ALAGAPPA UNIVERSITY

(A State University Established in 1985)
Karaikudi - 630003, Tamil Nadu, India

2017	2018	2018	2019	2019
Accredited with A+ Grade by NAAC (CGPA : 3.64)	MHRD Govt. of India, UGC — Graded as Category - 1 & Granted Autonomy	MHRD — Swachh Campus Rank : 4	NIRF National Institutional Ranking Framework — Rank : 28	QS — India Rank : 20, BRICS Rank : 104, Asia Rank : 216

DEPARTMENT OF ENERGY SCIENCE

M.Sc., ENERGY SCIENCE

[Choice Based Credit System (CBCS)]

[For the candidates admitted from the academic year 2019-**2020**]

CONTENTS

REGULATIONS AND SYLLABUS

[For the candidates admitted from the academic year 2019 onwards]

I. NAME OF THE PROGRAMME

The programme is named as **M.Sc. Energy Science (CBCS)**. The syllabus for this programme is framed under the rules of the Choice Based Credit Semester System of this University and both Core and Elective courses were incorporated as its components. The CBCS enables the students to select variety of subjects as per their interest and requirement. Acquiring knowledge in the related fields is advantageous to the students. Fast learners can earn more credits than the stipulated minimum of 90 credits.

II. PROGRAMME GENERAL OBJECTIVES

All basic life forms on Earth depend greatly on Energy for their survival, including us. Energy is a big part of our everyday life. We find energy is necessary for day to day life from lighting, cooking, transport, etc. Without energy it would be extremely hard for us to live. We need energy for everything we do.

Energy Science is a pervasive subject. It is an experimental science and students need to train in practicals to get expertise in doing fine experiments and handle sophisticated instruments. Along with the data obtained its statistical analysis is also required to establish authenticity in the fields like environmental science, space chemistry and biotechnology. There are immense potentialities for Energy Science and post graduates to undertake advanced research or in Industries as skilled professionals. It is important for the educators to provide a platform for the student community to study in detail the basics and advancements in Energy Science. Hence our goal in floating the M.Sc., programme in Energy Science is to educate the undergraduate students of chemistry, physics, electronic and material science in the fascinating fields of Energy in an effective manner. This syllabus presents essential contents in a detailed, clear and direct way.

PROGRAMME SPECIFIC OBJECTIVES

The specific objectives of M.Sc., in Energy Science programme are:

- To provide, thorough well designed studies of theoretical and experimental knowledge, a worthwhile educational experience for all students
- To acquire deep knowledge in fundamental aspects of all branches of Sciences related to Energy Science
- To acquire basic knowledge in the specialized thrust areas like Solar Energy, Hydrogen Energy, Nuclear Energy, Wind energy and Nanoscience and Technology etc.
- To develop abilities and skills that:
  - ➢ are relevant to the study and practice of science
  - ➢ are useful in everyday life
  - ➢ are encouraging efficient and safe practice and effective communication
- To develop attitudes relevant to science such as:
  - ➢ Concern for accuracy and precision
  - ➢ Objectivity
  - ➢ Integrity
  - ➢ Enquiry
  - ➢ Initiative and
  - ➢ Inventiveness

PROGRAMME OUTCOMES

Upon completion of M.Sc. Energy Science programme students should be able to:

- Apply knowledge obtained in Energy Science lecture to problem solving and critical thinking in the laboratory.
- Utilize mathematical knowledge gained from general Energy Science to perform common calculations, including mass balance, limiting reagent, and percentyield.
- Engage in safe laboratory practices by handling laboratory glassware, equipment, and chemical reagents appropriately, using general guidelines and basic knowledge about the common hazards associated with them in an Energy Science practical laboratory.
- Maintain an appropriate scientific notebook using notational and descriptive content containing information on relevant chemical reagents, experimental procedure followed, data collected, and observations made during the experimental process.
- Assemble glassware and perform the following techniques as a part of synthetic procedures: aqueous workup, distillation, reflux, separation, isolation, and crystallization.
- Predict the outcome of several common materials synthesis through a basic understanding of starting materials, mechanism, typical reaction conditions and applications.
- Characterize prepared substances by advanced characterization techniques.
- Develop the skill set necessary to continue the higher studies (Ph.D.) in Energy Science.
- Can confidently attend and clear competitive examinations especially CSIR NET.
- Become teachers in educational institutes and scientist in research laboratories.

III. ELIGIBILITY FOR ADMISSION

A candidate who is a B.Sc. graduate of this University or any recognized University in the main subject/subjects as given below or who has passed an examination accepted by the Syndicate as equivalent there to is eligible for admission to M.Sc. Energy Science programme.

M.Sc. in Energy Science	: B.Sc., Degree in Chemistry, Physics, Biology, Applied Physics, Electronics, Nuclear Physics, Biophysics, Industrial Chemistry, Polymer Chemistry, Applied Chemistry, Biotechnology, Biochemistry and Biological Sciences (Botany, Zoology and Microbiology) or equivalent Degree with at least 55% of marks in Part III.

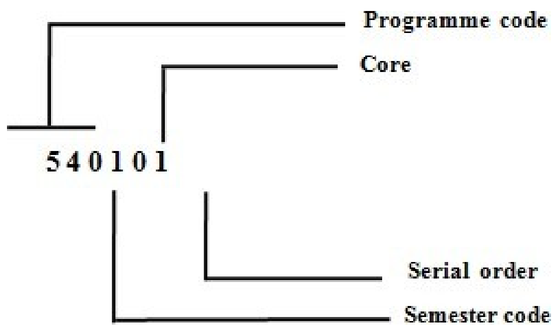
The admission is subject to the prevailing rules and regulations for PG admission of this University. The candidate has to undergo this programme in the Department of Energy Science, Alagappa University and complete all the examinations prescribed under the four semesters to qualify for this degree.

IV. DURATION OF THE PROGRAMME

The programme is for a period of two years. Each year shall consist of two semesters viz. Odd and Even semesters. Odd semesters shall be from July to November and even semesters shall be from December to April. There shall be 90 working days which shall comprise 540 teaching clock hours for each semester (exclusive of the days for the conduct of University end semester examination).

V. COURSES IN THE PROGRAMME

M.Sc., in Energy Science programme consists of number of courses. The term 'course' is applied to indicate a logical part of the subject matter of the programme and invariably equivalent to the subject matter of a "paper" in the conventional sense.



For elective, the fourth digit is '5'.
For Supportive course, the fourth digit is '7'

Credit Structure for M.Sc. ENERGY SCIENCE

Sem	Course Code	Course Title	Credit	Hrs	CIA Marks	ESE Marks	Total Marks
I	540101	Basic Energy Sciences	5	5	25	75	100
	540102	Physics for Energy Sciences	5	5	25	75	100
	540103	Chemistry for Energy Sciences	5	5	25	75	100
	540107	Energy Practical-I	4	8	25	75	100
	54050 X	Elective –I	4	4	25	75	100
		Library, Seminar, Yoga	-	3	-	-	-
		Total	**23**	**30**	**125**	**375**	**500**
II	540201	Environmental Science	5	5	25	75	100
	540202	Photovoltaics	5	5	25	75	100
	540203	Energy Storage Systems	5	5	25	75	100
	540207	Energy Practical-II	4	8	25	75	100
	54050X	Elective –II	4	4	25	75	100
		*NME I	2	3	25	75	100
	*SLC-I	MOOCs	E.C	-	-	-	-
		Total	**25 + E.C**	**30**	**150**	**450**	**600**
III	540301	Hydrogen Energy Systems	5	5	25	75	100
	540302	Wind and Hydro Energy	5	5	25	75	100
	540303	Solar Thermal Energy	5	5	25	75	100
	540307	Energy Practical-III	4	8	25	75	100
	54050X	Elective –III	4	4	25	75	100
		*NME II	2	3	25	75	100
	*SLC-II	MOOCs	E.C	-	-	-	-
		Total	**25 + E.C**	**30**	**150**	**450**	**600**
IV							
	540401	Energy Audit and Management	5	5	25	75	100
	54050X	Elective –IV	4	4	25	75	100
	540999	Project Work -Report & Viva-voce	8	16	25	75	100
		Library, Yoga, Seminar, Carrier Guidance	-	5	-	-	-
		Total	**17**	**30**	**75**	**225**	**300**
		GRAND TOTAL	**90 + E.C**	**120**	**500**	**1500**	**2000**

CC- Core Course, **EC-** Elective Course, **NME-** Non-Major Elective, **SLC-** Self Learning Course (MOOCs),
E.C- Extra Credit, **CIA** – Continues Internal Assessment, **ESE** – End Semester Examination.
*Credits earned through Self Learning Courses (MOOCs) shall be transferred in the credit plan of the programme as extra credits.

ELECTIVE COURSES

Course Code	Course Title
540501	Biochemistry for Energy Sciences
540502	Advanced Nanomaterials and Their Applications
540503	Nuclear Energy
540504	Advanced Instrumental Methods of Analysis
540505	Biofuels
540506	Polymer Science and Technology
540507	Climate Change and CO_2 Emission Assessment

NON-MAJOR ELECTIVE COURSES FOR OTHER DEPARTMENTS

Sl. No.	Course Title	Credit	CIA Marks	ESE Marks	Total Marks
1.	Basic concepts in Energy Sciences	2	25	75	100
2.	Renewable Energy and Energy Storage Systems	2	25	75	100
3.	Energy Conversion and Conservation Techniques	2	25	75	100

*Depending upon the requirement, any one of the above courses will be floated in a semester.

VI. PROJECT

Each candidate shall be required to take up a Project Work and submit the report at the end of the second year. The Head of the Department shall assign the Guide who in turn will suggest the Project Work to the student in the beginning of the second year. One typed copy of the Project Report shall be submitted to the University through Head of the Department on or before the date fixed by the University.

The project report will be evaluated by an Internal Examiner and an External, nominated by the University. The candidate concerned will have to defend his project in a Viva-Voce examination.

VII. SEMESTERS

An Academic year is divided into two **semesters.** In each semester, courses are offered in 18 teaching weeks including the duration of conduct of internal examination. Each week has 30 working hours spread over 5 days a week.

VIII. CREDITS

The term “Credit” refers to the weightage given to a course, usually in relation to the instructional hours assigned to it. For instance, a four hour course is assigned four credits, three hour course is assigned three credits. However, in no instance the credits of a course can be greater that the hours allotted it. The total minimum credits, required for completing a PG programme is 90. The details of credits for individual components are given in Table 1.

Table 1. Details on the number of courses and credits per course

S.No.	Study Components	Number of Courses	Credit per Courses	Total Credits	Hours per Courses	Total hours	Total marks
1.	Core Courses - Theory	10	5	50	90	900	1000
2.	Core Courses - Practicals	3	4	12	144	432	300
3.	Project work (Core)	1	8	8	216	216	100
4.	Elective Courses	4	4	16	72	288	400
5.	Non Major Elective	2	2	4	54	108	200
	Total	**20**	**--**	**90**	**-**	**1944**	**2000**

Total working hours = 1944 + 120 (Library, Seminar, Yoga, Carrier guidance.) = 2064 hours

IX. TEACHING METHODOLOGIES

The classroom teaching would be through conventional lectures and use of Power Point presentations and smart classroom facilities. The lecture would be such that the student should participate actively in the discussion. Student seminars would be conducted and scientific discussions would be arranged to improve their communicative skill.

In the laboratory, instruction would be given for the experiments followed by demonstration and finally the students have to do the experiments individually.

Periodic tests would be conducted and for the students of slow learners would be given special attention.

X. EXAMINATIONS

i) There shall be examinations at the end of each semester, for odd semesters in the month of October/November; for even semesters in April/May.

ii) A candidate who does not pass the examination in any course(s) may be permitted to appear in such failed course(s) in the subsequent examinations to be held in October/November or April/May. However candidates who have arrears in Practical shall be permitted to take their arrear practical examination only along with regular practical examination in the respective semester.

iii) A candidate should get registered for the first semester examination. If registration is not possible owing to shortage of attendance beyond condonation limit/regulation prescribed or belated joining or on medical grounds, the candidates are permitted to move to the next semester. Such candidates shall re-do the missed semester after completion of the course.

iv) Viva-Voce: Each candidate shall be required to appear for Viva-Voce Examination (in defending the Project only).

v) For the Project Report, the maximum marks will be 150 for project report evaluation and for the Viva-voce it is 50. At the end of fourth semester viva-voce will be conducted on the basis of the Dissertation/Project report submitted by the student. HOD and external examiner will conduct the viva-voce jointly in the presence of Guide.

vi) The results of all the examination will be published through the University Department where the student underwent the programme as well as through University Website.

vii) Practical examination for M.Sc. Energy Science programme shall be conducted at the end of each semester.

XI. CONDONATION

Student must have earned 75% of attendance in each course for appearing for the examination. Students who have earned 74% to 70% of attendance to be applied for condonation in the prescribed form with prescribed fee. Students who have earned 69% to 60% of attendance are to apply for condonation in the prescribed form with the prescribed fee along with the Medical Certificate. Students who have attended below 60% are not eligible to appear for the examination and they shall re-do the semester after completion of the programme, with the prior permission of the Registrar of the University.

XII. QUESTION PAPER PATTERN

(For all theory courses)

Time: 3 Hours **Max. Marks: 75**

PART-A: 10x2=20

(Answer all questions)

(Two questions from each unit)

Q.No. 1 – 10

PART-B: 5x5=25

(Answer all questions)

(One question from each unit with internal choice)

11. a) or b)

12. a) or b)
13. a) or b)
14. a) or b)
15. a) or b)

PART-C: 3x10=30

(Answer any three questions)
(One question from each unit)
Q.No. 16 – 20

XIII. EVALUATION

The performance of a student in each course is evaluated in terms of percentage of marks with a provision for conversion to grade points. Evaluation for each course shall be done by continuous internal assessment by the concerned Course Teacher as well as by an end semester examination and will be consolidated at the end of the course. The components for continuous internal assessment are:

Two tests	- 15marks (Third /repeat tests for genuine candidates/absentees)
Seminar/Quiz	- 05 marks
Assignment	- 05 marks
	25 marks

Attendance need not be taken as a component for continuous assessment, although the student should put in a minimum of 75% attendance in each course. In addition to continuous evaluation component, the end semester examination, which will be a written examination of at least 3 hours duration, would also form an integral component of the evaluation. The ratio of marks to be allotted to continuous internal assessment and to end semester examination is 25:75. The evaluation of laboratory component, wherever applicable, will also be based on continuous internal assessment for 25 marks and on end-semester practical examination 75 marks.

Distribution of marks for practical examinations

(CIA marks 25 + ESE Marks 75 marks)

ESE mark distribution	
Quantitative/ Qualitative analysis	50 marks
Viva – Voce in practical	15 marks
Record Note	10 marks
Total	75 marks

Project Work (PW)

Project report evaluation	75 marks
Viva-Voce examination	25 marks
Total	100 marks

(a) Topic:

The topic of the dissertation shall be assigned to the candidate before the end of first semester and a copy of the same should be submitted to the HOD.

(b) Plan of Work:

The student should prepare plan of work for the dissertation well in advance and get the approval of the guide during the first week of third semester of their study. In case the student wants to avail the facility or to carryout part of the work from other University/Research Institute/Laboratories in Industry, they can undertake the work with the permission of the guide and HOD and acknowledge the alien facilities/co-supervisor. The duration of the dissertation research shall be a minimum of three months in the fourth semester. In case the student stays away for work from the Department for more than one month, specific approval of the HOD should be obtained.

(c) No. of copies/distribution of dissertation:

The students should prepare four copies of dissertation and submit the same for the evaluation by Examiners. After evaluation one copy is to be retained in the Department library and one copy is to be submitted to the University, one copy can be given to the guide and one copy can be held by the student.

