM strategies that include Solar System integration for optimal energy usage. Demonstrate load-shifting and peak-shaving techniques in the operation of solar systems to improve energy consumption efficiency. 	





		Conduct cost-benefit analyses of DS measures to evaluate their effectiven propose improvements based on per- outcomes Use energy management software to energyplus or Hommer to monitor at manage DSM activities effectively	ness and formance ool like
			THERMAL ENGINEERING LABORATO
I IST OF	4 BOT TRVIENT BOR HICTHER NAT		THERMAL ENGINEERING LADORATO
	NAME	QUANTITY 2	
S/N 1. 2.	NAMESolar thermal system modelsHeat exchangers	QUANTITY 2 2	
S/N <u>1.</u> <u>2.</u> <u>3.</u>	NAMESolar thermal system modelsHeat exchangersBoilers	QUANTITY 2 2 2 2	
S/N <u>1.</u> <u>2.</u> <u>3.</u> <u>4.</u>	NAMESolar thermal system modelsHeat exchangersBoilersBlowers	QUANTITY 2 2 2 10	
S/N 1. 2. 3. 4. 5.	NAMESolar thermal system modelsHeat exchangersBoilersBlowersHeat exchanger test rigs	QUANTITY 2 2 2 2	
S/N 1. 2. 3. 4.	NAMESolar thermal system modelsHeat exchangersBoilersBlowers	QUANTITY 2 2 2 10	



REAL
FEDERAL GOVERNMENT OF
NIGERIA

7.	Refrigerator	1	
3.	Solar water heater	2	
).	Solar Air-Conditioner	2	
0.	Air-Conditioner	1	
1.	Multimeter	30	
2.	Electric circuit model	30	
3.	Power system simulator	1	
4.	Electrical Power System Model	2	
5.	Digital Power analyzer/ Energy loggers	5	
6.	Smart controllers	5	
7.	Different efficient bulbs	lot	
8.	Solar Panel	5	
9.	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		
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	10	
	Analogue	10	





of the Neth	erlands		
			Wicht
	Thermocouples	10	
	• Infrared	5	
34.	Sensors		
	• Thermocouple	30	
	• Pressure	15	
35.	Anemometer	2	
36.	Pressure gauge	5	
37.	Hygrometer	2	
38.	Pressure sensor	5	
39.	Actuators	5	
40.	Flow meters		<i>.OY</i>
	• Volumetric	5 each	
	• Mass		
41.	Stopwatch	10	
42.	Flashlight/Inspection light	10	
43.	Arduino Board	15	
44.	Low voltage Power supply pack	5	
45.	Bread Board		
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	1	
50.	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	Mr.
68.	Chiller		
<u>69</u> .	Solar thermal dryer	1	
70.	Solar thermal design software	1	
71.	Thermal energy meter		_
72.	Electric motor		_
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	1
80.	Data Logger	10	
81.	Sample layout design of a solar thermal system	Assorted	
82.	Charts	Assorted	





	Manufacturers manual and charts			
	Psychrometric chart			$\langle \rangle$
	ASHRAE Psychrometric chart		(
	Heat Transfer Media			
83.	Rock	Assorted		
84.	Concrete	Assorted	- ~~	
85.	Sand	Assorted	- 、	
86. 87.	Iron Iron oxide	Assorted Assorted		
88.	Water	Assorted		
89.	Paraffin wax	Assorted		
90.	Animal Fat	Assorted		
91.	Thermal Oil	Assorted		
92.	Sodium and potassium nitrate	Assorted	\mathbf{J}^{*}	
/2.	Consumables	Assolution	<u> </u>	
93.	Samples of:	Assorted	-	
/3.	Ammonia			
	Zeolite			
	Silica gel			
	Activated carbon			
	Calcium-chloride	•		
	• Calcium-cinoriac			
	8			
	LUDE			





S/N	NAME	QUANTITY	
1.	Toolbox		
	• Electrical	6 each	\sim
	Mechanical		
2.	Centre Punch	10	
3.	Hammer	5 each	
	• Mallet		
	• Claw		
	Chipping		MCALED
	• Club		
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	
20	Cosing	Assorted	
20.	Casing	Assorted	





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





27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37.	 Aluminium foil Coating Pencil and Sketch pad Drill bits Tapping bits Bolts and Nuts Brazing rod Flux Welding electrodes Sealants Cutting disc Grinding disc 	AssortedAssortedAssortedAssortedAssortedAssortedAssortedAssortedAssortedAssortedAssortedAssortedAssortedAssortedAssortedAssorted	MICA	
38. 39.	Sandpaper Emery cloth REQUIRED EQUIPMENT FOR COMPUTE	Assorted 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	1
	works)	
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





