ALAGAPPA UNIVERSITY

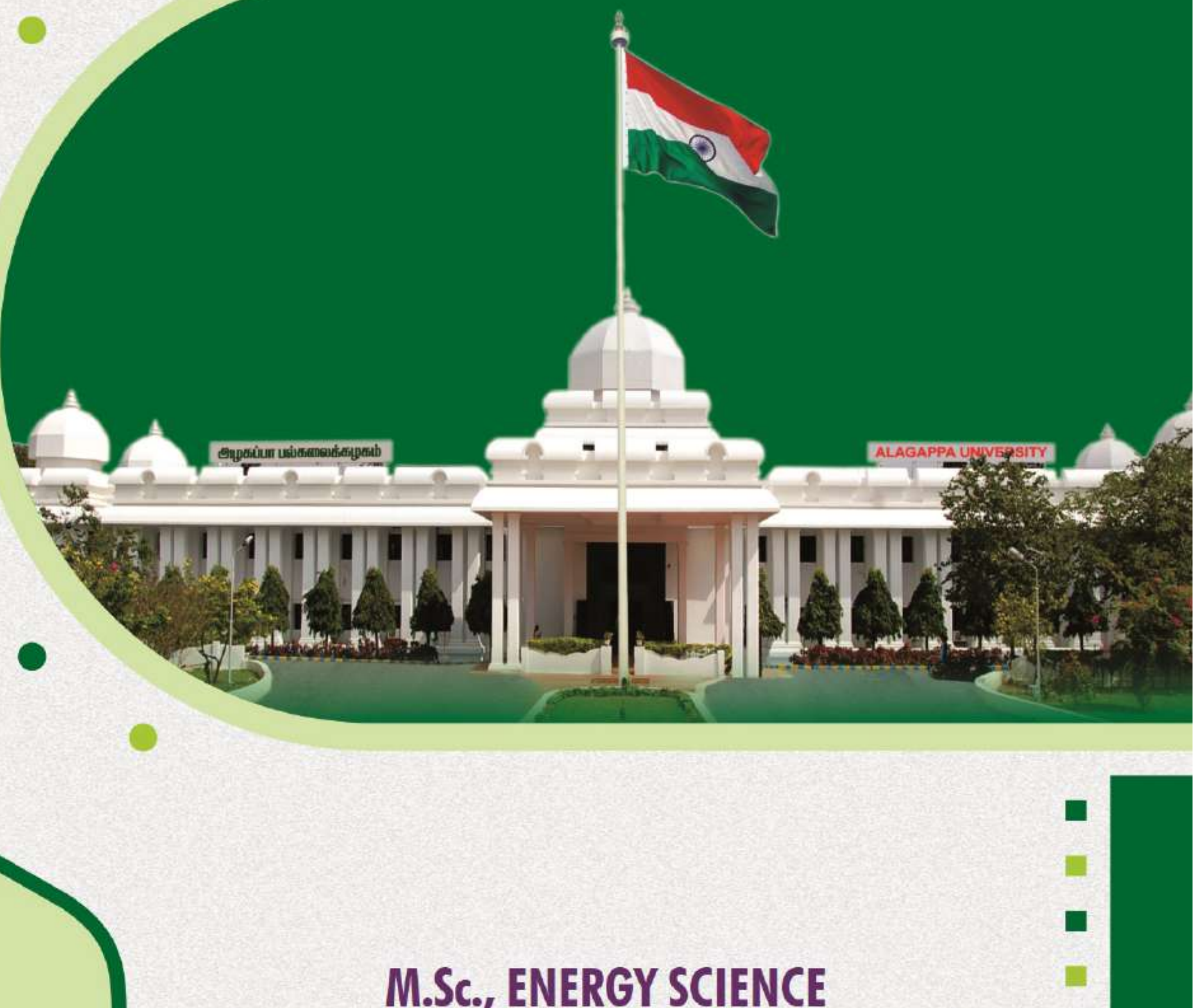
(A State University Established in 1985)

Karaikudi - 630003. Tamil Nadu, India

2017 Accredited with A+ Grade by NAAC (CGPA: 3.64) | 2018 MHRD Granted as Category - I Graded Autonomy | 2018 MHRD Swachh Campus Rank : 4 | 2021 nirf Rank : 33 | 2021 QS University Rankings Asia Rank : 199

FACULTY OF SCIENCE

DEPARTMENT OF ENERGY SCIENCE



M.Sc., ENERGY SCIENCE

REGULATIONS AND SYLLABUS

(For the candidates admitted from the Academic Year 2022 - 2023)

DEPARTMENT OF ENERGY SCIENCE
M.Sc., Energy Science

REGULATIONS AND SYLLABUS
[For the candidates admitted from the Academic Year 2022 – 2023 onwards]

ALAGAPPA UNIVERSITY
(A State University Accredited with "A+" grade by NAAC (CGPA: 3.64) in the Third Cycle andGraded as Category-I University by MHRD-UGC)
Karaikudi -630003, Tamil Nadu.

The panel of Members-Broad Based Board of Studies

Chairperson: Dr. S. Karuppuchamy, D.Sc., Professor and Head, Department of Energy Science, Alagappa University, Karaikudi. Teaching Experience: 23 years, Research Experience: 26 years, Area of Research: Nanotechnology, Renewable Energy (Solar and Bio Energy), Energy Storage Materials, Electrochemistry and Environmental Science.	
Foreign Expert: Dr. M. Wakisaka, Professor, Department of Biochemical Engineering and Science, Kyushu Institute of Technology, Japan. Teaching Experience: 20 years, Research Experience: 22 years, Area of Research: Marine Biomass, Food Engineering, Biochemical Engineering, Environmental Engineering.	
Indian Expert: Dr. P. Sakthivel, Professor, Department of Nanoscience and Technology, Bharathiar University, Coimbatore. Teaching Experience: 14 years, Research Experience: 17 years, Area of Research: Nanomaterials, Nanocomposite and Porous Carbon materials, Capacitive Deionization, Organic Solar Photovoltaic Cells, Synthetic Organic Chemistry, Polymer Synthesis and Characterization, Organic Light Emitting Diodes, Supercapacitor.	
Indian Expert: Dr. R. Thangamuthu, Senior Principal Scientist, Electrochemical Materials Science Division, Central Electrochemical Research Institute (CECRI), Karaikudi. Research Experience: 20 years, Area of Research: Dye Sensitized Solar cells, Electrode Kinetics, Electrocatalysis, Chemically Modified Electrodes for Sensor Applications, Materials Science, Proton Exchange Membrane Fuel Cells.	
Indian Expert: Dr. K. Jothivenkatachalam, Professor and Head, Department of Chemistry, BIT Campus, Anna University, Tiruchirappalli. Teaching Experience: 20 years, Research Experience: 23 years, Area of Research: Photochemistry of Coordination compounds, Photocatalysis, Photoelectrochemistry, Materials Synthesis for Energy Conversion and Environmental Applications.	
Indian Expert: Dr. R. Karvembu, Professor, Department of Chemistry, National Institute of Technology, Tiruchirappalli. Teaching Experience: 20 years, Research Experience: 23 years, Area of Research: Coordination Chemistry, Organometallic Chemistry, Catalysis, Bioinorganic Chemistry.	
Industry Expert: Mr. Rahuvamshi Rao, CEO, Elixir Technologies, Bangalore. Research Experience: 25 years, Area of Research: Dye Sensitized Solar Cells, Perovskite Solar Cells.	
Alumnus/Alumna: Mr. V. Arjun, Research Scholar, Department of Energy Science, Alagappa University, Karaikudi. Area of Research: Perovskite Solar Cells.	

ALAGAPPA UNIVERSITY
DEPARTMENT OF ENERGY SCIENCE
Karaikudi -630003, Tamil Nadu.

REGULATIONS AND SYLLABUS-(CBCS-University Department)
[For the candidates admitted from the Academic Year 2022–2023 onwards]

Name of the Department	:	Energy Science
Name of the Programme	:	M.Sc., Energy Science
Duration of the Programme	:	Full Time (Two Years)

Name of the Programme

The programme is named as **Master of Science (M.Sc.) in Energy Science**. The syllabus for this programme is framed under the rules of the Choice Based Credit System (CBCS) 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.

Semesters

An Academic year is divided into two **Semesters**. In each semester, courses are offered in 15 teaching weeks and the remaining 5 weeks are to be utilized for conduct of examination and valuation purposes. Each week has 30 working hours spread over 5 days a week.

Medium of Instruction

The medium of instruction is English.

Departmental Committee

The Departmental Committee consists of the faculty of the Department. The Departmental Committee shall be responsible for admission to all the programmes offered by the Department including the conduct of entrance tests, verification of records, admission, and evaluation. The Departmental Committee determines the deliberation of courses and specifies the allocation of credits semester-wise and course-wise. For each course, it will also identify the number of credits for lectures, tutorials, practicals, seminars etc. The courses (Core/Discipline Specific Elective/Non-Major Elective) are designed by teachers and approved by the Departmental Committees. Courses approved by the Departmental Committees shall be approved by the Board of Studies/Broad Based Board of Studies. A teacher offering a course will also be responsible for maintaining attendance and performance sheets (CIA-I, CIA-II, assignments and seminar) of all the students registered for the course. The Non-Major elective programme, MOOCs coordinator and Internship Mentor are responsible for submitting the performance sheet to the Head of the department. The Head of the Department consolidates all such performance sheets of courses pertaining to the programmes offered by the department. Then forward the same to be Controller of Examinations.

Programme Educational Objectives (PEOs)

PEO1	To mould students to excel in the workplace, higher education, research, and all aspects of science and technology.
PEO2	To impart the essential background knowledge related to energy science by providing a solid foundation in physics, chemistry and materials science.
PEO3	To equip students with a broad understanding of energy science concepts in order to develop new solutions that will benefit society.
PEO4	To prepare the students with the multifaceted skills required for advanced research, employment and successful entrepreneurship with a strong ethical foundation.
PEO5	To provide a better learning environment with state-of-art facilities that inspire and nurture the students to grow into successful professionals in the real world.
PEO6	To impart theoretical and practical knowledge in energy science concepts.
PEO7	To prepare the students to perform higher order skills and knowledge in higher studies, and the workplace.
PEO8	To equip students to understand the value of energy resources in order to proper utilization of resources.
PEO9	To impart the recent developments in the scientific domain, particularly in the field of energy and environment.
PE10	To prepare the students to contribute to the building of a nation and the development of the world.

Programme Specific Objectives (PSOs)

PSO1	To understand the fundamental scientific knowledge to solve problems associated with energy and the environment.
PSO2	To develop an appropriate methodology, and approach related to Energy Science.
PSO3	To develop problem-solving abilities to resolve real-world problems.
PSO4	To understand the noteworthy knowledge related to energy science for entrepreneurship, research, and placement.
PSO5	To apply fundamental knowledge of physics, chemistry and materials science concepts in the energy sector and other related disciplines.

Programme Outcomes (POs)

POs	Graduate Attributes	Programme Outcome
PO1	Scientific knowledge	Apply the knowledge of physics, chemistry and materials science.
PO2	Design/development of solutions	Design and develop appropriate solutions/processes for the advancement of the energy sector and other related disciplines.
PO3	Problem analysis	Identify, articulate, analyze and solve the issues related to energy and environment.
PO4	Modern tools usage	Understand and apply various tools and techniques for the fabrication and analysis of materials.
PO5	Contribution to society	Analyze and address societal challenges associated with energy and the environment.
PO6	Ethics	Understand and apply ethical principles, and responsibility for better academic, research, and placement practices.
PO7	Communication	Communicate and discuss effectively about diverse science concepts/ innovations. Write effective reports, design documentation, and deliver presentations.
PO8	Sustainability	Understand and analyze real-time issues and apply the knowledge/skills for sustainable development.
PO9	Life-long learning	Identify and update the necessary scientific knowledge and skills to engage in the challenging scientific world.
PO10	Career Progression	Develop knowledge and skills in Energy Science concepts for higher studies, competitive exams, employment and entrepreneurship.

Programme Specific Outcomes -(PSOs)

PSO1	Understand, analyze and apply fundamental knowledge of physics, chemistry and materials science concepts in the energy sector and other related disciplines.
PSO2	Analyze, design, and develop a system, methodology, and approach regarding Energy Science.
PSO3	Understand and analyze real-world problems associated with Energy and Environment. Develop problem-solving abilities to resolve real-world problems.
PSO4	Understand the noteworthy knowledge related to energy science for research, placement and entrepreneurship.
PSO5	Understand and apply relevant knowledge, skills, principles and fundamental concepts of Energy Science and other related fields.

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, Applied Physics, Electronics, Nuclear Physics, Biophysics, Industrial Chemistry, Polymer Chemistry, Applied Chemistry, Biotechnology, Biochemistry and Biological Sciences (Botany, Zoology and Microbiology), B.Voc., Degree in Renewable Energy 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.