(f) Format to be followed:

The format/certificate for dissertation to be submitted by the students is given below:

Format for the preparation of project work:

(a) Title page
(b) Bonafide Certificate
(c) Acknowledgement
(d) Table of contents

CONTENTS

CHAPTER NO.	TITLE	PAGE NO.
1.	Introduction	
2	Review of Literature and Scope	
3.	Materials and Methods / Experimental	
4.	Results and Discussion	
5.	Summary	
6.	References	

Format of the Title Page:

TITLE OF THE DISSERTATION

Dissertation Submitted in part fulfillment of the requirement for the Degree of Master of Science in Energy Science (CBCS) to the Alagappa University, Karaikudi.

By

Students Name:
Register Number:

Under the Guidance of
(Faculty Name)
University Emblem

Department of Energy Science
Alagappa University
(Accredited with A+ Grade by NAAC (CGPA: 3.64) in the Third Cycle and Graded as Category-I University by MHRD-UGC)
Karaikudi - 630003

Month and Year:

Format of the Certificate:

CERTIFICATE

This is to certify that the dissertation entitled -- --------------------------- submitted in part fulfillment of the requirement of the degree of Master of Science in Energy Science (CBCS) to the Alagappa University, Karaikudi is a record of bonafide research work carried out by -------------------------under my supervision and guidance and that no part of the dissertation has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journals or magazines.

Date:
Place: Signature of the Guide

XIV. PASSING MINIMUM

A candidate shall be declared to have passed in each course if he/she secures not less than 50% marks in the University ESE and not less than 50% in the aggregate, taking continuous assessment and University Examination marks together.

Candidates, who have secured the pass marks in the end-semester examination (ESE) but failed to secure the aggregate minimum pass mark (50%) are permitted to improve their CIA mark in the following semester and/or in University examinations.

A candidate shall be declared to have passed in the Project work if he/she gets not less than 50% in each of the Project Report and Viva-voce but not less that 50% in the aggregate of both the marks for Project Report and Viva-voce.

A candidate who gets less than 50% in the Project Report must resubmit the Project Report. Such candidates need take again the Viva-Voce on the resubmitted Project.

Improvement of marks – Norms for the Improvement marks

a) Candidates willing to improve his/her performance of marks in the University Examination (other than Practical /Project work) in Theory course shall be permitted to re-appear again in the succeeding semester examination for the theory course(s) in which he/she has passed in the first appearance.
b) Improvement of performance of marks is allowed only once of a (theory course) course.
c) If the candidate shows no improvement in such appearance, marks secured by him/her in the first appearance will remain. No fresh marks statement will be issued in such cases.
d) If the candidate shows improvement, a revised mark statement will be issued on production of the original mark statement issued to him/her.
e) On improvement of performance, if a candidate becomes eligible for a higher class/ GPA and CGPA it shall be incorporated/awarded in the mark statement/provisional certificate/degree certificate on an application made by the candidate (along with the original Mark Statemen/Provisional Certificate/Degree Certificate) already issued (as the case may be) together with a fee prescribed for the purpose. However, he/she is not eligible for Revision of Rank of for the award of Prize.
f) Candidates willing to appear for the examination for improvement of marks at his/her last semester examination may await for the result of his/her latest appearance and re-appear twice in the immediately succeeding examination session.
g) The fee for permission to re-appear for improvement of marks is to be paid in addition to the examination fee for each course for which he/she is appearingfor.
h) The application for permission of re-appearance must be sent separately to the Controller of Examination in the prescribed form duly recommended by the HOD of the College on or before the last date for receipt of application for registration.
i) Fees paid once by these candidates will not be refunded or adjusted under any circumstances.

XV. GRADING

Once the marks of the CIA and end-semester examination for each of the courses are available, they will be added. The marks, thus obtained will then be graded as per the scheme provided in Table 2.

Table 2 Grading of the Courses

Marks	Grade Point	Letter Grade
96 and above	10	S+
91 – 95	9.5	S
86 – 90	9.0	D++
81 – 85	8.5	D+
76 – 80	8.0	D
71 – 75	7.5	A++
66 – 70	7.0	A+
61 – 65	6.5	A
56 – 60	6.0	B
50 – 55	5.5	C
Below 50	0	F

Grading System

< 50 Marks in all	50 < Your Marks < 60	60 < Your Marks < 75	Your Marks ≥ 75
Fail	II Class	I Class	Distinction

From the second semester onwards the total performance within a semester continuous performance starting from the first semester is indicated respectively **Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA).** These two are calculated by the following formulae.

$$\mathbf{GPA} = \frac{\sum_{i=1}^{n} C_i G_i}{\sum_{i=1}^{n} C_i}$$

Where 'Ci' is the Credit earned for the course i in any semester; 'Gi' is the Grade Point obtained by the student for the course i and 'n' is the number of courses **passed** in that semester.

CGPA (Cumulative Grade Point Average) = Average Grade Point of all the Courses starting from the first semester to the current semester.

XVI. CONFERMENT OF THE MASTER'S DEGREE

A candidate shall be eligible for the conferment of the Degree only after he/she has earned the minimum required credits for the programme prescribed therefore (i,e. 90 credits).

XVII. RANKING: UNIVERSITY RANK EXAMINATION

Candidates who pass all the examinations prescribed for the programme in the first instance and within a period two academic years from the year of admission to the programme only are eligible for University Ranking.

A candidate is deemed to have secured first rank provided he/she

(i) should have passed all the papers in first attempt itself

(ii) should have secured the highest over all grade point average (CGPA)

Rank certificate will be issued for a programme as follows:

a) Only THREE ranks if the students strength is below 20.
b) Only FIVE ranks if the student strength is above 20 but below 50.
c) Only TEN ranks if the student strength is above 50 but below 100

XVIII. GRIEVANCE REDRESSAL COMMITTEE

The Department shall form a Grievance Redressal Committee for each course with the course Teacher and the HOD as the members. This committee shall solve all grievances relating to the internal Assessment marks of the students.

XIX. TRANSFER OF CREDITS

Students are permitted to transfer their programme credits from Directorate of Distance Education (DDE) of Alagappa University to Regular Stream and Vice-versa, if the PG degree programme is same.

XX. REVISION OF REGULATIONS AND CURRICULUM

The University may from time to time revise, amend and change the regulation and the curriculum, if found necessary.

XXI. COMMENCEMENT OF THIS REGULATION

These regulations shall take effect from the academic year 2019-2020 i.e., for students who are to be admitted to the first year of the programme during the academic year 2019-2020 and thereafter.

XXII. TRANSITORY PROVISION

Candidates who were admitted to the M.Sc. Energy Science programme of study from or after 2019-2020 shall be permitted to appear for the examinations under the above regulations for a period of four years. Thereafter, they will be permitted to appear for the examination only under the regulations then in force.

Assessment & Evaluation: Student evaluation is based on exams, assignments, Seminar/Quizzes and class participation. The grade allocation is as follows:

Continuous Internal Assessment (CIA): 25 Marks		**End-Semester Exam: 75 Marks**
Two, 2 hour tests for 15 marks in all	Assignments, Seminars for 10 Marks	Three Hour examination on the whole syllabus for 75 Marks.

Attendance: Attendance and participation are vital to the student's success in this course. Students are expected to attend class every day. Minimum attendance to be eligible to take end-semester-examination is 75%**.**

Punctuality: Punctuality is an essential element in achieving success. Therefore, anyone arriving after daily roll-call (about 5 minutes after the class begins) will be marked absent. A valid excuse for being absent from class shall be a medical or a personal emergency acceptable at the discretion of the Dean/Chairman/Head of the Dept.

Class Participation: Class participation and interaction helps to form a complete educational experience. However, class participation and interaction is to be relevant to course content and context. Deviant behavior may lead to dismissal or suspension

Submission of Assignments: When submitting any assignments, your name, your student identification number, course number and date of submission should be clearly written on every page and all pages should be stapled together. The timely submission of assignments is an essence of personal discipline and will contribute towards forming a person's professional responsibility. The soft copy of the assignment also submitted to the Faculty in charge.

Preparedness: Students are expected to have read and be able to discuss the assigned chapter before attending the lecture. In addition, students should be prepared to discuss homework problems.

Academic Dishonesty: Academic work produced using dishonest methods has no value. Academic dishonesty also includes copying - verbatim or otherwise, and plagiarism i.e., the use of an author's ideas, statements, or approaches without crediting the source. A clear indication of academic dishonesty will result in a grade of "F" being assigned to that particular piece of work.

Subject to change clause: This syllabus, the course schedule and reading assignments are subject to change at the discretion of the Professor to accommodate instructional and/or student needs.

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CORE COURSES

<table>
<tr><td colspan="4">Semester - I</td></tr>
<tr><td>Course Code: 540101</td><td>Course Name: Basic Energy Sciences</td><td>Credits: 5</td><td>Hours per week : 5</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To study the contemporary topics in energy resources, conventional and non-conventional energy resources and energy needs.
➢ To understand solar energy conversion, solar concentrator and other solar applications, solar photovoltaic, fabrication and types of solar cells.
➢ To knowledgeable on wind energy conversion, wind farms in India, advantages and disadvantages of wind energy conversions.
➢ To study about biomass energy, biofuels like biodiesel, bioethanol and biogas.
➢ To acquire more knowledge about geothermal energy and tidal power plant.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Energy Resources (18 Hrs)
Introduction to energy resources: Conventional and Non-conventional energy resources- Difference between conventional and non-conventional energy resources - Types of conventional and Non-conventional energy resources – Energy needs: Who needs what, where and how much - Overview of global/ India’s energy scenario.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Solar Energy (18 Hrs)
Solar radiation: measurements and prediction - India’s solar energy potential and challenges Photovoltaic effect - Solar thermal energy conversions systems: Flat plate collectors - Solar concentrators and applications. Solar Photovoltaic: Principle of photovoltaic conversion of solar energy - Types of solar cells and fabrication -Organic Solar cells, Dye Sensitized Solar Cells - Perovskite solar cell.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Wind Energy (18 Hrs)
Introduction: Electricity from thin air- Criteria for selecting site for a wind farm- Technology of wind energy conversion - Storage of wind energy - Developments of wind farms - Location of the wind farms in India - Government policy- Advantages and disadvantages of wind energy – Applications.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Bioenergy (18 Hrs)
Biomass as energy resources: Origins and use of biomass - India’s bio-energy potential and challenges- Classification and estimation of biomass - Source and characteristics of Biofuels – Biodiesel – Bioethanol – Biogas - Types of biomass energy conversion systems waste to energy conversions.</td></tr>
<tr><td>Unit-V</td><td colspan="3">Geothermal and Tidal energy (18 Hrs)
Introduction: Classifications and energy extractions - Advantages and disadvantages of geothermal energy over other energy forms - Geothermal energy in India: Prospects- Applications of Geothermal energy.
Tidal energy: Introduction - Main types - Tidal power plant - Advantages and limitations of tidal power generation.</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Almora, O., & Garcia-Belmonte, G. (2019). Light capacitances in silicon and perovskite solar cells. Solar Energy, 189, 103-110. Doi: 10.1016/j.solener.2019.07.048.
Babu, V., Thapliyal, A., & Patel, G. K. (2014). Biofuels production. John Wiley & Sons.
Bhatia, S. C. (2014). Advanced renewable energy systems, (Part 2). WPI Publishing.
Calio, L., Kazim, S., Grätzel, M., & Ahmad, S. (2016). Hole-transport materials for perovskite solar cells. Angewandte Chemie International Edition, 55(47), 14522-14545. Doi: 10.1002/anie.201601757.
Everett, R., Boyle, G., Peake, S., & Ramage, J. (2012). Energy systems and sustainability: Power for a sustainable future. Oxford University Press.
Gikonyo, B. (Ed.). (2014). Advances in biofuel production: algae and aquatic plants. CRC Press.
Kothari, D. P. (2014). Wind Energy-Renewable Energy Sources and Emerging Technologies. Phi</td></tr>
</table>

Learning Pvt. Ltd, New Delhi,.
Lee, S., & Shah, Y. T. (2012). *Biofuels and bioenergy: processes and technologies*. CRC Press.
Math, M.C. (2019). *Non-Conventional Energy Sources*. Yes Dee.
Rai, G.D. (1998). *Non-Conventional Energy Source*. Khanna Publishers.
Reddy, P. J. (2012). *Solar Power Generation: Technology, New Concepts & Policy*. CRC Press.
Rivkin, D. A., Toomey, K., & Silk, L. (2013). *Wind Turbine Technology and Design.* Jones & Bartlett Publishers.
Rosen, M. A., & Koohi-Fayegh, S. (2017). *Geothermal energy: Sustainable heating and cooling using the ground.* John Wiley & Sons.
Sukhatme, S. P., & Nayak, J. K. (2017). *Solar energy*. McGraw-Hill Education.
Tony, B. (2001). *Wind energy handbook*. Wiley Publishers.
Twidell, J., & Weir, T. (2015). *Renewable energy resources*. Routledge.
Vargas, S. A., Esteves, G. R. T., Maçaira, P. M., Bastos, B. Q., Oliveira, F. L. C., & Souza, R. C. (2019). *Wind power generation: A review and a research agenda*. Journal of Cleaner Production.doi: 10.1016/j.jclepro.2019.02.015.

Outcomes	➢ The students will be able to understand conventional and non-conventional energy resources. ➢ The students will able to acquire more knowledge about solar energy conversion, solar concentrator, solar energy applications, solar photovoltaic, fabrication and types of solar cells. ➢ The students will be able to gain knowledge about wind energy, advantages and disadvantages of wind energy conversions, ➢ The students gain more information about various biofuels, like biodiesel, bioethanol, biogas and biomass energy conversions. ➢ The students will be comprehended about the basics of tidal power plant, limitations of tidal power generation, geothermal energy and applications of geothermal energy.

Name of the Course Teacher: Dr. S. Karuppuchamy

<table>
<tr><td colspan="4">Semester -I</td></tr>
<tr><td>Course Code: 540102</td><td>Course Name: Physics for Energy Sciences</td><td>Credits: 5</td><td>Hours per week : 5</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand work, kinetic energy, potential energy, conservative and non-conservative forces.
➢ To study zeroth, first and second law of thermodynamics, work and heat in thermodynamic processes and energy transfer mechanisms.
➢ To acquire more information about AC and DC circuits; Kirchhoff's rules, RC circuits, rectifiers and filters, band theory of solids and free-electron theory of metals.
➢ To know more information about properties of nuclei, binding energy and nuclear forces, nuclear models; natural radioactivity and nuclear reactions.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Kinetic and Potential Energy (18 Hrs)
Work and Kinetic Energy: Work done by a constant force - Work done by a varying force - Kinetic Energy and the Work-Kinetic Energy Theorem, Potential Energy: Conservative and Nonconservative Forces - Relationship between Conservative Forces and Potential Energy- Energy Diagrams and the Equilibrium of a System, Mass-Energy Equivalence, Quantization of Energy.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Thermodynamics (18 Hrs)
Thermometers and the Celsius Temperature Scale - Constant-Volume gas thermometer and the Absolute Temperature Scale - Thermal Expansion of Solids and Liquids - Macroscopic Description of an Ideal Gas- Zeroth, First and Second Law of Thermodynamics - Heat and Internal Energy - Heat Capacity and Specific Heat - Latent Heat - Work and Heat in Thermodynamic Processes - First Law of Thermodynamics - Some Applications of the First law of Thermodynamics - Energy Transfer Mechanisms - Heat engines and second law of Thermodynamics.</td></tr>
<tr><td>Unit – III</td><td colspan="3">AC and DC Circuits (18 Hrs)
Direct Current Circuits: Electromotive Force - Resistors in Series and in Parallel - Kirchhoff's Rules - RC Circuits - Electrical Instruments - Household Wiring and Electrical Safety.
Alternating Current Circuits: AC Sources and Phasors - Resistors in an AC Circuit - Inductors in an AC Circuit - Capacitors in an AC Circuit - RLC Series Circuit - Power in an AC Circuit - Resonance in a Series RLC Circuit - Transformer and Power Transmission - Rectifiers and Filters.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Molecules and Solids (18 Hrs)
Molecules and Solids: Molecular Bonds - Energy and Spectra of Molecules- Bonding in Solids - Band Theory of Solids - Free-Electron Theory of Metals - Electrical Conduction in Metals, Insulators and Semiconductors - Semiconductor Devices – Superconductivity- Meissner effect – BCS Theory – Josephson's effect.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Nuclear Structure (18 Hrs)
Nuclear Structure: Properties of Nuclei-Binding Energy and Nuclear Forces - Nuclear Models – Shell model, Liquid drop Model - Radioactivity - Decay Processes - Natural Radioactivity - Nuclear Reactions – Nuclear Fission and Nuclear Fusion – Nuclear reactor, Breeder reactor- Uses of Radiation.</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Chandra, S. (2010). Physics of Atoms and Molecules. Narosa.
Chandra, S. (2016). Energy, Entropy and Engines: An Introduction to Thermodynamics. John Wiley & Sons.
Clark, E. (2002). Physics Electricity Magnetism and Waves. CBS.
John Rita. (2014). Solid State Physics. McGraw Hill.
Michael Shur.(2010). Physics of Semiconductor Devices. PHI Learning.
Nuclear Physics/Nuclear Fusion and Fission (2018, August 16). Retrieved from https://en.wikibooks.org/wiki/Nuclear_Physics/Nuclear_Fusion_and_Fission.</td></tr>
</table>

Perkins, D. H., & Perkins, D. H. (2000). *Introduction to high energy physics*. Cambridge University Press.

