M.Phil.,/Ph.D ENERGY STUDIES (CBCS)
REGULATIONS, SCHEME & SYLLABUS
WITH EFFECTIVE FROM 2017-2018 ONWARDS

DEPARTMENT OF ENERGY STUDIES

PERIYAR UNIVERSITY

PERIYAR PALKALAI NAGAR

SALEM – 636 011

TAMILNADU

DEGREE OF MASTER OF PHILOSOPHY (M.Phil) REGULATIONS
WITH EFFECTIVE FROM
2017-18 ONWARDS

FULL-TIME

1. Eligibility:

Candidates who have qualified for post graduate degree (M.Sc.,- Energy Studies, Physics, Chemistry, Geology & Electronics or M.E/M.Tech- Mechanical, Mechatronics, EEE, ECE, Auto & Chemical) of this University or any other University recognized by the Syndicate as equivalent thereto shall be eligible to register for the Degree of Master of Philosophy (M.Phil.) in their respective subject and undergo the prescribed course of study in an approved institution or department of this University.

Candidates who have qualified their postgraduate degree on or after 1st January 1991 shall be required to have obtained a minimum of 55 % of marks in their respective postgraduate degree to become eligible to register for the Degree of Master of Philosophy (M.Phil.) and undergo the prescribed course of study in an approved institution or department of this University.

In the case of teachers (or) others registering for part-time registration, the minimum percentage of marks for registration is 50 %.

For the candidates belonging to SC / ST community and those who have qualified for the Master's degree before 01.01.1991 the minimum eligibility marks shall be 50 % in their Master's Degree.

2. Duration:

The duration of the M.Phil. Course shall extend over a period of one year from the commencement of the course.

3. Course of study:

The course of study for the degree shall consist of (a) Part-I comprising three written papers according to the Syllabus prescribed from time to time; and (b) Part-II Dissertation. Part-I shall consist of Paper-I Research Methodology and Paper-II an advanced paper in the main subject. There shall also be a third paper which shall be the background paper relating to the proposed. Dissertation conducted internally by the College/Departments.

4. Structure of the Course

SUBJECT CODE	TITLE OF THE COURSE	CREDITS L T P C	TOTAL MARKS
17MPERS01	**PART-I** Scientific Research and Methodology	4 0 0 4	100
17MPERS02	Energy Resources and Conversion Techniques	4 0 0 4	100
17MPERS03	Optional Paper (Guide Paper)	4 0 0 4	100
17MPERS04	**PART-II** Project and Viva-voce	12 0 0 12	200

* 150 Project 50 Viva-voce

5. Scheme of Examinations

Part-I Written Examination: Paper I, II & III

The examination of papers I, II and III shall be held at the end of first semester. The duration for each paper shall be 3 hours carrying a maximum of 100 marks.

Paper - III examination will be conducted by the College / Departments and the marks obtained by the candidate along with the question paper and valued answer scripts shall be sent to the University at least 15 days before the commencement of the examinations of paper I and II.

The examiners will be appointed from the panel of four names of each paper (I and II) submitted by the College / Departments concerned. If one examiner awards a pass mark and the other fail mark the, paper will be valued by a third examiner whose award of marks will be final.

Part - II - Dissertation:

The area of the Dissertation, which should be relevant to the specialization course, shall be intimated to the office of the controller of examinations within a month from the date of the commencement of the second semester. Candidates shall submit two copies of the Dissertation to the controller of examination through the Supervisor and Head of the Department concerned at the end of the second semester. The supervisor should submit a panel of five examiners along with the dissertation for the evaluation of specialization course, dissertation and to conduct the viva voce. The respective supervisors shall be an internal examiner. The viva board should consist of the research supervisor, head of the department and external examiner.

The examiners who value the Dissertation shall report on the merit of candidates as “Highly Commended" (75 % and above) or "Commended" (50 % and above and below 75%) or "Not Commended" (below 50 %).

Submission or resubmission of the Dissertation will be allowed twice a year.