Minimum Duration of 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 June/July to October/November and even semesters shall be from November/December to April/May. Each semester there shall be 90 working days consisting of 6 teaching hours per working day (5 days/week).

Components

A PG programme consists of a number of courses. The term "course" is applied to indicate a logical part of the subject matter of the programme and is invariably equivalent to the subject matter of a "paper" in the conventional sense. The following are the various categories of the courses suggested for the PG programmes:

a. **Core Courses (CC)-** "Core Papers" means "the Core Courses" related to the programme concerned including practicals and project work offered under the programme and shall cover core competency, critical thinking, analytical reasoning, and research skill.

b. **Discipline-Specific Electives (DSE)** means the courses offered under the programme related to the major but are to be selected by the students, shall cover additional academic knowledge, critical thinking, and analytical reasoning.

c. **Non-Major Electives (NME)** - Exposure beyond the discipline
   i. Students have to undergo a total of two Non-Major Elective courses with 2 credits offered by other departments (one in II Semester and another in III Semester).
   ii. A uniform time frame of 3 hours on a common day (Tuesday) shall be allocated for the Non-Major Electives.

iii. Non-Major Elective courses offered by the departments pertaining to a semester should be announced before the end of previous semester.
iv. Registration process: Students have to register for the Non-Major Elective course within 15 days from the commencement of the semester either in the department or NME portal (University website).

d. Self-Learning Courses from MOOCs platforms.

i. MOOCs shall be on voluntary for the students.
ii. Students have to undergo a total of 2 Self Learning Courses (MOOCs) one in II semester and another in III semester.
iii. The actual credits earned through MOOCs shall be transferred to the credit plan of programmes as extra credits. Otherwise, 2 credits/course be given if the Self Learning Course (MOOCs) is without credit.
iv. While selecting the MOOCs, preference shall be given to the course related to employability skills.

e. Project/Dissertation (Maximum Marks: 200**)**

The student shall undertake the dissertation work during the fourth semester.

Project/Dissertation

The candidate shall undergo Project/Dissertation Work during the final semester. The candidate should prepare a scheme of work for the project/dissertation and should get approval from the guide. The candidate, after completing the project/dissertation, shall be allowed to submit it to the university departments at the end of the final semester. If the candidate is desirous of availing the facility from other departments/universities/laboratories/organizations they will be permitted only after getting approval from the guide and HOD. In such a case, the candidate shall acknowledge the same in their dissertation.

- **No. of copies of the project/dissertation report**

  The candidate should prepare three copies of the project/dissertation report and submit the same for the evaluation of examiners. After evaluation, one copy will be retained in the department library, one copy will be retained by the guide and the student shall hold one copy.

- **Format to be followed for project/dissertation report**

  The format/certificate for thesis to be followed by the student are given below

  - Title page
  - Certificate
  - Acknowledgment
  - Content as follows:

Chapter No.	Title	Page No.
1	Introduction	
2	Aim and objectives	
3	Review of Literature	
4	Materials and Methods	
5	Results	
6	Discussion	
7	Summary and Conclusion	
8	References	

- **Format of the title page**

Title of Project/Dissertation work

Project/Dissertation submitted in partial fulfilment of the requirement
for the degree of Master of Science to the Alagappa University,
Karaikudi -630003.

By

(Student Name)

(Register Number)

University Logo

Department of Energy Science

Alagappa University

(A State University Accredited with "A+" grade by NAAC (CGPA: 3.64) in the Third Cycle and Graded as Category-I University by MHRD-UGC, 2019: QS ASIA Rank- 216, QS BRICS Rank-104, QS India Rank-20)

Karaikudi - 630003

(Year)

- **Format of certificates**

Certificate (Guide)

This is to certify that the **Dissertation** entitled "---" submitted to Alagappa University, Karaikudi-630 003 in partial fulfilment for the degree of Master of Science in ----------- by Mr/Miss ---------------------(Reg. No.) under my supervision. This is based on the results of studies carried out by him/her in the Department of Energy Science, Alagappa University, Karaikudi-630 003. This dissertation/Project or any part of this work has not been submitted elsewhere for any other degree, diploma, fellowship, or any other similar titles or record of any University or Institution.

Place: Karaikudi   Research Supervisor

Date:___

Certificate (HOD)

This is to certify that the thesis entitled "--" submitted by Mr/Miss -----------------(Reg No: --------------) to the Alagappa University, in partial fulfilment for the award of the degree of Master of Science in Energy Science is a bonafide record of research work done under the supervision of Dr.------------------, Assistant Professor, Department of Energy Science, Alagappa University. This is to further certify that the thesis or any part thereof has not formed the basis of the award to the student of any degree, diploma, fellowship, or any other similar title of any University or Institution.

Head of the Department

Place: Karaikudi

Date:_____

Declaration (Student)

I hereby declare that the thesis entitled "--- submitted to the Alagappa University for the award of the degree of Master of Science in Energy Science has been carried out by me under the guidance of Dr. **-----------------**, Assistant Professor, Department of Energy Science, Alagappa University, Karaikudi – 630 003. This is my original and independent work and has not previously formed the basis of the award of any degree, diploma, associateship, fellowship, or any other similar title of any University or Institution.

Place: Karaikudi

Date: ________

Teaching Methods

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.

Attendance

Students must have earned 75 % of attendance in each course for appearing for the examination. Students who have earned 74 % to 70 % of attendance need to apply for condonation in the prescribed form with the prescribed fee. Students who have earned 69 % to 60 % of attendance need to apply for condonation in the prescribed form with the prescribed fee along with the Medical Certificate. Students who have below 60 % of attendance are not eligible to appear for the End Semester Examination (ESE). They shall re-do the semester(s) after completion of the programme.

Examinations

The examinations shall be conducted separately for theory and practicals to assess (remembering, understanding, applying, analyzing, evaluating, and creating) the knowledge required during the study. There shall be two systems of examinations viz., internal and external examinations. The internal examinations shall be conducted as Continuous Internal Assessment tests I and II (CIA Test I & II).

f. Internal Assessment

The internal assessment shall comprise a maximum of 25 marks for each subject. The following procedure shall be followed for awarding internal marks.

Theory-25 marks

Sr.No	Content	Marks
1	Average marks of two CIA test	15
2	Seminar/group discussion/quiz	5
3	Assignment/field trip report/case study report	5
	Total	**25**

Practical-25 Marks

1	Major Experiment	10 marks
2	Minor Experiment	5 marks
3	Spotter (2x 5/ 4 x4) or any other mode	10 marks
	Total	**25 Marks**

Project/Dissertation-50 Marks (assess by Guide/Incharge/HOD/Supervisor)

1	Two presentations (mid-term)	30 Marks
2	Progress report	20 Marks
	Total	**50 Marks**

g. External Examination

- 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.
- 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.
- 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 programme.

- For the Project Report/Dissertation Work the maximum marks will be 100 marks for project report evaluation and for the Viva-Voce it is 50 marks (if in some programmes, if the project is equivalent to more than one course, the project marks would be in proportion to the number of equivalent courses).
- Viva-Voce: Each candidate shall be required to appear for Viva-Voce Examination (in defense of the Dissertation Work/Project).

h. Scheme of External Examination (Question Paper Pattern)

Theory - Maximum 75 Marks

Section A	10 questions. All questions carry equal marks. (Objective type questions)	10 x 1 = 10 Marks	10 questions – 2 each from every unit
Section B	5 questions Either/Or type like 1.a (or) b. All questions carry equal marks.	5 x 5 = 25 Marks	5 questions – 1 each from every unit
Section C	5 questions Either/Or type like 1.a (or)b. All questions carry equal marks	5 x 8 = 40 Marks	5 question –1 each from every unit

Practical –Maximum 75 Marks

Section A	Major experiment	15 Marks
Section B	Minor experiment	10 Marks
Section C	Experimental setup	5 Marks
Section D	Spotters (5 x 5 marks)	25 Marks
Section E	Record note	10 Marks
Section F	Viva-voce	10 Marks

Dissertation /Project report/Internship report Scheme of evaluation

Dissertation /Project report/Internship report	100 Marks
Viva-voce	50 Marks

Results

The results of all the examinations will be published through the Department where the student underwent the course as well as through University Website.

Passing Minimum

- A candidate shall be declared to have passed in each course if he/she secures not less than 40% marks in the End Semester Examinations and 40 % marks in the Internal Assessment and not less than 50 % in the aggregate, taking Continuous Assessment and End Semester Examinations marks together.
- The candidates not obtained 50 % in the Internal Assessment are permitted to improve their Internal Assessment marks in the subsequent semesters (2 chances will be given) by writing the CIA tests and by submitting assignments.
- Candidates, who have secured the pass marks in the End Semester Examination and in the CIA but failed to secure the aggregate minimum pass mark (E.S.E + C.I.A), are permitted to improve their Internal Assessment mark in the following semester and/or in University examinations.
- A candidate shall be declared to have passed in the Project/Dissertation/Internship if he/she gets not less than 40 % in each of the Project/Dissertation Report and Viva-Voce and not less than 50 % in the aggregate of both the marks for Project Report and Viva-Voce.
- A candidate who gets less than 50 % in the Project/Dissertation Report must resubmit the thesis. Such candidates need to take again the Viva-Voce on the resubmitted Project report.

Grading of the Courses

The following table gives the marks, Grade points, Letter Grades and classifications meant to indicate the overall academic performance of the candidate.

Conversion of Marks to Grade Points and Letter Grade (Performance in Paper / Course)

RANGE OF MARKS	GRADE POINTS	LETTER GRADE	DESCRIPTION
90 - 100	**9.0 – 10.0**	**O**	**Outstanding**
80 - 89	**8.0 – 8.9**	**D+**	**Excellent**
75 - 79	**7.5 – 7.9**	**D**	**Distinction**
70 - 74	**7.0 – 7.4**	**A+**	**Very Good**
60 - 69	**6.0 – 6.9**	**A**	**Good**
50 - 59	**5.0 – 5.9**	**B**	**Average**
00 - 49	**0.0**	**U**	**Re-appear**
ABSENT	**0.0**	**AAA**	**ABSENT**

a) Successful candidates passing the examinations and earning GPA between 9.0 and 10.0 and marks from 90 – 100 shall be declared to have Outstanding (O).

b) Successful candidates passing the examinations and earning GPA between 8.0 and 8.9 and marks from 80 - 89 shall be declared to have Excellent (D+).

c) Successful candidates passing the examinations and earning GPA between 7.5 – 7.9 and marks from 75 - 79 shall be declared to have Distinction (D).

d) Successful candidates passing the examinations and earning GPA between 7.0 – 7.4 and marks from 70 - 74 shall be declared to have Very Good (A+).

e) Successful candidates passing the examinations and earning GPA between 6.0 – 6.9 and marks from 60 - 69 shall be declared to have Good (A).

f) Successful candidates passing the examinations and earning GPA between 5.0 – 5.9 and marks from 50 - 59 shall be declared to have Average (B).

g) Candidates earning GPA between 0.0 and marks from 00 - 49 shall be declared to have Re-appear (U).

h) Absence from an examination shall not be taken as an attempt.

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

GRADE POINT AVERAGE (GPA) = $\Sigma_i C_i \; G_i / \Sigma_i C_i$

$$\text{GPA} = \frac{\text{Sum of the multiplication of Grade Points by the credits of the courses}}{\text{Sum of the credits of the courses in a Semester}}$$

Classification of the final result

CGPA	Grade	Classification of Final Result
9.5 – 10.0 9.0 and above but below 9.5	**O+** **O**	First Class – Exemplary*
8.5 and above but below 9.0 8.0 and above but below 8.5 7.5 and above but below 8.0	**D++** **D+** **D**	First Class with Distinction*
7.0 and above but below 7.5 6.5 and above but below 7.0 6.0 and above but below 6.5	**A++** **A+** **A**	First Class
5.5 and above but below 6.0 5.0 and above but below 5.5	**B+** **B**	Second Class
0.0 and above but below 5.0	**U**	Re-appear

The final result of the candidate shall be based only on the CGPA earned by the candidate.

a) Successful candidates passing the examinations and earning CGPA between 9.5 and 10.0 shall be given Letter Grade (O+), those who earned CGPA between 9.0 and 9.4 shall be given Letter Grade (O) and declared to have First Class –Exemplary*.

b) Successful candidates passing the examinations and earning CGPA between 7.5 and 7.9 shall be given Letter Grade (D), those who earned CGPA between 8.0 and 8.4 shall be given Letter Grade (D+), those who earned CGPA between 8.5 and 8.9 shall be given Letter Grade (D++) and declared to have First Class with Distinction*.

c) Successful candidates passing the examinations and earning CGPA between 6.0 and 6.4 shall be given Letter Grade (A), those who earned CGPA between 6.5 and 6.9 shall be given Letter Grade (A+), those who earned CGPA between 7.0 and 7.4 shall be given Letter Grade (A++) and declared to have First Class.

d) Successful candidates passing the examinations and earning CGPA between 5.0 and 5.4 shall be given Letter Grade (B), those who earned CGPA between 5.5 and 5.9 shall be given Letter Grade (B+) and declared to have passed in Second Class.

i) Candidates those who earned CGPA between 0.0 and 4.9 shall be given Letter Grade (U) and declared to have Re-appear.

e) Absence from an examination shall not be taken as an attempt.