Schroeder, D.V. (2011). *An Introduction to Thermal Physics*. Perason.

Serway, R. A., & Jewett, J. W. (2009). *Physics for Scientists and Engineers*: pt. 1. Mechanics. Cengage Learning, UK.

Sorensen, B. (2015). *Renewable energy: Physics, engineering, environmental impacts, economics & planning.* Academic Press.

Sze, S.M. (2010*). Physics of Semiconductor Devices*. PHI Learning.

Wolf, E.L. (2013). *Nanophysics and nanotechnology: An introduction to modern concepts in Nanoscience.* Wiley.

Wong, S. S. M., & Wong, S. S. (1996). *Introductory nuclear physics (Vol. 129).* New Jersey: Prentice Hall.

Outcomes	➢ The students gain more knowledge about work, kinetic energy and potential energy, conservative and non-conservative forces. ➢ The students will be able to understand action of heat over the solids and liquids; various laws of thermodynamics and energy transfer mechanisms. ➢ The students will be to understand, Kirchhoff's rules, AC and DC circuits, RC circuits, rectifiers and filters and free-electron theory of metals. ➢ The students will acquire more information about properties of nuclei, binding energy, nuclear forces and nuclear reactions, nuclear models and natural radioactivity.

Name of the Course Teacher: Dr. S. Karuppuchamy

<table>
<tr><td colspan="4">Semester -I</td></tr>
<tr><td>Course Code: 540103</td><td>Course Name: Chemistry for Energy Sciences</td><td>Credits: 5</td><td>Hours per week : 5</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand acids and bases, Bronsted acids and bases, electrolytes and nonelectrolytes, oxidation, reduction and displacement reactions.
➢ To knowledgeable on chemical bonding, electron sharing and formation of ionic compounds, Lewis symbols, electronegativity and resonance.
➢ To acquire intermolecular attractions, properties of liquids, gas and solids, dynamic equilibrium and principle of Le Chatelier’s theory.
➢ To study the concept of thermodynamics, Gibbs free energy, entropy, enthalpy and kinetics of chemical reaction.
➢ To acquire more information about electrochemistry, industrial applications of electrolysis, standard reduction potential and applications of galvanic cell.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Chemical Reactions (18 Hrs)
Chemical Reactions: Acids and Bases - Theories of acids and bases - Bronsted-Lowry Concepts for Acids and Bases- Periodic Trend - Acid-Base Properties of the Oxides -Reactions of Metals with Acids - Displacement of One Metal by another from Compounds.
Chemical Reactions in Solution: Solutions and Chemical reactions - Electrolytes and Nonelectrolytes - Acids and Bases as Electrolytes - Acid-Base Neutralization – Precipitation Reactions - Predicting Metathesis Reactions - Oxidation-Reduction Reactions - Balancing Redox Equations by the Ion-Electron Method – Mole Concept.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Chemical Bonding (18 Hrs)
Chemical Bonding: Electron Transfer and the Formation of Ionic Compounds - Lewis Symbols - Electron Sharing: Formation of Covalent Bonds - Some Important Compounds of Carbon - Electronegativity and the Polarity of Bonds - Drawing Lewis Structures - Formal Charge and the Selection of Lewis Structures - Resonance: Concepts of resonance-Coordinate Covalent Bonds: Lewis Acids and Bases.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Unit III: Properties of Liquids and Solids (18 Hrs)
Intermolecular attractions - Properties of Liquids and Solids: Why Gases Differ from Liquids and Solids - Intermolecular Attractions - Some General Properties of Liquids and Solids - Changes of State and Dynamic Equilibrium - Vapor Pressures of Liquids and Solids - Boiling Points of Liquids - Energy Changes during Changes of State - Dynamic Equilibrium and Le Chatelier's Principle.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Thermodynamics and Chemical Kinetics (18 Hrs)
Thermodynamics: Introduction - Energy Changes in Chemical Reactions- Enthalpy Change and Spontaneity - Entropy and Spontaneous Change - Third Law of Thermodynamics – Gibbs Free Energy - Standard Free Energies - Free Energy and Maximum Work - Free Energy and Equilibrium.
Kinetics: Reaction rate -Factors that affect reaction rates - Measuring the Rate of Reaction - Concentration and Rate - Concentration and Time - Theories about Reaction Rates - Measuring the Activation Energy - Collision Theory and Reaction Mechanisms - Catalysts.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Fundamentals of Electrochemistry (18 Hrs)
Acid-Base Equilibria: Ionization of Water and the pH Concept - Solutions of Strong Acids and Bases - Ionization Constants for Weak Acids and Bases - Solutions of Salts: Ions as Weak Acids and Bases - Chemical Equilibrium - Buffers- Types of Buffers - Acid-Base Titrations.
Electrochemistry: Electricity and Chemical Change – Electrolysis - Stoichiometric Relationships in Electrolysis - Industrial Applications of Electrolysis - Cell Potentials and Reduction Potentials - Standard Reduction Potentials - Effect of Concentration on Cell Potentials- Galvanic Cells - Practical Application of</td></tr>
</table>

	Galvanic Cells.

Reference and Textbooks:

Ahluwalia, V.K. (2013). *Green chemistry: A text book.* Narosa.

Ajay Singh. (2013). *Engineering chemistry*. CBS.

Atkins, P. (2016). *Physical Chemistry*. Oxford.

Carpenter, N. E. (2014). *Chemistry of sustainable energy*. CRC.

Dahl, J. A., Maddux, B. L., & Hutchison, J. E. (2007). *Toward greener nanosynthesis*. Chemical reviews, 107(6), 2228-2269. doi: 10.1021/cr050943k.

Darrell D. Ebbing. (2009). *Fundamentals of chemistry*. Cengage.

Das, A. K. (2016). *Fundamental concepts of inorganic chemistry*. CBS.

Douglas A. Skoog.(2011). *Fundamental of analytical chemistry*. Cengage.

Glasstone, S. (2016). *An Introduction to Electrochemistry*. EMP.

Greenwood, N.N. (1997). *Chemistry of the elements.* Elsevier.

Jayaprakash, R. (2011). *Engineering chemistry-I*. CBS.

John Kenkel. (2015). *Basic Chemistry Concepts and Exercises*, CRC.

Lee, J.D. (2016). *Concise Inorganic Chemistry*. Wiley.

Madkour, L. H. (2019). Processing of Nanomaterials (NMs). *In Nanoelectronic Materials*, Springer, Cham. 116, 309-353. doi:10.1007/978-3-030-21621-4_10.

Sodhi, G.S. (2013). *Fundamental concepts of environmental chemistry*. Narosa.

Outcomes	➢ The students will be able to understand the concepts of acid, base, Bronsted theory, oxidation, reduction and displacement reactions. ➢ The students gain more knowledge about chemical bonding, Lewis symbols, electronegativity and Lewis acids, bases. ➢ The students will be able to understand properties of solids, gas, liquids, dynamic equilibrium and principle of Le Chatelier's theory. ➢ The students gain more information about thermodynamics, chemical kinetics, collision theory and reaction mechanism. ➢ The students will be able to obtain more knowledge about fundamentals of electrochemistry and its real time applications.

Name of the Course Teacher: Dr. C. Karthikeyan

<table>
<tr><th colspan="4">Semester-I</th></tr>
<tr><td>Course Code : 540107</td><td>Energy practical- I</td><td>Credit: 4</td><td>Hours per week : 8</td></tr>
<tr><td colspan="4">List of Experiments:
1. Conductometry titrations- Acid-Alkali titration.
2. Conductometry-Determination of dissociation constants of weak acids.
3. Potentiometric titrations- Acid-Alkali titration.
4. Potentiometric titrations-Redox titration.
5. Redox titrations: Fe (II) vs. Ce (IV), Fe (II) vs. dichromate.
6. Digital to Analog (D/A) converters (a) Ladder Network (b) Weighted resistor method.
7. Analog to digital (A/D) converter
8. Logic gates using Integrated chip.
9. Resistivity measurements of thin films.
10. Synthesis of metal oxide nanoparticles by chemical method.
11. Synthesis of metal oxide nanoparticles by microwaveirradiation method.
12. Synthesis of metal oxide nanoparticles by sol-gel method.
13. Any other equivalent experiments.</td></tr>
</table>

Name of the Course Teacher: Dr. S. Karuppuchamy, Dr. C. Karthikeyan, Dr. A. Nithya

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Semester -II			
Course Code: **540201**	Course Name: **Environmental Science**	Credits: **5**	Hours per week : **5**
Objectives	➢ To understand biogeochemical cycles, carbon, oxygen, nitrogen, phosphorous and sulphur cycles. ➢ To know about various pollutions, ozone depletion, global warming, greenhouse effect, climate change and its control methods. ➢ To acquire twelve basic principles of green synthesis and environmentally benign technologies. ➢ To understand more information about carbon capture, carbon sequestration, carbon footprint and carbon trading.		
Unit – I	**Air and Water (18 Hrs)** Air Quality and pollution: Biogeochemical cycles – Carbon – Oxygen – Nitrogen - Phosphorous and Sulphur - Classification of air pollutants - Sources of air pollution and control methods- Effects of air pollutants: Ozone depletion - Acid rain - Green house effect - Climate change - Global warming. Water Quality and pollution**:** Water Quality parameters – Colour – Odour – Temperature – Turbidity – Hardness – Alkalinity – pH – Conductivity – Cations - Anions - SS – VOC – TDS – DO – BOD – COD - Micro nutrients - Heavy metals and Coliform - Potable water quality - Industrial water quality - Sources of water pollution.		
Unit – II	**Water Treatment (18 Hrs)** Primary Methods: Aeration-Filtration-Sedimentation-Precipitation-Coagulation and flocculation- Disinfection. Secondary methods: Activated sludge- Trickling filters- Anaerobic digestion- Lagoons and ponds. Tertiary/Advanced methods: Activated carbon- Ultrafiltration- Ion-exchange- Electrodialysis- Reverse Osmosis.		
Unit – III	**Basic Concepts of Green Chemistry (18 Hrs)** Green Chemistry: Definition. Twelve Basic principles and their illustrations with examples - (i) Prevention of waste / byproducts - (ii) Atom Economy - (iii) Prevention / minimization of hazardous products - (iv) Designing safer chemicals - (v) Selection of appropriate auxiliary substances - (vi) Energy requirements for reactions - (vii) Selection in the use of renewable starting materials - (viii) Avoidance of unnecessary derivatization - (ix) Use of catalytic reagents - (x) Designing biodegradable products - (xi) Prevention of chemical accidents and (xii) Development of analytical techniques to prevent the generation of hazardous substances and for real time in process monitoring.		
Unit – IV	**Designing Green Synthesis (18 Hrs)** Designing Green Synthesis: Choice of starting materials – Reagents – Catalysts – Biocatalysts - Polymer supported catalysts and solvents - Synthesis involving principles of green chemistry-Renewable chemicals from biomass.		
Unit – V	**Sustainable and Eco-Friendly Technologies (18 Hrs)** Environmentally benign technologies: Solvent free microwave assisted organic synthesis - Reactions on solid supports - Phase transfer catalysis - Solvent free esters saponification. Reactions without support or catalyst - Example- Microwave assisted reactions in water - Advantages of green technologies - Carbon capture - Carbon sequestration - Carbon footprint and Carbon trading.		

Reference and Textbooks:

Ahluwalia, V.K. (2013). *Green chemistry: A text book*. Narosa.

Allouhi, A. (2019). *Advances on solar thermal cogeneration processes based on thermoelectric devices: A review*. Solar Energy Materials and Solar Cells, 200, 109954. doi: 10.1016/j.solmat.2019.109954.

Arvind N. Shukla. (2013). *Industrial bioprocess technology*. DPH.

Bhatia, S.C. (2002). *Environmental chemistry*. CBS.

Coronado, J. M., Fresno, F., Hernández-Alonso, M. D., & Portela, R. (Eds.). (2013). *Design of advanced photocatalytic materials for energy and environmental applications* (pp. 1-348). London: Springer.

Ferreira, G. (Ed.). (2013). *Alternative energies: updates on progress (Vol. 34).* Springer Science & Business Media.

He, J. (2016). *Nanomaterials in energy and environmental applications*. Pan Stanford.

Kartite, J., & Cherkaoui, M. (2019). *Study of the different structures of hybrid systems in renewable energies:* A review. Energy Procedia, 157, 323-330. doi: 10.1016/j.egypro.2018.11.197.

Singh, M.P. (2010). *Future energy sources*. Pearl Books.

Sodhi, G.S. (2013). *Fundamental concepts of environmental chemistry*. Narosa.

Sorensen, B. (2015). *Renewable Energy: Physics, Engineering, Environmental Impacts. Economics & Planning*, Academic Press.

Outcomes	➢ The students will be gain noteworthy knowledge in various environmental cycles, ➢ The students will be gained more information about the sources, effect and control measures of air pollution, causes of ozone depletion and greenhouse effect. ➢ The students will be acquiring more information about principles of green chemistry and environmentally benign technologies. ➢ The students will be able to know about carbon capture, carbon sequestration and carbon footprint.