06. QUESTION PAPER PATTERN

Question paper pattern for University Examinations

Time - 3 Hours

Maximum - 100 marks

Passing Minimum - 50 marks

Part - A (5x5=25 Marks)

Answer all questions

(Either or Type)

Part - B (5x15=75 Marks)

Answer all questions

(Either or Type)

7. Passing Minimum

A candidate shall be declared to have passed Part-I of the examination if he/she secure not less than 50% of the marks in each paper including Paper-III for which examination is conducted internally. A candidate shall be declared to have passed Part-II of the examination if his/her dissertation is at least commended. All other candidates shall be declared to have failed in the examination.

8. Restriction in number of chances:

No candidate shall be permitted to reappear for the written examination in any paper on more than two occasions or to resubmit a Dissertation more than once. Candidates shall have to qualify for the degree passing all the written papers and dissertation within a period of three years from the date of commencement of the course.

9. Conferment of Degree:

No candidate shall be eligible for conferment of the M.Phil degree unless he/she is declared to have passed both the parts of the examinations as per the Regulations.

10. Eligibility for research supervisors conducting the M.Phil. Programme:

As per the regulations of Periyar University.

1. PROGRAMME OUTCOMES (POs):

After studying M.Phil/ Ph.D in Energy Studies, 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 research problems.
3	Design/development of solutions	Design of experiment to attain the expected solutions or findings.
4	Conduct investigations of complex problems	Conduct experiments & collect, analyze and interpret the data.
5	Modern tool usage	Adopt various tools and techniques to solve the identified problem
6	Environment and sustainability	Find new solutions with environment consciousness and sustainable development.
7	Ethics	Interact in industry, business and society in a professional and ethical manner and also kept the research ethics.
8	Communication	Proficiency in oral and written Communication.
9	Project management and finance	Implement cost effective and improved system.
10	Life-long learning	Continue professional development and learning as a life-long activity.

2. PROGRAM SPECIFIC OUTCOMES (PSOs):

1. To create awareness on problem identification, design of experiments, experimentation, data collection and analysis, data interpretation relevant to energy generation, emission, distribution and consumption.
2. To impart the knowledge about writing the research articles and thesis in ethical manner.
3. To insist knowledge regarding various forms of energy such as solar, wind, Bio, Hydrogen, energy storage techniques and also knowledge about power electronics.
4. Ability to use knowledge in various domains to identify research gaps and ideate innovations by simulation of energy systems using various simulation tools.
5. To impart knowledge regarding Nano technology, coating technology, materials behavior for the benefit of selecting the suitable material for energy applications to get maximum output.

Mapping of Course Outcome and Programme Outcome

	Course Name	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
M.Phil	**Part-I**										
	Research Methodology	✓	✓	✓	✓	✓		✓	✓		
	Part - II										
	Energy resources and conversion Techniques	✓	✓			✓	✓			✓	✓
	Part - III										
	Solar energy technologies	✓		✓			✓	✓		✓	
	Wind energy systems	✓	✓	✓	✓		✓	✓		✓	
	Bio energy Technologies	✓	✓	✓	✓		✓			✓	
	Nanotechnology for energy systems	✓				✓	✓	✓		✓	✓
	Power electronics for renewable energy systems	✓			✓		✓	✓		✓	✓
	Hydrogen and fuel cells	✓	✓	✓	✓	✓	✓			✓	✓
	Computational fluid dynamics for energy systems	✓	✓	✓		✓			✓	✓	✓
	Energy storage systems		✓	✓		✓		✓		✓	
	Advanced crystallography	✓			✓	✓					✓
	Thin film deposition technology	✓	✓	✓		✓				✓	✓

PAPER I – RESEARCH METHODOLOGY

OBJECTIVES

1. To learn and study the objective and various categories of research.
2. To learn about problem identification and formulation.
3. To learn about design of experiment.
4. To learn about data collection, Analysis and interpretation.
5. To acquire knowledge on report writing.

UNIT-I - OBJECTIVES AND TYPES OF RESEARCH

Motivation and objectives – Research methods *vs* Methodology. Types of research – Descriptive *vs*. Analytical, Applied *vs*. Fundamental, Quantitative *vs*. Qualitative, Conceptual *vs*. Empirical.

UNIT-II - RESEARCH FORMULATION

Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review - Development of working hypothesis.

