REGULATIONS AND SYLLABUS
(University Department)

(For the candidates admitted from the academic year 2019-2020 onwards)

MASTER OF TECHNOLOGY IN ENERGY TECHNOLOGY

(Under Choice Based Credit System)

DEPARTMENT OF ENERGY SCIENCE
PERIYAR UNIVERSITY
(Reaccredited with "A" Grade by the NAAC)
SALEM– 636 011
TAMIL NADU

Regulations & Scheme

M.Tech., Energy Technology

Choice Based Credit System(CBCS) Regulation,

Scheme and Syllabus

(W.e.f.2019-2020onwards)

1. Eligibility for Admission

Candidate who has passed the B.E/B.Tech degree in Mechanical/ Mechatronics/Electrical & Electronics /Chemical Engineering or M.Sc., degree in Physics/Chemistry/Energy Studies/Energy Science of this University or any other University shall be eligible for admission to M.Tech., degree of this University

2. Mode of Selection

The admission is subject to the prevailing rules and regulations for PG admission of this University and also as per the norms of Tamil Nadu Government.

3. Duration of the Course

The duration of the M.Tech., degree shall be two years consist of four semesters. Each semester consist of 90 working days.

4. Distribution of Credit Points

The minimum credit requirement for M.Tech., degree shall be 90 Credits. The break-up of credits for the Programme is as follows;

- Core Courses : 68 credits
- Elective Courses : 16 credits
- Supportive Courses : 06 credits

5. Course of Study

The course of study for the M.Tech., degree shall be in Energy Technology (CBCS) with internal assessment according to syllabi prescribed from time to time.

5.1 Components of Internal Examination

The allotment of marks and scheme of examination as follows;

Internal Tests (Best of 2 out of 3)	05 Marks
Model Examination	05 Marks
Seminar	05 Marks
Assignment	05 Marks
Attendance	05 Marks
Total	25 Marks

5.2 Theory Core Paper

External	75 Marks
Internal	25 Marks
Total	100 Marks
Duration of Examination	3 Hours

5.3 Practical Internal &External

Model Practical	30 Marks
Record	05 Marks
Viva Voce	05 Marks
Internal Total	40 Marks
External	60 Marks
Total	100 Marks

5.4 Marks allotment for attendance as follows

%of attendance	Marks
91% - 100%	5
85%- 90%	4
81% - 84%	3
75% - 80%	2
Below 75%	No marks

6. Details of Project Marks

Phase I

Project work	**Internal (40 Marks)**			**External (60 marks)**			
	Review I	Review II	Review III	Thesis Evaluation (External)	Viva –voice 45 Marks		
					Supervisor	External	Internal
Phase I	10	10	20	15	15	15	15

Phase II

Project work	**Internal (80 Marks)**			**External (120 marks)**			
	Review I	Review II	Review III	Thesis Evaluation (External)	Viva –voice 90 Marks		
					Supervisor	External	Internal
Phase II	20	20	40	30	30	30	30

The project work is an important component of post graduate programme. The Project work consists of Phase – I and Phase – II. The Phase – I is to be undertaken during III semester. Phase – II, which is a continuation of Phase – I is to be undertaken during IV semester.

The Project work for Phase II shall be pursue for a minimum of 90 days during the final semester. Students may be permitted to carried out project work either internal or external mode i.e, Industrial / Research Organization, etc., on the recommendations of the Head of the Department. In case of external, the Project work shall be jointly guided by a supervisor of the department and an expert as joint supervisor from the organization and the student shall be instructed to meet the supervisor periodically and to attend the review committee meetings for evaluating the progress.

7. Question Paper Pattern

Time: 3 Hrs **Maximum Marks: 75**

PART – A (20X1=20 Marks)

Objective Type Question

PART – B (3X5=15 Marks)

Analytical Questions (One question from each Unit)

Any 3 out of 5

PART – C(5X8=40Marks)

Either or Type descriptive question (Two questions from each Unit)

8. Passing Minimum

1. There shall be no Passing Minimum Marks for Internal.
2. For External Examination, Passing Minimum shall be of 50% (Fifty Percentage) of the maximum marks prescribed for the paper.
3. In aggregate (External +Internal) the passing minimum shall be of 50% for each Paper/Practical/Project and Viva-voce.
4. Grading shall be based on overall marks obtained (internal + external).

9. Classification of Successful Candidates

Cgpa	Grade	Classification of final result
9.5-10.0	O+	First Class with Exemplary
9.0 and above but blow 9.5	O	
8.5 and above but blow 9.0	D++	First Class with Distinction
8.0 and above but blow 8.5	D+	
7.5 and above but blow 8.0	D	
7.0 and above but blow 7.5	A++	First Class
6.5 and above but blow 7.0	A+	
6.0 and above but blow 6.5	A	
5.5 and above but blow 6.0	B+	Second Class
5.0 and above but blow 5.5	B	
0.0 and above but blow 5.5	U	Re-appear

10. Marks and Grades

Range of Marks	Grade points	Letter Grade	Description
90 – 100	9.0 – 10.0	**O**	**Outstanding**
80-89	8.0 – 8.9	**D+**	**Excellent**
75-79	7.5 – 7.9	**D**	**Distinction**
70-74	7.0 – 7.4	**A+**	**Very Good**
60-69	6.0 – 6.9	**A**	**Good**
50-59	5.0 – 5.9	**B**	**Average**
00-49	0.0	**U**	**Re-Appear**
Absent	**0.0**	**AAA**	**Absent**

11. Internship

The students may undergo internship training at Research organization / University/ industry for a period as specified in the curriculum during summer vacation. In this case the training has to be undergone continuously for the entire period.

Duration of Internship	Credits
2 Weeks to 4 weeks	2

At the end of internship, the student shall submit a report. The Viva-Voce Examination will be conducted by a three member committee constituted by the Head of the Department. The committee comprises of one expert from an industry/

organisation and two members (co-ordinator and supervisor) from the Department. Certificates (issued by the Organization) submitted by the student shall be attached to the mark list and sent to the Controller of Examinations by the Head of the Department.

INTERNSHIP TRAINING

EVALUATION

Report	Presentation	Viva Voce	Total
40	30	30	100

12. Industrial Course

Industrial course should be offered in second or third semester with one or two credits in every department

13. Supportive Paper

Supportive paper should be offered only in second and third semesters. Students are expected to opt Supportive Course (Non major elective) offered by other departments. Students can earn three credit from suppotive course.

14. Swayam Course

SWAYAM is a programme initiated by Government of India and designed to achieve the three cardinal principles of Education Policy namely access, equity, and quality. The objective of this effort is to take the best teaching learning resources to all, including the most disadvantaged. SWAYAM seeks to bridge the digital divide for students who have hitherto remained untouched by the digital revolution and have not been able to join the mainstream of the knowledge economy. The courses hosted on SWAYAM are in 4 quadrants – (1) video lecture, (2) specially prepared reading material that can be downloaded/printed (3) self-assessment tests through tests and quizzes and (4) an online discussion forum for clearing the doubts. Steps have been taken to enrich the learning experience by using audio-video and multi-media and state of the art pedagogy / technology. In order to ensure best quality content are produced and delivered, nine National Coordinators have been appointed: They are AICTE for self-paced and international courses, NPTEL for engineering, UGC for non-technical post-graduation education, CEC for under-graduate education, NCERT and NIOS for school education, IGNOU for out-of-the school students, IIMB for management studies and NITTTR for Teacher Training programme. Courses delivered through SWAYAM are available free of cost to the learners, however, students wanting certifications if they register will be offered a certificate on successful completion of the course, for a small fee. At the end of each course, there will be an assessment of the student through proctored examination and the marks/ grades secured in this exam could be transferred to the academic record of the students.

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

The Energy Technology program seeks to prepare PG students for productive and rewarding careers in the Energy arena. The PEOs are listed below

I. Acquire knowledge and accomplish a decent employment in energy sector and advance to significant positions of leadership in their Profession.

II. Inclination towards advanced research for mitigating the shortcomings in energy systems.

III. Ascending as an energy consultant for providing solutions towards improving the efficacy of energy systems.

IV. Become a successful entrepreneur and be a part of a supply chain or manufacture or market energy products for sustainable development.

V. Lead an ethical life by engaging in lifelong learning experiences for developing environmentally benign and economically affordable energy products for societal upliftment

2. PROGRAMME OUTCOMES (POs):

After studying Energy Technology, our students will exhibit ability to:

PO	Graduate Attribute	Programme Outcome
1	Knowledge	Apply knowledge of mathematics, basic science and engineering science.
2	Problem analysis	Identify, formulate and solve engineering problems.
3	Design/development of solutions	Design a system or process to improve its performance, satisfying its constraints.
4	Conduct investigations of complex problems	Conduct experiments & collect, analyze and interpret the data.
5	Modern tool usage	Apply various tools and techniques to improve the efficiency of the system.
6	The Engineer and society	Conduct themselves to uphold the professional and social obligations.
7	Environment and sustainability	Design the system with environment consciousness and sustainable development.
8	Ethics	Interact in industry, business and society in a professional and ethical manner.
9	Individual and team	Function in a multidisciplinary team.
10	Communication	Proficiency in oral and written Communication.
11	Project management and finance	Implement cost effective and improved system.
12	Life-long learning	Continue professional development and learning as a life-long activity.

3. PROGRAM SPECIFIC OUTCOMES (PSOs):

1. To create awareness on the energy sourcing, generation, distribution, consumption, and emission patterns of India Vs Globe, apart from computation of plant load factor, efficiency, quantification of emissions along with cost of power generation from various energy sources
2. To carry out energy audit in Industries by accounting its energy consumption pattern, determining its specific energy consumption, diagnosing the causes for deviation from the industry benchmarks and suggestions for improving the performance of the plant
3. To instil ability to use knowledge in various domains to identify research gaps and ideate innovations by simulation of energy systems using software such as MATLAB, ANSYS- CFD, Fluent, TRNSYS, PV-SYST

4. PEO / PO Mapping:

Programme Educational Objectives	Programme Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
II	✓	✓	✓	✓	✓				✓		✓	✓
III	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
IV	✓	✓	✓		✓		✓	✓	✓	✓	✓	
V	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Mapping of Course Outcome and Programme Outcome

		Course Name	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11	PO12
I YEAR	Semester 1	Energy Resources	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓
		Fluid Mechanics and Heat Transfer	✓	✓	✓	✓	✓		✓					✓
		Thermodynamics	✓	✓	✓		✓	✓	✓	✓	✓			✓
		Environmental Engineering and Pollution Control	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
		Energy Auditing and Management				✓	✓	✓	✓	✓	✓	✓	✓	✓
		Elective I												
		Energy Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓
	Semester 2	Energy Conservation in Industrial Utilities	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
		Energy Efficient Buildings Design	✓	✓	✓		✓	✓	✓					✓
		Power Generation, Transmission and Distribution	✓	✓	✓	✓		✓	✓					
		Elective II												
		Elective III												
		Supportive												
		Analysis and Simulation Laboratory	✓	✓	✓	✓	✓		✓		✓	✓		✓
II YEAR	Semester 3	Advanced Power Plant Engineering	✓	✓	✓	✓	✓		✓				✓	✓
		Advanced Energy Storage technologies	✓		✓	✓	✓	✓		✓	✓		✓	✓
		Elective IV												
		Supportive												
		Internship	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Project work Phase I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Semester 4	Project Work Phase II	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