1000 A				6
11.	OpenSolar	1	CAL-EDU	
12.	PsyCalc	1	-	
13.	Odyssey	1	-	N
14.	MATLAB	1		× ·
11.	Power System Analysis Tool Box (PSAT)	1		
	Simulink			
	Python			
	Python for Power System Analysis (PyPSA)			
15.	ASHRAE Psychrometric chart App	1		
16.	System Advisor Model (SAM)	1		
17.	RiskMatrix	1		
18.	RETScreen software	1		
	MALBOAR	for		
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LIST OF PARTICIPANTS FOR CURRICULUM PRE-CRITIQUE WORKSHOP ON HND SOLAR THERMAL ENGINEERING TECHNOLOGY

S/N	NAME	ADDRESS	EMAIL ADDRESS
1	Yusuf A. Khalil	NAPTIN, Kano	yuskhalil@yahoo.com
2	Dr. Sani Umar Mohammed	N. D. A Kaduna	sumuhammed@nda.edu.ng
3	Muhammed Tijjani Yusuf	HFGC Energy and Power Solutions Ltd	Muhammadi jjani 21@gmail.com
4	Engr. Jibril Waziri	Kaduna Polytechnic, Kaduna	jibwaz@gmail.com
5	Com\Sir\Engr. Ozomata John Ozomata	Afam V330kv, Themal Power Station P/H Rivers State NBTE STAFF	ozomatajohnozomata@gmail.com
6	Prof. Idris M. Bugaje	NBTE, Kaduna	es@nbte.gov.ng
7	Prof. Hassan Diyya'uddeen	NBTE, Kaduna	-
8	Dr. Hassan F. Akande	NBTE, Kaduna	akandelf@gmail.com
9	Dr. Musa Hatim Koko	NBTE, Kaduna	hatimlion@gmail.com
10	Engr. Kabir Salisu Danja	NBTE, Kaduna	ksdanja@gmail.com
11	Maryam Abubakar Habib	NBTE, Kaduna	myuabubakar@gmail.com
12	Foluke Adegoke	NBTE, Kaduna	





14	Abdulhameed Usman	NBTE, Kaduna	
14	CL/INCLUDE TEAM		
	NORBERT EDOMAH	PAN-ATLANTIC UNIVERSITY	nedomah@pau.edu.ng
15	ANIEBIET OBOT	SAABI-FINDING IMPACT CONSULTING	aniebiet06@gmail.com
16	ESTHER F MAIKANO	ADVOCACY FOR POLICY AND INNOVATION (API)	esther@anjintelligence.org
17	VICTORIA MANYA	INCLUDE KNOWLEDGE PLATFORM	o.manya@asc.leidenuniv.nl
		OAN	
		MAL BORN	





LIST OF PARTICIPANTS FOR CURRICULUM FINAL CRITIQUE WORKSHOP ON HIGHER NATIONAL BIRLOMA (HND) SOLAR THERMAL ENGINEERING TECHNOLOGY

S/N	NAME	ADDRESS	EMAIL ADDRESS
1	Prof. Mu'azu Musa	SERC, (ECN) UDUS	muazu.musa@udusok.edu.ng
2	Engr Uche Nwafor	COREN	uchevivid@gmail.com
3	Engr Dr Said Sharif Nura	HFGC Energy & Power ltd	techsaidsharif@gmail.com
4	Engr Dr Emmanuel Ajani	NASENI, Abuja	ajant.emmanuel@naseni.gov.ng
5	Engr Emmanuel E. Mudi	Transcorp Power Plc	emtoboese@gmail.com
6	Engr Abubakar Namadi Mohammed	Kaduna Polytechnic, Kaduna	Namadiba_2001@yahoo.com
		NBTE STAFF	
6	Prof. Idris M. Bugaje	NBTE, Kaduna	es@nbte.gov.ng
7	Prof. Hassan Diyya'uddeen	NBTE, Kaduna	-
8	Dr. Hassan F. Akande	NBTE, Kaduna	akandelf@gmail.com
9	Dr. Musa Hatim Koko	NBTE, Kaduna	hatimlion@gmail.com
10	Dr. Zakari Abdullahi	NBTE Kadona	zakariabdullahi@nbte.gov.ng
11	Muhammad Umar Auna	NBCE, Kaduna	muhammadauna.mu@gmail.com
13	Abdulhameed Usman	NBTE, Kaduna	Hamidco97@gmail.com
14	Yusuf Rabiu Dalhat	NBTE, Kaduna	yrabiudalhat@gmail.com





ASC			
110	CL/INCLUDE TEAM		
15	NORBERT EDOMAH	PAN-ATLANTIC UNIVERSITY	nedomah@pau.edu.ng
16	ANIEBIET OBOT	SAABI-FINDING IMPACT CONSULTING	aniebiet06@gmail.com
17	ESTHER F MAIKANO	ADVOCACY FOR POLICY AND INNOVATION (API)	esther@apiintelligence.org
18	VICTORIA MANYA	INCLUDE KNOWLEDGE PLATFORM	v.o.manya@asc.leidenuniv.nl
		\sim	
		MALBOARD	