UNIT-III - RESEARCH DESIGN AND METHODS

Research design – Basic Principles- Need of research design –– Features of good design – Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan - Exploration, Description, Diagnosis, Experimentation. Determining experimental and sample designs.

UNIT-IV - DATA COLLECTION AND ANALYSIS

Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation.

UNIT-V - REPORTING AND THESIS WRITING

Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes - Oral presentation – Planning – Preparation – Practice – Making presentation – Use of visual aids - Importance of effective communication – Plagiarism - Citation and acknowledgement- Reproducibility and accountability.

OUTCOMES

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

1. Distinguish various research methods.
2. Identify and formulate the research problem.
3. Design the experiments.
4. Collect data, Analyse and interpret the data using various tools.
5. Write a report on research findings.

REFERENCES

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5. Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.
6. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
7. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
8. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.

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

PAPER- II - ENERGY RESOURCES AND CONVERSION TECHNIQUES

OBJECTIVES

1. To study the energy scenario.
2. To study the various energy conversion system.
3. To learn about various solar energy conversion techniques.
4. To learn wind energy systems.
5. To know about other renewable energy sources.

UNIT I –GLOBAL AND INDIAN ENERGY SCENARIO

Role of energy in economic development and social transformation - Energy sources - overall Energy demand and availability - Energy consumption in various sectors and its changing pattern - Depletion of energy sources

Energy resources & Consumption-Commercial and noncommercial forms of energy- fossil fuels- renewable sources in India- Sector wise energy Consumption - impact of energy on economy – Need for use of new and renewable energy sources-present status and future of nuclear and renewable energy -Renewable Energy-Power sector reforms-restructuring of energy supply sector-energy strategy for future.

UNIT- II ENERGY CONVERSION SYSTEM

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

UNIT-III SOLAR ENERGY

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– 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-solar PV power plant – Net metering concept.

UNIT-IV 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 - Repowering concept.

UNIT IV - OTHER TYPES OF ENERGY

Biomass resources and their classification - Biomass conversion processes – thermo-chemical conversion- bio diesel production – urban waste to energy conversion -

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 - Fuel cell – principle of working - various types - construction and applications.

Outcomes

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

1. Understand the current energy scenario of global as well as India.
2. Knowing various methods of energy conversion techniques.
3. Understand solar energy and conversion techniques.
4. Aware about wind energy systems.
5. Understand the various renewable energy sources.

REFERENCES:

1. J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams: Energy for a Sustainable World, Wiley Eastern, 1990.
2. World Energy Resources : Charles E. Brown, Springer, 2002.
3. Sukhatme, S.P., Solar Energy, Tata McGraw Hill, 1984.
4. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd.,1986.
5. Kishore VVN, Renewable Energy Engineering and Technology, Teri Press, New Delhi, 2012.
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10. Anthony San Pietro, Biochemical and Photosynthetic aspects of Energy Production, Academic Press, 1980.
11. Bridgurater, A.V., Thermochemical processing of Biomass, Academic Press, 1981.
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4	M	-	-	-	M	-	L	L	L	-	-	-	M	M	M
5	M	L	L	L	L	H	L	-	-	-	-	-	M	L	L

PAPER-III SOLAR ENERGY TECHNOLOGIES

OBJECTIVES

1. To learn and study the solar energy, radiation and estimation.
2. To study the various solar thermal energy technologies and their applications
3. To learn about various solar Photovoltaic effect materials and conversion techniques
4. To learn different kinds of solar energy observed materials
5. To know about various solar collectors and solar cell techniques

UNIT I INTRODUCTION

Basics of solar energy - Blackbody radiation- Relation between radiation field energy density and radiation spectrum - Planck's formula in energy unit - Maximum spectral density - Planck's formula in wavelength unit - Wien displacement law - Stefan - Boltzmann law - Photoelectric effect - Einstein's theory of photons - Einstein's derivation of the black-body formula.