Name of the Course Teacher: Dr. C. Karthikeyan

<table>
<tr><td colspan="4">Semester -II</td></tr>
<tr><td>Course Code: 540202</td><td>Course Name: Photovoltaics</td><td>Credits: 5</td><td>Hours per week : 5</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand semiconductors, direct & indirect band gap Intrinsic and extrinsic semiconductor.
➢ To acquire more information about anti-reflection principles and coatings, P-N junction, p-i-n junction and its properties.
➢ To understand solar cells, characterization technique, PV modules, identical and non-identical Cells.
➢ To know about remote area power systems, specific purpose photovoltaic systems, solar PV concentrators, concentrator photovoltaic materials and devices.
➢ To understand hybrid SPV power systems, SPV power plant design tools and methodologies and SPV economics.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Properties of Semiconductor: (18 Hrs)
Semiconductors: Direct & Indirect band gap- Intrinsic - Extrinsic semiconductor - Compound semiconductors - p & n doping and carrier concentration - Diffusion and drift of carriers optical absorption – Temperature - Silicon: purification and crystallization - Amorphous materials – Transparent conducting oxides – Anti-reflection principles and coatings – Organic materials.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Device Fabrication and Characterization: (18 Hrs)
Semiconductor junctions: Schottky barriers – MIS - P-N junction - p-i-n junction and its properties - Thin film technology - Physical vapour deposition (PVD) - Electro-deposition - Molecular beam epitaxy (MBE) - Metal organic chemical vapour deposition (MOCVD) - Plasma enhanced chemical vapour deposition (PECVD) - Organic and Nano tech solar cells - Characterization technique: I-V.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Solar cell module materialsand assembly (18 Hrs)
Introduction to PV modules: Identical and Non-identical Cells - Module Structuring and assembly - Environmental Protection - Thermal Considerations - Electrical Considerations and output conditioning - Assembly materials – Interconnects – Crystalline and thin film modules - Issues with solar PV modules – Module testing and analysis.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Solar PV system components & system design (18 Hrs)
Introduction to PV systems - System components: module and array – Charge controllers – Inverters – Batteries – Power conditioning and Regulation –Grid connected power systems – Remote area power systems – Specific purpose Photovoltaic systems: Space – Marine – Telecommunication – Water pumping – Refrigeration.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Advanced SPV technologies (18 Hrs)
Solar PV concentrators – Concentrator photovoltaic materials and devices – Hybrid SPV power systems – SPV power plant design tools and methodologies – SPV economics.</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Balfour, J. R., & Shaw, M. (2013). Introduction to photovoltaic system design. Jones & Bartlett Publishers.
Conings, B., Babayigit, A., & Boyen, H. G. (2019). Fire Safety of Lead Halide Perovskite Photovoltaics. ACS Energy Letters, 4(4),873-878.Doi: 10.1021/acsenergylett.9b00546.
Day, J., Senthilarasu, S., & Mallick, T. K. (2019). Improving spectral modification for applications in solar cells: A review. Renewable energy, 132, 186-205. doi:10.1016/j.renene.2018.07.101.
Hernández-Ramírez, A., & Medina-Ramírez, I. (2015). Photocatalytic semiconductors. Springer International Pu.
Lee, J., Lee, S. M., Chen, S., Kumari, T., Kang, S. H., Cho, Y., & Yang, C. (2019). Organic Photovoltaics with Multiple Donor–Acceptor Pairs. Advanced Materials, 31(20), 1804762.</td></tr>
</table>

Doi: 10.1002/adma.201804762.

Mukerjee, A.K. (2014). *Photovoltaic systems: Analysis and design*. PHI Learning.

Sawhney, G.S. (2016). *Non- Conventional energy resource*. PHI Learning.

Solanki, C.S.(2015).*Solar photovoltaic technology and systems: A manual for technicians, trainers and engineers.* PHI Learning Pvt. Ltd.

Tiwari, G. N., & Dubey, S. (2010). *Fundamentals of Photovoltaic Modules and Their Applications*. RSC Publishing.

Walker, A. (2014). *Solar Energy: Technologies and project delivery for buildings*. John Wiley & Sons.

Yariv,A.(2007).*Optical electronics in modern communications*. Oxford University Press, USA.

Outcomes	➢ The students will be able to understand semiconductors and types of semiconductor. ➢ The students will be acquire more information about anti-reflection principles and coatings, P-N junction, p-i-n junction and its properties ➢ The students gain more remarkable knowledge about solar cells, characterization technique, PV modules, identical and non-identical cells. ➢ The students gain more knowledge about remote area power systems, photovoltaic systems, solar PV concentrators, concentrator photovoltaic materials and devices. ➢ The students gain significant knowledge about hybrid SPV power systems, SPV power plant design tools, methodologies and SPV economics.

Name of the Course Teacher: Dr. S. Karuppuchamy

<table>
<tr><td colspan="4">Semester -II</td></tr>
<tr><td>Course Code: 540203</td><td>Course Name: Energy Storage Systems</td><td>Credits: 5</td><td>Hours per week : 5</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand electrochemical reactions, charge and discharge properties of lead acid batteries, Lead acid battery for PV and automotive applications.
➢ To acquire advanced anodes and cathode materials, theoretical capacity, battery fabrication technology and testing and batteries for electric vehicles.
➢ To study hybrid vehicles, solar photovoltaic applications, sulphur batteries, lithium sulphur and sodium sulphur battery
➢ To learn fuel cell, precious and non-precious metal catalysts, bi-functional catalysts and nanomaterials for low temperature fuel cells.
➢ To understand reversible fuel cells, fuel cell stacks and systems, fuel cells for vehicles and grid connected applications.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Lead Acid Battery (18 Hrs)
Advantages and disadvantages of lead acid batteries - Electrochemical reactions - Physical and chemical properties of active materials - Characteristics and properties of sulfuric acid - Constructional features - Materials and manufacturing methods - SLI (Automotive) batteries - charge and discharge properties of lead acid batteries – Sealed lead acid or maintenance free batteries fabrication technology and testing - Lead acid battery for PV and automotive applications.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Lithium-ion Battery (18 Hrs)
Advanced anodes and cathodes – Theoretical capacity – Merits and demerits - Nanomaterials for anodes: Carbon nanotubes - SnO_2 – NiO - TiO_2 & $LiTiO_4$ - Battery fabrication technology and testing - Batteries for electric vehicles - Hybrid vehicles and solar photovoltaic applications- Sulphur Batteries- Lithium Sulphur, Sodium Sulphur battery.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Metal-Air Batteries (18 Hrs)
Lithium-Air, Sodium-Air, Zinc-Air batteries: Principle – Components – Anodes – Cathodes - Fabrication – Evaluation – Merits - Demerits and applications.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Fuel Cells (18 Hrs)
Membrane electrode assemblies – Fabrication - Catalyst layer - Fuel cell supports – GDL - bipolar plates - Fuel cell catalysts – Precious and non-precious metal catalysts - bi-Functional catalysts – Nanomaterials for low temperature fuel cells – Reversible fuel cells - Fuel cell stacks and systems - Fuel cells for vehicles and grid connected applications.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Hybrid Energy Systems (18 Hrs)
Concept of hybrid energy systems- Battery/supercapacitor hybrid systems- Example- Applications - Hybrid fuel cell/battery systems- Example-Applications.</td></tr>
</table>

Reference and Textbooks:

Andrews, J., & Jelley, N. (2007). *Energy science: principles, technologies, and impacts*. Oxford University Press.

Awasthi, O.N. (2015). *Application of light and energy management*. Narosa.

Berg, H. (2015). *Batteries for electric vehicles: materials and electrochemistry*. Cambridge university press.

Cetin, T. H., Kanoglu, M., & Yanikomer, N. (2019). *Cryogenic energy storage powered by geothermal energy*. Geothermics, 77, 34-40. Doi:10.1016/j.geothermics.2018.08.005.

Cheng, J. (Ed.). (2017). *Biomass to renewable energy processes*. CRC press.

Ding, Y., & Zhang, Z. (2016). *Nanoporous metals for advanced energy technologies (p. 175)*. Springer International Publishing.

Fornasiero, P., & Graziani, M. (2012). *Renewable resources and renewable energy: a global challenge.* CRC press.

Franco, A. (Ed.). (2015). *Rechargeable lithium batteries: from fundamentals to applications*.

Woodhead publishing.

Huggins, R. A. (2009). *Solid electrolytes. Advanced Batteries: Materials Science Aspects,* 339-373.

Lee, S., & Shah, Y. T. (2012). *Biofuels and bioenergy: processes and technologies*. CRC Press.

Lewis,J. (2013). *Encyclopedia of electrochemistry: Principles and applications. Introduction to electrochemistry*. Anmol.

Quaschning, V. V. (2010). *Renewable energy and climate change*. Wiley.

Robert, H.M. (2007). *Handbook of Energy Conservation*, Volume-I. CBS.

Singh, M.P. (2010). *Future energy sources*. Pearl Books.

Sorensen, B. (2017). *Renewable energy*, 5^{th} Edition. Academic Press.

Thorpe, D. (2018). *Solar Energy Pocket Reference*. Routledge.

Outcomes	➢ The students will be able to learn electrochemical reactions, lead acid batteries, and lead acid battery for PV and automotive applications. ➢ The students attain remarkable knowledge about advanced anodes and cathode materials, theoretical capacity, battery fabrication technology and testing. ➢ The students will be able to known about solar photovoltaic applications, sulphur batteries, lithium sulphur and sodium sulphur battery. ➢ The students will be obtain more information about fuel cell, precious and non-precious metal catalysts, bi-functional catalysts and nanomaterials for low temperature fuel cells. ➢ The students will be learning more knowledge about fuel cells for vehicles and grid connected applications.

Name of the Course Teacher: Dr. A. Nithya

<table>
<tr><th colspan="4">Semester-II</th></tr>
<tr><td>Course Code : 540207</td><td>Energy practical- II</td><td>Credit: 4</td><td>Hours per week :
8</td></tr>
<tr><td colspan="4">List of Experiments:
1. Synthesis of one dimensional nanomaterial by electrospinningmethod.
2. Synthesis of nanocomposite materials by solution growth method using capping agent.
3. Synthesis of oxide nanomaterials by hydrothermal method.
4. XRD studies for calculating the size of the nanoparticles by Scherrer’s formula.
5. Electrochemical characterization of metal oxide nanomaterials.
6. Synthesis of conducting polymer for energy applications.
7. UV-Visible spectral analysis of dye-modified semiconductor oxide thin films.
8. Synthesis of visible light active nanomaterials.
9. Decomposition of organic pollutants using photocatalyst.
10. Estimation of dissolved oxygen in industrial wastewater.
11. Estimation of chromium in industrial wastewater.
12. Any other equivalent experiments.</td></tr>
</table>

Name of the Course Teacher: Dr. S. Karuppuchamy, Dr.C. Karthikeyan, Dr. A.Nithya

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<table>
<tr><td colspan="4">Semester -III</td></tr>
<tr><td>Course Code: 540301</td><td>Course Name: Hydrogen Energy Systems</td><td>Credits: 5</td><td>Hours per week : 5</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand present and projected uses for hydrogen, natural gas, reforming of natural gas, gas separation processes and characteristics of steam reforming of methane.
➢ To acquire more information about partial oxidation of hydrocarbons and membrane developments for gas separation.
➢ To learn about phosphoric acid fuel cell, alkaline fuel cell, direct borohydride fuel cell, proton exchange membrane fuel cell, direct methanol fuel cell and miniature fuel cells.
➢ To know about types of fuel cell, fuel cell efficiencies and applications of fuel cells.
➢ To acquire more knowledge about cryo compression, carbon nanotubes, clathrate hydrates, glass capillary arrays, glass microspheres, stationary hydrogen storage and underground hydrogen storage.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Hydrogen from Fossil Fuels (18 Hrs)
Present and Projected Uses for Hydrogen - Natural Gas - Reforming of Natural Gas - Gas Separation Processes - Characteristics of Steam Reforming of Methane - Partial Oxidation of Hydrocarbons - Membrane Developments for Gas Separation - Membrane Types - Membrane Reactors - Coal and Other Fuels.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Hydrogen from Biomass (18 Hrs)
Photobiological hydrogen production potential – Hydrogen production by fermentation – Overview – Energetics – Thermotogales - Biochemical pathway for fermentative hydrogen production – Thermotoga - Hydrogen production by other bacteria - Co-product formation - Batch fermentation - Hydrogen inhibition
- Role of sulphur – Sulfidogenesis - Use of other carbon sources obtained from agricultural residues - Process and culture parameters</td></tr>
<tr><td>Unit – III</td><td colspan="3">Water Splitting (18 Hrs)
Electrolysis – Electrolyzers - Water Splitting with Solar Energy - Photovoltaic Cells-Solar -Thermal Process - Photo-electrochemical Cells - Direct Hydrogen Production - Tandem Cells - Photo-biochemical Cells.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Fuel Cells (18 Hrs)
Fuel Cell History - Fuel Cell Operation -Types of Fuel Cells: Low-to-Medium Temperature -Phosphoric Acid Fuel Cell - Alkaline Fuel Cell - Direct Borohydride Fuel Cell – Proton -exchange Membrane Fuel Cell - Direct Methanol Fuel Cell - Micro Fuel Cells.
Types of Fuel Cell: High Temperature - Molten Carbonate Fuel Cell - Internal Reforming - Direct Carbon Fuel Cell - Solid Oxide Fuel Cell - Fuel Cell Efficiencies - Applications of Fuel Cells - Large Stationary Power Generation - Small Stationary Power Generation - Mobile Power - Portable Power - Prognosis for Fuel Cells.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Hydrogen Storage Materials (18 Hrs)
Hydrogen storage technologies: Compressed hydrogen - Liquid hydrogen - Chemical Storage: Metal hydrides – Carbohydrates – Ammonia - Amine borane complexes -Phosphonium borate - Carbonite substances - Physical storage: Cryo compressed - Carbon nanotubes - Clathrate hydrates - Glass capillary arrays - Glass microspheres - Stationary hydrogen storage - Underground hydrogen storage</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Ahluwalia, V.K. (2013). Green chemistry: A text book. Narosa.
Ajay Singh, (2013). Engineering chemistry. CBS.
Bhatia, S. C. (2014). Advanced renewable energy systems,(Part 1). WPI Publishing.</td></tr>
</table>

Cheng, J. (Ed.). (2006). *Biomass to renewable energy processes*. CRC press.

Ferreira, G. (Ed.). (2013). *Alternative energies: updates on progress (Vol. 34).* Springer Science & Business Media.

Kikuchi, Y., Ichikawa, T., Sugiyama, M., & Koyama, M. (2019). *Battery-assisted low-cost hydrogen production from solar energy: Rational target setting for future technology systems.* International Journal of Hydrogen Energy, 44(3), 1451-1465. Doi: 10.1016/j.ijhydene.2018.11.119.

Lee, S., & Shah, Y. T. (2013). *Biofuels and bioenergy: processes and technologies*. CRC Press.

Math, M.C. (2019). *Non-Conventional Energy Sources*, Yes Dee Publishers.

Singh, M.P.(2010). *Future energy sources*. Pearl Books.

Welder, L., Stenzel, P., Ebersbach, N., Markewitz, P., Robinius, M., Emonts, B., & Stolten, D. (2019*). Design and evaluation of hydrogen electricity reconversion pathways in national energy systems using spatially and temporally resolved energy system optimization.* International Journal of Hydrogen Energy, 44(19), 9594-9607. Doi: 10.1016/j.ijhydene.2018.11.194.

Outcomes	➢ The students will be able to understand uses for hydrogen, natural gas, reforming of natural gas, gas separation processes and characteristics of steam reforming of methane. ➢ The students will be able to learn more information about membrane developments for gas separation, partial oxidation of hydrocarbons. ➢ The students will be able to comprehend about phosphoric acid fuel cell, alkaline fuel cell, direct borohydride fuel cell, proton exchange membrane fuel cell, direct methanol fuel cell and miniature fuel cells. ➢ The students will be able to know about types of fuel cell, high temperature, molten carbonate fuel cell, direct carbon fuel cell, solid oxide fuel cell, fuel cell efficiencies and applications of fuel cells. ➢ The students will be able to acquire knowledge on carbon nanotubes, glass capillary arrays, glass microspheres, stationary hydrogen storage and underground hydrogen storage.

Name of the Course Teacher: Dr. S. Karuppuchamy

<table>
<tr><td colspan="4">Semester -III</td></tr>
<tr><td>Course Code: 540302</td><td>Course Name: Wind and Hydro Energy</td><td>Credits: 5</td><td>Hours per week : 5</td></tr>
</table>

Objectives	➢ To understand wind tower components, wind turbine size classes, towers and types of propellers. ➢ To understand wind chargers, grid connected wind turbines, wind farms, offshore wind farms, planning and designs ➢ To acquire more information about hydrology, potential of hydropower in India, classification of hydropower plants and small hydropower systems. ➢ To comprehend about tidal power plants, wave power plants, ocean current power plants and hydropower markets. ➢ To gain knowledge of hydro projects, potential of hydro power in north east India.
Unit – I	**Basics Concepts–Wind Energy (18 Hrs)** Wind tower components - Wind turbine size classes – Towers - Types of propellers - Electrical generator – Power - Air density - Swept area - Cube of wind speed - Height and wind speed - Power in the Wind equation - Air density equation.
Unit – II	**Wind Energy Systems (18 Hrs)** Utilizing wind- Installations and parks: Wind chargers - Grid connected wind turbines -Wind farms - Offshore wind farms - Planning and designs – Economics – Ecology - Wind power markets - Outlook and Development potential.
Unit – III	**Hydropower Plants-I (18 Hrs)** Hydrology - Potential of hydropower in India - Classification of Hydropower Plants - Small Hydropower Systems: Overview of micro - Mini and small hydro systems - Status of Hydropower Worldwide and India - Case studies.
Unit – IV	**Hydropower Plants-II (18 Hrs)** Introduction to Run-of-river power plants - Storage power plants - Pumped storage power plants - Tidal power plants - Wave power plants - Ocean current power plants - Hydropower markets - Outlook and development potential.
Unit – V	**Design of Power Plant (18 Hrs)** Selection of site for hydroelectric plant - Essential elements of hydroelectric power plant - Economics: Cost structure - Initial and operation cost - Environmental issues related to large hydro projects - Potential of hydro power in North East India.