PERIYAR UNIVERSITY, SALEM
UNIVERSITY DEPARTMENT REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM
M.TECH. ENERGY TECHNOLOGY

CURRICULUM AND SYLLABUS

SEMESTER I

S. No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1.	19UPESC2C01	Energy Resources	PC	4	4	0	0	4
2.	19UPESC2C02	Fluid Mechanics and Heat Transfer	PC	4	4	0	0	4
3.	19UPESC2C03	Thermodynamics	PC	4	4	0	0	4
4.	19UPESC2C04	Environmental Engineering and Pollution Control	PC	4	4	0	0	4
5.	19UPESC2C05	Energy Auditing and Management	PC	4	4	0	0	4
6.	-	Elective I	PE	4	4	0	0	4
PRACTICALS								
7	19UPESC2C06	Energy Laboratory	PC	3	0	0	3	2
			TOTAL	**27**	**24**	**0**	**3**	**26**

SEMESTER II

S. No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
	THEORY							
1.	19UPESC2C07	Energy Conservation in Industrial Utilities	PC	4	4	0	0	4
2.	19UPESC2C08	Energy Efficient Buildings Design	PC	4	4	0	0	4
3.	19UPESC2C09	Power Generation, Transmission and Distribution	PC	4	4	0	0	4
4.	-	Elective II	PE	4	4	0	0	4
5.	-	Elective III	PE	4	4	0	0	4
6.	-	Supportive	NM	3	3	0	0	3
7.	19UPESC2C10	Analysis and Simulation Laboratory Engineering	PC	4	0	0	0	2
			TOTAL	27	23	0	4	25

SEMESTER III

S. No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
THEORY								
1	19UPESC2C11	Advanced Power Plant Engineering	PC	4	4	0	0	4
2.	19UPESC2C12	Advanced Energy Storage technologies	PC	4	4	0	0	4
3.	-	Elective IV	PE	4	4	0	0	4
4.	-	Supportive	NM	3	3	0	0	3
5.	19UPESC2C13	Internship	PC	0	0	0	0	2
PRACTICALS								
6.	19UPESC2C14	Project Work Phase I	PC	14	0	0	14	7
			TOTAL	**29**	15	0	14	24

SEMESTER IV

S. No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
THEORY								
1	19UPESC1C15	Project Work Phase II	PC	30	0	0	30	15
TOTAL				**30**	0	0	30	15

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE = 90

S. No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1	SWAYAM Course – I (I Year)							
2	SWAYAM Course –II (II Year)							

PROFESSIONAL CORE (PC)

S.No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
1.	19UPESC2C01	Energy Resources	PC	4	4	0	0	4
2.	19UPESC2C02	Fluid Mechanics and Heat Transfer	PC	4	4	0	0	4
3.	19UPESC2C03	Thermodynamic analysis of energy systems	PC	4	4	0	0	4
4.	19UPESC2C04	Environmental Engineering and Pollution Control	PC	4	4	0	0	4
5.	19UPESC2C05	Energy Auditing and Management	PC	4	4	0	0	4
6.	19UPESC2C06	Energy Laboratory	PC	4	4	0	0	4
8.	19UPESC2C07	Energy Conservation in Industrial Utilities	PC	4	4	0	0	4
9.	19UPESC2C08	Energy Efficiently Buildings Design	PC	4	4	0	0	4
10	19UPESC2C09	Power Generation, Transmission and Distribution	PC	4	4	0	0	4
11	19UPESC2C10	Analysis and Simulation Laboratory	PC	4	4	0	0	4
12	19UPESC2C11	Advanced Power Plant Engineering	PC	4	4	0	0	4
13	19UPESC2C12	Advanced Energy Storage techniques	PC	4	4	0	0	4
14	19UPESC2C13	Internship	PC	**0**	0	0	2	2
15	19UPESC2C14	Project Work Phase I	PC	14	0	0	14	7
16	19UPESC2C15	Project Work Phase II	PC	30	0	0	30	15

PROFESSIONAL ELECTIVE (PE)

S. No	Course Code	Course Title	Category	Contact Periods	L	T	P	C
Semester-I								
1.	19UPESC2E01	Solar Energy Technologies	PE	4	4	0	0	4
2.	19UPESC2EC02	Design of Heat Exchangers	PE	4	4	0	0	4
3.	19UPESC2E03	Power Electronics for Renewable Energy Systems	PE	4	4	0	0	4
Semester -II								
4.	19UPESC2E04	Wind Energy Systems	PE	4	4	0	0	4
5.	19UPESC2E05	Computational Fluid Dynamics	PE	4	4	0	0	4
6.	19UPESC2E06	Fluidized Bed Systems	PE	4	4	0	0	4
7.	19UPESC2E07	Bio Energy Technologies	PE	4	4	0	0	4
8.	19UPESC2E08	Hydrogen and Fuel Cell	PE	4	4	0	0	4
9.	19UPESC2E09	Instrumentation for Thermal Systems	PE	4	4	0	0	4
Semester -III								
10	19UPESC2E10	Waste Management and Energy Recovery Techniques	PE	4	4	0	0	4
11	19UPESC2E11	Energy Forecasting, Modelling and Project Management Technique	PE	4	4	0	0	4
12	19UPESC2E12	Design and Analysis of Turbo Machines	PE	4	4	0	0	4
13	19UPESC2E13	Modelling and Analysis of Energy Systems	PE	4	4	0	0	4
14	19UPESC2E14	Electrical Drives and Controls	PE	4	4	0	0	4

NON-MAJOR ELECTIVE COURSES (NM)

S. No	Course Code	Course title	Category	Contact Periods	L	T	P	C
1	19UPESC2S01	Basic Concepts in Energy Sciences	NM	3	3	0	0	3
2	19UPESC2S02	Climate Change and CO_2 Emission Assessment	NM	3	3	0	0	3
3	19UPESC2S03	Energy and Environmental Impacts	NM	3	3	0	0	3
4	19UPESC2S04	Erection and Maintenance of Refrigeration and Air-Conditioning Equipments	NM	3	3	0	0	3
5	19UPESC2S05	Green Concepts in Building	NM	3	3	0	0	3

19UPESC2C01 **ENERGY RESOURCES**

OBJECTIVES

- To familiarize with the all forms of renewable energy Resources.
- To inculcate information on energy transitions in domestic and commercial application.
- To learn various energy conversion techniques.
- To understand the techno economic aspects of energy conversions.
- To learn forecasting and formulate optimal framework for various energy conversion systems.

UNIT I SOLAR ENERGY

Present energy scenario in India - Solar radiation at the earth's surface – solar radiation measurements – estimation of average solar radiation - solar thermal flat plate collectors - concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications: battery charger, domestic lighting, street lighting, water pumping etc - solar PV power plant – Net metering concept.

UNIT II WIND ENERGY

Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - wind resource assessment - Betz limit - site selection - wind energy conversion devices - classification, characteristics, applications – offshore wind energy - Hybrid systems - safety and environmental aspects – wind energy potential and installation in India – Wind turbine performance measurement – Loading analysis- Repowering concept.

UNIT III BIO-ENERGY

Biomass resources and their classification -Techniques for biomass-Assessment- Biomass conversion processes - Thermo chemical conversion - direct combustion – biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - types of biogas Plants - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India.

UNIT IV OTHER TYPES OF ENERGY

Ocean energy resources - principle of ocean thermal energy conversion (OTEC) - ocean thermal power plants - ocean wave energy conversion - tidal energy conversion – small hydro - geothermal energy - geothermal power plants – hydrogen production and storage -Magneto-hydro-dynamic (MHD) energy - Fuel cell – principle of working - various types - construction and applications.

UNIT V DIRECT CONVERSION OF THERMAL TO ELECTRICAL ENERGY

Conventional energy conversion cycles - Reversible and irreversible cycles – Thermodynamics analysis of Carnot – Stirling – Ericsson – Otto – Diesel – Dual – Lenoir – Atkinson – Brayton - Rankine. Thermoelectric Converters –Thermionic converters – MHD – Ferro electric converter – Nernst effect generator

OUTCOMES

Upon completion of this course, the students will be able to:

- To get a familiar knowledge in various forms of energy resources.
- Familiarity with principles of energy conversion.
- Capability to design optimal energy conversion system.
- Acquired skills on the choice of energy conversion technique for specific applications.
- Identify pros and cons of energy resources.

REFERENCES:

1. Sukhatme, S.P., Solar Energy, Tata McGraw Hill,4th edition,2017.
2. Twidell, J.W. and Weir, A., Renewable Energy Sources, Routledge; 3rd edition 2015
3. Fundamentals and Applications (SIE) 5e Jul7 2017 by Yunus A Cengel and Afshin J. Ghajar
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7. Veziroglu, T.N., Alternative Energy Sources, Vol 5 and 6, McGraw Hill, 1990.
8. Bridgurater, A.V., Thermochemical processing of Biomass, Academic Press, 1981.
9. Bent Sorensen, Renewable Energy, Elsevier, Academic Press, 2011.
10. McCormick, Michael E. Ocean wave energy conversion. Courier Corporation, 2013.

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	M	M	M	M	-	M	L	H	H	M	L	M	H	L	H
2	M	H	H	L	-	L	L	M	M	M	L	M	M	L	M
3	H	H	H	M	M	H	H	M	M	M	L	M	-	-	H
4	L	M	M	L	H	M	H	M	M	M	L	M	L	-	H
5	L	M	-	-	-	L	M	M	-	-	-	L	H	L	-

19UPESC2C02 FLUID MECHANICS AND HEAT TRANSFER

OBJECTIVES

- To make students familiarize with the application of conservation equations
- To explain the incompressible and compressible fluid flow concepts
- To inculcate the analysis of conduction and gas radiation heat transfer
- To provide the details of turbulent forced convective heat transfer
- To impart the knowledge of design of single phase and multi-phase heat exchangers

UNIT I BASIC EQUATION, POTENTIAL FLOW THEORY AND BOUNDARY LAYER CONCEPT

Three dimensional continuity equation – differential and integral forms – equations of mass, momentum and Energy and their engineering applications.Rotational and irrotational flows – circulation – vorticity – stream and potential functions.Boundary Layer - displacement and momentum thickness – laminar and turbulent boundary layers in flat plates – circular pipes.

UNIT II INCOMPRESSIBLE AND COMPRESSIBLE FLOWS

Laminar and turbulent flow between parallel plates – flow through circular pipe – friction factor – smooth and rough pipes – Moody diagram – losses during flow through pipes. Pipes in series and parallel – transmission of power through pipes.One dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers.

UNIT III CONDUCTION AND RADIATION HEAT TRANSFER

Governing Equation and Boundary conditions, Extended surface Heat Transfer, Transient conduction – Use of Heisler's charts, Conduction with moving boundaries, Radiation Heat Transfer, Gas Radiation

UNIT IV TURBULENT FORCED CONVECTIVE HEAT TRANSFER

Turbulence theory – mixing length concept – turbulence model – k Є model – analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube – high speed flows.

UNIT V PHASE CHANGE HEAT TRANSFER AND HEAT EXCHANGER

Condensation on bank of tubes – boiling – pool and flow boiling, Heat exchanger – Є – NTU approach and design procedure – compact heat exchanger.

OUTCOMES

Upon completion of this course, the students will be able to:

- Identify, formulate and analyze the governing equations for various engineering applications
- Learn the flow concepts of incompressible and compressible flow.
- Solve the conduction and gas radiation heat transfer problems.
- Understand the turbulent forced convective heat transfer
- Design a heat exchanger as per the industrial needs.