UNIT II SOLAR RADIATION MEASUREMENT AND ESTIMATION

Measurement of solar radiation - Solar energy measuring instruments – Pyranometer – Pyrheliometer – Sunshine recorder - Estimation of average solar radiation - Ratio of beam and total radiation on tilted surface of that on horizontal surface.- Radiation Processing - Long Term- Evaluation of the Apparent Sunrise and Sunset Angles- Estimation of Daily/Monthly Average daily Tilt Factor Under Terrestrial Conditions

UNIT III SOLAR PHOTOVOLTAIC POWER GENERATION

Solar PV technologies overview - Stationary and concentrated PV - Inverter and control technologies - Master slave inverter system design - Standalone systems - Grid connected systems - Hybridization, synchronization and power evacuation - Site selection and land requirements - Techno-economic analysis of solar PV power plants - Environmental considerations.

UNIT IV MATERIALS FOR SOLAR COLLECTORS AND SOLAR CELLS COLLECTOR

Materials for Low, Medium and High Temperature Applications - Glazing Materials, Optical Materials - Absorber Coatings, Insulations, Desiccants, Use of Plastics - Reliability and Durability of Solar Collectors - Environmental Degradation of Low Cost Solar Collectors. Silicon, Cadmium Telluride, Galium-Arsenic, GaInP / GaAs / Ge - Thin Film, Single Crystalline, Polycrystalline Materials - Multi Junction and Tandem Junction Solar Cells - Low Cost and High Efficiency Materials - Conversion Efficiency of Solar Cells.

UNIT V THERMAL and electrical ENERGY STORAGE MATERIALS

Thermal Storage Concepts - Materials for Sensible and Latent Heat Energy Storage. Organic, Inorganic Eutectic Materials, Materials for Low and High Temperature Storage Applications. Chemical storage Concepts - Rechargeable Batteries – Types, Operating range, Comparison and suitability for various applications - Super Capacitors.

OUTCOMES

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

1. Qualitatively and quantitatively analyse solar energy and radiation
2. Knowing various solar thermal energy technologies and their applications
3. Understand solar Photovoltaic effect and conversion techniques
4. Aware about different types of solar energy observed materials
5. Perform research and development collectors and solar cell techniques

REFERENCES

1. Duffie, J.A., and Beckman, W.A. Solar Energy Thermal Process, John Wiley and Sons, New York, 2006.
2. Jui Sheng Hsieh, Solar Energy Engineering, Prentice- Hall, 2007.
3. Garg, H.P.,Treatise on Solar Energy, John Willey & Sons, 2006.
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8. Jef Poortmans and Vladimir Arkhipov, Thin Film Solar Cells, John Wiley and Sons, 2008. Thomas Markvart, Solar Electricity, John Wiley and Sons, 2007.
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11. Thomas P J Crompton, Battery Reference Book, NEWNES, 2000
12. JA Duffie and WA Beckman: Solar Engineering ofThermal Processes, Third Edition, John Wiley & Sons, 2006. 23
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3	M	M	L	L	H	M	M	L	L	-	L	-	M	M	H
4	M	L	L	L	L	M	M	L	M	M	M	-	H	M	L
5	H	L	L	L	L	M	L	M	M	M	H	-	M	L	-

PAPER-III WIND ENERGY SYSTEMS

OBJECTIVES

1. To understand the fundamentals of wind energy and its conversion system
2. To impart knowledge on air foil design and braking system
3. To learn gear coupled generator wind turbine components
4. To brief on the working of different generators and power conditioning system used in grid tied wind systems
5. 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 46 M.Tech., Energy Technology Syllabus 2019-2020 onwards

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

1. Analyse the energy in conversion techniques of wind energy
2. Analyse the performance of wind turbine aerodynamics and breaking system
3. Explain about various gear coupled generators with its construction
4. Explain about different types of generators and power condition used in wind systems
5. 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
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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,
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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, 201

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

PART III BIO ENERGY TECHNOLOGIES

OBJECTIVES

1. To detail on the types of biomass, its surplus availability and characteristics.
2. To create awareness on the technologies available for conversion of biomass to energy in terms of its technical competence and economic implications.
3. To impart knowledge on stoichiometry and combustion of bio fuels
4. To elucidate on the influence of equivalence ratio on thermochemical conversion of biomass
5. 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:

1. Estimate the surplus biomass availability of any given area
2. Design a biogas plant for a variety of biofuels
3. Determine and compare the cost of steam generation from biofuels with that of coal and petroleum fuels
4. Analyse the influence of process governing parameters in thermochemical conversion of biomass
5. 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
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6. Eriksson S. and M. Prior, The briquetting of Agricultural wastes for fuel, FAO Energy and Environment paper, 1990
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3	L	M	M	M	L	M	M	L	M	-	M	L	L	M	L
4	L	L	M	M	L	M	M	M	M	-	M	M	M	M	M
5	L	L	L	M	L	L	M	M	M	-	M	M	M	M	L

PAPER-III NANOTECHNOLOGY FOR ENERGY SYSTEMS

OBJECTIVES

1. To learn and study the basics and scale of nanotechnology.
2. To study the Factors nanomaterials and classification.
3. To learn about various synthesis of nanomaterials technique.
4. To learn importance and analysis of properties of nanomaterials.
5. To know about conditions for the fabrication and characterization of nanostructures

UNIT I BASICS AND SCALE OF NANOTECHNOLOGY

Introduction and scientific revolutions-Time and length scale in structures -Definition of a nano system Dimensionality and size dependent phenomena -Surface to volume ratio -Fraction of surface atoms and surface energy -Surface stress and surface defects -Properties at nanoscale – optical & mechanical -Properties at nanoscale – electronic & magnetic

UNIT II NANOMATERIALS OF ENERGY SYSTEMS CLASSIFICATION

Classification based on dimensionality -Quantum dots- wells and wires -Carbon-based nano materials – fullerences and buckyballs-Carbon nanotubes and graphene - Metal based nano materials – Nanogold and Nanosilver -Metal oxide based nano materials -Nanocomposites and nanopolymers -Nanoglasses and nano ceramics -Biological nanomaterials

UNIT III SYNTHESIS OF NANOMATERIALS

Chemical methods: Metal nanocrystals by reduction- Sol-Gel Process -Template Process -Solvothermal synthesis and photochemical synthesis -Sonochemical routes and chemical vapor deposition -Metal oxide chemical vapor deposition (MOCVD) **Physical methods:** Ball milling -Electrodeposition techniques- Inert Gas Condensation Technique (IGCT) – Thermal evaporation – Pulsed Laser Deposition (PLD) -Spray pyrolysis and flame pyrolysis -DC/RF magnetron sputtering, Molecular beam epitaxy (MBE)

UNIT IV PROPERTIES OF NANOMATERIALS

Elasticity-Strengths- Harnesses and Hall Petch Relationships in Nanomaterials-Melting point-Thermal conductivity- Specific heat- light absorption- color- light emission-Photoluminescence- Electroluminescence- Magneto optical effect–Resistivity- Thermoelectric Conversion Efficiency- Superconductivity -Magnetic Moment of Nanometre - Curie Temperature - magnetization and coercivity- magnetoresistance

UNIT V FABRICATION AND CHARACTERIZATION OF NANOSTRUCTURES

Nanofabrication: Photolithography and its limitation and electron beam lithography (EBL)-Nanoimprinting and soft lithography patterning

Characterization: X-ray diffraction -Fourier transform infrared spectroscopy-Photoluminescence spectroscopy –Ultraviolet spectroscopy(UV)- Photoluminescence

Spectroscopy(PL)- Nuclear Magnetic Resonance spectroscopy(NMR) -Atomic force Microscope(AFM) -Differential thermal analysis (DTA) -Field emission scanning electron microscopy (FESEM) and environmental scanning electron microscopy (ESEM)-High resolution transmission electron microscope (HRTEM)-X-ray photoelectron spectroscopy (XPS)

OUTCOMES

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

1. Qualitatively and quantitatively analyse scale of nanotechnology.
2. Understand the nanomaterials and classification of technology
3. Knowing various synthesis of nanomaterials technique
4. Understand importance and analysis of properties of nanomaterials..
5. Gain the ability to perform research and development for the fabrication and characterization of nanostructures

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PAPER-III POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

OBJECTIVES

1. To impart knowledge on conversion techniques and renewable energy technologies.
2. To study the mechanisms of machines for the conversion of renewable energy sources.
3. To learn the power converters and its applications in renewable energy systems.
4. To understand the different conversion mechanisms of wind and solar systems.
5. 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 II ELECTRICAL 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

1. Analyse the various conversion techniques in renewable energy technologies.
2. Apply the various mechanisms for the conversion of renewable energy sources.
3. Identify the appropriate power converters for renewable energy systems.
4. Implement the different conversion mechanisms for wind and solar systems.
5. Recognize the importance of various hybrid renewable energy systems.