Reference and Textbooks:

Ahmed, S. (2015). *Wind energy: theory and practice*. PHI Learning Pvt. Ltd.

Boyle, G. (2012). *Renewable Energy: Power for a Sustainable Future*. Oxford.

Burton Tony. (2011).*Wind energy handbook*. Wiley.

Jayarama Reddy, P. (2012). *Solar power generation: Technology, new concepts and policy*. CRC Publishers.

Kothari, D.P. (2014). *Wind Energy Systems and Applications*. Narosa Publishers.

Kraan, O., Chappin, E., Kramer, G. J., & Nikolic, I. (2019). *The influence of the energy transition on the significance of key energy metrics*. Renewable and Sustainable Energy Reviews, 111, 215-223. Doi: 10.1016/j.rser.2019.04.032.

Liu, Z., Zhang, Z., Zhuo, R., & Wang, X. (2019). *Optimal operation of independent regional power grid with multiple wind-solar-hydro-battery power.* Applied energy, 235, 1541-1550. Doi: 10.1016/j.apenergy.2018.11.072.

Math, M.C. (2019). *Non-Conventional Energy Sources*. Yes Dee Publishers.

Rai, G.D. (1998). *Non Conventional Energy Sources*. Khanna Publishers.

Rivkin, D. A., & Silk, L. (2013). *Wind Energy*. Jones & Bartlett Publishers.

Şen, Z. (2019*). Innovative methodologies in renewable energy: A review*. International Journal of Energy Research. Doi: 10.1002/er.4619.

Outcomes	➢ The students will be gain noteworthy knowledge about wind power plant like wind tower components, wind turbine size classes, towers and types of propellers. ➢ The students will be able to learn wind chargers, grid connected wind turbines, wind farms, offshore wind farms, planning and designs ➢ The students will be able to attain more information about hydrology, potential of hydropower in India, classification of hydropower plants and small hydropower systems. ➢ The students will be able to know more information about tidal power plants, wave power plants, ocean current power plants and hydropower markets. ➢ The students will be able to learn importance of power plant and hydro power in north east India.

Name of the Course Teacher: Dr. C. Karthikeyan

<table>
<tr><td colspan="4">Semester -III</td></tr>
<tr><td>Course Code: 540303</td><td>Course Name: Solar Thermal Energy</td><td>Credits: 5</td><td>Hours per week : 5</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand solar radiation on the earth surface, extraterrestrial radiation characteristics, terrestrial radiation, solar insolation and measurement of solar radiation.
➢ To acquire carnot cycle, supercritical rankine cycles, brayton cycle, stirling cycle, binary cycles and combined cycles.
➢ To learn more knowledge about solar collectors and swimming pool absorbers.
➢ To comprehend about solar water heating system, solar space heating and cooling, domestic water heating and solar cooking.
➢ To lean more information about solar panel manufacturing technologies, economics, ecology, solar thermal market, outlook and development potential.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Solar Radiation and Measurement (18 Hrs)
Solar radiation on the earth surface - Extraterrestrial radiation characteristics - Terrestrial radiation - Solar insolation - Spectral energy distribution of solar radiation - Depletion of solar radiation – Absorption – Scattering - Beam radiation - Diffuse and Global radiation - Measurement of solar radiation – Pyranometer – Pyrheliometer - Sunshine recorder.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Solar Thermal Energy Conversion (18 Hrs)
Thermodynamic cycles – Carnot – Organic – Reheat - Regeneration and supercritical Rankine cycles - Brayton cycle – Stirling cycle – Binary cycles – Combined cycles - Solar thermal power plants - Parabolic trough system - Distributed collector - Hybrid solar-Gas power plants - Solar pond based electric power plant.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Solar Collectors (18 Hrs)
Introduction to Solar Collectors – Types of Solar Collectors, Non-Concentrating type - Concentrating type - Flat plate collectors -Concentrating collectors – Air-Based Collectors –Evacuated tube Collectors - Swimming pool absorbers.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Solar Thermal Systems (18 Hrs)
Solar water heating system - Active solar heating - Passive Solar heating- Solar Communities - Solar Thermal Energy Applications, Solar Space Heating and Cooling, Domestic water heating, Solar cooking.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Design of Industrial Solar Systems (18 Hrs)
Solar panel manufacturing technologies - Solar Panel Specifications (Mechanical and Electrical specifications - Solar thermal Heating as support heating – Economics – Ecology - Solar thermal Market - Outlook and Development potential.</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Garg, H.P. (2016). Solar energy: Fundamentals and applications. McGraw Hill.
Khan, B.H.(2017). Non- Conventional energy resource. McGraw Hill.
Kothari, D.P.(2014). Renewable energy resources and emerging technologies. PHI Learning.
Mukerjee, A.K.(2014). Photovoltaic systems: Analysis and design. PHI Learning.
Solanki,C.S.(2013).Solar photovoltaic technology and systems: a manual for technicians, trainers and engineers. PHI Learning Pvt. Ltd.
Sukhatme, S.P. (2015).Solar energy: Principles of thermal collection and storage. McGraw Hill.
Tester, J. W., Drake, E. M., Driscoll, M. J., Golay, M. W., & Peters, W. A. (2012). Sustainable energy: choosing among options. PHI Learning.
Twidell, J., & Weir, T. (2015). Renewable energy resources. Routledge.
Walker, A. (2014). Solar Energy: Technologies and project delivery for buildings. John Wiley & Sons.</td></tr>
</table>

Wang, Z., Roffey, A., Losantos, R., Lennartson, A., Jevric, M., Petersen, A. U., & Börjesson, K. (2019). Macroscopic heat release in a molecular solar thermal energy storage system. Energy & Environmental Science, 12(1), 187-193. Doi: 10.1039/c8ee01011k.	
Outcomes	➢ The students will be able to learn solar radiation on the earth surface, extraterrestrial radiation characteristics, terrestrial radiation, solar insolation and measurement of solar radiation. ➢ The students gain more knowledge about carnot cycle, supercritical rankine cycles, brayton cycle, stirling cycle, binary cycles and combined cycles. ➢ The students will be able to understand about solar collectors and swimming pool absorbers. ➢ The students will be comprehend about solar water heating system, solar space heating and cooling, domestic water heating and solar cooking. ➢ The students will gain noteworthy information about solar panel manufacturing technologies, economics, ecology, solar thermal market, outlook and development potential.

Name of the Course Teacher: Dr. S. Karuppuchamy

<table>
<tr><td colspan="4" align="center">Semester-III</td></tr>
<tr><td>Course Code : 540307</td><td>Energy practical- III</td><td>Credit: 4</td><td>Hours per week : 8</td></tr>
<tr><td colspan="4">List of Experiments:
1. Fabrication of dye-sensitized solar cells.
2. Synthesis of photo anode materials by Solution growth technique.
3. Fabrication of p-n hetrojuntion solar cells.
4. I-V characterization of dye-sensitized solar cells.
5. Performance evaluation of supercapacitors.
6. Performance test on solar flat plate collector.
7. Effect of temperature and light intensity on solar cell characteristics.
8. Charging characteristics of battery using PV panel.
9. Performance testing of solar PV cells.
10. Preparation of biodiesel-alkaline transesterification.
11. Preparation of energy audit plan and analyzing energy audit data.
12. Any other equivalent experiments.</td></tr>
</table>

Name of the Course Teacher: Dr. S. Karuppuchamy, Dr. C. Karthikeyan, Dr. A. Nithya

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<table>
<tr><td colspan="4" align="center">Semester - IV</td></tr>
<tr><td>Course Code: 540401</td><td>Course Name: Energy Audit and Management</td><td>Credits: 5</td><td>Hours per week : 5</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To provide the basic knowledge about energy audit, need of energy audit and management, general principles of energy management, energy management skills and energy management strategy.
➢ To understand methodology and approach, maximizing system efficiency, optimizing the input energy requirements, fuel and energy substitution.
➢ To create awareness about energy policy, role and responsibilities of energy manager, motivation of employees, requirements for energy action planning, information systems, marketing, training and planning.
➢ To educate first law of efficiency, second law of efficiency, materials and energy balance diagram, energy balance sheet and management information system.
➢ To know about instruments for energy audit and monitoring energy, energy savings, types and accuracy.</td></tr>
<tr><td>Unit – I</td><td colspan="3">General Aspects (18 Hrs)
General Philosophy and need of Energy Audit and Management - Definition and Objective of Energy Management - General Principles of Energy Management - Energy Management Skills - Energy Management Strategy.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Energy Audit (18 Hrs)
Energy Audit: Need – Types - Methodology and Approach - Energy Management Approach - Understanding Energy Costs - Bench marking - Energy performance - Matching energy usage to requirements - Maximizing system efficiency - Optimizing the input energy requirements - Fuel and Energy substitution.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Energy Policy Planning and Implementation (18 Hrs)
Energy Policy – Purpose – Perspective - Contents and Formulation - Format and Ratification - Organizing: Location of Energy Manager - Role and responsibilities of Energy Manager – Accountability - Motivating – Motivation of employees - Requirements for Energy Action Planning - Information Systems: Designing - Barriers, Strategies - Marketing and Communicating Training and Planning.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Energy Balance & MIS (18 Hrs)
First law of efficiency and Second law of efficiency - Facility as an Energy system - Methods for preparing process flow - Materials and Energy Balance diagram - Identification of losses – Improvements - Energy Balance sheet and Management Information System (MIS).</td></tr>
<tr><td>Unit – V</td><td colspan="3">Energy Audit Instruments (18 Hrs)
Instruments for Audit and Monitoring Energy and Energy Savings - Types and Accuracy.</td></tr>
</table>

Reference and Textbooks:

Akyuz, M. K., Altuntas, O., Sogut, M. Z., & Karakoc, T. H. (2019). *Energy Management at the Airports*. In Sustainable Aviation (pp. 9-36). Springer, Cham. Doi: 10.1007/978-3-030-14195-0.

Andrews, J., & Jelley, N. (2007). *Energy science: principles, technologies, and impacts*. Oxford University Press.

Awasthi, O.N. (2015). *Application of light and energy management*. Narosa.

Everett, R., Boyle, G., Peake, S., & Ramage, J. (2012). *Energy systems and sustainability: Power for a sustainable future*. Oxford University Press.

Fornasiero, P., & Graziani, M. (2012). *Renewable resources and renewable energy: a global challenge*. CRC press.

Kreith, F. (2008). *Energy management and conservation handbook*. CRC.

Murphy, W.R. (2014). *Energy management*. Elsevier.

Robert, H.M. (2007). *Handbook of energy conservation*. V.1. CBS. Singh, M.P. (2010). *Future energy sources*. Pearl Books. Tester, J. W., Drake, E. M., Driscoll, M. J., Golay, M. W., & Peters, W. A. (2012). *Sustainable energy: choosing among options*. PHI Learning.	
Outcomes	➢ The students will be able to know basic information about energy audit, general principles of energy management, energy management skills and energy management strategy. ➢ The students will be able to understand methodology and approach, maximizing system efficiency, optimizing the input energy requirements, fuel and energy substitution. ➢ The students will be able to aware about energy policy, role and responsibilities of energy manager, requirements for energy action planning, information systems, marketing, training and planning. ➢ The students will be able to know more knowledge about first law of efficiency, second law of efficiency, energy balance diagram, energy balance sheet and management information system. ➢ The students will be able to know about instruments for energy audit and monitoring energy, energy savings, types and accuracy.

Name of the Course Teacher: Dr. S. Karuppuchamy, Dr. C. Karthikeyan,

Semester- IV			
Course Code: **540999**	Course Name: **Project Work & Viva-Voce**	Credit: **8**	Hours per week : **16**

Name of the Course Teacher: Dr. S. Karuppuchamy

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Elective Courses

<table>
<tr><td colspan="4">Elective Course</td></tr>
<tr><td>Course Code: 540501</td><td>Course Name: Biochemistry for Energy Sciences</td><td>Credits: 4</td><td>Hours per week : 4</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand biological macromolecules, storage and transfer of biological information, biochemistry of water, water as the biological solvent, hydrogen bonding and solubility and buffer systems.
➢ To learn about amino acids and proteins, structural properties of proteins, studying protein structure and function.
➢ To understand about enzymes, kinetic properties of enzymes, substrate binding, mechanism of enzyme action and enzyme inhibition.
➢ To study about carbohydrates, reactions of monosaccharides, polysaccharides, glycoproteins, structure and biological function, fatty acids, polar and nonpolar lipids.
➢ To understand about biochemical conversion process, biogas production mechanism and technology, types of digesters, design of biogas plants, installation, operation and maintenance of biogas plants and biogas applications.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Biochemistry (14 Hrs)
An Introduction to Biochemistry: Roots of Biochemistry - All Living Matter Contains C,H,O,N,P and S, Biological Macromolecules – Organelles – Cells - and Organisms - Storage and Transfer of Biological Information - The Biochemistry of Water: Water as the Biological Solvent - Hydrogen Bonding and Solubility - Buffer Systems.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Amino Acids and Proteins (15 Hrs)
Amino Acids and Proteins: Amino Acids in Proteins - Polypeptides and Proteins - Protein Function - Structural Properties of Proteins - Studying Protein Structure and Function.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Enzymes (15 Hrs)
Introduction to Enzymes - Types of Enzymes - Enzymes as Biological Catalysts - Kinetic Properties of Enzymes - Substrate Binding and Mechanism of Enzyme Action - Enzyme Inhibition.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Carbohydrates (14 Hrs)
Carbohydrates: Chemical Structure and Biological Function – Monosaccharides - Carbohydrates in Cyclic Structures - Reactions of Monosaccharides – Polysaccharides – Glycoproteins - Structure and Biological Function: Fatty Acids - Polar and Nonpolar Lipids.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Biochemical conversion process (14 Hrs)
Biochemical conversion process: Anaerobic digestion – Biogas production mechanism and technology - Types of digesters - Design of biogas plants – Installation - Operation and maintenance of biogas plants - Biogas slurry utilization and management - Biogas applications.</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Babu, V., Thapliyal, A., & Patel, G. K. (2013). Biofuels production. John Wiley & Sons.
Bhatia, S.C. (2014). Advanced Renewable Energy Systems, Part –II. WPI Publishers.
Boyle, G. (2012). Renewable Energy: Power for a Sustainable Future. Oxford.
Gikonyo, B. (Ed.). (2014). Advances in biofuel production: algae and aquatic plants. CRC Press.
Kothari, D.P. (2014). Renewable Energy Resources. PHI Learning.
Lee, S., & Shah, Y. T. (2012). Biofuels and bioenergy: processes and technologies. CRC Press.
Math, M.C. (2019). Non-Conventional Energy Sources. Yes Dee Publishers.
Twidell, J., & Weir, T. (2015). Renewable energy resources. Routledge.</td></tr>
</table>

Zhou, X., Mandal, S., Jiang, S., Lin, S., Yang, J., Liu, Y., & Yan, H. (2019). *Efficient Long-range, Directional Energy Transfer through DNA-Templated Dye Aggregates*. Journal of the American Chemical Society. Doi: 10.1021/jacs.9b01548.	
Outcomes	➢ The students will be able to understand biological macromolecules, storage and transfer of biological information, biochemistry of water, water as the biological solvent, hydrogen bonding and solubility and buffer systems. ➢ The students will be able to know about amino acids and proteins, structural properties of proteins, studying protein structure and function. ➢ The students study more information about enzymes, kinetic properties of enzymes, substrate binding, mechanism of enzyme action and enzyme inhibition. ➢ The students will be able to learn about carbohydrates, reactions of monosaccharides, polysaccharides, glycoproteins, structure and biological function, fatty acids, polar and nonpolar lipids. ➢ The students will be able to learn about biochemical conversion process, biogas production mechanism and technology, installation, operation and maintenance of biogas plants and biogas applications.