REFERENCES:

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5. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw Hill Co., 1985.
6. Holman.J.P., Heat Transfer, Tata McGraw Hill, 2002.
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9. Shiv Kumar, “Fluid Mechanics Basic Concepts & Principles “ Ane Books Pvt. Ltd, Second Edition, 2011
10. Venkateshan S P., “Heat Transfer “ Ane Books Pvt. Ltd, 2011

CO	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
1	H	H	H	H	L	L	L	L	L	L	L	L	L	L	H
2	H	H	H	H	L	L	L	L	L	L	L	L	L	L	H
3	H	H	H	H	L	L	L	L	L	L	L	L	L	L	H
4	H	H	H	H	L	L	L	L	L	L	L	L	L	L	H
5	H	H	H	H	L	L	L	L	L	L	L	L	L	L	H

19UPESC2C03 **THERMODYNAMICS**

OBJECTIVES

- To understand the properties of ideal gas real gas and pure substance.
- To understand the concept of energy and its interaction applied to thermodynamic system.
- Signifies the increase of entropy principles.
- Importance of exergy analysis of thermodynamic system.
- Significance of thermodynamic property relation

Unit I: Properties of ideal gas, real gas and pure substances

The Ideal-Gas Equation of State, Compressibility Factor—A Measure of Deviation from Ideal-Gas Behavior, Other Equations of State, Pure Substance, Phases of a Pure Substance, Phase-Change Processes of Pure Substances, Property Diagrams for Phase-Change Processes, Property tables.

Unit II: Energy and its interactions

Forms of Energy, Energy Transfer by Heat, Work and Mass, Internal Energy, Enthalpy, The First Law of Thermodynamics – closed system and open system, steady and unsteady flow devices, Energy Conversion Efficiencies, Energy and Environment, Second law of thermodynamics.

Unit III: Entropy

Entropy, The Increase of Entropy Principle, Entropy Change of Pure Substances, The Increase of Entropy Principle, Entropy Change of Pure Substances, Entropy Balance.

Unit IV: Exergy

Exergy: Work Potential of Energy, Reversible Work and Irreversibility, Second-Law Efficiency, Exergy Change of a System, Exergy Transfer by Heat, Work, and Mass, The Decrease of Exergy Principle and Exergy Destruction, Exergy Balance: Closed Systems, Exergy Balance: Control Volumes.

Unit V: Thermodynamic Property Relations

The Maxwell Relations, The Clapeyron Equation, General Relations for Change in Internal Energy, Enthalpy, Entropy of Ideal, and Real gas, The Joule-Thomson Coefficient.

OUTCOMES

Upon completion of this course, the students will be able to:

- Know the behaviour of ideal gas, real gas and pure substance.
- Apply energy balance to closed and open system to estimate heat and work transfer.
- To evaluate entrophy generation during a thermodynamic process.
- To determine exergy destruction and second law efficiency of a thermodynamic system.
- To calculate non measurable properties like internal energy, enthalpy and entropy using thermodynamic property relations.

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10. Van Wylen and Sonntag, "Classical Thermodynamics", Wiley Eastern, 1987.
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19UPESC2C04 ENVIRONMENTAL ENGINEERING AND POLLUTION CONTROL

OBJECTIVES

- To impart knowledge on the atmosphere and its present condition and, global warming.
- To detail on the sources of water pollution and possible solutions for mitigating their degradation.
- To detail on the sources of air pollution and possible solutions for mitigating their degradation.
- To detail on the sources of solid waste and possible ways to dispose them safely.
- To impart knowledge on hazardous waste management.

UNIT I INTRODUCTION

Man & Environment – Types of Pollution – Global Environmental issues – Environmental Impact Assessment – Global Warming Issues –CO2 Mitigation – Basic definition of Pollution Indicators – Noise Pollution

UNIT II WATER POLLUTION

Pollutants in Water & Wastewater – Physical and Chemical Treatment Methods – (An Overview) Neutralization – Aeration –Colour / Odour Removal - Sludge dewatering – Biological Treatment including Aerobic & Anaerobic Treatment

UNIT III AIR POLLUTION

Sources – Ambient Air Quality Standards – Emission Limits – Equipment for Ambient Air & Stack Monitoring – Principles of operation of Particulate Control Equipment (ESPs, Bag Filters, Cyclone Separators etc.,) – Vehicular Pollution and its Control.

UNIT IV SOLID & HAZARDOUS WASTE MANAGEMEN

Types & Sources – Types (Municipal, Biomedical, Industrial, Hazardous etc.,) – Waste Generation – Composition – Physical / Chemical / Biological Properties – Transformation Technologies for Waste Treatment – Landfill Management – Leachate Generation – e Waste Disposal

UNIT V GLOBAL WARMING & CLIMATE CHANGE

Impact of Global Warming / Climate Change on various sectors – Green House Gases & Effect– Carbon Cycle – CDM – Carbon Trading – Carbon Sequestration – Carbon Capture & Storage– UNFCCC – IPCC Protocols

OUTCOMES

Upon completion of this course, the students will be able to:

- Types and effects of each type of pollution on man – earth will be made known.
- Technical aspects of Global Warming will make them understand the impact they have on climate
- Technologies that are available for reduction of pollutants dumped into the atmosphere
- Cursory / superficial formation - the students – had in Hazardous waste, waste disposal hitherto will be deep & sensible enough after studying this subject
- Comprehend the different techniques available for safe disposal of hazardous waste

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3. Ludwig, H. W.Evans: Manual of Environmental Technology in Developing Countries, International Book Company, Absecon Highlands, N.J, 1991
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19UPESC2C05 ENERGY AUDITING AND MANAGEMENT

OBJECTIVES

- To learn the process of forecasting energy utilization and energy loss rates.
- To acclimatize with power quality issues in energy management.
- To learn sufficient knowledge on energy monitoring methods and optimal regulations.

UNIT I INTRODUCTION

Types & Forms of Energy - Primary / Secondary Energy Sources –Energy Conservation Act 2001-Electricity Act 2003 - Energy Auditing: Types, classifications, deliverables, barriers – Benchmarking - Roles & Responsibility of Energy Managers-Matching Energy Usage to Requirements-Fuel and Energy Substitution-Optimizing input energy requirements.

UNIT II ENERGY COSTING, MONITORING & TARGETING

Data & Information Analysis – Cost / Energy Share Diagram – Data Graphing – Electricity Billing : Components & Costs – kVA – Need & Control – Determination of kVA demand & Consumption – Time of Day Tariff – Power Factor Basics – Penalty Concept for PF – PF Correction – Wheeling and Banking - Demand Side Management – comparison on unit cost of power cost from various sources – steam cost from different sources-noneconomic factors

UNIT III METERING FOR ENERGY MANAGEMENT & POWER QUALITY ANALYSES

Instruments Used in Energy systems: Load and power factor measuring equipment, Wattmeter, flue gas analysis, Temperature and thermal loss measurements, air quality analysis etc. Relationships between parameters-Units of measure-Typical cost factors- Utility meters – Timing of meter disc for kilowatt measurement - Demand meters - Paralleling of current transformers - Instrument transformer burdens-Multitasking solid-state meters - Metering location vs. requirements – Net metering - Metering techniques and practical examples.

UNIT IV LIGHTING SYSTEMS & COGENERATION

Concept of lighting systems - The task and the working space - Light sources - Ballasts - Luminaries - Lighting controls - Optimizing lighting energy - Power factor and effect of harmonics on power quality - Cost analysis techniques - Lighting and energy standards Cogeneration: Forms of cogeneration - feasibility of cogeneration- extraction turbines and steam cycle of cogeneration- Electrical interconnection.

UNIT V ECONOMICS

Energy Economics – Depreciation - Financial Analysis Techniques – Discount Rate, Payback Period, Internal Rate of Return, Net Present Value, Life Cycle Costing – ESCO concept - CUSUM Technique – ESCO Concept – ESCO Contracts-life cycle costing, case flow in power projects-energy market analysis.

OUTCOMES

Upon completion of this course, the students will be able to:

- Familiarized about the energy sources, energy acts, and energy auditing and energy management methods.
- Eligible to perform micro and macroeconomic forecasting of energy consumption and utilization.
- Involve in energy extraction and efficiency rate improvement through incorporation of hybrid systems.
- Adopt energy standards based on various acts officially established for qualitative and quantitative improvement in energy utilization.
- To acquired a knowledge about energy in economic view.

REFERENCES:

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19UPESC2C06 **ENERGY LABORATORY**

OBJECTIVES

- To learn the working of different renewable energy gadgets
- To understand the methodology adopted for performance evaluation of various renewable energy systems

LIST OF EXPERIMENTS

1. Performance testing of Solar Hot Water Collector
2. Characteristics of Solar photovoltaic devices
3. Testing of biomass Gasifier in up draught / downdraught mode
4. Testing of biogas plant
5. Fuel characterization
6. Solar Radiation measurement
7. Thermal Energy Storage Systems
8. I-V Characteristics of Solar PV Module
9. Performance of solar PV module at various tilt angle
10. Impact of shadow and efficiency of solar PV Module

OUTCOME

Upon completion of this course, the students will be able to:

- Evaluate the performance of renewable energy gadgets
- Analyse the factors influencing the efficiency and suggest methods for improving the adaptability and efficiency of renewable energy gadgets

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19UPESC2C07 ENERGY CONSERVATION IN INDUSTRIAL UTILITIES

OBJECTIVES

- To understand the types of fuels used in Industries and their characteristics
- To Know the techniques adopted for performance evaluation of thermal utilities
- To Learn and appreciate the working principle employed in VCRS and VAM systems
- To list the parameters considered in electricity billing and the losses associated with a motor
- To Comprehend the techniques available for energy conservation in electrical utilities

UNIT – I BOILERS

Types - Performances evaluation via direct and indirect method – energy conservation avenues. Properties of steam - Assessment of steam distribution losses - Steam trapping - Condensate and flash steam recovery system - Opportunities for energy saving in steam consumption systems

UNIT – II FURNACES AND THERMIC FLUID HEATERS

Furnaces and Thermic Fluid Heaters : Types - Performances evaluation via direct and indirect method – energy conservation avenues.Insulation and Refractory : types and application

UNIT – III HVAC AND WASTE HEAT RECOVERY

VCRS – performance assessment – energy savings opportunities – VAM: working, types, benefits, comparison with vapor compression system.WHR systems: Classification – Benefits - Commercial waste heat recovery devices: recuperator, regenerator, heat pipe, heat exchangers (Plate, Shell & Tube), heat pumps, thermocompressor. CHP – Polygeneration

UNIT – IV ELECTRICAL SYSTEMS AND INDUCTION MOTORS

Electricity billing - Demand side management - Power factor improvement transformer losses – Harmonics induction Motors : Types – Losses – performance assessment adopting direct and indirect method - Factors affecting motor performance - energy efficient motors

UNIT – V ENERGY CONSERVATION IN ELECTRICAL UTILITIES

Performance assessment and energy conservation avenues in : fans - blowers – pumps – air compressors - illumination systems - cooling towers

OUTCOMES

Upon completion of this course, the students will be able to:

- Compute stoichiometric air for any given fuel and suggest measures for efficient combustion
- Diagnose the cause for under performance of thermal utilities and suggest suitable remedial measures thereof
- Analyse the factors affecting the COP of a VCR and VAR system
- Evaluate the performance of induction motors and transformers
- Perform energy audit in an Industry

REFERENCES:

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2. Hamies, Energy Auditing and Conservation; Methods Measurements, Management and Case study, Hemisphere, Washington, 1980
3. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997
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5. Handbook on Energy Efficiency, TERI, New Delhi, 2001

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19UPESC2C08 ENERGY EFFICIENT BUILDINGS DESIGN

OBJECTIVES

- To learn the green buildings concepts applicable to alternate design
- To be familiar with basic terminologies related to buildings
- To learn the building (air) conditioning techniques
- To know the methods to evaluate the performance of buildings
- To incorporate Renewable energy systems in buildings

UNIT I INTRODUCTION

Conventional versus Energy Efficient buildings – Historical perspective - Water – Energy – IAQ requirement analysis – Future building design aspects – Criticality of resources and needs of modern living

UNIT II LANDSCAPE AND BUILDING ENVELOPES

Energy efficient Landscape design - Micro-climates – various methods – Shading, water bodies-Building envelope: Building materials, Envelope heat loss and heat gain and its evaluation, paints,Insulation, Design methods and tools.