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PAPER-III HYDROGEN AND FUEL CELLS

OBJECTIVES

1. To study the basic production techniques of Hydrogen.
2. To understand the concepts of various storage methods of Hydrogen.
3. To study the thermodynamics and kinetics of fuel cell process.
4. To understand the classifications, construction and working of fuel cells.
5. 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 – Hydride – chemical Storage – comparisons. Safety and management of hydrogen. Applications of Hydrogen.

UNIT III INTRODUCTION TO 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 CLASSIFICATION OF FUEL CELLS

Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC, MFC – principle, construction and working – relative merits and demerits.

UNIT V FUEL CELL APPLICATIONS 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

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

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PAPER-III COMPUTATIONAL FLUID DYNAMICS FOR ENERGY SYSTEMS

OBJECTIVES

1. To make students familiarize with the computational analysis
2. To explain the numerical analysis of solving of steady and unsteady diffusion heat transfer
3. To explain the numerical analysis of solving of convection-diffusion heat transfer
4. To provide the details of discretization of incompressible flow governing equations
5. 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, Discretization of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes.

UNIT III CONVECTION - DIFFUSION PROCESSES: FINITE VOLUME METHOD

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

UNIT IV INCOMPRESSIBLE FLOW PROCESSES: FINITE VOLUME METHOD

Discretization of incompressible flow equations – Stream Function – Vortices methods - Pressure based algorithms, SIMPLE, SIMPLER, SIMPLEC&PISO algorithms

UNIT V TURBULENCE MODELLING

Kolmogorov's Theory - Turbulence - Algebraic Models, One equation model & $k - \varepsilon$, $k - \omega$ models - Standard and High and Low Reynolds number models

OUTCOMES

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

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

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PAPER-III ENERGY STORAGE SYSTEMS

OBJECTIVES

1. To understand the various types of energy storage technologies and its applications.
2. To study the various modelling techniques of energy storage systems
3. To learn the concepts and types of batteries.
4. To make the students to get understand the concepts of Hydrogen storage.
5. 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 ENERGY STORAGE SYSTEM

Thermal Storage – Types – Modeling Of Thermal Storage Units – Simple Water and Rock Bed Storage System – Pressurized Water Storage System – Modeling Of Phase Change Storage System – Simple Units, Packed Bed Storage Units - Modeling Using Porous Medium Approach - Use Of Tran system

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 FUEL CELL

Fuel Cell – History Of Fuel Cell, Principles Of Electrochemical Storage – Types – Hydrogen Oxygen Cells - Hydrogen Air Cell - Hydrocarbon Air Cell - Alkaline Fuel Cell - Detailed Analysis – Advantage And Drawback of Each Type.

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

1. Identify the energy storage technologies for suitable applications.
2. Analyse the energy storage systems.
3. Recognize the concepts and types of batteries.
4. Diagnose the principle operations of Hydrogen enegy storage.
5. Analyse the concepts of Flywheel and compressed energy storage system.

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5	M	M	M	M	M	L	M	L	L	M	L	M	L	L	M

PAPER-III ADVANCED CRYSTALLOGRAPHY

OBJECTIVES

1. To learn and study the Crystallography basic parameter and laws.
2. To study the Factors and methods of crystallography technology.
3. To learn about various Chemical analysis by diffraction technique.
4. To learn importance and analysis of Crystallographic software.
5. To know about conditions for Data collection of atoms in molecules.

Unit -I INTRODUCTION

Two-dimensional lattices -two-dimensional basis vectors and unit cells -Two-dimensional transformations between sets of-Basis vectors-Three-dimensional basis vectors, unit cells, and lattice transformations- X-ray radiation, X-ray diffraction- origin of X-ray radiation, synchrotron, Bragg's law- Ewald construction-Structure factor.