CUMULATIVE GRADE POINT AVERAGE (CGPA) = $\Sigma_n \Sigma_i C_{ni} \; G_{ni} / \Sigma_n \Sigma_i C_{ni}$

$$CGPA = \frac{\text{Sum of the multiplication of Grade Points by the credits of the entire Programme}}{\text{Sum of the credits of the courses for the entire Programme}}$$

Where '**Ci**' is the Credit earned for Course i in any semester; '**Gi**' is the Grade Point obtained by the student for Course i and 'n' refers to the semester in which such courses were credited.

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

Note: * The candidates who have passed in the first appearance and within the prescribed Semesters of the PG Programme are alone eligible for this classification.

Maximum Duration of the Completion of the Programme

The maximum period for completion of **M.Sc.** in Energy Science shall not exceed four semesters continuing from the first semester.

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 (i.e. 90 credits).

Village Extension Programme

The Sivaganga and Ramnad districts are very backward districts where a majority of people Lives in poverty. The rural mass is economically and educationally backward. Thus the aim of the introduction of this Village Extension Programme is to extend out to reach environmental awareness, social activities, hygiene, and health to the rural people of this region. The students in their third semester have to visit any one of the adopted villages within the jurisdiction of Alagappa University and can arrange various programs to educate the rural mass in the following areas for three day based on the theme.1. Environmental awareness 2. Hygiene and Health. A minimum of two faculty members can accompany the students and guide them.

M.Sc. ENERGY SCIENCE –PROGRAMME STRUCTURE

S. No	Course Code	Core	Course Title	T/P	Credits	Hours/ Weeks	Marks		
	I Semester						**I**	**E**	**Total**
1	540101	Core	Basic Energy Sciences	T	5	5	25	75	100
2	540102	Core	Chemistry for Energy Sciences	T	5	5	25	75	100
3	540103	Core	Physics for Energy Sciences	T	4	4	25	75	100
4	540104	Core	Polymer Science and Technology	T	4	4	25	75	100
5	540107	Core	Energy Practical-I	P	4	8	25	75	100
6		DSE	DSE*-1	T	4	4	25	75	100
			Total		**26**	**30**	**150**	**450**	**600**
	II Semester								
7	540201	Core	Environmental Science	T	5	5	25	75	100
8	540202	Core	Solar Thermal Energy	T	5	5	25	75	100
9	540203	Core	Hydrogen Energy Systems	T	5	5	25	75	100
10	540207	Core	Energy Practical-II	P	4	8	25	75	100
11		DSE	DSE*2	T	4	4	25	75	100
12		NME	Non-Major Elective **	T	2	3	25	75	100
13			Self-learning course (SLC) – MOOCs***		Extra credit				
			Total		**25 +E.C**	**30**	**150**	**450**	**600**
	III Semester								
14	540301	Core	Photovoltaics	T	5	5	25	75	100
15	540302	Core	Energy Storage Systems	T	5	5	25	75	100
16	540303	Core	Advanced Instrumental Methods of Analysis	T	5	5	25	75	100
17	540307	Core	Energy Practical-III	P	4	8	25	75	100
18		DSE	DSE*3	T	4	4	25	75	100
19		NME	Non-Major Elective **	T	2	3	25	75	100
20			Self-learning course (SLC) – MOOCs***		Extra credit				
			Total		**25 +E.C**	**30**	**150**	**450**	**600**
	IV Semester								
21	540999	Core	****Dissertation Work		14	30	50	150	200
			Total		**14**	**30**	**50**	**150**	**200**
GRAND TOTAL					**90 +E.C**	**120**	**500**	**1500**	**2000**

DSE – Student Choice and it may be conducted by parallel sections.
** NME – Students have to select courses offered by other (Faculty) departments.
***SLC – Voluntary basis
*** Dissertation report – Marks – Viva-voce (50) + thesis (100) + internal (50) = 200
T – Theory, P – Practical

DISCIPLINE SPECIFIC ELECTIVES COURSES (DSE)

Course Code	Course Title	Credits	Hours /Week	Marks		
				I	E	Total
540501	Biofuels	4	4	25	75	100
540502	Wind and Hydro Energy	4	4	25	75	100
540503	Advanced Nanomaterials and Their Applications	4	4	25	75	100
540504	Nuclear Energy	4	4	25	75	100
540505	Climate Change	4	4	25	75	100
540506	Energy Audit and Management	4	4	25	75	100
540507	Research Methodology	4	4	25	75	100

NON-MAJOR ELECTIVE COURSES (for Other Departments)

Course Code	Course Title	Credits	Hours/ Week	Marks		
				I	E	Total
540701	Basic Concepts in Energy Sciences	2	3	25	75	100
540702	Renewable Energy and Energy Storage Systems	2	3	25	75	100
540703	Energy Conversion and Conservation Techniques	2	3	25	75	100

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

CORE COURSES

<table>
<tr><td colspan="6" align="center">Semester –I</td></tr>
<tr><td>Core</td><td>Course Code: 540101</td><td>Basic Energy Sciences</td><td>T</td><td>Credits: 5</td><td>Hours: 5</td></tr>
</table>

<table>
<tr><td colspan="3" align="center">Unit-I</td></tr>
<tr><td>Objective 1</td><td colspan="2">To study the contemporary topics in energy resources, conventional and non-conventional energy resources and energy needs.</td></tr>
<tr><td colspan="3">Energy Resources (18 Hrs)
Introduction – 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>Outcome 1</td><td>The students will be able to compare the strength and limitations of conventional and non-conventional energy sources.</td><td>K4</td></tr>
<tr><td colspan="3" align="center">Unit-II</td></tr>
<tr><td>Objective 2</td><td colspan="2">To understand solar energy conversion, solar concentrators, solar photovoltaic and types of solar cells.</td></tr>
<tr><td colspan="3">Solar Energy (18 Hrs)
Introduction – Radiations, measurements and prediction – Flat plate collectors - Solar concentrators – Solar thermal energy conversions systems – India's solar energy potential and challenges.
Solar Photovoltaics: Principle of photovoltaic conversion of solar energy – Types of solar cells: Silicon Solar cells – Thin Film Solar Cells - Organic Solar cells – Dye Sensitized Solar Cells – Perovskite solar cells.</td></tr>
<tr><td>Outcome 2</td><td>The students will gain working of solar cells and their applications</td><td>K2</td></tr>
<tr><td colspan="3" align="center">Unit-III</td></tr>
<tr><td>Objective 3</td><td colspan="2">To be knowledgeable on wind and hydro energy conversion, wind farms and hydropower stations in India, advantages and disadvantages of wind and hydro energy conversions.</td></tr>
<tr><td colspan="3">Wind and Hydro Energy (18 Hrs)
Wind Energy: Introduction – Wind power – Wind energy from wind – Wind resources – Criteria for selecting site for a wind farm – Technologies for wind energy conversion – Storage of wind energy – Developments of wind farms – Location of the wind farms in India.
Hydro Energy: Hydrology – Potential of hydropower in India – Classification of Hydropower plants – Small hydropower systems.</td></tr>
<tr><td>Outcome 3</td><td>The students will understand hydro and wind energy conversions.</td><td>K2</td></tr>
<tr><td colspan="3" align="center">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="2">To study biomass energy, biofuels like biodiesel, bioethanol and biogas.</td></tr>
<tr><td colspan="3">Bioenergy (18 Hrs)
Introduction – Biomass as energy resources – Origin 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>Outcome 4</td><td>The students will apply this knowledge to the synthesis of biofuel particularly, biodiesel.</td><td>K6</td></tr>
<tr><td colspan="3" align="center">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="2">To acquire more knowledge about geothermal energy and tidal power plant.</td></tr>
<tr><td colspan="3">Geothermal and Tidal energy (18 Hrs)
Geothermal Energy: Introduction – Geothermal resources – Geothermal energy in India – Advantages and disadvantages of geothermal energy over other energy forms – Applications of geothermal energy.
Tidal energy: Introduction - Main types – Tidal power plant – Advantages and limitations of tidal power generation.</td></tr>
<tr><td>Outcome 5</td><td>The students will comprehend the importance of tidal and geothermal energy and its applications.</td><td>K2</td></tr>
</table>

Suggested Readings:					
David A. Rivkin & Laurel Silk. (2013). *Wind Energy*. Jones & Bartlett Learning. Sawhney, G. S. (2012). *Non-Conventional Energy resources*. PHI Learning Private Limited. Tiwari, G.N. (2016) *Solar Energy Fundamentals, Design, Modelling and Applications.* Narosa Publishing House. Sunggyu, L and Shah, Y.T. (2013). *Biofuels and Bioenergy Processes and Technologies*. CRC press. Khan, B. H. (2017). *Non-Conventional Energy Resources (3rd edition)* McGraw-Hill Education (India) Private Limited. Tiwari, G.N. (2015). *Greenhouse Technology for Controlled Environment*. Narosa Publishing House. Math, M.C. (2019). *Non-Conventional Energy Sources*. Yes Dee. Reinders, A., Verlinden, P., Van Sark, W and Freundlich, A. (2017). *Photovoltaics Solar Energy from Fundamentals to Applications*. Wiley. Solanki, C.S. (2015). *Solar photovoltaic technology and systems: A manual for technicians, trainers and engineers*. PHI Learning Pvt. Ltd.					
Online resources: https://www.britannica.com/science/energy Energy Science - Google Books- principle, technologies and impact Renewable-Energy-Driven Future Technologies, Modelling, Applications, Sustainability and Policies - https://www.google.co.in/books/edition/Renewable_Energy_Driven_Future https://www.google.co.in/books/edition/An_Introduction_to_Renewable_Energy_Soure					
K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***
Name of the Course Teacher: Dr. S. Karuppuchamy					

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	1	2	-	1	-	1	1	2	2
CO2	3	2	2	3	2	1	2	1	2	3
CO3	2	2	3	-	1	-	2	2	1	2
CO4	2	2	2	3	2	1	2	1	2	2
CO5	2	1	1	1	1	1	2	2	1	2
W.Avg.	2.4	1.6	2.0	1.4	1.4	0.6	1.8	1.4	1.6	2.2

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	**PSO**				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	1	2	2	2
CO2	3	2	2	2	2
CO3	2	1	2	2	1
CO4	2	2	1	1	1
CO5	1	-	1	2	1
W.Av.	2	1.2	1.6	1.8	1.4