UNIT III HEATING, VENTILATION AND AIR-CONDITIONING

Natural Ventilation, Passive cooling and heating - Application of wind, water and earth for cooling, evaporative cooling, radiant cooling – Hybrid Methods – Energy Conservation measures, Thermal Storage integration in buildings

UNIT IV HEAT TRANSMISSION IN BUILDINGS

Surface co-efficient: air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; Solar temperature; Decrement factor; Phase lag. Design of daylighting; Estimation of building loads: Steady state method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance.

UNIT V PASSIVE COOLING & RENEWABLE ENERGY IN BUILDINGS

Passive cooling concepts: Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth air-tunnel. Introduction of renewable sources in buildings, Solar water heating, small wind turbines, stand-alone PV systems, Hybrid system – Economics.

OUTCOMES

Upon completion of this course, the students will able to

- Will be familiar with climate responsive building design and basic concepts
- Will Know the basic terminologies related to buildings
- Will Know the passive (air) conditioning techniques
- Will be able to evaluate the performance of buildings
- Gets acquainted with Renewable energy systems in buildings

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3. Krieder, J and Rabi, A., Heating and Cooling of buildings : Design for Efficiency, McGraw Hill, 1994.
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19UPESC2C09 POWER GENERATION, TRANSMISSION AND DISTRIBUTION

OBJECTIVES

- To impart knowledge on Conventional Power Plants (Steam, Hydro, Nuclear and
- Gas Turbine plants)
- To impart knowledge on Non - Conventional Power Plants (Renewable Energy Power generation)
- To understand various components and factors affecting power transmission
- To impart knowledge on major electrical energy components
- To understand the Economics of Power generation and Utilization of Electrical
- Energy for Various applications.

UNIT I CONVENTIONAL POWER GENERATION

Steam power plant - Selection of site - Generated Layout - coal and Ash Handling -Steam Generating Plants - Feed Make Circuit - Cooling Towers - Turbine Governing -Hydro Power Plant-Selection of Site - Classification Layout Governing of Turbines -Nuclear Power Plants - Selection of Site - Classification Layout Governing of Turbines - Nuclear Power Plants - Gas Turbine Plants.

UNIT II NON CONVENTIONAL POWER GENERATION

Wind power generation - characteristics of wind power-design of windmills - Tidal power generation - Single and two-basin systems -Turbines for tidal power - Solar power generation - Energy from biomass, biogas and waste

UNIT III ELECTRICAL POWER TRANSMISSION

Online diagram of transmission - substation and distribution systems - comparison of systems (DC and AC) - EHVAC and HVDC transmission - layout of substations and bus bar arrangements - Equivalents circuit of short, medium and long lines -Transmission efficiency-regulation-reactive power - compensation-transmission - loss minimization

UNIT IV UTILISATION OF ELECTRICAL ENERGY

Selection of Electrical Drives - Electrical characteristics and mechanical considerations -size, rating and cost, Transformer characteristics – illumination - laws of illumination-polar curve –incandescent - fluorescent and vapour lamps - Design of OLTC lighting Scheme of industry-electrical welding - energy efficient aspects of devices

UNIT V ECONOMICS OF POWER GENERATION & TRANSMISSION

Daily load curves - load factor - diversity factor - load deviation curve - load management - number and size of generating unit, distribution losses, cost of electrical energy – tariff - power factor improvement

OUTCOMES

Upon completion of this course, the students will able to

- The Operation of Conventional Power Plants (Steam, Hydro, Nuclear and Gas Turbine plants) and concepts of Renewable Energy Power generation.
- The Operation of Non - Conventional Power Plants (Renewable Energy Power generation)
- Explain about the functioning of major electrical energy component
- Explain about power transmission and various factors involved affecting it
- The Economics of Power generation and Utilization of Electrical Energy for Various applications.

REFERENCES

1. S.N.Singh, Electrical Power generation, Transmission and Distribution 2nd Edition, PHI Learning Private Limited, 2010
2. C.L.Wadhwa, Generation Distribution and utilization of Electrical Energy, New Age International, 2012
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19UPESC2C10 ANALYSIS AND SIMULATION LABORATORY

OBJECTIVES

- To provide a platform to learn and get familiar with computational analysis
- To learn the simulation and analysis software for solving of flow with heat transfer related problems

1. Heat exchanger analysis – NTU method
2. Heat exchanger analysis – LMTD method
3. Convection heat transfer analysis – Velocity boundary layer
4. Convection heat transfer analysis – Internal flow
5. Radiation heat transfer analysis – Emissivity
6. Lumped heat transfer analysis
7. Conduction heat transfer analysis

OUTCOMES

Upon completion of this course, the students will be able to:

- Use modern engineering software tools to analyze the flow with heat transfer related problems
- Analyse the various parameters influencing the performance of thermodynamic systems

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19UPESC2C11 ADVANCED POWER PLANT ENGINEERING

OBJECTIVES

- Understand the thermodynamics associated with power plants
- Detail on the role of various utilities in coal based thermal power plants
- Acquire know-how on the working of gas turbine and diesel power plants
- Appreciate the concept of Polygeneration for total energy recovery from a system
- Brief on the working of hydroelectric and nuclear power plants

UNIT I INTRODUCTION

Overview of Indian power sector – load curves for various applications – types of power plants – merits and demerits – criteria for comparison and selection - Economics of power plants.

UNIT II STEAM POWER PLANTS

Basics of typical power plant utilities - Boilers, Nozzles, Turbines, Condensers, Cooling Towers, Water Treatment and Piping system - Rankine Cycle – thermodynamic analysis. Cycle improvements – Superheat, Reheat, Regeneration

UNIT III DIESEL AND GAS TURBINE POWER PLANTS

I.C Engine Cycles - Otto, Diesel & Dual –Theoretical vis-à-vis actual – Typical diesel power plant – Types – Components - Layout - Performance analysis and improvement – Combustionin CI engines - E.C cycles – Gas turbine & Stirling - Gas turbine cycles – thermodynamic analysis – cycle improvements - Intercoolers, Re heaters, regenerators.

UNIT IV ADVANCED POWER CYCLES

Cogeneration systems – topping & bottoming cycles - Performance indices of cogeneration systems – Heat to power ratio - Thermodynamic performance of steam turbine cogeneration systems – gas turbine cogeneration systems – reciprocating IC engines cogeneration systems- Binary Cycle - Combined cycle – IGCC – AFBC / PFBC cycles – Thermionic steam power plant. MHD – Open cycle and closed cycle- Hybrid MHD & steam power plants

UNIT V HYDROELECTRIC & NUCLEAR POWER PLANTS

Hydroelectric Power plants – classifications - essential elements – pumped storage systems – micro and mini hydel power plants General aspects of Nuclear Engineering – Components of nuclear power plants - Nuclear reactors & types – PWR, BWR, CANDU, Gas Cooled, Liquid Metal Cooled and Breeder reactor - nuclear safety – Environmental issue

OUTCOMES

Upon completion of this course, the students will be able to:

- Suggest appropriate power generation technologies for mitigating the energy gap
- Compute the steam rate, heat rate and cost for generating electricity from coal based thermal power plants
- Analyse and suggest measures for improving the performance of gas turbine and diesel power plants
- Assess the applicability and performance of a cogeneration system
- Identify a suitable type of hydroelectric/nuclear power plant commensurate with the prevailing conditions

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19UPESC2C12 ADVANCED ENERGY STORAGE TECHNOLOGIES

OBJECTIVES

- To understand the various types of energy storage technologies and its applications.
- To study the various modelling techniques of energy storage systems using TRNSYS.
- To learn the concepts and types of batteries.
- To make the students to get understand the concepts of Hydrogen and Biogas storage.
- To provide the insights on Flywheel and compressed energy storage systems.

UNIT I INTRODUCTION

Necessity of energy storage – types of energy storage – comparison of energy storage technologies – Applications

UNIT II THERMAL STORAGE SYSTEM

Thermal storage – Types – Modelling of thermal storage units – Simple water and rock bed storage system – pressurized water storage system – Modelling of phase change storage system – Simple units, packed bed storage units - Modelling using porous medium approach, Use of TRNSYS

UNIT III ELECTRICAL ENERGY STORAGE SYSTEM

Fundamental concept of batteries – measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide and modern batteries for example (i) zinc-Air (ii) Nickel Hydride, (iii) Lithium Battery

UNIT IV HYDROGEN AND BIOGAS STORAGE

Hydrogen storage options – compressed gas – liquid hydrogen – Metal Hydrides, chemical Storage, Biogas storage - comparisons.Safety and management of hydrogen and Biogas storage - Applications.

UNIT V ALTERNATE ENERGY STORAGE TECHNOLOGIES

Flywheel , Super capacitors, Principles & Methods – Applications, Compressed air Energy storage, Concept of Hybrid Storage – Applications

OUTCOMES

Upon completion of this course, the students will be able to

- Identify the energy storage technologies for suitable applications.
- Analyze the energy storage systems using TRNSYS.
- Recognize the concepts and types of batteries.
- Diagnose the principle operations of Hydrogen and Biogas storage.
- Analyze the concepts of Flywheel and compressed energy storage systems

REFERENCES

1. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, JohnWiley& Sons 2002
2. S.Kalaiselvam and R.Parameshwaran., "Thermal Energy Storage Technologies for Sustainability system Dsesign, assessment and Applications",Elsevier publications (2014)
3. Energy Storage for Sustainable microgrid- David Wenzhong Gao., Elsevier publication (2015).
4. Fuel cell systems Explained, James Larminie and Andrew Dicks, Wiley publications, 2003.
5. Ibrahim, Hussein, Adrian Ilinca, and Jean Perron. "Energy storage systems—Characteristics and comparisons." Renewable and sustainable energy reviews 12, no. 5 (2008): 1221-1250.
6. Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliang sun, Wiley publications, 2012

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19UPESC2C13 **INTERNSHIP**

The students may undergo internship training at Research organization / University/ industry for a period as specified in the curriculum during summer vacation. In this case the training has to be undergone continuously for the entire period.