Name of the Course Teacher: Dr. S. Karuppuchamy

Elective Course			
Course Code: **540502**	Course Name: **Advanced Nanomaterials and Their Applications**	Credits: **4**	Hours per week : **4**

Objectives	➢ To understand electrochemical deposition and microwave irradiation method for synthesis of nanoparticles and advantages of nano materials. ➢ To know more information about various methods for synthesis of nanowires, nanorods, nanoclusters, carbon nanotubes and nanocomposites. ➢ To comprehend on design factors for biomaterials, biopolymers and bioplastic. ➢ To acquire knowledge about diamagnetism, paramagnetism and ferrromagnetism. ➢ To understand anti-ferromagnetism, magnetic hysteresis, perovskite solar cells-advanced batteries , supercapacitor, designate solid oxide fuel cell and self-cleaning
Unit – I	**Synthesis of Nanomaterials** **(15 Hrs)** Preparation methods such as hydrothermal method - Precipitation method - Solvothermal method – Electrospinning - Electrochemical deposition and Microwave irradiation method for synthesis of nanoparticles - Advantages and disadvantages - Various methods for synthesis of nanowires – Nanorods - Nanoclusters - Carbon nanotubes – Nanocomposites - Polymeric nanoparticles and nanofibers.
Unit – II	**Hybrid Materials** **(15 Hrs)** Nanocomposites - Preparation of Metal - Metal oxide composites - Chemical structure and its properties - Metal oxide-polymer composite preparation – Chemical structure - Energy storage properties - CNT-Metal oxide composites preparation - Chemical structure - Thermal properties - Natural fiber composite – Properties and Applications of Hybrid materials.
Unit – III	**Biomaterials** **(14 Hrs)** Background of Biomaterials: Historical development of Biomaterials - Design factors for biomaterials - Implant materials - Biomaterials classifications – Bioinert - Bioactive and bioresorbable biomaterials – Biopolymers - Synthetic biodegradable polymer - Bioplastics.
Unit – IV	**Magnetic Materials** **(14 Hrs)** Introduction: Types of magnetic materials – Diamagnetism– Paramagnetism– Ferrromagnetism – Anti-ferromagnetism – Magnetic hysteresis – Soft and hard magnetic materials – Ferrimagnetic materials (Ferrite) – Applications of ferrites.
Unit – V	**Applications of Nanomaterials** **(14 Hrs)** Pharmaceutical Water purification - Dye sensitized solar cells - Perovskite solar cells - Electrochemical analysis - Advanced batteries – supercapacitors - Hybrid capacitors - Electrical devices - Magnetic devices – Sensors - Solid oxide fuel cell and Self-cleaning.

Reference and Textbooks:

Cheng, J. (Ed.). (2017). *Biomass to renewable energy processes*. CRC press.

Edminister, Joseph A. (2016). *Electromagnetics*. McGraw Hill.

Gogotsi, Y. (2012). *Nanomaterials handbook*. CRC.

He, J. (2016). *Nanomaterials in energy and environmental applications*. Pan Stanford.

Hosokawa, M. (2009). *Nanoparticle technology handbook*. Elsevier.

Hougen, O.A., Waston, K.M., Ragatz, R.A.(2004). *Chemical process principles. Part-1: Material and energy balances.* CBS.

Lee, S., & Shah, Y. T. (2012). *Biofuels and bioenergy: processes and technologies*. CRC Press.

Poole, Charles P. (2006). *Introduction to nanotechnology*. Wiley.

Qurashi, A. (Ed.). (2015). *Metal chalcogenide nanostructures for renewable energy applications*. John Wiley & Sons.

Upadhyaya G. S. & Anish, U. (2014). *Materials Science and Engineering*. Viva Books.
Wautelet, Michel. (2009). *Nanotechnologies*. IET.
Wolf, Edward L. (2013). *Nanophysics and nanotechnology: An introduction to modern concepts in Nanoscience.* Wiley.

Outcomes	➢ The students will be able to understand electrochemical deposition, synthesis of nanoparticles and advantages of nanomaterials. ➢ The students will be able to know more information about various methods for synthesis of nanomaterials. ➢ The students will learn design factors for biopolymers, bioplastic and biomaterials. ➢ The students gain more information about anti-ferromagnetism, perovskite solar cells, advanced batteries and super capacitors. ➢ The students acquire more information about various methods for synthesis nanomaterials.

Name of the Course Teacher: Dr. C. Karthikeyan

<table>
<tr><th colspan="4">Elective Course</th></tr>
<tr><td>Course Code: 540503</td><td>Course Name: Nuclear Energy</td><td>Credits: 4</td><td>Hours per week : 4</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand about the nuclear reactions, nuclear reactors, heat transfer techniques and reactor shielding.
➢ To educate nuclear fuel cycle, uranium production, purification, nuclear fuels like zirconium, thorium and beryllium.
➢ To understand nuclear fuel cycles, spent fuel characteristics, role of solvent extraction in reprocessing and solvent extraction equipment.
➢ To learn fuel element dissolution, precipitation process, ion exchange, redox, purex, refining, isotopes and principles of isotope separation.
➢ To understand more information about nuclear wastes, safety control -pollution control and abatement, international convention on safety aspects and radiation hazards prevention</td></tr>
<tr><td>Unit – I</td><td colspan="3">Nuclear Reactions (15 Hrs)
Mechanism of Nuclear Fission - Nuclides - Radioactivity – Decay Chains - Neutron Reactions - Fission Process - Reactors - Types of Fast Breeding Reactor - Design and Construction of Nuclear reactors - Heat Transfer Techniques in Nuclear Reactors - Reactor Shielding.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Reactor Materials (15 Hrs)
Nuclear Fuel Cycles - Characteristics of Nuclear Fuels - Uranium - Production and Purification of Uranium - Conversion to UF_4 and UF_6 - Other Fuels like Zirconium - Thorium - Berylium.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Reprocessing (14 Hrs)
Nuclear Fuel Cycles -Spent Fuel Characteristics - Role of solvent extraction in Reprocessing - Solvent Extraction Equipment.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Separation of Reactor Products (14 Hrs)
Processes to be Considered - 'Fuel Element' Dissolution - Precipitation Process – Ion Exchange - Redox - Purex - Chelation - U^{235} - Hexone - TBP and Thorax Processes - Oxidative Slagging and Electro - Refining - Isotopes - Principles of Isotope Separation.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Waste Disposal and Radiation Protection (14 Hrs)
Types of Nuclear wastes - Safety control -Pollution control and abatement- International convention on safety aspects - Radiation hazards prevention.</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Bhatia, S.C. (2014). Advanced Renewable Energy Systems, Part –II. WPI Publishers.
Boyle, G.(2012). Renewable Energy: Power for a Sustainable Future. Oxford.
Dresselhaus, M. S., & Thomas, I. L. (2001). Alternative energy technologies. Nature, 414(6861), 332. Doi: 10.1038/35104599.
Fonseca, J. D., Camargo, M., Commenge, J. M., Falk, L., & Gil, I. D. (2019). Trends in design of distributed energy systems using hydrogen as energy vector: A systematic literature review. International Journal of Hydrogen Energy, 44(19), 9486-9504. Doi: 10.1016/j.ijhydene.2018.09.177.
Kothari, D.P. (2014). Renewable Energy Resources. PHI Learning.
Math, M.C. (2019). Non-Conventional Energy Sources. Yes Dee Publishers.
Rai, G.D. (1998). Non Conventional Energy Sources. Khanna Publishers. Delhi.
Twidell, J., & Weir, T. (2015). Renewable energy resources. Routledge.</td></tr>
<tr><td>Outcomes</td><td colspan="3">➢ The students will be able to know about the nuclear reactions, nuclear reactors, heat transfer techniques and reactor shielding.
➢ The students gain noteworthy knowledge about nuclear fuel cycle, uranium production and purification, nuclear fuels like zirconium, thorium and beryllium.</td></tr>
</table>

	➢ The students will be able to acquire more information about nuclear fuel cycles, spent fuel characteristics, role of solvent extraction in reprocessing and solvent extraction equipment. ➢ The students gain more knowledge about fuel element dissolution, precipitation process, isotopes and principles of isotope separation. ➢ The students will be able to gain more knowledge about nuclear wastes, safety control, pollution control, international convention on safety aspects and radiation hazards prevention.

Name of the Course Teacher: Dr. S. Karuppuchamy

<table>
<tr><td colspan="4">Elective Course</td></tr>
<tr><td>Course Code: 540504</td><td>Course Name: Advanced Instrumental Methods of Analysis</td><td>Credits: 4</td><td>Hours per week : 4</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand various spectroscopic techniques like AAS, AFS, X-ray flurosence and X-ray absorption.
➢ To comprehend about principle and instrumentation of IR spectroscopy, Raman spectroscopy and applications of Raman spectroscopy.
➢ To know about electroanalytical techniques such as potentiometry, coulometry, voltammetric, cyclic voltammetry, and pulse voltammetry.
➢ To acquire more information about applications of voltammetry stripping methods and electrochemical impedance spectroscopy.
➢ To understand advanced characterization techniques like XRD, SEM, EDAX, and TEM and XPS.
➢ To understand about thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetric and micro thermal analysis.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Atomic spectroscopy (15 Hrs)
Optical atomic spectroscopy: Designs of Optical Instruments - Types of Optical Instruments - Principles of Fourier Transform Optical Measurements - Atomic absorption spectrometry - atomic fluorescence spectrometry - Atomic Absorption Instrumentation - Atomic Fluorescence Spectroscopy - X-ray Fluorescence Methods - X-ray Absorption Methods.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Molecular spectroscopy (15 Hrs)
Ultraviolet – Visible molecular absorption spectroscopy - Principle and instrumentation - Infra-red Absorption Spectroscopy - IR Instrumentation - IR Sources and Transducers - FTIR - Raman Spectroscopy - Applications of Raman Spectroscopy - SERS.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Electroanalytical chemistry (14 Hrs)
Electrochemical Cells Potentials - Currents in Electrochemical Cells - Types of Electroanalytical methods – Potentiometry – Principles - Metallic Indicator Electrodes -Membrane Indicator Electrodes.
Potentiometric Titrations - Coulometry – Current - Voltage Relationships during Electrolysis – Controlled - Potential Coulometry - Coulometric Titrations - Voltammetric Instrumentation - Cyclic Voltammetry - Pulse Voltammetry - Applications of Voltammetry Stripping Methods - Electrochemical impedance spectroscopy.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Advanced Characterization Techniques for Energy Materials (14 Hrs)
Principles and Applications of X-ray Photoelectron Spectroscopy (XPS) - Scanning Electron Microscopy (SEM) - Scanning Tunneling Microscopy (STM) - Atomic Force Microscopy (AFM) - Transmission Electron Microscopy (TEM) - X-ray diffraction (XRD) and Energy dispersive X-ray spectroscopy (EDAX).</td></tr>
<tr><td>Unit – V</td><td colspan="3">Thermal Analysis (14 Hrs)
Thermal Methods: Thermo gravimetric Analysis - Differential Thermal Analysis - Differential Scanning Calorimetry - Micro thermal Analysis.</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Ahuja, S. (2006). Comprehensive analytical chemistry. V.47: Modern instrumental analysis. Elsevier.
Aruldhas, G. (2014). Molecular structure and spectroscopy. PHI Learning.
Christian, G.D. (2004). Analytical chemistry. Wiley.
Mane, R. S., & Lokhande, C. D. (2003). HRTEM, SEM and XRD characterization of nanocrystalline Sb_2S_3 thin films deposited by chemical bath route. Surface and Coatings Technology, 172(1), 51-56. Doi: 10.1016/S0257-8972(03)00316-5.
Skoog, D. A., (2011). Fundamentals of analytical chemistry. Cengage.
Skoog, D. A., Holler, F. G., & Nieman, T. A. (2004). Principles of Instrumental Analysis, Thomson</td></tr>
</table>

Brooks/Cole Asia Pvt. Ltd., Singapore, 5, 4-7.

Willard, H.H. (2012). *Instrumental methods of analysis*. CBS.

Willard, M., Meritt, L. L., Dean, J. A., & Settle, F. A. (1986). *Instrumental methods of analysis*, CBS Publishers and Distributors. CBS Publishers, 580, 626.

Zou, Y., Meng, L. Y., Cui, M., Zhao, J., He, M., Kim, J., & Li, D. (2019). *Fast on-fiber derivatization and GC/MS analysis of phytohormones in wheat based on pencil-type coated carbon fibers.* Food chemistry, 274, 254-260. Doi: 10.1016/j.foodchem.2018.09.009.

Outcomes	➢ The students gain more knowledge about AAS, AFS, X-ray flurosence and X-ray absorption. ➢ The students will be able to understand about principle and instrumentation of IR spectroscopy, Raman spectroscopy and applications of Raman spectroscopy. ➢ The students will be gain more information about potentiometry, coulometry, voltammetric, cyclic voltammetry, and pulse voltammetry. ➢ The students will be able to acquire more information about applications of voltammetry stripping methods and electrochemical impedance spectroscopy. ➢ The students gain noteworthy knowledge about XRD, SEM, EDAX, and TEM and XPS. ➢ The students gain more knowledge about thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetric and micro thermal analysis.

Name of the Course Teacher: Dr. A. Nithya

Elective Course			
Course Code: **540505**	Course Name: **Biofuels**	Credits: **4**	Hours per week : **4**

Objectives	➢ To understand biomass resources, biomass assessment, biomass to biofuel and characteristics of biomass. ➢ To acquire various biofuels feedstocks such as sugar, pant oil, solid and animal waste. ➢ To study biofuel production, biorefinery and biochemical reactions. ➢ To understand ethanol production technology and feedstocks. ➢ To study biodiesel, feedstock, production process and catalyst in biodiesel production
Unit – I	**Biomass (15 Hrs)** Biomass resources: Classification and characteristics - Techniques for biomass assessment - Application of remote sensing in forest assessment - Biomass estimation - Biomass to biofuel - Source and classification of biofuels and their characteristics.
Unit – II	**Biofuel Feedstocks (15 Hrs)** Biofuel feedstocks – Starch - Cereal grains - Other grains - Tubers and roots - Sugar feedstocks - Sugarcane sugar beet – Lignocellulosic biomass feedstocks - Forest products and residues - Agricultural residues - Agricultural processing bioproducts - Dedicated energy crops - Plant oils and animal fats - Miscellaneous feedstocks - Animal waste - Municipal solid waste.
Unit – III	**Biorefinery (14 Hrs)** Biorefinery - Biofuel production and use - Harvesting Energy from Biochemical Reaction - Biochemical Pathways - Review for Organo- Heterotrophic metabolism - Aerobic respiration - Anaerobic respiration – Fermentation - Overview for Lithotrophic growth - Overview for Phototrophic metabolism - Light reactions - Anabolic dark reactions.
Unit – IV	**Ethanol Production (14 Hrs)** Ethanol production - Ethanol production from sugar and starch feedstocks - Micro-Organisms - Process technology - Ethanol production from Lignocellulosic feedstocks: The sugar platform - The syngas platform.
Unit – V	**Biodiesel Production (14 Hrs)** Introduction to biodiesel production process - Transesterification – Esterification – Lipase -Catalyzed inter - Esterification and Transesterification - Base or alkali catalysis - Acid catalysis - Enzyme catalysis - Oil sources and production - Plant oils - Microbial and algal oils - Used cooking oils - Straight vegetable oil.