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">Semester –I</td></tr>
<tr><td>Core</td><td>Course Code:
540102</td><td>Chemistry for Energy Sciences</td><td>T</td><td>Credits: 5</td><td>Hours: 5</td></tr>
<tr><td colspan="6">Unit-I</td></tr>
<tr><td>Objective 1</td><td colspan="5">To understand the structure and bonding, the basic concept of acids and bases.</td></tr>
<tr><td colspan="6">Structure, Bonding & Concept of Acids and Bases (18 Hrs)
Chemical periodicity – Ionic radii – Ionization potential – Electron affinity – Electronegativity – Concept of hybridization – Molecular orbitals and electronic configuration of homonuclear and heteronuclear diatomic molecules – Shapes of polyatomic molecules. Bond order and magnetism – Types of chemical bonds – Intermolecular forces – Dipole moment – Lattice energy – Bronsted and Lewis concept of acids and bases – Hard and Soft acids and bases.</td></tr>
<tr><td>Outcome 1</td><td colspan="4">The students will demonstrate potentiometric and conductometric titrations.</td><td>K3</td></tr>
<tr><td colspan="6">Unit-II</td></tr>
<tr><td>Objective 2</td><td colspan="5">To be knowledgeable on the fundamental concept of Electrochemistry, Types of cells, Standard potential, Nernst equation and Faraday law.</td></tr>
<tr><td colspan="6">Electrochemistry (18 Hrs)
Introduction − Fundamental concepts − Electrochemical reaction − Redox reaction − Balancing redox reaction − Types of Cells − Common Components − Electrolytic cells and Voltaic (Galvanic) cells − Cell potential − Standard potentials − Standard Reduction Potentials − E^0 cell and ΔG^0 − Calculating E^0 cell − Nernst equation − Concentration cells − Batteries − Fuel cells − Electrolysis − Stoichiometry − Faraday constant.</td></tr>
<tr><td>Outcome 2</td><td colspan="4">The students will apply electrochemistry concepts to drive the Nernst equation and Faraday law for various systems.</td><td>K3</td></tr>
<tr><td colspan="6">Unit-III</td></tr>
<tr><td>Objective 3</td><td colspan="5">To study chemical thermodynamics, Ideal gas, Thermodynamics laws, Carnot's principle, Gibbs and Helmholtz energies, Le-Chatelier principle.</td></tr>
<tr><td colspan="6">Thermodynamics (18 Hrs)
Chemical Thermodynamics: Thermodynamic properties – Boyle's Laws – Ideal gas absolute temperature scale – Reversible and Irreversible P-V works – First law of thermodynamics – Joule-Thomson experiments – Second law of thermodynamics – Carnot's principle – Gibbs and Helmholtz energies – Maxwell relations – Le-Chatelier principle.</td></tr>
<tr><td>Outcome 3</td><td colspan="4">The students will be able to understand the properties of solids, gas, liquids</td><td>K2</td></tr>
<tr><td colspan="6">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="5">To acquire theories of reaction rate, reaction order, Arrhenius parameter and transport properties.</td></tr>
<tr><td colspan="6">Chemical Kinetics (18 Hrs)
Theories of Reaction Rates: Rate laws and rate constants – Reaction order – Determination of rate law – Reactions approaching equilibrium – Temperature dependence of reaction rates – Arrhenius parameters – Consecutive elementary reactions – Steady-state approximation – Kinetic isotope effect.
Transport Properties: Diffusion – Thermal conductivity – Viscosity – Effusion – Drift velocity – Nernst-Einstein equation – Stokes-Einstein equation – Complex reactions – Chain reactions.</td></tr>
<tr><td>Outcome 4</td><td colspan="4">The students will apply the collision theory to various conditions.</td><td>K3</td></tr>
<tr><td colspan="6">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="5">To acquire more information about Photochemical laws, the Jablonski diagram, Energy level diagram and Forbidden transitions.</td></tr>
<tr><td colspan="6">Photochemistry (18 Hrs)
Introduction – Photochemical laws – Quantum yield – Electronically excited states – Jablonski diagram – Radiation less processes – Energy level diagrams – Assignment of n-π* and π-π* configurations – Forbidden transitions – Fluorescence and Phosphorescence – Photoluminescence and Chemiluminescence.</td></tr>
<tr><td>Outcome 5</td><td colspan="4">The students will be able to analyze photochemical laws, Jablonski diagram, and the energy level diagram.</td><td>K4</td></tr>
</table>

Suggested Readings: Atkins, P. (2016). *Physical Chemistry*. Oxford. Carpenter, N. E. (2014). *Chemistry of sustainable energy*. CRC. 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. John Kenkel. (2015). *Basic Chemistry Concepts and Exercises*, CRC. Lee, J.D. (2016). *Concise Inorganic Chemistry*. Wiley.					
Online resources: Electrochemistry, The Basics, With Examples: Electrochemistry: The Basics, With Examples | SpringerLink. Books on Fundamental Electrochemistry and Electroanalytical Techniques: Books on Fundamental Electrochemistry and Electroanalytical Techniques | SpringerLink. https://assets.cambridge.org/97805218/50421/frontmatter/ -Thermodynamics: Thermodynamics | SpringerLink					
K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***
Name of the Course Teacher: Dr. C. Karthikeyan					

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	1	1	2	2	1	2	2	3	2
CO2	2	2	2	2	2	-	2	1	2	2
CO3	2	2	2	1	2	-	2	2	2	1
CO4	2	2	1	1	1	-	2	1	1	1
CO5	2	2	2	2	2	-	2	1	3	2
W.Avg.	2.2	1.8	1.6	1.6	1.8	0.2	2.0	1.4	2.2	1.6

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	**PSO**				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	3	1	2	2
CO2	3	2	2	2	2
CO3	1	2	1	2	1
CO4	2	2	1	1	1
CO5	2	2	2	2	1
W.Avg.	2	2.2	1.4	1.8	1.4

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><th colspan="6">Semester –I</th></tr>
<tr><td>Core</td><td>Course Code: 540103</td><td>Physics for Energy Sciences</td><td>T</td><td>Credits: 4</td><td>Hours : 4</td></tr>
<tr><td colspan="6">Unit – I</td></tr>
<tr><td>Objective 1</td><td colspan="5">To understand work, kinetic energy, potential energy, conservative and non-conservative forces.</td></tr>
<tr><td colspan="6">Kinetic and Potential Energy (14 Hrs)
Work and Kinetic Energy: Work done by a constant force – Work done by a varying force – Kinetic energy and Work – Kinetic energy theorem, Potential Energy: Conservative and Non-conservative 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>Outcome 1</td><td colspan="4">The students gain more knowledge about work, kinetic energy and potential energy, conservative and non-conservative forces.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – II</td></tr>
<tr><td>Objective 2</td><td colspan="5">To study the Zeroth, First and Second law of thermodynamics, work and heat in thermodynamic processes and energy transfer mechanisms.</td></tr>
<tr><td colspan="6">Thermodynamics (15 Hrs)
Basic concepts: Thermometers and Celsius temperature scale – Constant volume gas Thermometer and the Absolute temperature scale – Thermal expansion of solids and Liquids – Definition of entropy – 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>Outcome 2</td><td colspan="4">The students will be able to understand the various important concept in thermodynamics.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – III</td></tr>
<tr><td>Objective 3</td><td colspan="5">To acquire more information about AC and DC circuits; Kirchhoff's rules, RC circuits, rectifiers and filters.</td></tr>
<tr><td colspan="6">AC and DC Circuits (15 Hrs)
Direct Current Circuits: Electromotive force – Resistors in series and in parallel – Kirchhoff's rules – RC circuits – Electrical instruments – Household wiring and Electrical safety. Resistance and Resistivity – Temperature variation of resistance – 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>Outcome 3</td><td colspan="4">The students will be to develop logic gates.</td><td>K6</td></tr>
<tr><td colspan="6">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="5">To study about band theory of solids and the free-electron theory of metals.</td></tr>
<tr><td colspan="6">Molecules and Solids (14 Hrs)
Molecules and Solids: Spectral lines – Electron orbits – 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>Outcome 4</td><td colspan="4">The students will know about free-electron theory of metals.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="5">To know more information about structure and properties of nuclear structure</td></tr>
<tr><td colspan="6">Nuclear Structure (14 Hrs)
Nuclear Structure: Properties of Nuclei-Binding energy and Nuclear forces – Reduced mass – 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>Outcome 5</td><td colspan="4">The students will acquire more information about nuclear structure.</td><td>K2</td></tr>
</table>

Suggested Readings: Serway, R. A., & Jewett, J. W. (2009). *Physics for Scientists and Engineers*: pt. 1. Mechanics. Cengage Learning, UK. Pandya, M.L & Yadav, R.P.S. (2015). *Elements of Nuclear Physics*. Kedar Nath Ram Nath. Chandra, S. (2016). *Energy, Entropy and Engines: An Introduction to Thermodynamics*. John Wiley & Sons. Serway, R. A & Vuille, C. (2016). *College Physics, Volume 1 (Vol. 1)*. Cengage Learning Weinberg, S. (2021). *Foundations of modern physics*. Cambridge University Press. Chandra, S. (2010). *Physics of Atoms and Molecules*. Narosa Publication. Michael Shur. (2010). *Physics of Semiconductor Devices*. PHI Learning.					
Online resources: Kinetic and Potential Energy: Understanding Changes Within Physical Systems- Kinetic and Potential Energy - Google Books DC/AC Circuitshttps://www.google.co.in/books/edition/Fundamentals_of_Electronics https://www.cambridge.org/highereducation/books/the-physics-of energy/7FE67626190E6D164A71B0D61E061E63#overview					
K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***
Name of the Course Teacher: Dr. S. Natarajan					

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	1	2	1	2	-	2	2	2	1
CO2	2	1	1	-	1	-	2	1	2	2
CO3	2	3	2	2	3	1	2	1	2	2
CO4	1	1	1	3	1	-	1	1	1	2
CO5	1	1	1	-	1	-	2	1	2	2
W.Avg.	1.8	1.4	1.4	1.2	1.6	0.2	1.8	1.2	1.8	1.8

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	**PSO**				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	2	2	1	2
CO2	1	1	2	1	1
CO3	2	2	2	2	2
CO4	1	1	1	1	1
CO5	1	1	1	1	1
W.Avg.	1.4	1.4	1.6	1.2	1.4

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">Semester I</td></tr>
<tr><td>Core</td><td>Course Code:
540104</td><td>Polymer Science and Technology</td><td>T</td><td>Credits: 4</td><td>Hours: 4</td></tr>
<tr><td colspan="6">Unit – I</td></tr>
<tr><td>Objective 1</td><td colspan="5">To understand the basic concept of polymers, polymerization, mechanism and kinetics of polymerization reactions.</td></tr>
<tr><td colspan="6">Basic Concepts (14 Hrs)
Definition – Nomenclature of polymers – Functionality of monomers – Degree of polymerization – Types of polymerization: Addition – Condensation –Copolymerization – Mechanism of free radical, cationic and anionic polymerization – Polymer kinetics – Polymerization techniques.</td></tr>
<tr><td>Outcome 1</td><td colspan="4">The students will gain more information about the principle, types and process of polymerization and the kinetics of polymerization.</td><td>K2</td></tr>
<tr><td colspan="6">Unit II</td></tr>
<tr><td>Objective 2</td><td colspan="5">To learn more information about polymeric components, structure and properties, polymer processing and fabrication techniques.</td></tr>
<tr><td colspan="6">Material and Processing (14 Hrs)
Multicomponent polymeric materials – Polymer structure and Properties – Polymeric process – Polymer reactors – Polymer compounding and Fabrication – Fabrication techniques.</td></tr>
<tr><td>Outcome 2</td><td colspan="4">The students will be able to know about polymeric components, structure and properties, polymer processing and fabrication techniques.</td><td>K2</td></tr>
<tr><td colspan="6">Unit III</td></tr>
<tr><td>Objective 3</td><td colspan="5">To acquire more information about polymer testing and molecular weight determination.</td></tr>
<tr><td colspan="6">Characterization of Polymers (15 Hrs)
Polymer testing – Melting point – Softening point – Thermal conductivity – Shrinkage – Melt flow index test – Particle size – Density and bulk factor – Water and Moisture absorption.
Molecular weight determination – Number average – Weight average – Viscosity average – Molecular weight of polymers – Molecular weight determination by Light scattering – Osmotic, Centrifuge and Viscosity methods.</td></tr>
<tr><td>Outcome 3</td><td colspan="4">The students will acquire more knowledge about the characterization and testing of polymers. Apply this knowledge to determine the molecular weight of polymers.</td><td>K3</td></tr>
<tr><td colspan="6">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="5">To understand polymer materials, biodegradable, conducting, magnetic polymers and non-linear optical polymers.</td></tr>
<tr><td colspan="6">Polymeric materials (15 Hrs)
Frontiers of polymer materials – Biodegradable polymers – Biomedical polymers – Conducting polymers – Magnetic polymers – Polymers for space – Nonlinear optical polymers.</td></tr>
<tr><td>Outcome 4</td><td colspan="4">The students will be able to attain more information about polymer materials, biodegradable polymers, conducting polymers and nonlinear optical polymers.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="5">To identify various applications of polymers in energy, optical, electrical, sensors, thermoxidative degradation, toxicity, and effluent disposal.</td></tr>
<tr><td colspan="6">Application of polymers (14 Hrs)
Application of polymers – Energy, Optical, Electrical, Sensors, Cosmetics, Drug delivery, Tissue engineering and Water treatment – Problems of polymer –Thermoxidative degradation – Fire hazards – Toxicity – Effluent disposal – Feedstock scarcity.</td></tr>
<tr><td>Outcome 5</td><td colspan="4">The students will be able to understand the applications of polymers and the methodology of effluent disposal.</td><td>K2</td></tr>
</table>

Suggested Readings:					
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. Jain, Jain. M. (2016). *Engineering Chemistry*. Dhanpat Rai. Misra, G.S. (2010). *Introductory polymer chemistry*. New Age international. Mohan kumar, H. (2017). *Advanced polymer chemistry*. Centrum Press. Robert O. Ebewele. (2000). *Polymer Science and Technology*. CRC Press.					
Online resources: Textbook of Polymer Science, 3rd Edition | Wiley- https://www.wiley.com/en-in/Textbook+of+Polymer+Science https://www.google.co.in/books/edition/Basics_of_Polymer_Chemistry https://chemistry.pixel-online.org/					
K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***
Name of the Course Teacher: Dr. A. Nithya					