Duration of Internship	Credits
2 Weeks to 4 weeks	2

At the end of internship, the student shall submit a report. The Viva-Voce Examination will be conducted by a three member committee constituted by the Head of the Department. The committee comprises of one expert from an industry/organisation and two members (co-ordinator and supervisor) from the Department. Certificates (issued by the Organization) submitted by the student shall be attached to the mark list and sent to Controller of Examinations by the Head of the Department.

INTERNSHIP TRAINING

EVALUATION

Report	Presentation	Viva Voce	Total
40	30	30	100

19UPESC2C14 **PROJECT WORK PHASE I**

OBJECTIVES

- A research project topic may be selected either from published lists or from the creative ideas of the students themselves in consultation with their project supervisor.

EVALUATION

Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Periyar University

OUTCOME

- The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated in their project work phase – II.

19UPESC2C15 **PROJECT WORK PHASE II**

OBJECTIVES

- The objective of the research project work is to produce factual results of their applied research idea in the thermal Engineering, from phase – I.

EVALUATION

- Project work evaluation is based on Regulations of Credit system University Departments - Post graduate programmes of Periyar University

OUTCOME

- The students' would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated project outcome of the aimed work.

19UPESC2E01 **SOLAR ENERGY TECHNOLOGIES**

OBJECTIVES

- To learn and study the solar radiation and various solar collectors
- To study the various solar thermal energy technologies and their applications
- To learn about various solar PV cell materials and conversion techniques
- To learn various Solar SPV systems designs and their applications
- To know about various solar passive building techniques for cooling and heating applications

UNIT I SOLAR RADIATION AND COLLECTORS

Solar angles – Sun path diagrams – Radiation - extra-terrestrial characteristics - measurement and estimation on horizontal and tilted surfaces - flat plate collector thermal analysis - testing methods- evacuated tubular collectors - concentrator collectors – classification - design and performance parameters - tracking systems - compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors

UNIT II SOLAR THERMAL TECHNOLOGIES

Principle of working, types, design and operation of - Solar heating and cooling systems - Thermal Energy storage systems – Solar Desalination – Solar cooker : domestic, community – Solar pond – Solar drying

UNIT III SOLAR PV FUNDAMENTALS

Semiconductor – properties - energy levels - basic equations of semiconductor devices physics. Solar cells - p-n junction: homo and hetro junctions - metal-semiconductor interface - dark and illumination characteristics - figure of merits of solar cell - efficiency limits - variation of efficiency with band-gap and temperature - efficiency measurements - high efficiency cells – Solar thermo-photovoltaics.

UNIT IV SPV SYSTEM DESIGN AND APPLICATIONS

Solar cell array system analysis and performance prediction- Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - voltage regulation - maximum tracking - centralized and decentralized SPV systems - stand-alone - hybrid and grid connected system - System installation - operation and maintenances - field experience - PV market analysis and economics of SPV systems

UNIT V SOLAR PASSIVE ARCHITECTURE

Thermal comfort - bioclimatic classification – passive heating concepts: direct heat gain – indirectheat gain - isolated gain and sunspaces - passive cooling concepts: evaporative cooling - Radiative cooling - application of wind, water and earth for cooling; shading - paints and cavity walls for cooling - roof radiation traps - earth air-tunnel. – energy efficient landscape design - thermal comfort

OUTCOMES

Upon completion of this course, the students will be able to:

- Learn and study the solar radiation and various solar collectors
- Know the various solar thermal energy technologies and their applications
- Aware about various solar PV cell materials and conversion techniques
- Learn various Solar SPV systems designs and their applications
- Know about various solar passive building techniques for cooling and heating applications

REFERENCES

1. Goswami, D.Y., Kreider, J. F. and & Francis., Principles of Solar Engineering, Taylor and Francis, 2000
2. Chetan Singh Solanki, Solar Photovoltatics – Fundamentals, Technologies and Applications, PHI Learning Private limited 2011
3. Sukhatme S P, J K Nayak, Solar Energy – Principle of Thermal Storage and collection, Tata McGraw Hill, 2008.
4. Solar Energy International, Photovoltaic – Design and Installation Manual – New Society Publishers, 2006
5. Roger Messenger and Jerry Vnetre, Photovoltaic Systems Engineering, CRC Press, 2010.

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4	H	H	M	-	-	M	H	M	-	-	-	H	L	-	M
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19UPESC2E02 DESIGN OF HEAT EXCHANGERS

OBJECTIVES

- To make students familiarize with the various types of heat exchangers
- To explain the importance of thermal and stress analysis of heat exchangers
- To inculcate the thermal design aspects of tubular heat exchangers
- To provide the details of design aspects of compact heat exchangers
- To explain the function and design aspects of condensers and cooling towers

UNIT I FUNDAMENTALS OF HEAT EXCHANGER

Temperature distribution and its implications types – shell and tube heat exchangers – regenerators and recuperators – analysis of heat exchangers – LMTD and effectiveness method

UNIT II FLOW AND STRESS ANALYSIS

Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses - types of failures.

UNIT III DESIGN ASPECTS

Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe - finned tube - shell and tube heat exchangers - simulation of heat exchangers.

UNITIV COMPACT AND PLATE HEAT EXCHANGERS

Types–merits and demerits – design of compact heat exchangers – plate heat Exchangers, Performance influencing parameters – limitations.

UNIT V CONDENSERS AND COOLING TOWERS

Design of surface and evaporative condensers – cooling tower – performance Characteristics.

OUTCOMES

Upon completion of this course, the students will be able to

1. Know the types and applications of various types of heat exchangers
2. Understand the significance of stress analysis of heat exchangers
3. Understand the design of tubular heat exchangers for various applications
4. Recognize the design of compact heat exchangers for industrial requirements
5. Know the performance calculation of condensers and cooling towers

REFERENCES

1. Arthur. P Frass, Heat Exchanger Design, John Wiley & Sons, 1988.
2. SadikKakac and Hongtan Liu, Heat Exchangers Selection, Rating and Thermal Design, CRC Press, 2002
3. Taborek.T, Hewitt.G.F and Afgan.N, Heat Exchangers, Theory and Practice, McGraw Hill Book Co. 1980.
4. Hewitt.G.F, Shires.G.L and Bott.T.R, Process Heat Transfer, CRC Press, 1994.

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19UPESC2E03 **POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS**

OBJECTIVES

- To impart knowledge on conversion techniques and renewable energy technologies.
- To study the mechanisms of machines for the conversion of renewable energy sources.
- To learn the power converters and its applications in renewable energy systems.
- To understand the different conversion mechanisms of wind and solar systems.
- To understand the various hybrid systems of renewable energy conversion techniques.

UNIT I INTRODUCTION

Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment (cost-GHG Emission) - Qualitative study of different renewable energy resources: Solar, wind, ocean, Biomass, Fuel cell, Hydrogen energy systems and hybrid renewable energy systems

UNIT IIELECTRICAL MACHINES FOR RENEWABLE ENERGY CONVERSION

Review of reference theory fundamentals-principle of operation and analysis: IG, PMSG, SCIG and DFIG

UNIT III POWER CONVERTERS

Solar: Block diagram of solar photo voltaic system -Principle of operation: line commutated converters (inversion-mode) - Boost and buck-boost converters- selection Of inverter, battery sizing, array sizing Wind: three phase AC voltage controllers- AC-DC-AC converters:uncontrolled rectifiers, PWM Inverters, Grid Interactive Inverters-matrix converters. Power Quality Measurements.

UNIT IV ANALYSIS OF WIND AND PV SYSTEMS

Stand-alone operation of fixed and variable speed wind energy conversion systems and solar system- Grid connection Issues -Grid integrated PMSG and SCIG Based WECS Grid Integrated solar system

UNIT V HYBRID RENEWABLE ENERGY SYSTEMS

Need for Hybrid Systems- Range and type of Hybrid systems- Case studies of Wind-PV Maximum Power Point Tracking (MPPT).

OUTCOMES

Upon completion of this course, the students will be able to

- Analyze the various conversion techniques in renewable energy technologies.
- Apply the various mechanisms for the conversion of renewable energy sources.
- Identify the appropriate power converters for renewable energy systems.
- Implement the different conversion mechanisms for wind and solar systems.
- Recognize the importance of various hybrid renewable energy systems.

REFERENCES

1. 1.Rashid .M. H "power electronics Hand book", Academic press, 2007.
2. Leon Freris, David Infield, "Renewable energy in power systems", John Wiley & Sons, 2008.
3. Rai. G.D, "Non-conventional energy sources", Khanna publishes, 2010.
4. Ali Keyhani, Design of Smart Power Grid Renewable Energy Systems, John Wiley & Sons, 2011.
5. Wind Electric Systems: S.N. Bhadra, D. Kastha, OXFORD university press, 2005.

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5	L	L	L	L	-	L	L	-	-	-	-	-	L	M	L

19UPESC2E04 **WIND ENERGY SYSTEMS**

OBJECTIVES

- To understand the fundamentals of wind energy and its conversion system
- To impart knowledge on airfoil design and braking system
- To learn gear coupled generator wind turbine components
- To brief on the working of different generators and power conditioning system used in grid tied wind systems
- To impart knowledge on modern wind turbine control & monitoring

UNIT I WIND ENERGY FUNDAMENTALS & WIND MEASUREMENTS

Wind Energy Basics, Wind Speeds and scales, Terrain, Roughness, Wind Mechanics, Power Content, Class of wind turbines, Atmospheric Boundary Layers, Turbulence. Instrumentation for wind measurements, Wind data analysis, tabulation, Wind resource estimation, Betz's Limit, Turbulence Analysis

UNIT II AERODYNAMICS THEORY & WIND TURBINE TYPES

Airfoil terminology, Blade element theory, Blade design, Rotor performance and dynamics, Balancing technique (Rotor & Blade), Types of loads; Sources of loads Vertical Axis Type,Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control , Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator

UNIT III GEAR COUPLED GENERATOR WIND TURBINE COMPONENTSAND THEIR CONSTRUCTION

Electronics Sensors /Encoder /Resolvers, Wind Measurement : Anemometer & Wind Vane, Grid Synchronisation System, Soft Starter, Switchgear [ACB/VCB], Transformer, Cables and assembly, Compensation Panel, Programmable Logic Control, UPS, Yaw & Pitch System : AC Drives, Safety Chain Circuits, Generator Rotor Resistor controller (Flexi Slip), Differential Protection Relay for Generator, Battery/Super Capacitor Charger & Batteries/ Super Capacitor for Pitch System, Transient Suppressor / Lightning Arrestors, Oscillation & Vibration sensing

UNIT IV DIRECT ROTOR COUPLED GENERATOR (MULTIPOLE) [VARIABLE SPEED VARIABLE FREQ.]

Excited Rotor Synch.Generator / PMG Generator, Control Rectifier, Capacitor Banks, Step Up / Boost Converter (DC-DC Step Up), Grid Tied Inverter, Power Management, Grid Monitoring Unit (Voltage and Current), Transformer, Safety Chain Circuits

UNIT V MODERN WIND TURBINE CONTROL & MONITORING SYSTEM

Details of Pitch System & Control Algorithms, Protections used & Safety Consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases: Remote Monitoring and Generation Reports, Operation & Maintenance for Product Life Cycle, Balancing technique (Rotor & Blade), FACTS control & LVRT & New trends for new Grid Codes.