Reference and Textbooks:

Ahluwalia, V.K. (2013). *Green chemistry: A text book*. Narosa.

Arvind, N.S. (2013). *Industrial bioprocess technology*. DPH.

Babu, V., Thapliyal, A., & Patel, G. K. (2014). *Biofuels production*. John Wiley & Sons.

Ballesteros, M., & Manzanares, P. (2019). *Liquid Biofuels. In The Role of Bioenergy in the Bioeconomy* (pp. 113-144). Academic Press. Doi: 10.1016/B978-0-12-813056-8.00003-0.

Barampouti, E. M., Mai, S., Malamis, D., Moustakas, K., & Loizidou, M. (2019). *Liquid biofuels from the organic fraction of municipal solid waste: A review.* Renewable and Sustainable Energy Reviews, 110, 298-314. Doi: 10.1016/j.rser.2019.04.005.

Cheng, J. (2016). *Biomass to renewable energy processes*. CRC.

Ferreira, G. (Ed.). (2013). *Alternative energies: updates on progress* (Vol. 34). Springer Science & Business Media.

Gikonyo, B. (Ed.). (2013). *Advances in biofuel production: algae and aquatic plants*. CRC Press.

Lee Sunggyu. (2012). *Biofuels and Bioenergy: Process and Technologies*. CRC.

Math, M.C. (2019).*Non-Conventional Energy Sources.* Yes Dee Publishers.

<table>
<tr><td colspan="2">
Quaschning, V. (2016). Understanding renewable energy systems. Routledge.
Quaschning, V. V. (2019). Renewable energy and climate change. Wiley.
Sodhi, G.S. (2013). Fundamental concepts of environmental chemistry. Narosa.
Sorensen, B. (2017). Renewable energy, 5th Edition. Academic Press.
</td></tr>
<tr><td>Outcomes</td><td>
➢ The students will be able to understand biomass resources, biomass assessment, biomass to biofuel and characteristics of biomass.
➢ The students acquire more information about various biofuels feedstocks such as sugar, pant oil, solid and animal waste.
➢ The students will be able understand biofuel production, biorefinery and biochemical reactions.
➢ The students will be able to understand more knowledge about ethanol production technology and feedstocks.
➢ The students will be able to study biodiesel, feedstock, production process and catalyst in biodiesel production
</td></tr>
</table>

Name of the Course Teacher: Dr. C. Karthikeyan

<table>
<tr><td colspan="4" align="center">Elective Course</td></tr>
<tr><td>Course Code: 540506</td><td>Course Name: Polymer Science and Technology</td><td>Credits: 4</td><td>Hours per week : 4</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand basic concept of polymer chemistry, polymerization, raw materials and kinetics of polymerization reactions.
➢ To learn more information about property and structure of polymers, polymer testing and analysis of polymer,
➢ To study product design, applications, characterization and fabrications of polymers.
➢ To understand polymer materials, biodegradable, conducting, magnetic polymers and non-linear optical polymers.
➢ To identify various applications of polymers in energy devices, thermoxidative degradation, toxicity, effluent disposal and feedstock scarcity.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Basic Concepts of Polymer Chemistry (14 Hrs)
Basic Materials Science: Basic concepts - Polymer raw materials - Polymerization principles and processes (step, chain and other polymerizations - Polymer kinetics - Polymerization techniques)</td></tr>
<tr><td>Unit – II</td><td colspan="3">Polymer Production (14 Hrs)
Polymer manufacture (Unit operations - Polymer reactors - Polymer isolation - Handling and storage) - Polymer structure and property - Polymer testing (sample preparation - Testing standards and methods - Polymer and additives analysis) - Polymer product design - Polymer applications.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Characterization of Polymers (14 Hrs)
Polymer characterization: Polymer modification - Multicomponent polymeric materials (Polymer miscibility - Polymer blends and alloys - Filled plastics - Polymer composites) - Polymer compounding and fabrication (Polymer additives - Compounding processes - Fabrication techniques - Post fabrication operations).</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Types of Polymers (15 Hrs)
Frontiers of polymer materials: Biodegradable polymers - Biomedical polymers - Conducting polymers - Magnetic polymers - Polymers for space - Nonlinear optical polymers.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Application of polymers inenergy devices (15 Hrs)
Application of polymers in energy devices - Problems of polymer (Thermoxidative degradation - Fire hazards – Toxicity - Effluent disposal - Feedstock scarcity).</td></tr>
</table>

Reference and Textbooks:

Buitrón, G., Muñoz-Páez, K. M., & Hernández-Mendoza, C. E. (2019). *Biohydrogen production using a granular sludge membrane bioreactor*. Fuel, 241, 954-961.doi: 10.1016/j.fuel.2018.12.104.

Charles E. Carraher. (2005). *Polymer chemistry*. Marcel Dekker.

Ferry, M.H. (2004). *Handbook of polymer science and technology, Volume. 2: Polymer, rheology, properties, applications, testing and recycling of polymers*. CBS.

Giddey, S., Badwal, S. P., & Ju, H. (2019). *Polymer electrolyte membrane technologies integrated with renewable energy for hydrogen production*. In Current Trends and Future Developments on (Bio-) Membranes (pp. 235-259). Elsevier. doi: 10.1016/B978-0-12-813545-7.00010-6.

Jain, Jain. M. (2016). *Engineering Chemistry*. Dhanpat Rai.

Misra, G.S. (2010). *Introductory polymer chemistry*. New Age international.

Moawia, R. M., Nasef, M. M., Mohamed, N. H., Ripin, A., & Zakeri, M. (2019). *Biopolymer catalyst for biodiesel production by functionalisation of radiation grafted flax fibres with diethylamine under optimised conditions*. Radiation Physics and Chemistry, 108375. doi: 10.1016/j.radphyschem.2019.108375.

Mohan kumar, H. (2017). *Advanced polymer chemistry*. Centrum Press.

Okan, M., Aydin, H. M., & Barsbay, M. (2019). *Current approaches to waste polymer utilization and minimization: A review.* Journal of Chemical Technology & Biotechnology, 94(1), 8-21. doi:

10.1002/jctb.5778. Rudnik, E. (2013). *Compostable polymer materials*. Elsevier	
Outcomes	➢ The students gain more information about polymer chemistry, polymerization principles and processes, types of polymerization and polymer kinetics. ➢ The students will be able to know about fabrication, structure, testing, and property of polymers, polymer product design and applications of polymers. ➢ The students acquire more knowledge about characterization of polymers, compounding of polymers and post fabrication operations. ➢ The students will be able to attain more information about polymer materials, biodegradable polymers, conducting polymers and nonlinear optical polymers. ➢ The students will be able to understand application of polymer in energy device and problems of polymers.

Name of the Course Teacher: Dr. A. Nithya

<table>
<tr><td colspan="4">Elective Course</td></tr>
<tr><td>Course Code: 540507</td><td>Course Name: Climate Change and CO_2 Emission Assessment</td><td>Credits: 4</td><td>Hours per week : 4</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand the important contemporary topics in the field of environmental science especially in the area of climate change.
➢ To learn about the overview of energy sources and technologies and social and economic implications of energy uses.
➢ To understand about the mechanism of greenhouse gases emission and international concern on climate change and mitigation efforts.
➢ To acquire advanced knowledge about carbon dioxide emission and conversion/consumption.
➢ To understand about carbon credit and mitigation techniques.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Introduction to Energy (14 Hrs)
Introduction to Energy: Overview of energy sources and technologies - Energy consumption pattern - Social and economic implications of energy uses - Equity and disparity.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Introduction to Global Climate Change (14 Hrs)
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.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Carbon dioxide (CO_2) Emissions and Conversion/Consumption (14 Hrs)
Carbon dioxide (CO_2) emissions in relation to energy conversion/consumption: Theory of CO_2 emission in relation to energy conversion processes - Fundamental concept on combustion - Practical examples and comparison of (i) Different technologies and (ii) Different resources used for energy conversion in relation to CO_2 emission - Role of technology upgradation and alternative resources on reduction of CO_2 emission.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Methodology for CO_2 Assessment/Carbon foot print (15 Hrs)
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) - Case examples for each sector.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Carbon Credit (15 Hrs)
Carbon Credit: Definition - Concept and examples - Carbon credit - National policies visàvis International market scenario - Current efforts and future prospect-Limitation of carbon trading mechanism.</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Basile, A., & Nunes, S. P. (Eds.). (2011). Advanced membrane science and technology for sustainable energy and environmental applications. Woodhead.
Boyle, G.(2012). Renewable energy: Power for a sustainable future. Oxford.
Everett, R., Boyle, G., Peake, S., & Ramage, J. (2012). Energy systems and sustainability: Power for a sustainable future. Oxford University Press.
Jayaprakash, R. (2015). Engineering chemistry. CBS.
Math, M.C. (2019). Non-Conventional Energy Sources. Yes Dee Publishers.
Quaschning, V. V. (2010). Renewable energy and climate change. Wiley.
Singh, M.P. (2010). Future energy sources. Pearl Books.</td></tr>
<tr><td>Outcomes</td><td colspan="3">➢ The students will be able to know important contemporary topics in the field of environmental science especially in the area of climate change.
➢ The students gain more knowledge about overview of energy sources and technologies and social and economic implications of energy uses.
➢ The students will be able to understand mechanism of greenhouse gases emission and international concern on climate change and mitigation efforts.</td></tr>
</table>

	➢ The students gain noteworthy knowledge about carbon dioxide emission and conversion/consumption. ➢ The students will be able to acquire more information about carbon credit and mitigation techniques.

Name of the Course Teacher: Dr. C. Karthikeyan

NON MAJOR ELECTIVE COURSE (For other Departments)

<table>
<tr><td>Course Code: 540701</td><td>Course Name: Basic Concepts in Energy Sciences</td><td>Credits: 2</td><td>Hours per week : 3</td></tr>
<tr><td>Objectives</td><td colspan="3">➢ To understand energy resources, conventional and non-conventional energy resources, energy needs.
➢ To knowledgeable on solar energy conversion, solar concentrator and other applications, solar photovoltaic, fabrication and types of solar cells.
➢ To acquire about wind energy conversion, wind farms in India, advantagesand disadvantages of wind energy conversions.
➢ To know about origins, uses of biomass energy, sources and characteristics of biofuels like biodiesel, bioethanol and biogas.
➢ To understand geothermal energy, applications of geothermal energy, tidal power plant and limitations of tidal power generation.</td></tr>
<tr><td>Unit – I</td><td colspan="3">Energy Sources (10 Hrs)
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.</td></tr>
<tr><td>Unit – II</td><td colspan="3">Solar Energy (11 Hrs)
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.</td></tr>
<tr><td>Unit – III</td><td colspan="3">Wind Energy (11 Hrs)
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.</td></tr>
<tr><td>Unit – IV</td><td colspan="3">Bioenergy (11 Hrs)
Biomass as energy resources - Classification and estimation of biomass - Source and characteristics of biofuels – Biodiesel – Bioethanol – Biogas - Waste to energy conversions.</td></tr>
<tr><td>Unit – V</td><td colspan="3">Geothermal energy (11 Hrs)
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.</td></tr>
<tr><td colspan="4">Reference and Textbooks:
Babu, V., Thapliyal, A., & Patel, G. K. (2014). Biofuels production. John Wiley & Sons.
Bhatia, S.C. (2014). Advanced Renewable Energy Systems, Part –II, WPI Publishers.
Boyle, G.(2012). Renewable Energy: Power for a Sustainable Future. Oxford.
Burton Tony. (2011).Wind energy handbook. Wiley.
Gikonyo, B. (Ed.). (2014). Advances in biofuel production: algae and aquatic plants. CRC Press.
Jayarama Reddy, P. (2012). Solar power generation: Technology, new concepts and policy.CRC Publishers.
Kothari, D.P. (2014). Renewable Energy Resources. PHI Learning.
Lee Sunggyu. (2012). Biofuels and Bioenergy: Process and Technologies. CRC.
Math, M.C. (2019). Non-Conventional Energy Sources. Yes Dee Publishers.
Rai, G.D. (1998).Non Conventional Energy Sources. Khanna Publishers.
Rivkin, D. A., & Silk, L. (2013). Wind Energy. Jones & Bartlett Publishers.
Rosen, M. A., & Koohi-Fayegh, S.(2017). Geothermal Energy. Wiley.
Sukhatme, S.P. (1984).Solar Energy: principles of Thermal Collection and Storage. Tata McGraw-</td></tr>
</table>

Hill. Twidell, J., & Weir, T. (2015). *Renewable energy resources*. Routledge.	
Outcomes	➢ The students will be able to understand energy resources, conventional and non-conventional energy resources, energy needs. ➢ The students gain more information about solar energy conversion, solar concentrator and other applications, solar photovoltaic, fabrication and types of solar cells. ➢ The students will be able to acquire about wind energy conversion, wind farms in India, advantages and disadvantages of wind energyconversions. ➢ The students know about origins, uses of biomass energy, sources and characteristics of biofuels like biodiesel, bioethanol andbiogas. ➢ The students will be able to understand about geothermal energy, applications of geothermal energy, tidal power plant and limitations of tidal power generation.

Name of the Course Teacher: Dr. S. Karuppuchamy

Course Code: **540702**	Course Name: **Renewable Energy and Energy Storage Systems**	Credits: **2**	Hours per week : **3**

Objectives	To understand world energy use, energy scenario in India, potentials and applications. To acquire various energy storage and conversion systems. To know about energy system, time variable, PV power production, wind power production, food production and biofuels production. To learn more information about geothermal sources, materials selection and applications of geothermal energy. To understand more knowledge about hydrogen storage, utilization, safety management and hydrogen technology in India.
Unit – I	**Introduction (10 Hrs)** World energy use – Reserves of energy resources – Environmental aspects of energy utilization – Renewable energy scenario in India – Potentials – Achievements – Applications.
Unit – II	**Energy Storage and Conversion Systems (11 Hrs)** Introduction – Storage of mechanical energy - Electrical energy - Chemical energy - Thermal energy - Electrochemical energy (Batteries and supercapacitors) Basics – Working - Advantages and drawbacks – Types – Comparative analysis – Thermodynamics and kinetics of fuel cell process – Performance of fuel cell – Applications.
Unit – III	**Energy Supply Systems (11 Hrs)** Energy systems – Stimulation of system performance – Treatment of time variable – Load structure - Photovoltaic power production – Wind power production – Food production – Biofuels production.
Unit – IV	**Geothermal Energy (11 Hrs)** 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.
Unit – V	**Hydrogen Energy (11 Hrs)** Introduction – Hydrogen Production- Hydrogen storage – Hydrogen Transportation - Utilization of Hydrogen Gas – Hydrogen as an Alternative Fuel for Motor Vehicles – Safety and management – Hydrogen Technology Development in India.

Reference and Textbooks:

Abdin, Z., & Khalilpour, K. R. (2019). *Single and Polystorage Technologies for Renewable-Based Hybrid Energy Systems. In Polygeneration with Polystorage for Chemical and Energy Hubs* (pp. 77-131). Academic Press. Doi: 10.1016/B978-0-12-813306-4.00004-5.

Bhatia, S.C. (2014). *Advanced Renewable Energy Systems*, Part –II. WPI Publishers.

Boukortt, N., Patanè, S., & Hadri, B. (2019). *Development of High-Efficiency PERC Solar Cells Using Atlas Silvaco.* Silicon, 11(1), 145-152. Doi: 10.1007/s12633-018-9838-8.

Boyle, G.(2012). *Renewable Energy: Power for a Sustainable Future*. Oxford.

Ferreira, G. (Ed.). (2013). *Alternative energies: updates on progress*. Springer Science & Business Media.

Kothari, D.P. (2014).*Renewable Energy Resources*. PHI Learning.

Rai, G.D. (1998). *Non Conventional Energy Sources*. Khanna Publishers.

Twidell, J. (2015). *Renewable Energy Resources*. Routleadge Publishers.