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	2	2	1	-	-	2	-	-	3
CO2	3	2	2	1	1	1	2	2	2	2
CO3	2	2	1	3	2	1	2	2	2	2
CO4	2	2	2	-	1	-	2	2	2	2
CO5	2	2	2	1	1	-	2	2	2	2
W.Avg.	2.2	2.0	1.8	1.2	1.0	0.4	2.0	1.6	1.6	2.2

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	-	1	1
CO2	2	1	2	1	2
CO3	2	2	2	2	2
CO4	2	2	1	1	2
CO5	2	1	2	2	2
W.Avg.	2.2	1.6	1.4	1.4	1.8

S –Strong (3), M-Medium (2), L- Low (1)

Semester-I					
Core	**Course Code : 540107**	**Energy Practical- I**	**P**	**Credit: 4**	Hours : **8**

Conductometric and Potentiometric Titration		
Objective 1	**To measure the strength of unknown materials through conductometric and potentiometric methods.**	
1. Conductometric titrations: Acid-Alkali titration. 2. Conductometric titrations: Determination of dissociation constants of weak acids. 3. Potentiometric titrations: Acid-Alkali titration. 4. Potentiometric titrations: Redox titration.		
Outcome 1	**The students will learn to analyze conductance and EMF changes caused by acid-alkali reactions.**	K4
Digital Circuits		
Objective 2	**To understand the digital behavior of the corresponding circuits.**	
5. Digital to analog (D/A) converters (a) Ladder network (b) Weighted resistor method 6. Analog to digital (A/D) converter 7. Logic gates using Integrated chip.		
Outcome 2	**The students will be able to analyze the digital behavior of the corresponding circuits**	K4
Synthesis of Nanomaterials		
Objective 3	**To prepare nanomaterials through chemical methods.**	
8. Synthesis of metal oxide nanoparticles by chemical method. 9. To prepare nanostructured materials through the chemical method		
Outcome 3	**The students will fabricate nanostructured materials via chemical methods**.	K6
Polymer Science		
Objective 4	**To find out the molecular weight of given polymer solutions.**	
10. To measure the molecular weight of the polymer solution		
Outcome 4	**The students will determine the molecular weight of polymer solutions.**	K4
Thin films Measurement		
Objective 5	**To measure the resistance of thin films.**	
11. Resistivity measurements of thin films.		
Outcome 5	**The students will evaluate the resistance of thin films.**	K5
*Any other equivalent experiments.		

Suggested Readings:

S. Karuppuchamy. (2015). Nanoscience and technology, Laboratory Manual. United Agencies.

S. Karuppuchamy. (2015). Energy Science, Laboratory Manual. United Agencies.

Online Resources:					
https://vlab.amrita.edu/?sub=3&brch=193&sim=352&cnt=1 - Acid Base Titration (Theory) : Inorganic Chemistry Virtual Lab : Biotechnology and Biomedical Engineering : Amrita Vishwa Vidyapeetham Virtual Lab chem.pg.edu.pl/documents/175260/14212622/chf_epm_lab_1.pdf					
K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***
Name of the Course Teacher: Dr. S. Karuppuchamy, Dr. C. Karthikeyan, Dr. A. Nithya, Dr. S. Natarajan					

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	3	2	2	1	2	2	2	2
CO2	1	1	1	2	1	1	1	1	1	1
CO3	3	3	3	1	2	1	3	3	3	2
CO4	2	2	3	2	1	1	2	2	2	1
CO5	3	2	1	1	1	1	3	3	2	1
W.Avg.	2.4	2.0	2.2	1.6	1.4	1.0	2.2	2.2	2.0	1.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	**PSO**				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	2	2	2
CO2	2	1	1	1	1
CO3	3	2	2	2	2
CO4	1	1	1	1	2
CO5	2	2	2	2	2
W.Avg.	2.2	1.6	1.6	1.6	1.8

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">Semester –II</td></tr>
<tr><td>Core</td><td>Course Code: 540201</td><td>Environmental Science</td><td>T</td><td>Credits: 5</td><td>Hours: 5</td></tr>
</table>

<table>
<tr><td colspan="3">Unit-I</td></tr>
<tr><td>Objective 1</td><td colspan="2">To study the environmental pollution, effects and controlling methods of various pollutions.</td></tr>
<tr><td colspan="3">Environmental Pollution (18 Hrs)
Introduction – Sources, Effects and Control methods of Air pollution – Water pollution – Soil pollution – Noise pollution – Marine pollution – Thermal pollution and Nuclear hazards.</td></tr>
<tr><td>Outcome 1</td><td>The students will understand the values of the environment and analyze the causes, effects and remedial measures of environmental pollution.</td><td>K4</td></tr>
<tr><td colspan="3">Unit-II</td></tr>
<tr><td>Objective 2</td><td colspan="2">To know about water analysis, water quality standards, water quality parameters and water treatment methods.</td></tr>
<tr><td colspan="3">Water Analysis (18 Hrs)
Water Quality Standard: 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.
Water Treatment Methods: 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.</td></tr>
<tr><td>Outcome 2</td><td>The students will understand the necessity of water treatment methods.</td><td>K2</td></tr>
<tr><td colspan="3">Unit-III</td></tr>
<tr><td>Objective 3</td><td colspan="2">To acquire basic concepts of green chemistry, green methods, green products and twelve principles of green chemistry.</td></tr>
<tr><td colspan="3">Green Chemistry (18 Hrs)
Definition – Need of Green Chemistry – Difference between green and environmental chemistry – Basis of green methods and green products – Twelve principles of green chemistry and their illustrations with examples.</td></tr>
<tr><td>Outcome 3</td><td>The students will apply this knowledge to carry out green synthesis of nanostructured materials.</td><td>K6</td></tr>
<tr><td colspan="3">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="2">To understand more information about designing green synthesis, choice of starting materials, catalyst and various green synthesis methods.</td></tr>
<tr><td colspan="3">Designing Green Synthesis (18 Hrs)
Choice of starting materials – Reagents – Catalysts – Biocatalysts – Polymer supported catalysts and solvents – Synthesis involving principles of green chemistry – Microwave assisted synthesis – Ultrasound assisted synthesis – Photoinduced synthesis – Polymer supported synthesis – Synthesis using biocatalyst.</td></tr>
<tr><td>Outcome 4</td><td>The students will comprehend the characteristics of starting materials in green synthesis and the role of catalysts.</td><td>K2</td></tr>
<tr><td colspan="3">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="2">To know about the application of green chemistry in energy, biomedical, pharmaceutical and agricultural.</td></tr>
<tr><td colspan="3">Green Technologies (18 Hrs)
Application of green chemistry – Environmental applications – Energy applications – Biomedical applications – Pharmaceutical applications – Agricultural applications.</td></tr>
<tr><td>Outcome 5</td><td>The students will be able to understand and analyze the value of green chemistry in energy, biomedical, pharmaceutical and agriculture applications.</td><td>K4</td></tr>
</table>

Suggested Readings:
Ahluwalia, V.K. (2013). *Green chemistry: A text book*. Narosa Publishing House. 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. He, J. (2016). *Nanomaterials in energy and environmental applications*. Pan Stanford. Sodhi, G.S. (2013). *Fundamental concepts of environmental chemistry*. Narosa Publishing House. Sorensen, B. (2015). *Renewable Energy: Physics, Engineering, Environmental Impacts. Economics & Planning*, Academic Press.
Online resources: Introduction to Environmental Science - 2nd Edition - Open Textbook Library (umn.edu) https://open.umn.edu/opentextbooks/textbooks/562 https://bookboon.com/en/environmental-science-ebooks https://onlinelibrary.wiley.com/doi/book/10.1002/9781118720011

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***
Name of the Course Teacher: Dr. S. Karuppuchamy					

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	3	1	2	1	2	2	1	2
CO2	2	2	2	2	2	-	2	2	2	2
CO3	2	2	2	-	2	1	2	2	2	-
CO4	2	2	2	2	1	-	2	1	-	1
CO5	3	1	3	2	2	-	2	1	1	2
W.Avg.	2.2	1.8	2.4	1.4	1.8	0.4	2.0	1.6	1.2	1.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	**PSO**				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	1	2	1	2
CO2	2	2	2	2	2
CO3	2	1	2	1	1
CO4	1	1	2	1	1
CO5	2	2	2	1	2
W.Avg.	1.8	1.4	2	1.2	1.6

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">Semester –II</td></tr>
<tr><td>Core</td><td>Course Code: 540202</td><td>Solar Thermal Energy</td><td>T</td><td>Credits: 5</td><td>Hours : 5</td></tr>
<tr><td colspan="6">Unit – I</td></tr>
<tr><td>Objective 1</td><td colspan="5">To understand solar radiation on the earth surface, extraterrestrial radiation, terrestrial radiation and measurement of solar radiation.</td></tr>
<tr><td colspan="6">Solar Radiation and Measurement (18 Hrs)
Solar radiation on the earth surface – Spectral energy distribution of solar radiation – Extraterrestrial radiation – Terrestrial radiation – Solar insolation – Depletion of solar radiation – Absorption – Scattering – Beam radiation – Diffuse and Global radiation – Measurement of solar radiation – Pyranometer – Pyrheliometer – Sunshine recorder.</td></tr>
<tr><td>Outcome 1</td><td colspan="4">The students will be able to learn solar radiation on the earth surface, extraterrestrial radiation, terrestrial radiation and measurement of solar radiation.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – II</td></tr>
<tr><td>Objective 2</td><td colspan="5">To learn more knowledge about solar collectors and types of solar collectors.</td></tr>
<tr><td colspan="6">Solar Collectors (18 Hrs)
Introduction– Types of solar collectors – Non-Concentrating type (Flat plate collectors) – Concentrating type (Focusing type collectors) – Air based solar collectors – Evacuated tube collectors – Swimming pool absorbers.</td></tr>
<tr><td>Outcome 2</td><td colspan="4">The students gain more knowledge about solar collectors and the types of solar collectors.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – III</td></tr>
<tr><td>Objective 3</td><td colspan="5">To study the thermodynamic cycles and solar thermal power plants.</td></tr>
<tr><td colspan="6">Solar Thermal Power Plant (18 Hrs)
Thermodynamic cycles – Carnot cycle – Rankine cycle – Brayton cycle – Stirling cycle – Binary cycle – Combined cycles – Solar thermal power plants – Hybrid solar power plants – Solar pond based electric power plant.</td></tr>
<tr><td>Outcome 3</td><td colspan="4">The students analyze the advantages and challenges of solar thermal power plants.</td><td>K4</td></tr>
<tr><td colspan="6">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="5">To comprehend about solar water heating systems, solar space heating and cooling, domestic water heating and solar cooking.</td></tr>
<tr><td colspan="6">Solar Thermal Heating and Cooling System (18 Hrs)
Solar water heating system – Active solar heating – Passive solar heating – Solar furnace – Solar chimney plant – Solar cookers – Solar powered distiller – Solar space heating – Solar powered refrigeration systems.</td></tr>
<tr><td>Outcome 4</td><td colspan="4">The students will comprehend about solar water heating systems, solar space heating and cooling, domestic water heating and solar cooking. Apply this knowledge to develop solar heating systems.</td><td>K3</td></tr>
<tr><td colspan="6">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="5">To learn more information about solar panel manufacturing technologies, economics, ecology, solar thermal market, outlook and development potential.</td></tr>
<tr><td colspan="6">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>Outcome 5</td><td colspan="4">The students will gain noteworthy information about solar panel manufacturing technologies, economics, ecology, solar thermal market, outlook and development potential.</td><td>K2</td></tr>
</table>

Suggested Readings:

Sukhatme, S.P. & Nayak J.K. (2015). *Solar energy: Principles of thermal collection and storage*. McGraw Hill Education (India) Private Limited.

Vignola, F., Michalsky, J., & Stoffel, T. (2012). *Solar and Infrared Radiation Measurements*. CRC Press.

Yogi Goswami, D. (2018). *Principles of Solar Engineering (3rd Edition)*. CRC Press

Garg, H.P. (2016). *Solar energy: Fundamentals and applications*. McGraw Hill.

Kothari, D.P. (2014). *Renewable energy resources and emerging technologies*. PHI Learning.

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.

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

Md Hasanuzzaman (2022) *Technologies for Solar Thermal Energy: Theory, Design and Optimization*, Academic Press Publishers.

Zhifeng Wang (2019) *Design of Solar Thermal Power Plants*, Academic Press Publishers.

Brian Norton (2012) *Solar Energy Thermal Technology*, Springer Science & Business media.