OUTCOMES

Upon completion of this course, the students will be able to

- Analyse the energy in conversion techniques of wind energy
- Analyse the performance of wind turbine aerodynamics and breaking system
- Explain about various gear coupled generators with its construction
- Explain about different types of generators and power condition used in wind systems
- Analyse the concept of modern wind turbine control & monitoring

REFERENCES

1. Freris, L.L., Wind Energy Conversion Systems, Prentice Hall, 1990
2. Kaldellis J.K, Stand – alone and Hybrid Wind Energy Systems, CRC Press, 2010
3. Mario Garcia –Sanz, Constantine H. Houpis, Wind Energy Systems, CRC Press 2012
4. Spera, D.A., Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press, 1994.
5. Duffie, A and Beckmann, W. A., Solar Engineering of Thermal Processes, John Wiley, 1991.
6. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press,
7. C-Wet : Wind Energy Resources Survey in India.
8. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., 1983
9. John D Sorensen and Jens N Sorensen, Wind Energy Systems, Woodhead Publishing Ltd, 2011

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19UPESC2E05 **COMPUTATIONAL FLUID DYNAMICS**

OBJECTIVES

- To make students familiarize with the computational analysis
- To explain the numerical analysis of solving of steady and unsteady diffusion heat transfer
- To explain the numerical analysis of solving of convection-diffusion heat transfer
- To provide the details of discretisation of incompressible flow governing equations
- To impart the knowledge of turbulence modelling

UNIT I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretisation techniques using finite difference methods – Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT II DIFFUSION PROCESSES : FINITE VOLUME METHOD

Steady one-dimensional diffusion, Two and three dimensional steady state diffusion problems, Discretisation of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes,Stability of schemes.

UNIT IIICONVECTION - DIFFUSION PROCESSES : FINITE VOLUME METHOD

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

UNIT IV FLOW PROCESSES : FINITE VOLUME METHOD

Discretisation of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms

UNIT V MODELLING OF COMBUSTION AND TURBULENCE

Mechanisms of combustion and Chemical Kinetics, Overall reactions and intermediate reactions, Reaction rate, Governing equations for combusting flows. Simple Chemical Reacting System (SCRS), Turbulence - Algebraic Models, One equation model & k – ε, k – ω models - Standard and High and Low Reynolds number models.

OUTCOMES

Upon completion of this course, the students will be able to

- Know the differences between various discretisation techniques.
- Learn the finite volume based numerical method for solving diffusion heat transfer problems.
- Learn the finite volume based numerical method for solving convection-diffusion heat transfer problems.
- Understand the discretisation of incompressible flow governing equations
- Recognize the impact of various turbulence modelling

REFERENCES:

1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2. Ghoshdastidar, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw Hill Publishing Company Limited, New Delhi, 1998.
3. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
4. Subas and V. Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation,1980.
5. JiyuanTu, Guan HengYeoh, Chaogun Liu, "Computational Fluid Dynamics A Practical Approach" Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
6. John D. Anderson . JR. "Computational Fluid Dynamics The Basics with Applications" McGraw Hill International Editions, 1995.

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19UPESC2E06 **FLUIDIZED BED SYSTEMS**

OBJECTIVES

- To understand the behavior of fluidized beds
- To learn about the heat transfer process
- To differentiate the combustion and gasification, and appreciate the relative merits
- To design components of fluidized bed systems
- To understand the industrial applications of fluidized bed systems

UNIT I FLUIDIZED BED BEHAVIOUR

Characterization of bed particles - comparison of different methods of gas - solid contacts. Fluidization phenomena - regimes of fluidization – bed pressure drop curve. Two phase and well-mixed theory of fluidization. Particle entrainment and elutriation – unique features of circulating fluidized beds

UNIT II HEAT TRANSFER

Different modes of heat transfer in fluidized bed – bed to wall heat transfer – gas to solid heat transfer – radiant heat transfer – heat transfer to immersed surfaces. Methods for improvement – external heat exchangers – heat transfer and part load operations

UNIT III COMBUSTION AND GASIFICATION

Fluidized bed combustion and gasification – stages of combustion of particles – performance - start- up methods. Pressurized fluidized beds

UNIT IV DESIGN CONSIDERATIONS

Design of distributors – stoichiometric calculations – heat and mass balance – furnace design – design of heating surfaces – gas solid separators.

UNIT V INDUSTRIAL APPLICATIONS

Physical operations like transportation, mixing of fine powders, heat exchange, coating, drying and sizing. Cracking and reforming of hydrocarbons, carbonization, combustion and gasification. Sulphur retention and oxides of nitrogen emission Control.

OUTCOMES

Upon completion of this course, the students will be able to:

- Calculate the behavior of fluidized beds
- Analyze the heat transfer process in fluidized beds
- Apply concepts of combustion and gasification in fluidized beds
- Design fluidized beds for given applications
- Apply fluidized bed systems for various industrial applications

REFERENCES

1. Kunii, D and Levespiel, O., Fluidization Engineering, John Wiley and Son Inc, New York,1969.
2. Howard,J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, NewYork, 1983.
3. Geldart, D., Gas Fluidization Technology, John Willey and Sons, 1986.
4. Howard, J.R. (Ed), Fluidized Beds: Combustion and Applications, Applied Science Publishers, New York, 1983.
5. Botteril, J.S.M., Fluid Bed Heat Transfer, Academic Press, London, 1975.

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19UPESC2E07 **BIO ENERGY TECHNOLOGIES**

OBJECTIVES

- To detail on the types of biomass, its surplus availability and characteristics.
- To create awareness on the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.
- To impart knowledge on stoichiometry and combustion of bio fuels
- To elucidate on the influence of equivalence ratio on thermochemical conversion of biomass
- To provide insight to the possibilities of producing liquid fuels form biomass

UNIT I INTRODUCTION

Biomass: types – advantages and drawbacks – Indian scenario – characteristics – carbon neutrality – conversion mechanisms – fuel assessment studies – densification technologies – Comparison with coal – Proximate & Ultimate Analysis - Thermo Gravimetric Analysis – Differential Thermal Analysis – Differential Scanning Calorimetry

UNIT II BIOMETHANATION

Microbial systems – phases in biogas production – parameters affecting gas production – effect of additives on biogas yield – possible feed stocks. Biogas plants – types – design – constructional details and comparison – biogas appliances – burner, luminaries and power generation – effect on engine performance.

UNIT III COMBUSTION

Perfect, complete and incomplete combustion - stoichiometric air requirement for biofuels - equivalence ratio – fixed Bed and fluid Bed combustion – fuel and ash handling system s – steam cost comparison with conventional fuels

UNIT IV GASIFICATION, PYROLYSIS AND CARBONISATION

Chemistry of gasification - types – comparison – application – performance evaluation – economics – dual fuelling in IC engines – 100 % Gas Engines – engine characteristics on gas mode – gas cooling and cleaning systems - Pyrolysis - Classification - process governing parameters – Typical yield rates. Carbonization Techniques – merits of carbonized fuels

UNIT V LIQUIFIED BIOFUELS

History of usage of Straight Vegetable Oil (SVO) as fuel - Biodiesel production from oil seeds, waste oils and algae - Process and chemistry - Biodiesel health effects / emissions / performance. Production of alcoholic fuels (methanol and ethanol) from biomass – engine modifications

OUTCOMES

Upon completion of this course, the students will be able to:

- Estimate the surplus biomass availability of any given area
- Design a biogas plant for a variety of biofuels
- Determine and compare the cost of steam generation from biofuels with that of coal and petroleum fuels
- Analyse the influence of process governing parameters in thermochemical conversion of biomass
- Synthesize liquid biofuels for power generation from biomass

REFERENCES

1. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981
2. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester, 1984.
3. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986
4. Mahaeswari, R.C. Bio Energy for Rural Energisation, Concepts Publication,1997
5. Best Practises Manual for Biomass Briquetting, I R E D A, 1997
6. Eriksson S. and M. Prior, The briquetting of Agricultural wastes for fuel, FAO Energy and Environment paper, 1990
7. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S

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19UPESC2E08 **HYDROGEN AND FUEL CELL**

OBJECTIVES

- To study the basic production techniques of Hydrogen.
- To understand the concepts of various storage methods of Hydrogen.
- To study the thermodynamics and kinetics of fuel cell process.
- To understand the classifications, construction and working of fuel cells.
- To provide insights into fuel cell applications and its economics.

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES

Hydrogen – physical and chemical properties, salient characteristics. Production of hydrogen – steam reforming – water electrolysis – gasification and woody biomass conversion – biological hydrogen production – photo dissociation – direct thermal or catalytic splitting of water

UNIT II HYDROGEN STORAGE AND APPLICATIONS

Hydrogen storage options – compressed gas – liquid hydrogen – Metal Hydrides – chemical Storage – comparisons. Safety and management of hydrogen.Applications of Hydrogen.

UNIT III FUEL CELLS

History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery vs fuel cell

UNIT IV FUEL CELL – TYPES

Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits. Selection and use of Materials.

UNIT V APPLICATION OF FUEL CELL AND ECONOMICS

Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells

OUTCOMES

Upon completion of this course, the students will be able to

- Analyze the techniques of Hydrogen generation.
- Apply the various options for Hydrogen storage.
- Recognize the principle operations of fuel cell, types, its thermodynamics and kinetics.
- Comprehend the different types of fuel cells.
- Apply the fuel cells for domestic, automotive, space craft power generations and evaluate the techno-economics of a fuel cells.

REFERENCES

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19UPESC2E09 INSTRUMENTATION FOR THERMAL SYSTEMS

OBJECTIVES

- To understand the working of measuring instruments and errors associated with them
- To carry out error analysis and uncertainty of measurements
- To develop skills on the measurement and control applicable to a thermal systems
- To understand the measurement of fuel properties and pollutants
- To get a knowledge on design of measurement and control system.

UNIT I MEASUREMENT CHARACTERISTICS

Introduction to measurements, Errors in measurements, Statistical analysis of data, Regression analysis, correlation, estimation of uncertainty and presentation of data, design of experiments – Experimental design factors and protocols

UNIT II MEASUREMENTS IN THERMAL SYSTEMS

Basic Electrical measurements, Transducers and its types, Signal conditioning and processing - Measurement of temperature, pressure, velocity, flow – basic and advanced techniques, and radiation properties of surfaces

UNIT III MESAURMENT OF FUEL PROPERTIES AND POLLUTANTS

Thermo / Physical / Chemical and transport properties of solids, liquids and gaseous fuels, Analysers – Flame Ionisation Detector, Non-Dispersive Infrared Analyser, Chemiluminescent detector, Smoke meters, and Gas chromatography

UNIT IV CONTROL SYSTEMS, COMPONENTS AND CONTROLLERS

Introduction, Open and closed loop control systems, Transfer function. Types of feedback and feedback control system characteristics – Control system parameters – DC and AC servomotors, servo amplifier, potentiometer, synchro transmitters, synchro receivers, synchro control transformer, stepper motors - Continuous, Discontinuous and Composite control modes – Analog and Digital controllers

UNIT V DESIGN OF MEASUREMENT AND CONTROL SYSTEMS

Data logging and acquisition - Sensors for error reduction, elements of computer interfacing, Timers, and Counters, Designing of measurement and control systems for specific applications -Fault finding – Computer based controls

OUTCOMES

On successful completion of this course the student will be able to

- Familiar in handling the measuring devices.
- Calibrate the measurement devices
- Plan their experiments and understand the suitability, accuracy and uncertainty associated with the instrument used for measuring thermal system parameters**.**
- Measure the various fuel properties and exhaust emission characteristics
- Design a new measurement and control system.