Outcomes	The students will be able to gain more information about world energy use, energy scenario in India, potentials and applications. The students gain more information about various energy storage and conversion systems. The students will be able to acquire about energy system, time variable, PV power

	production, wind power production, food production and biofuels production. The students gain more information about learn more information about geothermal sources, materials selection and applications of geothermal energy. The students will be able to know more knowledge about hydrogen storage, utilization, safety management and hydrogen technology in India.

Name of the Course Teacher: Dr. S. Karuppuchamy, Dr. C. Karthikeyan, Dr. A.Nithya

<table>
<tr><td colspan="2">Course Code: 540703</td><td>Course Name: Energy Conversion and Conservation Techniques</td><td>Credits: 2</td><td>Hours per week : 3</td></tr>
<tr><td>Objectives</td><td colspan="4">➢ To understand more information about solar and wind energy conversion.
➢ To acquire wave energy conversion and pneumatic converters.
➢ To understand conversion of fuel and biological materials, Fuel production from biomass, generation of liquid biofuels and other conversion process
➢ To understand energy conservation, conventional technique, reversible and irreversible cycles, carnot, stirling and rankine cycle.
➢ To acquire economic concept of energy, principles of energy conversion, energy conservation technologies, combined cycle power generation, stirling engine, instrumentation and control.</td></tr>
<tr><td>Unit – I</td><td colspan="4">Conversion of Solar and Wind Energy (10 Hrs)
Heat generation - Application for cooling – Pumping – Solar electricity generation - Conversion of wind flow – Propeller type converters – Cross wind converters – Augmenters and other converters – Heat – Electrical - Mechanical power and fuel generation – Commercial wind power development.</td></tr>
<tr><td>Unit – II</td><td colspan="4">Conversion of Wave Energy (11 Hrs)
Pneumatic converters – Oscillating wave converter – Conversation of water flows – Elevated water – Conversation heat.</td></tr>
<tr><td>Unit – III</td><td colspan="4">Conversion of Fuels and Biological Materials (11 Hrs)
Fuel cell Technologies – Conversion of biological material - Heat production from biomass – Fuel production from biomass – Overview and Generation of Gaseous fuels – Generation of Liquid Biofuels – Other Conversion process – Conversion of Salinity Gradient Resources.</td></tr>
<tr><td>Unit – IV</td><td colspan="4">Basics of Energy Conservation (11 Hrs)
Energy Conservation - Conventional Technique – Reversible and Irreversible cycles – Carnot - Stirling and Rankine cycle.</td></tr>
<tr><td>Unit – V</td><td colspan="4">Introduction to Energy Conservation (11 Hrs)
Economic Concept of Energy – Principles of Energy Conversion – Energy Conservation Approach/ technologies – Co-generation – Waste Heat utilization – Combined Cycle Power Generation – Heat Recuperators – Heat Regenerators – Heat Pipes - Heat pumps – Stirling Engine – Instrumentation and Control.</td></tr>
<tr><td colspan="5">Reference and Textbooks:
Arvind N. Shukla. (2013).Industrial bioprocess technology. DPH.
Kadambi, V. (2010). An introduction to energy conversation. Volume. 2: Energy conversion cycles. New Age international.
McCormick, M. E. (2007). Ocean Wave Energy Conversion.Dover Publication Inc.
Oakey, J. (Ed.). (2015). Fuel flexible energy generation: Solid, liquid and gaseous fuels. Woodhead Publishing.
Oyedepo, S. O. (2019). Energy Use and Energy Saving Potentials in Food Processing and Packaging: Case Study of Nigerian Industries. In Bottled and Packaged Water (pp. 423-452). Woodhead Publishing. Doi: 10.1016/B978-0-12-815272-0.00015-5.
Quaschning, V. V. (2019). Renewable energy and climate change. Wiley.
Sorensen, B. (2015). Renewable energy: Physics, engineering, environmental impacts, economics & planning. Elsevier.</td></tr>
<tr><td>Outcomes</td><td colspan="4">➢ The students will be able to understand more information about solar and wind energy conversion.
➢ The students will be able to gain more information about wave energy conversion and pneumatic converters.
➢ The students will be able to understand about conversion of fuel and biological materials, Fuel production from biomass, generation of liquid biofuels and other conversion process
➢ The students gain more knowledge about energy conservation, conventional technique, reversible and irreversible cycles, carnot, stirling and rankine cycle.</td></tr>
</table>

	➢ The students will be able to acquire more information about economic concept of energy, principles of energy conversion, energy conservation technologies, combined cycle power generation, stirling engine, instrumentation and control.

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Educational qualification:

- Ph.D., Uppsala University, 1993.
- Post-doctoral fellow, EPFL, Lausanne, Switzerland, 1993 to 1994.
- M.S., Physics and Chemistry, Uppsala University, 1989.

Professional experience:

- Visiting Professor, Institute of Materials Research and Engineering, Singapore, 2008.
- Professor chair in Physical Chemistry, Uppsala University, 2007.
- Visiting Professor, Dalian University of Technology, Dalian, China, 2006.
- Visiting Professor, Royal Institute of Technology, Stockholm, Sweden, 2005.
- Professor in Chemical Physics, Uppsala University, 2004.
- Associate Professor, Uppsala University, 2000 to 2004.

Honours and Awards:

- The Norblad-Ekstrand medal from The Swedish Chemical Society, Stockholm, 2009
- The Thuréus award from Royal Society of Sciences, Uppsala, 2008.
- The chemistry student's IUPAK award for best teacher, Uppsala, 1999
- The Benzelius award from Royal Society of Sciences,Uppsala, 1995

Recent publications:

- Buene, A. F., Hagfeldt, A., & Hoff, B. H. (2019). A comprehensive experimental study of five fundamental phenothiazine geometries increasing the diversity of the phenothiazine dye class for dye-sensitized solar cells. Dyes and Pigments, 169, 66-72.
- Tress, W., Domanski, K., Carlsen, B., Agarwalla, A., Alharbi, E. A., Graetzel, M., & Hagfeldt, A. (2019). Performance of perovskite solar cells under simulated temperature-illumination real-world operating conditions. Nature Energy,1.
- Sivakumar, G., Bertoni, A. H., Kim, H. S., Marchezi, P. E., Bernardo, D. R., Hagfeldt, A. & Nogueira, A. F. (2019). Design, synthesis and characterization of 1, 8-naphthalimide based fullerene derivative as electron transport material for inverted perovskite solar cells. Synthetic Metals, 249, 25-30.

Total Citation: 79515
h- index: 129
i10- index: 439

CURRICULUM VITAE

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Educational qualification:

- Ph.D, Materials Engineering, Gifu University, Gifu, Japan, 2002.
- M.Sc., Chemistry, Madurai Kamaraj University, Madurai, India, 1996.
- B.Sc., Chemistry, Madurai Kamaraj University, Madurai, India, 1994.

Professional experience:

- Professor & Head, Alagappa University, Karaikudi, India, 5th March 2016 to till date.
- Associate Professor & Head, Alagappa University, Karaikudi, India, 4th March 2013 to 4th March 2016.
- Associate Professor, Kongu Engineering College, Erode, India, 01st July 2012 to 03rd March 2013.
- Senior Researcher, Kyushu Institute of Technology, Japan, 01st April 2011 to 30th June 2012.
- Scientific Advisor, TSM Co.Ltd, South Korea, 01st April 2009 to 30th March 2011
- Senior Scientist, Yokohama Rubber Co. Ltd, Japan, 01st Dec. 2006 to 31st March 2009.

Honours and Awards:

- Tamil Nadu Scientists Award (TANSA) award from Government of Tamilnadu, India, 2017.
- Alagappa Excellence Award for Research, Alagappa University, Karaikudi, India, 2016-2017.
- Best Researcher Award, EET CRS-17, India, 2017
- Young Scientist award, Department of Science and Technology, Government of India, 2013.
- Leading scientists of the World 2013, Int. Biographical Centre, Cambridge, UK, 2013.

Recent publications:

- Karuppuchamy, S., Murugadoss, G., Ramachandran, K., Saxena, V., & Thangamuthu, R. (2018). Inorganic based hole transport materials for perovskite solar cells. Journal of Materials Science: Materials in Electronics, 29(10), 8847-8853.
- Selvamurugan, M., Natarajan, C., Andou, Y., & Karuppuchamy, S. (2018). Synthesis and characterization of lithium titanate ($Li_4Ti_5O_{12}$) nanopowder for battery applications. Journal of Materials Science: Materials in Electronics, 29(20), 17826-17833.
- Kumar, R. D., Andou, Y., & Karuppuchamy, S. (2017). Facile synthesis of Co–WO 3/functionalized carbon nanotube nanocomposites for supercapacitor applications. Journal of Materials Science: Materials in Electronics, 28(7), 5425-5434.
- Brundha, C., Govindaraj, R., Santhosh, N., Pandian, M. S., Ramasamy, P., & Karuppuchamy, S. (2017). Preparation of one dimensional titanium dioxide nanowires using electrospinning process for dye-sensitized solar cells. Journal of Materials Science: Materials in Electronics, 28(15), 11509-11514.

Total Citation: 2157
h- index: 30
i10- index: 53

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Educational qualification:

- Ph.D., Chemistry– Polymers, Anna University, India, 2005.
- M.Phil. Chemistry, University of Madras, India, 2001.
- M.Sc., Chemistry, Govt. Arts and Science College, Coimbatore, India,2000.
- B.Sc., Chemistry, Kandasamy Kandar College, Velur, India, 1998.

Professional experience:

- Professor, Bharathiar University, Coimbatore, India, from 25.11.2016 to till date.
- Associate Professor, VIT University, Vellore, India, from Sep. 2013 to Nov.2016 .
- Assistant Professor (Senior), VIT University, Vellore, India Jul. 2009 to Aug. 2013.
- Contract Professor, Pusan National University, Korea, Mar 2008 to Feb 2009.
- Post Doctoral Fellow, Pusan National University, Korea, Sep 2006 to Feb 2008.
- Post Doctoral Fellow, Gyeongsang National University, Korea, Nov 2005 to Sep 2006.

Honours and Awards:

- Research Awards, VIT University, 2015.
- Research Awards for project, VIT University, 2015.
- CSIR Senior Research Fellowship, Anna University, India, 2002.

Recent publications:

- Ramki, K., Venkatesh, N., Sathiyan, G., Thangamuthu, R., & Sakthivel, P. (2019). A comprehensive review on the reasons behind low power conversion efficiency of dibenzo derivatives based donors in bulk heterojunction organic solar cells. Organic Electronics.
- Ramki, K., Venkatesh, N., Sathiyan, G., Thangamuthu, R., & Sakthivel, P. (2019). A comprehensive review on the reasons behind low power conversion efficiency of dibenzo derivatives based donors in bulk heterojunction organic solar cells. Organic Electronics.
- Ganesamoorthy, R., Vijayaraghavan, R., Ramki, K., & Sakthivel, P. (2018). Synthesis, characterization of bay-substituted perylene diimide based DAD type small molecules and their applications as a non-fullerene electron acceptor in polymer solar cells. Journal of Science: Advanced Materials and Devices, 3(1), 99-106.

Cumulative Impact factor: 102.169
Total Citation: 603
h- index: 14
i10- index: 17

CURRICULUM VITAE

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Educational qualification:

- **Ph.D., Physical Chemistry – Electrochemistry, University of Madras, 2002.**
- **M.Phil., Chemistry, University of Madras, 1994.**
- **B.Ed., Physical Sciences, Annamalai University, 1991.**
- **M.Sc., Physical Chemistry, University of Madras, 1990.**
- B.Sc., Chemistry University of Madras, 1987.

Professional experience:

- Principal Scientist, Materials Electrochemistry Division, Central Electrochemical Research Institute, Karaikudi, India,14th December 2009 to till date.

Honours and Awards:

- Post Doctoral Fellow, Dept. of Chemical Engineering and Biotechnology, National Taipei University of Technology, Taipei, Taiwan, 11th August 2006 to 2nd December 2009.
- Post Doctoral Fellow, Dept. of Chemical Engineering, National Taiwan University of Science & Technology, Taipei, Taiwan, 1st August 2005 to 10th August 2006.
- Post Doctoral Fellow, Dept. of Chemical Engineering, National Yunlin University of Science & Technology, Taiwan, 13th September 2002 to 31th July 2005
- Post Doctoral Fellow, Centre for Energy Research (CER), SPIC Science Foundation (SSF), Guindy, Chennai-600 032, India, 19th April 2001 to 26th August 2002.

Recent publications:

- Selvakumar, K., Ulaganathan, M., Senthil Kumar, S. M., Thangamuthu, R., Periasamy, P., & Ragupathy, P. (2019). Electrospun Carbon Nanofiber Sprinkled with Co_3O_4 as an Efficient Electrocatalyst for Oxygen Reduction Reaction in Alkaline Medium. ChemistrySelect, 4(17), 5160-5167.
- Murugadoss, G., Thangamuthu, R., Kumar, S. M. S., Anandhan, N., Kumar, M. R., & Rathishkumar, A. (2019). Synthesis of ligand-free, large scale with high quality all-inorganic $CsPbI_3$ and $CsPb_2Br_5$ nanocrystals and fabrication of all-inorganic perovskite solar cells. Journal of Alloys and Compounds, 787, 17-26.
- Duraisamy, V., Palanivel, S., Thangamuthu, R., & Kumar, S.M.S. (2018). KIT−6 Three Dimensional Template Derived Mesoporous Carbon for Oxygen Reduction Reaction: Effect of Template Removal on Catalytic Activity. ChemistrySelect, 3(42), 11864-11874.

Total Citation: 2150
h- index: 25
i10- index: 50

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Educational qualification:

- Ph.D., Chemistry,National Tsing Hua University,Taiwan, 2005.
- M.Sc.,Organic Chemistry, Madras University,India, 2001.
- B.Sc., Chemistry, St. Joseph's College, Madras University,India, 1998.

Professional experience:

- Associate professor, Indian Institute of Technology Madras, Chennai, India, October 2016 to till date.
- Associate professor, Indian Institute of Science Education and Research Pune (IISER Pune), India, April 2016 to September 2016.
- Assistant professor, Indian Institute of Science Education and Research Pune (IISER Pune), India, November 2010 to March 2016.
- Postdoctoral researcher, Alexander von Humboldt fellowship, Prof. Paul Knochel's group, Ludwig-Maximilians-Universität, Germany, November 2009 to Oct 2010,
- Postdoctoral researcher, National Science Council fellowship (NSC), Prof. Chien-Hong Cheng's group, National Tsing Hua University, Taiwan, August 2005 to July 2009.

Honours and Awards:

- ISCB Award of Appreciation for Chemical Science, CSIR-CDRI Lucknow, 2014.
- Alkyl Amines – ICT Young Scientist Award by Institute of Chemical Technology Mumbai, India, 2013.
- Science Academy Medal for Young Scientists, Indian National Science Academy, New Delhi, India, 2013.
- Science Academy Medal for a young associate, Indian Academy of Sciences, Bangalore, India, 2012 – 2015.

Recent publications:

- Manoharan, R.; Jeganmohan, M. "Alkylation, Annulation and Alkenylation of Organic Molecules with Maleimides via Transition-Metal-Catalyzed C−H Bond Activation" Asian J. Org. Chem, 2019, DOI:10.1002/ajoc.201900054.
- Ramesh, B., Tamizmani, M., & Jeganmohan, M. (2019). Rhodium (III)-Catalyzed Redox-Neutral 1, 1-Cyclization of N-Methoxy Benzamides with Maleimides via C–H/N–H/N–O Activation: Detailed Mechanistic Investigation. The Journal of organic chemistry, 84(7), 4058-4071.
- Sihag, P., & Jeganmohan, M. (2019). Regioselective Synthesis of Isocoumarins via Iridium (III)-Catalyzed Oxidative Cyclization of Aromatic Acids with Propargyl Alcohols. The Journal of organic chemistry, 84(5), 2699-2712.

Total Citation: 3719
h- index: 38