Unit –II FACTORS OF CRYSTALLOGRAPHY

crystallography- Symmetry operations- Direct and reciprocal lattice- rotation axis, inversion axis, glide planes, centrum of symmetry- International tables for Crystallography- Factors affecting the intensity of diffraction- absorption correction, Lp- correction, secondary extinction- Fourier transformation- Phase problem methods - Patterson synthesis, direct methods

Unit- III CHEMICAL ANALYSIS BY DIFFRACTION

Hanawait method - Examples of qualitative analysis -Practical difficulties -Identification of surface deposits -Quantitative analysis (Single Phase) -Chemical analysis by parameter measurement -Quantitative analysis (Multiphase) -Direct comparison method -Internal standard method -Practical difficulties Absorption

Unit IV CRYSTALLOGRAPHIC SOFTWARE

Crystallographic software, disorder, modulated structure, error analysis- Cambridge structural database, statistical treatment of structural data- quality, quantity, crystal structure from powder data-Huge facilities for structural analysis- Neutronography, spin density- neutron reactor, synchrotron, XFEL- sample requirements, magnetic structure, spin density- Interpretation of the structural results- interpretation and visualisation of the crystal structure, interpretation of publishes structural results

Unit-V DATA COLLECTION ATOMS IN MOLECULES

Data collection of accurate structure factors for multipolar refinement- quality of single crystal, data collection at low temperature, error analysis Charge density analysis- AIM analysis-

relation of the experimental and theoretical electronic structure and their correlation to chemical and physico-chemical properties.

OUTCOMES

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

1. Qualitatively and quantitatively analyse crystallography basic parameter and laws. be able to understand the Factors and methods of crystallography technology
2. Knowing various Chemical analysis by diffraction technique
3. Understand importance and analysis of Crystallographic software.
4. Perform research and development for the Crystallography

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PAPER-III THIN FILM DEPOSITION TECHNOLOGY

OBJECTIVES

1. To learn and study the Physical Vapor Deposition (PVD) thin film technology.
2. To study the Chemical Vapor Deposition (CVD) thin film technology.
3. To learn about various thin film spray deposition technique.
4. To learn different kinds of techniques about the thin film of techniques.
5. To know about conditions for the formation of thin films.

UNIT I PHYSICAL VAPOR DEPOSITION (PVD)

Introduction, vacuum pumps and systems, Physics and chemistry behind evaporation, film thickness, uniformity and purity, evaporation hardware and techniques; thermal, ebeam etc. sputtering; RF, DC, DC magnetron sputtering, hybrid and modified PVD processes, advantages of PVD, disadvantages of PVD.

UNIT II CHEMICAL VAPOR DEPOSITION (CVD)

Introduction, reaction types, thermodynamics of CVD, gas transport and growth kinetics, CVD process and basic systems; Low-Pressure CVD (LPCVD), Plasma-Enhanced C VD (PECVD), Atmosphere-Pressure CVD (APCVD), Metal-Organic CVD (MOCVD), advantages of CVD, disadvantages of CVD.

UNIT III DEPOSITION TECHNIQUES

Introduction, basic instrumentation, different type of spray techniques; spray pyrolysis technique, electrospray deposition technique, electro-spin deposition technique, spray printing, advantages and disadvantages of spry deposition techniques.

UNIT IV OTHER TECHNIQUES

Electroplating, Spin coating, Sol gel, Langmuir Blodgett (LB) Techniques, Epitaxial Film Growth, SILAR technique, Doctor blade technique etc. their introduction, basic instrumentation, varying parameters, their advantages and disadvantages.

UNIT V CONDITIONS FOR THE FORMATION OF THIN FILMS

Environment for thin film deposition, capillarity theory, Growth modes: zone model for sputtering and evaporation, Microstructure in thin films, adhesion, -Mechanical, electrical, and optical properties of thin films, few applications of thin films in various fields- Application to Renewable energy technology – Thin film solar cells, Quantum well and Quantum dot solar cells, dye – sensitized solar cells.

OUTCOMES

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

1. Qualitatively and quantitatively analyse Physical Vapor Deposition (PVD) thin film technology.
2. Qualitatively and quantitatively analyse Chemical Vapor Deposition (CVD) thin film technology.
3. Knowing various thin film spray deposition technique
4. Understand different kinds of techniques about the thin film of techniques.
5. Perform research and development conditions for the formation of thin films.

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