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19UPESC2E10 WASTE MANAGEMENT AND ENERGY RECOVERY TECHNIQUES

OBJECTIVES

- To provide information on various methods of waste management
- To familiarize students with recent energy generation techniques
- To detail on the recent technologies of waste disposal
- To know about the disposal of hazardous wastes.
- To make student realize on the importance of healthy environment

UNIT I CHARACTERISTICS AND PERSPECTIVES

Sources – Types – Composition – Generation – Estimation Techniques – Characterization – Types of Collection System – Transfer Stations – Transfer Operations – Material Recycle / Recovery Facilities

UNIT II UNIT OPERATIONS & TRANSFORMATION TECHNOLOGIES

Separation &Processing : Size Reduction – Separation through Density Variation, Magnetic / Electric Field : Densification - Physical, Chemical and Biological Properties and Transformation Technologies – Selection of Proper Mix of Technologies

UNIT III WASTE DISPOSAL

Landfill Classification – Types – Siting Considerations – Landfill Gas (Generation, Extraction, Gas Usage Techniques) – Leachates Formation, Movement, Control Techniques – Environmental Quality Monitoring – Layout, Closure & Post Closure Operation – Reclamation

UNIT IV TRANSFORMATION TECHNOLOGIES AND VALUE ADDITION

Physical Transformation: Component Separation & Volume Reduction: Chemical Transformation
– Combustion / Gasification / Pyrolysis: Energy Recovery - Biological Transformation – Aerobic Composting – Anaerobic Digestion

UNIT V HAZARDOUS WASTE MANAGEMENT & WASTE RECYCLING

Definition – Sources – Classification – Incineration Technology - Incineration vs Combustion Technology – RDF / Mass Firing – Material Recycling : Paper / Glass / Plastics etc., - Disposal of White Goods & E-Wastes

OUTCOMES

Upon completion of this course, the students will be able to

- Waste characterization, Segregation, Disposal will be made known
- Technologies that are available for effective waste disposal along with pros / cons will become cleaner to students
- Able to convert waste into useful energy.
- First-hand information on present day waste related problems (Hazardous Waste, Pharma Waste, Biomedical Waste etc).
- Get awareness on the healthy environment.

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19UPESC2E11 ENERGY FORECASTING, MODELING AND PROJECT MANAGEMENT TECHNIQUE

OBJECTIVES

- To understand about National energy scenario.
- To predict the energy demand using various forecasting models.
- To develop an optimization model for the effective utilisation of energy sources.
- To know the procedure to the write the project proposal.
- To know the energy policies in the country.

UNIT I ENERGY SCENARIO

Role of energy in economic development and social transformation: Energy & GDP,GNP and its dynamics - Energy Sources and Overall Energy demand and Availability - Energy Consumption in various sectors and its changing pattern - Status of Nuclear and Renewable Energy: Present Status and future promise

UNIT II FORECASTING MODEL

Forecasting Techniques - Regression Analysis - Double Moving Average - Double Experimental Smoothing - Triple Exponentia Smoothing – ARIMA model – Validation techniques – Qualitative forecasting – Delphi technique - Concept of Neural Net Works

UNIT III OPTIMIZATION MODEL

Principles of Optimization - Formulation of Objective Function - Constraints - Multi Objective Optimization – Mathematical Optimization Software – Development of Energy Optimization Model - Development of Scenarios – Sensitivity Analysis - Concept of Fuzzy Logic.

UNIT IV PROJECT MANAGEMENT

Project Preparation – Feasibility Study – Detailed Project Report - Project Appraisal – Social-cost benefit Analysis - Project Cost Estimation – Project Risk Analysis - Project Financing – Financial Evaluation.

UNIT V ENERGY POLICY

National & State Level Energy Issues - National & State Energy Policy - Energy Security - National solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)

OUTCOMES

Upon completion of this course, the students will be able to

- Have knowledge in the National energy scenario.
- Do Energy prediction using various forecasting techniques.
- Develop optimization model for energy planning.
- Capable of writing project proposals.
- Understand the National and state energy policies.

REFERENCES

1. S. Makridakis, Forecasting Methods and applications. Wiley 1983
2. Austin H. Church, centrifugal pumps and blowers, John Wiley and sons, 1980.
3. Yang X.S. Introduction to mathematical optimization: From linear programming to Metaheuristics, Cambridge, Int. Science Publishing, 2008
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4	M	L	L	M	-	M	-	M	M	H	H	M	M	H	M
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19UPESC2E12 DESIGN AND ANALYSIS OF TURBOMACHINES

OBJECTIVES

- To understand the energy transfer process in turbo machines and to derive governing equations
- To understand the functional aspects and performance of turbo machines
- To learn about the components of combustion chamber and their functions
- To understand the working and performance of turbines
- To calculate the performance of gas turbines and jet engines

UNIT I INTRODUCTION

Basics of isentropic flow – static and stagnation properties – diffuser and nozzle configurations - area ratio – mass flow rate – critical properties. Energy transfer between fluid and rotor velocity triangles for a generalized turbo machines - velocity diagrams.Euler's equation for turbo machines and its different forms. Degree of reaction in turbo-machines – various efficiencies – isentropic, mechanical, thermal, overall and polytrophic

UNIT II CENTRIFUGAL AND AXIAL FLOW COMPRESSORS

Centrifugal compressor - configuration and working – slip factor - work input factor – ideal and actual work - pressure coefficient - pressure ratio. Axial flow compressor – geometry and working – velocity diagrams – ideal and actual work – stage pressure ratio - free vortex theory – performance curves and losses

UNIT III COMBUSTION CHAMBER

Basics of combustion.Structure and working of combustion chamber – combustion chamber arrangements - flame stability – fuel injection nozzles. Flame stabilization - cooling of combustion chamber.

UNIT IV AXIAL AND RADIAL FLOW TURBINES

Elementary theory of axial flow turbines - stage parameters- multi-staging - stage loading and flow coefficients. Degree of reaction - stage temperature and pressure ratios – single and twin spool arrangements – performance.Matching of components.Blade Cooling.Radial flow turbines.

UNIT V GAS TURBINE AND JET ENGINE CYCLES

Gas turbine cycle analysis – simple and actual.Reheated, Regenerative and Intercooled cycles for power plants. Working of Turbojet, Turbofan, Turboprop, Ramjet, Scramjet and Pulsejet Engines and cycle analysis – thrust, specific impulse, specific fuel consumption, thermal and propulsive efficiencies.

OUTCOMES

Upon completion of this course, the students will be able to

- Analyze the energy transfer process in thermodynamic systems
- Calculate the performance of centrifugal flow and axial flow combustion systems
- Design and analyze the combustion chamber for turbomachines
- Compute and analyze the performance of axial and radial flow turbines
- Predict the performance of gas turbines and thermodynamic energy systems

REFERENCES

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3. Cohen, H., Rogers, G F C and Saravanmotto, H I H, Gas Turbine Theory, John Wiley, 5th Edition 2001.
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5. Mattingly J D, Elements of Gas turbine Propulsion, McGraw Hill, 1st Edition. 1997

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19UPESC2C13 MODELLING AND ANALYSIS OF ENERGY SYSTEMS

OBJECTIVES

- To learn to apply mass and energy balances for the energy systems
- To learn the modeling and simulation techniques for energy systems.
- To learn the optimization techniques to optimize the energy system.
- To learn to use the energy-economy models.
- To understand the application of case studies.

UNIT I INTRODUCTION

Primary energy analysis - energy balance for closed and control volume systems - applications of energy analysis for selected energy system design - modelling overview - levels and steps in model development - Examples of models – curve fitting and regression analysis

UNIT II MODELLING AND SYSTEMS SIMULATION

Modelling of energy systems – heat exchanger - solar collectors – distillation -rectification turbo machinery components - refrigeration systems - information flow diagram - solution of set of non- linear algebraic equations - successive substitution - Newton Raphson method- examples of energy systems simulation

UNIT III OPTIMISATION TECHNIQUES

Objectives - constraints, problem formulation - unconstrained problems - necessary and sufficiency conditions. Constrained optimization - Lagrange multipliers, constrained variations, Linear Programming - Simplex tableau, pivoting, sensitivity analysis - New generation optimization techniques – Genetic algorithm and simulated annealing – examples.

UNIT IV ENERGY- ECONOMY MODELS

Multiplier Analysis - Energy and Environmental Input / Output Analysis - Energy Aggregation – Econometric Energy Demand Modelling - Overview of Econometric Methods - Dynamic programming - Search Techniques - Univariate / Multivariate

UNIT V APPLICATIONS AND CASE STUDIES

Case studies of optimization in Energy systems problems- Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis

OUTCOMES

Upon completion of this course, the students will be able to

- Apply mass and energy balances for the energy systems
- Do Simulation and Modeling of typical energy system
- Use the optimization techniques to optimize the energy system.
- Perform Energy-Economic Analysis for the typical applications
- Have knowledge in optimization of Energy systems problems

REFERENCES

1. Reddy, T. Agami. Applied data analysis and modeling for energy engineers and scientists. Springer Science & Business Media, 2011.
2. Bejan, A, Tsatsaronis, G and Moran, M., Thermal Design and Optimization, John Wiley & Sons 1996
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4. Huang, J. P., K. L. Poh, and B. W. Ang. "Decision analysis in energy and environmental modeling." *Energy* 20, no. 9 (1995): 843-855.
5. Yogesh Jaluria, Design and Optimization of Thermal Systems, CRC Press INC, 2008
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19UPESC2E14 **ELECTRICAL DRIVES AND CONTROLS**

OBJECTIVES

- To impart the knowledge on the principle of conventional motor drives, various starting and speed control methods of motors.
- To understand the concepts of various losses and harmonics effects in motors.
- To study the Power Electronics components and controllers.
- To provide insights of Superconductivity theory and super conducting magnetic energy storage.
- To understand the concept of Solid State motor controllers and their applications

UNIT I CONVENTIONAL MOTOR DRIVES

Characteristics of DC and AC motor for various applications - starting and speed control - methods of braking.

UNIT II PHYSICAL PHENOMENA IN ELECTRICAL MACHINES

Various losses in motors-Saturation and Eddy current effects - MMF harmonics and their influence of leakage-stray losses - vibration and noise.

UNIT III SOLID STATE POWER CONTROLLERS

Power devices: Triggering Circuits, Rectifiers – Single Phase and Three Phase with R, RLand Freewheeling Diode, Choppers - Type-A, Type-B, Type C and Type D, Inverters - Single Phase and Three Phase with R, RL and Freewheeling Diode, AC Voltage Controllers

UNIT IV SUPERCONDUCTIVITY

Principle of Super conductivity, Super conducting generators-motors and magnets - Super conducting magnetic energy storage (SMES).

UNIT V SOLID STATE MOTOR CONTROLLERS

Single and Three Phase fed DC motor drives - AC motor drives - Voltage Control - Rotor resistance control - Frequency control - Slip Power Recovery scheme

OUTCOMES

Upon completion of this course, the students will be able to

- Diagnose the operations of conventional motor drives, various starting and speed control methods of motors.
- Analyze the different losses and harmonic effects in motors.
- Recognize the Power electronics components and design the controllers.
- Apply the Superconductivity theory and analyze the super conducting magnetic energy storage.
- Analyse the concept of Solid State motor controllers and their applications

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3. Rene Husson, Modelling and Control of Electrical machines, Elsevier Science Ltd, 2009
4. D.Singh, K.B.Khanchandani, Power Electronics, Tata McGraw Hill Education Ltd, 2006
5. Austin Hughes, Electric Motor & Drives, Newnes, 2006.