Online resources:

https://onlinelibrary.wiley.com/doi/10.1002/9781118720011.ch9

https://link.springer.com/referenceworkentry/10.1007/978-1-0716-1422-8_923- Solar Thermal Energy: Introduction

https://link.springer.com/referencework/10.1007/978-1-0716-1422-8 - solar thermal energy

K1-Remember	*K2-Understand*	*K3-Apply*	*K4-Analyze*	*K5-Evaluate*	*K6-Create*

Name of the Course Teacher: Dr. A. Nithya

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	1	2	2	1	1	1	1	1
CO2	2	2	2	2	2	-	2	2	2	1
CO3	2	1	2	3	2	-	2	2	2	2
CO4	2	2	2	2	2	-	2	2	2	2
CO5	3	2	2	1	2	1	2	2	2	3
W.Avg.	2.2	1.8	1.8	2.0	2.0	0.4	1.8	1.8	1.8	1.8

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	1	1	1	1
CO2	3	2	2	2	2
CO3	2	2	2	3	2
CO4	2	2	3	2	2
CO5	2	2	2	1	2
W.Avg.	1.8	1.4	2	1.2	1.6

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">Semester –II</td></tr>
<tr><td>Core</td><td>Course Code: 540203</td><td>Hydrogen Energy Systems</td><td>T</td><td>Credits: 5</td><td>Hours : 5</td></tr>
</table>

<table>
<tr><td colspan="3">Unit-I</td></tr>
<tr><td>Objective 1</td><td colspan="2">To study about the basic of hydrogen energy, properties of hydrogen storage and production of hydrogen from water splitting.</td></tr>
<tr><td colspan="3">Introduction (18 Hrs)
General introduction to infrastructure requirement for hydrogen production, storage, dispensing, utilization – Properties of hydrogen storage as fuel – hydrogen production plants.
Hydrogen from Water Splitting
Water electrolysis – Water splitting with solar energy – Thermochemical water splitting – Photoelectrochemical cells – Direct hydrogen production – Photo-Biochemical cells – Oxygen Evolution Reaction (OER) – Hydrogen Evolution Reaction (HER).</td></tr>
<tr><td>Outcome 1</td><td>The students will be able to understand various production methods and storage of hydrogen energy.</td><td>K2</td></tr>
<tr><td colspan="3">Unit – II</td></tr>
<tr><td>Objective 2</td><td colspan="2">To acquire more information about hydrogen production from fossil fuels.</td></tr>
<tr><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>Outcome 2</td><td>The students will be able to analyze the feasibility of hydrogen production from fossil fuels.</td><td>K4</td></tr>
<tr><td colspan="3">Unit – III</td></tr>
<tr><td>Objective 3</td><td colspan="2">To learn about hydrogen production from biomass.</td></tr>
<tr><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>Outcome 3</td><td>The students will be able to apply this knowledge to produce hydrogen</td><td>K3</td></tr>
<tr><td colspan="3">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="2">To know about types of fuel cell, fuel cell efficiencies and applications of fuel cells.</td></tr>
<tr><td colspan="3">Fuel Cells (18 Hrs)
Principle and components – Electrochemistry of fuel cells – Nernst equation – Performance and evaluation of fuel cells – 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.
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>Outcome 4</td><td>The students will be able to know about the types of fuel cell, fuel cell efficiencies and applications of fuel cells.</td><td>K2</td></tr>
</table>

Unit – V		
Objective 5	**To acquire more knowledge about chemical storage and physical storage materials for hydrogen storage.**	

Hydrogen Storage Materials and Technology **(18 Hrs)**

Hydrogen storage: 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 – Hydrogen powered vehicles – Advantage and Disadvantage of hydrogen as a transport fuel.

Outcome 5	**The students will be able to acquire knowledge on chemical storage and physical storage materials for hydrogen storage.**	K2

Suggested Readings:

Gabriele Zini & paolo Tartarini (2012) *Solar Hydrogen Energy System: Science and Technology for the hydrogen economy*, Springer science and Business Media Publishers.

K.S.V. Santhanam, Roman J. press, Massoud J. Miri, Alla V. Bailey & Gerald A. Takacs (2017) *Introduction to Hydrogen Technology*, John wiley & Sons Publishers.

International Energy Agency & Organisation for Economics Co-operation and Development (2004) *Hydrogen and Fuel cells*, Simon and Schuster Publishers.

Paulo Emilio Miranda (2018) *Science and Engineering of Hydrogen-Based Energy Technologies*, Academic press Publishers.

Kazunari Sasaki, Hai-wen Li, Akan Hayashi, Junichiro Yamabe, Teppei Ogura & Stephe M.Lyth Springer (2016) *Hydrogen Energy Engineering: A Japanese perspective*, Technology and Engineering Publishers.

Online Resources:

https://onlinelibrary.wiley.com/doi/book/10.1002/9783527674268 - Hydrogen Science and Engineering : Materials, Processes, Systems and Technology

https://link.springer.com/book/10.1007/978-3-319-93461-7 - hydrogen energy

https://www.sciencedirect.com/science/article/pii/S1364032121004688

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***

Name of the Course Teacher: Dr. S. Natarajan

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	3	1	2	1	2	2	2	2
CO2	2	1	2	1	1	-	2	2	2	2
CO3	2	2	2	2	2	1	2	1	2	2
CO4	2	1	1	2	2	-	1	2	1	2
CO5	2	2	2	2	1	-	2	2	2	2
W.Avg.	2.2	1.6	2.0	1.6	1.6	0.4	1.8	1.8	1.8	2.0

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2
CO2	2	2	2	2	2
CO3	2	1	2	2	2
CO4	2	2	2	3	2
CO5	3	2	1	2	2
W.Avg.	2.4	1.8	1.8	2.2	2

S –Strong (3), M-Medium (2), L- Low (1)

Semester-II					
Core	**Course Code : 540207**	**Energy Practical- II**	**P**	**Credit: 4**	Hours : **8**

Synthesis of Nanomaterials

Objective 1	**To prepare nanostructured materials.**

1. Synthesis of one-dimensional nanomaterial by electrospinning method.
2. Synthesis of nanocomposite materials by solution growth method using a capping agent.
3. Synthesis of oxide nanomaterials by hydrothermal method.
4. Synthesis of conducting polymer for energy applications.
5. Synthesis of visible light active nanomaterials.

Outcome 1	**The students will be able to develop nanomaterials by various methods.**	**K6**

Analysis of Nanomaterials

Objective 2	**To understand the physiochemical properties of nanomaterials**

6. XRD studies for calculating the size of the nanoparticles by Scherrer's formula.
7. Electrochemical characterization of metal oxide nanomaterials.
8. UV-Visible spectral analysis of dye-modified semiconductor oxide thin films.
9. I-V Characterization of Diode, Photo-diodes and Resistances.

Outcome 2	**The students will able to analyze the various physiochemical properties.**	**K4**

Photocatalysis and Water Analysis

Objective 3	**To find out the dye removal efficiency of photocatalyst and estimate the dissolved oxygen and chromium in waste water.**

10. Decomposition of organic pollutants using photocatalyst.
11. Estimation of dissolved oxygen in industrial wastewater.
12. Estimation of chromium in industrial wastewater.

Outcome 3	**The students will determine the dye removal efficiency and dissolved oxygen and chromium**.	**K5**

**Any other equivalent experiments*

Suggested Readings:

S. Karuppuchamy. (2015). *Nanoscience and technology*, *Laboratory Manual.* United Agencies.
S. Karuppuchamy. (2015). *Energy Science*, *Laboratory Manual.* United Agencies.

Online resources:

https://www.sciencedirect.com/topics/materials-science/nanostructured-material
https://www.sciencedirect.com/science/article/abs/pii/B9780128205693000013
https://pubs.rsc.org/en/content/articlelanding/2021/ma/d0ma00807a#!

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***

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

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	3	2	1	1	2	2	2	2
CO2	3	3	2	3	3	1	2	2	2	2
CO3	2	2	2	2	1	1	2	2	1	1
W.Avg.	2.7	2.3	2.3	2.3	1.7	1.0	2.0	2.0	1.7	1.7

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	2	2	2	2
CO2	3	2	3	3	2
CO3	2	2	2	2	2
W.Avg.	2.3	2.0	2.3	2.3	2.0

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="7">Semester –III</td></tr>
<tr><td>Core</td><td>Course Code:
540301</td><td colspan="2">Photovoltaics</td><td>T</td><td>Credits: 5</td><td>Hours : 5</td></tr>
<tr><td colspan="7">Unit-I</td></tr>
<tr><td>Objective 1</td><td colspan="6">To understand semiconductors, direct & indirect bandgap, Intrinsic & extrinsic semiconductors and device fabrication.</td></tr>
<tr><td colspan="7">Basic Concepts (18 Hrs)
Principle of solar cell technologies – Materials and Design – Semiconductors: Direct & Indirect band gap – Intrinsic – Extrinsic semiconductor – Compound semiconductors – p & n doping and carrier concentration – Diffusion and drift of carriers optical absorption – Semiconductor junctions: P-N junction – Schottky barriers.
Device Fabrication: Transparent conducting oxides – Anti-reflection coatings – Metal contact – Device characterization.</td></tr>
<tr><td>Outcome 1</td><td colspan="5">The students will be able to understand the characteristics of semiconductors and apply this knowledge to fabricate semiconducting materials..</td><td>K4</td></tr>
<tr><td colspan="7">Unit-II</td></tr>
<tr><td>Objective 2</td><td colspan="6">To acquire more information about silicon solar cells and thin film solar cells.</td></tr>
<tr><td colspan="7">Silicon and Thin Film Solar Cells (18 Hrs)
Silicon Solar Cells: Introduction – Types of silicon solar cells: Mono-crystalline – Poly-crystalline solar cells – Commercial silicon solar cells – Processing technologies in silicon solar cells.
Thin Film Solar Cells: Introduction – Thin film solar cells Manufacturing: Amorphous Si solar cell – Cadmium Telluride solar cell – CIGS solar cell – CZTS solar cell – New materials for thin film solar cells – Thin film deposition techniques – Physical Vapour Deposition (PVD) – Electro-deposition – Molecular Beam Epitaxy (MBE) – Metal Organic Chemical Vapour Deposition (MOCVD) – Plasma Enhanced Chemical Vapour Deposition (PECVD) – Advantages of thin films.</td></tr>
<tr><td>Outcome 2</td><td colspan="5">The students will acquire more information about silicon solar cells and thin film solar cells.</td><td>K2</td></tr>
<tr><td colspan="7">Unit-III</td></tr>
<tr><td>Objective 3</td><td colspan="6">To learn about organic-based solar cells and tandem solar cells.</td></tr>
<tr><td colspan="7">Organic based Photovoltaics (18 Hrs)
Dye Sensitized Solar Cells (DSSC) – Components and Working principles – Fabrication techniques. Organic Solar Cells (OSC) – Materials and Mechanism of OSCs. Perovskite Solar Cells (PSC) – Working mechanism - Types of PSC – Materials for PSC – Tandem solar cells.</td></tr>
<tr><td>Outcome 3</td><td colspan="5">The students will gain more knowledge about organic solar cells and tandem solar cells. Apply this knowledge to develop solar cells.</td><td>K3</td></tr>
<tr><td colspan="7">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="6">To understand PV modules, identical and non-identical cells, and hybrid SPV power systems</td></tr>
<tr><td colspan="7">Solar Cell Module Materials and 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. Solar PV concentrators – Concentrator photovoltaic materials and devices – Hybrid SPV power systems.</td></tr>
<tr><td>Outcome 4</td><td colspan="5">The students gain more knowledge about PV modules, identical and non-identical cells, and hybrid SPV power systems</td><td>K2</td></tr>
</table>

Unit – V	
Objective 5	**To know about PV system components, remote area power systems, specific purpose photovoltaic systems, SPV power plant design tools, methodologies and SPV economics**.

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. SPV power plant design tools and methodologies – SPV economics.

Outcome 5	**The students gain more knowledge about Solar PV System, Components and System Design. Critically analyze the solar PV for indoor and outdoor applications.**	**K4**

Suggested Readings:

Balfour, J. R., Shaw, M. & Jarosek, S. (2013). *Introduction to photovoltaic*. Jones & Bartlett Publishers.

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

Solanki, C.S. (2015). *Solar photovoltaics Fundamentals, Technologies and Applications.* PHI Learning Pvt. Ltd.

Sean, W. (2015). *Solar Photovoltaics Basics*. Routledge Taylor & Francis Group.

Sabhu, T. & Aparna, T. (2018). *Perovskite Photovoltaics Basics to advanced concepts and implantation*. Academic Press.

Pankaj Kumar (2017). *Organic Solar Cells.* CRC Press.

Balfour, J. R & Shaw, M. (2013). *Introduction to photovoltaic system design*. Jones & Bartlett Publishers.