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SUPPORTIVE COURSES

19UPESC2S01 BASIC CONCEPTS IN ENERGY SCIENCES

OBJECTIVES

- To get a knowledge about the energy sources
- To analyze the working principle, pros and cons of Conventional energy conversion techniques
- To know the impact of non-renewable energy systems on the environment.
- To know the importance and methods of conversion of bio based waste into useful form of energy.
- Direct energy conversion systems Need and necessity of energy storage systems and their desirable characteristics & Fuel cells

UNIT –I ENERGY SOURCES

Environment and sustainable development - Energy sources - sun as the source of energy – photosynthesis - classification of energy sources - fossil fuel reserves and resources - overview of global/ India's energy scenario.

UNIT- II SOLAR ENERGY

Solar radiation: measurements and prediction - Solar thermal energy conversions systems: flat plate collectors - solar concentrators and other applications - Solar Photovoltaic: Principle of photovoltaic conversion of solar energy.

UNIT – III WIND ENERGY

Wind Resource: Meteorology of wind, India's wind energy potential and challenges - distribution across the world - Eolian features - Biological indicators - Wind measurement systems - Wind Energy Conversion Systems.

UNIT- IV BIOENERGY

Biomass as energy resources - Classification and estimation of biomass - Source and characteristics of biofuels – Biodiesel – Bioethanol – Biogas - Waste to energy conversions.

UNIT- V GEOTHERMAL ENERGY

Introduction - Geothermal sources - advantages and disadvantages of geothermal energy over other energy forms - Geothermal energy in India: Prospects - Applications of Geothermal energy - Material selection for geothermal power plants

OUTCOMES

Upon completion of this course, the students will be able to

- Awareness on the energy status in India as well as globe and familiarised in the different form of energy sources and energy conversion techniques.
- Able to select the suitable energy source based on the working principle, pros and cons of energy conversion systems.
- The knowledge about importance of energy conservation and the impact of non-renewable energy sources.
- To understand the concept of conversion of bio based waste into useful form of energy.
- Awareness on the existence of various mechanisms for conversion and storage of energy, their merits, constraints and drawbacks

REFERENCES:

1. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
2. S.P. Sukhatme, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
3. Loulou, Richard, Waaub, Jean-Philippe; Zaccour, Georges, Energy and Environment Set: Mathematics of Decision Making, (Eds.), (2005), XVIII, 282 p. ISBN: 978-0-387-25351-0.
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19UPESC2S02 CLIMATE CHANGE AND CO_2 EMISSION ASSESSMENT

OBJECTIVES

- To study the global climate change
- To analysis emission assessment
- To familiarize about impact of climate changes on the environment.
- To know the carbon dioxide conversion and carbon footprint
- To understand the concept of carbon credit.

UNIT-I INTRODUCTION TO ENERGY

Introduction to Energy: Overview of energy sources and technologies - energy consumption Pattern - social and economic implications of energy uses - equity and disparity.

UNIT-II INTRODUCTION TO GLOBAL CLIMATE CHANGE

Introduction to global climate change: theory of global climate change - mechanism of Greenhouse Gases Emission - theory and proof of climate change impacts - global overview - International concern on Climate change and mitigation efforts.

UNIT-III CARBON DIOXIDE (CO_2) EMISSIONS AND CONVERSION/CONSUMPTION

Carbon dioxide (CO_2) emissions in relation to energy conversion/consumption: theory of CO_2 emission in relation to energy conversion processes.

UNIT- IV METHODOLOGY FOR CO_2 ASSESSMENT/CARBON FOOT PRINT

Methodology for CO_2 assessment/carbon foot print: estimation of emission from fossil fuel combustion (Fuels and their composition - fuel to energy conversion - concept of emission factor) - emission from major sectors (industry – transport – agriculture – domestic - service)

UNIT-V CARBON CREDIT

Carbon credit: Definition - concept and examples - Carbon credit - national policies *vis-à-vis* international market scenario - Current efforts and future prospect/limitation of carbon trading mechanism.

OUTCOMES

Upon completion of this course, the students will be able to

- Depth knowledge in global climate change and the impact of climate change on the living things.
- Able to analysis emission characteristics and its impact on the globe.
- Obtained elaborate knowledge about impact of climate changes on the environment.
- Knowledge on carbon dioxide conversion and carbon footprint
- Knowledge on concept of carbon credit and their importance.

REFERENCES:

1. Franchetti M. J. and Apul D. S., Carbon Footprint Analysis: concepts, methods, implementation and case studies, CRC Press, (2013).
2. Clean Development Mechanism, UNFCC Website; http://cdm.unfccc.int/
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4. Barrett S. Why Cooperate? The Incentive to Supply Global Public Goods. Oxford University Press, (2007).

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19UPESC2S03 ENERGY AND ENVIRONMENTAL IMPACTS

OBJECTIVES

- To teach the principal of energy and environmental issues
- To explore the environmental impact of various energy sources and also the effects of different types of pollutants.
- To know the solar energy and conversion technologies.
- To understand the biomass and geothermal energy systems and conversion techniques.
- To get an elaborate knowledge on pollution control methods.

UNIT-I ENERGY SOURCES

Present Energy resources in India and its sustainability - Different type of conventional Power Plant--Energy Demand Scenario in India-Advantage and Disadvantage of conventional Power Plants – Conventional vs Non-conventional power generation

UNIT-II SOLAR ENERGY

Basics of Solar Energy- Solar Thermal Energy- Solar Photovoltaic- Advantages and Disadvantages-Environmental impacts and safety.

UNIT-III BIOMASS AND GEO THERMAL ENERGY

Biomass resources-Biomass conversion Technologies- Feedstock preprocessing and treatment methods- Bioenergy program in India-Environmental benefits and impacts.Geothermal Energy resources –Ocean Thermal Energy Conversion – Tidal.

UNIT-IV POLLUTION CONTROL

Air pollution- Sources, effects, control, air quality standards, air pollution act, air pollution measurement. Water pollution-Sources and impacts, Soil pollution-Sources and impacts, disposal of solid waste.

UNIT-V ENVIRONMENTAL AFFECT FACTORS

Greenhouse gases – effect, acid rain. Noise pollution.Pollution aspects of various power plants. Fossil fuels and impacts, Industrial and transport emissions- impacts.

OUTCOMES

Upon completion of this course, the students will be able to

- Learned challenges and opportunities related to energy use and conversion. Learn how to evaluate the sustainability of energy systems.
- Able to analyse environmental impact of various energy sources and also the effects of different types of pollutants.
- Familiar knowledge on solar energy and conversion technologies.

- Good knowledge on biomass and geothermal energy systems and conversion techniques.
- Elaborate knowledge on pollution control methods.

REFERENCES:

1. B H Khan, 'Non Conventional Energy Resources'-The McGraw –Hill Second edition.
2. Boyle, G.. Renewable energy: Power for a sustainable future'. Oxford University press, (2004).

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19UPESC2S04 ERECTION AND MAINTENANCE OF REFRIGERATION AND AIR-CONDITIONING EQUIPMENT'S

OBJECTIVES

- To analyse the working principle, pros and cons of Conventional energy conversion techniques.
- To know about energy based testing measurement
- To know about energy based measurement & maintenance system
- To get good knowledge in R & AC systems.
- To get a knowledge in maintenance.

UNIT-I INTRODUCTION

Refrigeration and air-conditioning plant layout, parameters affecting the location.

UNIT-II ERECTION OF R&AC SYSTEMS

Erection methodology, foundation, padding, network analysis, critical path, interconnections; safety precautions, air handling equipment's.Maintenance procedures.

UNIT-III TESTING OF EQUIPMENTS

Testing of compressors, condensers, evaporators, cooling towers, motors, controls, test rings, ISI standards. Testing of control systems, circuitry and trouble shooting, condition monitoring

UNIT-IV TOTAL PREVENTIVE MAINTENANCE

TPM Principles, Corrective and preventive measures and Reliability analysis.

UNIT-V MAINTENANCE SCHEDULES

Studies on different maintenance schedules followed by various industries

OUTCOMES

Upon completion of this course, the students will be able to

- Awareness on the existence of various instrument objective and their merits, constraints and drawbacks
- Knowledge on various kinds of R & AC systems.
- Able to measure and design an appropriate AC system.
- Able to test the equipments.
- Good knowledge on maintenance.

REFERENCES:

1. Arora C.P., Refrigeration and Air conditioning II Ed. McGraw-Hill, Pub., (2000).
2. ASHRAE Hand book on Refrigeration & Air conditioning, Published by ISHRAE, Bangalore, (1998).

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3	-	-	L	L	M	M	H	M	-	-	M	M	M	L	L
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5	-	-	L	L	M	M	M	M	-	-	M	H	M	M	L

19UPESC2S05 GREEN CONCEPTS IN BUILDINGS

OBJECTIVES

- To understand and apply the concept of availability and to calculate the behavior of real gases
- To predict the condition of systems and analyze them by the criteria of equilibrium
- To know the building technologies
- To get a knowledge on use of solar energy in green buildings.
- To know the concept of green composites for buildings.

UNIT –I ENVIRONMENTAL IMPLICATIONS OF BUILDINGS

Environmental implications of buildings energy, carbon emissions, water use, waste disposal; Building materials: sources, methods of production and environmental Implications. Embodied Energy in Building Materials: Transporation Energy for Building Materials; Maintenance Energy for Buildings.

UNIT- II IMPLICATIONS OF BUILDING TECHNOLOGIES

Implications of Building Technologies Embodied Energy of Buildings: Framed Construction, Masonry Construction. Resources for Building Materials, Alternative concepts.Recycling of Industrial and Buildings Wastes.Biomass Resources for buildings.

UNIT –III COMFORTS IN BUILDING

Comforts in Building: Thermal Comfort in Buildings- Issues; Heat Transfer Characteristic of Building Materials and Building Techniques. Incidence of Solar Heat on Buildings- Implications of Geographical Locations.

UNIT- IV UTILITY OF SOLAR ENERGY IN BUILDINGS

Utility of Solar energy in buildings concepts of Solar Passive Cooling and Heating of Buildings.Low Energy Cooling. Case studies of Solar Passive Cooled and Heated Buildings.

UNIT- V GREEN COMPOSITES FOR BUILDINGS

Green Composites for buildings: Concepts of Green Composites. Water Utilisation in Buildings, Low Energy Approaches to Water Management.Management of Solid Wastes.Management of Sullage Water and Sewage.Urban Environment and Green Buildings. Green Cover and Built Environment.

OUTCOMES

Upon completion of this course, the students will be able to

- To calculate the availability of the systems and cycles
- Analyze the engineering systems to improve and optimize its performance
- Elaborate knowledge on the building technologies
- Able to apply solar energy in green buildings.
- Familiar in the concept of green composites for buildings.

REFERENCES:

1. Low Energy Cooling For Sustainable Buildings. John Wiley and Sons Ltd, (2009).
2. K.S.Jagadish, B. U. Venkataramareddy and K. S. Nanjundarao. Alternative Building Materials and Technologies. New Age International, (2007).

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4	M	M	L	-	-	L	H	L	-	-	M	H	M	-	M
5	M	M	L	-	-	L	H	L	-	-	M	H	M	-	M