Online resources:

https://onlinelibrary.wiley.com/doi/book/10.1002/9781118927496 - Photovoltaic Solar Energy: From Fundamentals to Applications

https://onlinelibrary.wiley.com/doi/book/10.1002/9780470974704 - Handbook of Photovoltaic Science and Engineering

https://onlinelibrary.wiley.com/doi/book/10.1002/9781119976998 - Photovoltaics: System Design and Practice

K1-Remember	*K2-Understand*	*K3-Apply*	*K4-Analyze*	*K5-Evaluate*	*K6-Create*

Name of the Course Teacher: Dr. S. Karuppuchamy

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	2	3	1	2	1	2	2	2	2
CO2	3	1	2	2	1	-	2	2	2	2
CO3	2	2	2	2	2	1	2	1	2	2
CO4	2	1	1	2	2	-	1	2	1	3
CO5	3	2	2	2	2	1	2	2	2	3
W.Avg.	2.4	1.6	2.0	1.8	1.8	0.6	1.8	1.8	1.8	2.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2
CO2	3	1	2	2	2
CO3	2	2	2	2	1
CO4	2	1	2	2	2
CO5	2	2	1	2	2
W.Avg.	2.4	1.6	1.8	2	1.8

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">Semester –III</td></tr>
<tr><td>Core</td><td>Course Code: 540302</td><td>Energy Storage Systems</td><td>T</td><td>Credits: 5</td><td>Hours : 5</td></tr>
<tr><td colspan="6">Unit – I</td></tr>
<tr><td>Objective 1</td><td colspan="5">To understand energy storage, the need for energy storage and different modes of energy storage.</td></tr>
<tr><td colspan="6">Introduction (18 Hrs)
Introduction to energy storage – Need for energy storage and different modes of energy storage – Electric energy – Chemical energy – Thermal energy – Electrochemical energy – Biological energy storage – Comparative analysis.</td></tr>
<tr><td>Outcome 1</td><td colspan="4">The students will be able to understand noteworthy knowledge about energy storage systems.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – II</td></tr>
<tr><td>Objective 2</td><td colspan="5">To study the batteries, types, design and construction.</td></tr>
<tr><td colspan="6">Batteries (18 Hrs)
Introduction – Types, Design, Characteristics and Construction of batteries – Lead Acid Battery: Principle and Construction – Types of lead acid battery – Charging and Discharging properties of SLA Batteries – SLI (Automative) batteries.</td></tr>
<tr><td>Outcome 2</td><td colspan="4">The students will understand the science behind the batteries and apply this knowledge to develop battery.</td><td>K6</td></tr>
<tr><td colspan="6">Unit – III</td></tr>
<tr><td>Objective 3</td><td colspan="5">To learn more knowledge about lithium ion and metal-air batteries.</td></tr>
<tr><td colspan="6">Lithium-ion & Metal-Air Batteries (18 Hrs)
Lithium-ion Batteries: Principle and Construction – Anodes and cathodes – Nanomaterials for anodes and cathodes – Fabrication – Lithium-Sulphur battery – Merits and demerits of Li-ion batteries.
Metal-Air Batteries: Lithium-Air, Sodium-Air, Zinc-Air batteries: Principle – Components – Anodes – Cathodes - Fabrication – Evaluation – Merits – Demerits and applications.</td></tr>
<tr><td>Outcome 3</td><td colspan="4">The students will be able to understand the performance of Lithium-ion battery.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="5">To know about the principle and fabrication of supercapacitors and fuel cells.</td></tr>
<tr><td colspan="6">Supercapacitor & Fuel Cells (18 Hrs)
Supercapacitor: Basic Components of Supercapacitor – Types of electrodes - Electrolyte – Merits and demerits – Applications.
Fuel Cells: Fabrication of fuel cell – Membrane electrode assemblies – Bipolar plates – Fuel cell catalysts – Precious and non-precious metal catalysts – Low temperature fuel cells – Reversible fuel cells – Fuel cell stacks and systems – Applications.</td></tr>
<tr><td>Outcome 4</td><td colspan="4">The students will be able to understand the working principle of supercapacitors and fuel cells and apply this knowledge to develop supercapacitors.</td><td>K6</td></tr>
<tr><td colspan="6">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="5">To understand the concept of hybrid energy systems and its applications.</td></tr>
<tr><td colspan="6">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>
<tr><td>Outcome 5</td><td colspan="4">The students will be learning more knowledge about the concept of hybrid energy systems and its applications.</td><td>K2</td></tr>
</table>

Suggested Readings:

Fu-Bao Wu. & Bo Yang, Ji-Lei Ye. (2019). *Grid-Scale Energy Storage Systems and Applications*. Academic Press.

Kiehne, H.A. (2013). *Battery Technology Handbook (2nd Edition).* Marcel Dekker, Inc.

Joey, J., Lei, Z. & JiuJun, Z. (2016). *Lead-Acid Battery Technologies Fundamentals, Materials, and Applications.* CRC Press

Gianfranco Pistoia (2014). *Lithium-Ion Batteries Advances and Applications*. Elsevier

Aulice Scibioh, M & Viswanathan, B. (2020). *Materials for Supercapacitor Applications*. Elsevier

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

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*. Wood head publishing.

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

Online Resources:

https://onlinelibrary.wiley.com/doi/book/10.1002/9781119555599 - Energy Storage

https://link.springer.com/book/10.1007/978-3-319-21239-5 - Energy Storage Fundamentals, Materials and Applications

https://iopscience.iop.org/book/mono/978-0-7503-1531-9.pdf Energy Storage Systems - Book - IOPscience

K1-Remember	*K2-Understand*	*K3-Apply*	*K4-Analyze*	*K5-Evaluate*	*K6-Create*

Name of the Course Teacher: Dr. A. Nithya

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	3	3	2	2	-	2	2	2	3
CO2	2	2	2	3	1	1	2	2	3	2
CO3	3	2	2	2	2	-	2	2	2	3
CO4	2	2	2	2	2	-	3	3	2	2
CO5	2	2	2	2	2	1	2	2	2	2
W.Avg.	2.4	2.2	2.2	2.2	1.8	0.4	2.2	2.2	2.2	2.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	2	2	3	2
CO2	2	2	2	2	2
CO3	2	2	2	2	2
CO4	3	2	2	3	3
CO5	2	2	3	2	2
W.Avg.	2.4	2	2.2	2.4	2.2

S –Strong (3), M-Medium (2), L- Low (1)

Semester III					
Core	Course Code: **540303**	**Advanced Instrumental Methods of Analysis**	**T**	Credits: **5**	Hours : **5**

Unit – I

Objective 1	**To understand various spectroscopic techniques like AAS, AES, X-ray fluorescence and Molecular spectroscopy.**	
Atomic and Molecular Spectroscopy (18 Hrs) Introduction – Interaction of electromagnetic radiations – Electronic spectra and Molecular spectra – Atomic Spectroscopy: Principle and instrumentation – Atomic Emission Spectroscopy – Flame Emission Spectroscopy – Atomic Absorbance Spectroscopy – X-ray Fluorescence Spectroscopy. Molecular Spectroscopy: Principle and instrumentation – Fourier Transform Infrared Spectroscopy – Ultraviolet-Visible Spectroscopy – Raman Spectroscopy – Ultraviolet Photoelectron Spectroscopy.		
Outcome 1	**The students will apply this knowledge to the characterization of nanomaterials.**	**K3**

Unit – II

Objective 2	**To comprehend about electroanalytical techniques, and types of electro analytical methods such as potentiometry, coulometry, voltametry, cyclic voltammetry, and pulse voltammetry.**	
Electroanalytical Techniques (18 Hrs) Introduction to electroanalytical techniques – Electrochemical cells – Types of electroanalytical methods: Potentiometry – Amperometry – Conductometry – Electrogravimetry – Voltametry and Polarography – Cyclic Voltametry – Coulometry and Impedance analysis.		
Outcome 2	**The students will understand the electroanalytical techniques for real-time applications.**	**K2**

Unit – III

Objective 3	**To understand advanced characterization techniques like SEM, EDAX, TEM, XPS and NMR.**	
Microscopic and Elemental Analysis (18 Hrs) Microscopic Analysis: Principle – Instrumentation and analysis – Scanning Electron Microscopy (SEM) – Scanning Tunneling Microscopy (STM) – Atomic Force Microscopy (AFM) – Transmission Electron Microscopy (TEM). Elemental Analysis: Principle – Instrumentation and Analysis – X-ray Photoelectron Spectroscopy (XPS) – X-ray Diffraction (XRD) and Energy Dispersive X-ray Spectroscopy (EDAX) – Mass Spectroscopy – Nuclear Magnetic Resonance Spectroscopy (NMR).		
Outcome 3	**The students will apply the knowledge of XRD, SEM, EDAX, TEM, XPS and NMR to study the physicochemical properties of materials.**	**K3**

Unit – IV

Objective 4	**To understand thermal and surface analysis**	
Thermal and Surface Analysis (18 Hrs) Thermal Analysis: Principle and Instrumentation – Thermo Gravimetric Analysis – Differential Thermal Analysis – Differential Scanning Calorimetry – Micro thermal Analysis. Surface Analysis: Principle and instrumentation – BET (Brunauer, Emmett and Teller) – Surface Area Analyser – Auger Electron Spectroscopy (AES).		
Outcome 4	**The students will be able acquire more knowledge about principle, instrumentation and applications of thermal and surface techniques.**	**K2**

Unit – V

Objective 5	**To understand the electrical and thin film characterization**.	
Electrical Characterization (18 Hrs) DC electrical conductivity as a function of temperature – Hall effect – Types of charge carriers – Charge carrier density – Impedance spectroscopy – DC electrical resistivity – Activation energy – Bulk and grain boundary capacitances – Relaxation times of dipoles. **Thin film Characterization** Introduction of thin film characterization – Mechanical, Electrical, Magnetic and Optical characterization of thin film – Analysis of thin films – Interface phenomena– Multilayer films.		
Outcome 5	**The students will able to compare the electrical and thin film characteristics of materials.**	**K4**

Suggested Readings:
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.

Skoog, D. A., Holler, F. G., & Nieman, T. A. (2004). *Principles of Instrumental Analysis*, Thomson 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.

Rawesh Kumar (2022) *Surface Characterization Techniques: From Theory to Research*, Walter de Gruyter GmbH & Co KG Publishers.

Simonpietro Agnello (2021) *Spectroscopy for Materials Characterization*, John Wiley & Sons Publishers.

Elsevier (2012) *Thermal Analysis*, Academic Press Publishers.

F. James Holler & Stanley R. Crouch (2018) *Skoog and Wests, Fundamentals of Analytical Chemistry*, Cengage Learning Publishers.

Online resources:
https://link.springer.com/chapter/10.1007/978-3-319-27013-5_4- Advanced Characterization Techniques
https://link.springer.com/book/10.1007/978-3-319-92955-2 - Handbook of Materials Characterization
https://link.springer.com/chapter/10.1007/978-3-662-47314-6_6 - Advanced Characterization Techniques

K1-Remember	*K2-Understand*	*K3-Apply*	*K4-Analyze*	*K5-Evaluate*	*K6-Create*

Name of the Course Teacher: Dr. C. Karthikeyan

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	-	3	1	2	3
CO2	3	2	2	2	2	1	2	2	2	2
CO3	2	3	2	3	2	-	3	1	3	3
CO4	2	2	2	2	2	1	2	1	2	2
CO5	2	2	1	2	1	-	2	2	1	2
W.Avg.	2.4	2.4	1.8	2.4	1.8	0.4	2.4	1.4	2.0	2.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	1	1	2	2
CO2	2	2	3	2	2
CO3	2	1	2	2	2
CO4	3	2	2	2	2
CO5	1	1	1	1	1
W.Avg.	2.2	1.4	1.8	1.8	1.8

S –Strong (3), M-Medium (2), L- Low (1)

Semester-III					
Core	Course Code : 540307	Energy Practical- III	P	Credit: 4	Hours : 8

Fabrication of Solar Cell

Objective 1	**To fabricate photo anode/cathode materials, p-n heterojunction and DSSC.**

1. Synthesis of photo anode/cathode materials by solution growth technique.
2. Fabrication of p-n heterojunction solar cells.
3. Fabrication of dye-sensitized solar cells.

Outcome 1	**The students will be able to fabricate solar cells, photo anode/cathode materials and p-n heterojunction.**	**K6**

Characterization of Solar Cell and Supercapacitors

Objective 2	**To analyze the performance of solar cells and supercapacitors**

4. I-V characterization of dye-sensitized solar cells.
5. Effect of temperature and light intensity on solar cell characteristics.
6. Performance testing of solar PV cells.
7. Performance evaluation of supercapacitors.
8. Performance test on solar flat plate collector.
9. Charging characteristics of battery using PV panel.

Outcome 2	**The students will be able to analyze the performance of solar cells and supercapacitor. .**	**K4**

Bioenergy

Objective 3	**To prepare biodiesel from vegetable oil through the alkaline transesterification method**

10. Preparation of biodiesel-alkaline transesterification.

Outcome 3	**The students will be able to prepare biodiesel from vegetable oil through alkaline transesterification.**	**K6**

Energy Audit

Objective 4	**To prepare an effective audit plan and assess the energy utilization**

11. Preparation of energy audit plan and analyzing energy audit data.

Outcome 4	**The students will develop an audit plan and analyze the energy utilization.**	**K4**

**Any other equivalent experiments*

Suggested Readings:

S. Karuppuchamy. (2015). *Nanoscience and technology*, *Laboratory Manual.* United Agencies.

S. Karuppuchamy. (2015). *Energy Science*, *Laboratory Manual.* United Agencies.

Online resources:

https://www.sciencedirect.com/science/article/abs/pii/S0927024822003841#

https://onlinelibrary.wiley.com/doi/abs/10.1002/9781119760801.ch1

https://link.springer.com/chapter/10.1007/978-3-030-89780-2_2

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

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	3	2	2	1	3	2	2	3
CO2	3	2	3	2	2	1	2	2	2	3
CO3	2	1	1	1	1	1	2	1	1	1
CO4	2	2	1	1	1	1	2	1	1	1
W.Avg.	2.5	1.8	2.0	1.5	1.5	1.0	2.3	1.5	1.5	2.0

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	2	2	2
CO2	3	1	2	2	2
CO3	2	1	2	2	2
CO4	2	2	1	1	1
W.Avg.	2.5	1.5	1.8	1.8	1.8

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">Semester- IV</td></tr>
<tr><td>Core</td><td>Course Code: 540999</td><td>Dissertation/ Project Report</td><td>P</td><td>Credit: 14</td><td>Hours : 30</td></tr>
<tr><td colspan="6">Literature Collections</td></tr>
<tr><td>Objective 1</td><td colspan="5">To gain a better understanding of the literature collection process.</td></tr>
<tr><td>Outcome 1</td><td colspan="4">The students will gain more knowledge about collecting relevant literature related to their research topic.</td><td>K2</td></tr>
<tr><td colspan="6">Synthesize of Nanomaterials</td></tr>
<tr><td>Objective 2</td><td colspan="5">To prepare nanostructure materials by physical, chemical and biological methods for energy and environmental applications.</td></tr>
<tr><td>Outcome 2</td><td colspan="4">The students will develop nanostructured materials using various methods.</td><td>K6</td></tr>
<tr><td colspan="6">Characterization of Nanomaterials</td></tr>
<tr><td>Objective 3</td><td colspan="5">To analyze the physicochemical properties of synthesized materials.</td></tr>
<tr><td>Outcome 3</td><td colspan="4">The student will systematically analyze and compare the physicochemical properties of synthesized materials.</td><td>K4</td></tr>
<tr><td colspan="6">Performance Analysis</td></tr>
<tr><td>Objective 4</td><td colspan="5">To analyze the performance of the prepared materials for various applications such as solar cells, supercapacitors, batteries, biodiesel and photocatalysis, etc.,</td></tr>
<tr><td>Outcome 4</td><td colspan="4">The students will evaluate the performance of the prepared materials.</td><td>K5</td></tr>
<tr><td colspan="6">Preparation of Thesis and Viva-Voce Presentation</td></tr>
<tr><td>Objective 5</td><td colspan="5">To systemically compile the entire research work into a thesis and present it during the Viva-Voce.</td></tr>
<tr><td>Outcome 5</td><td colspan="4">The students will acquire noteworthy knowledge and skills related to their research work.</td><td>K1-K6</td></tr>
<tr><td colspan="6">Online Resources:
https://pubs.acs.org
https://pubs.rsc.org
https://www.nature.com
https://www.elsevier.com
https://link.springer.com</td></tr>
<tr><td>K1-Remember</td><td>K2-Understand</td><td>K3-Apply</td><td>K4-Analyze</td><td>K5-Evaluate</td><td>K6-Create</td></tr>
<tr><td colspan="6">Name of the Course Teacher: Dr. S. Karuppuchamy</td></tr>
</table>

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	1	2	1	2	1	1	1
CO2	3	3	2	3	2	2	3	3	2	3
CO3	3	2	3	1	2	1	2	1	2	3
CO4	3	3	2	3	3	2	3	2	2	3
CO5	3	3	2	2	3	2	3	2	2	3
W.Avg.	3.0	2.6	2.2	2.0	2.4	1.6	2.6	1.8	1.8	2.6

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	1	2	2
CO2	3	3	3	3	3
CO3	3	2	2	2	2
CO4	3	3	3	3	3
CO5	3	2	3	3	3
W.Avg.	3	2.4	2.4	2.6	2.6

S –Strong (3), M-Medium (2), L- Low (1)

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)

DSE	Course Code: **540501**	**Biofuels**	**T**	Credits: **4**	Hours : **4**

Unit – I

Objective 1	**To understand biomass resources, biomass assessment, biomass to biofuel and characteristics of biomass.**

Introduction **(14 Hrs)**

Biomass resources: Classification and characteristics – Techniques for biomass assessment – Application of remote sensing in forest assessment – Biomass estimation – Biomass to biofuel.

Outcome 1	**The students will be able to understand biomass energy.**	K2

Unit – II

Objective 2	**To acquire various generations of biofuel feedstocks such as sugar, pant oil, solid and animal waste.**

Biofuel Generation **(15 Hrs)**

Generation of biofuels – First Generation: Starch – Sugar – Vegetable oils or Animal fats. Second Generation: Stems – Husks – Wood chips – Fruit skins and peeling. Third Generation: Algae – Aquatic biomass – Cynobacteria – Biorefinery.

Outcome 2	**The students will analyze the accessibility of different biofuel feedstocks.**	K4

Unit – III

Objective 3	**To study the production of biomethanol, bioethanol, biopropanol and biobutanol.**

Biomethanol, Bioethanol, Biopropanol and Biobutanol **(14 Hrs)**

Introduction – Principle, Materials, Feedstocks and Process technologies of Biomethanol, Bioethanol, Biopropanol and Biobutanol – Advantages and limitations.

Outcome 3	**The students will analyze the suitability of various biofuels production process**.	K4

Unit – IV

Objective 4	**To understand biodiesel production technology and feedstocks.**

Biodiesel **(14 Hrs)**

Introduction of biodiesel − Microorganisms and raw materials used for microbial oil production − Treatment of the feedstocks prior to production of the biodiesel − Current technologies of biodiesel production − Purification of biodiesel – Industrial production of biodiesel − Biodiesel production from single cell oil.

Outcome 4	**The students will understand and apply the knowledge to produce biodiesel**.	K6

Unit – V

Objective 5	**To study biogas and biohydrogen production technologies and its limitations.**

Biogas and Biohydrogen **(15 Hrs)**

Biogas: Introduction – Biogas production – Mechanism of biogas production – Properties of biogas – Biogas plant – Advantage and limitations.

Biohydrogen: Introduction – Biological hydrogen production methods − Fermentative hydrogen production − Hydrogen economy − Advantages and limitations.

Outcome 5	**The students will compare the production technologies of biogas and biohydrogen.**	K5

Suggested Readings:

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

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

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

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.

Sorensen, B. (2017). *Renewable energy*, 5th Edition. Academic Press.
Online resources: https://link.springer.com/book/10.1007/978-3-319-07641-6 - Biomass and Bioenergy Processing and Properties https://www.sciencedirect.com/book/9780124079090/bioenergy - Bioenergy Biomass to Biofuels https://harperandharley.org/pdf/bioenergy/ - Bioenergy

K1-Remember	*K2-Understand*	*K3-Apply*	*K4-Analyze*	*K5-Evaluate*	*K6-Create*
Name of the Course Teacher: Dr. S. Karuppuchamy					

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	1	-	1	-	2	2	1	1
CO2	2	1	1	-	1	-	2	2	1	1
CO3	2	2	2	1	2	1	2	1	2	2
CO4	2	2	2	3	2	1	2	2	2	2
CO5	1	2	2	1	2	1	2	2	2	2
W.Avg.	1.8	1.8	1.6	1.0	1.6	0.6	2.0	1.8	1.6	1.6

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	2	1	1
CO2	1	1	2	1	1
CO3	2	1	2	2	2
CO4	2	2	2	2	2
CO5	2	2	2	2	2
W.Avg.	1.6	1.4	2	1.6	1.6

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><th colspan="6">DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)</th></tr>
<tr><td>DSE</td><td>Course Code: 540502</td><td>Wind and Hydro Energy</td><td>T</td><td>Credits: 4</td><td>Hours : 4</td></tr>
<tr><td colspan="6">Unit – I</td></tr>
<tr><td>Objective 1</td><td colspan="5">To understand wind tower components, wind turbine size classes, towers and types of propellers.</td></tr>
<tr><td colspan="6">Wind Energy (14 Hrs)
Basics concepts – 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.</td></tr>
<tr><td>Outcome 1</td><td colspan="4">The students will summarize the power production from wind turbines.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – II</td></tr>
<tr><td>Objective 2</td><td colspan="5">To understand the wind chargers, grid-connected wind turbines, wind farms, offshore wind farms, planning and designs.</td></tr>
<tr><td colspan="6">Wind Energy Systems (15 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.</td></tr>
<tr><td>Outcome 2</td><td colspan="4">The students will compare the necessity, planning and design, transmission and components of the wind turbine.</td><td>K4</td></tr>
<tr><td colspan="6">Unit – III</td></tr>
<tr><td>Objective 3</td><td colspan="5">To acquire more information about hydrology, the potential of hydropower in India, classification of hydropower plants and small hydropower systems.</td></tr>
<tr><td colspan="6">Hydropower Plants-I (15 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.</td></tr>
<tr><td>Outcome 3</td><td colspan="4">The students will critically analyze the role of hydropower plants in electricity production.</td><td>K4</td></tr>
<tr><td colspan="6">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="5">To comprehend tidal power plants, wave power plants, ocean current power plants and hydropower markets.</td></tr>
<tr><td colspan="6">Hydropower Plants-II (14 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.</td></tr>
<tr><td>Outcome 4</td><td colspan="4">The students will compare the importance of various power plants such as tidal, wave, ocean and hydro.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="5">To gain knowledge of hydro projects, the potential of hydropower in northeast India.</td></tr>
<tr><td colspan="6">Design of Power Plant (14 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.</td></tr>
<tr><td>Outcome 5</td><td colspan="4">The students will analyze the necessity of power plants in India's energy supply.</td><td>K4</td></tr>
<tr><td colspan="6">Suggested Readings:
Ahmed, S. (2015). Wind energy: theory and practice. PHI Learning Pvt. Ltd.
Boyle, G. (2012). Renewable Energy: Power for a Sustainable Future. Oxford.
Burton, T., Jenkins, N., Sharpe, D., & Bossanyi, E. (2011). Wind energy handbook. Wiley.
Ion Bostan, Adrian V. Gheorghe, Ion Sobor Viorel Bostan & Anatolie Sochirean (2012) Resilient Energy Systems: Renewables: Wind, Solar, Hydro, Springer Science and Business Media.</td></tr>
</table>

Kothari, D.P. (2014). *Wind Energy Systems and Applications*. Narosa Publishing House.
Rai, G.D. (1998). *Non-Conventional Energy Sources*. Khanna Publishers.
Rivkin, D. A., & Silk, L. (2013). *Wind Energy*. Jones & Bartlett Publishers.

Online Resources:

http://web.mit.edu/windenergy/windweek/Presentations/Wind%20Energy%20101.pdf
https://www.witpress.com/Secure/elibrary/papers/9781845642051/9781845642051001FU1.pdf
https://www.mdpi.com/2073-4441/12/9/2457/htm - https://www.mdpi.com/2073 4441/12/9/2457/html

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***

Name of the Course Teacher: Dr. C. Karthikeyan

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	1	2	1	-	1	-	2	2	1	2
CO2	2	1	1	-	1	-	2	2	1	1
CO3	1	2	2	1	2	1	1	1	1	2
CO4	1	2	2	1	2	1	2	2	1	1
CO5	1	2	2	1	2	1	1	2	1	1
W.Avg.	1.2	1.8	1.6	0.6	1.6	0.6	1.6	1.8	1.0	1.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	1	2	1	1	1
CO2	1	1	1	1	2
CO3	1	1	2	2	1
CO4	2	2	1	2	2
CO5	1	2	2	1	1
W.Avg.	1.2	1.6	1.4	1.4	1.4

S –Strong (3), M-Medium (2), L- Low (1)

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)					
DSE	Course Code: **540503**	**Advanced Nanomaterials and Their Applications**	**T**	Credits: **4**	Hours : **4**

Unit – I

Objective 1	**To understand the nanoscale significance, type of nanocrystals, and properties.**	

Introduction **(14 Hrs)**

Significance of nanoscale – Surface area, quantum confinement effect, penetration of a barrier – Tunnel effect. Types of nanocrystals – Zero dimensional – One dimensional – Two dimensional – Three dimensional nanostructured materials – Metals – Semiconductors – Ceramics – Composites – Size dependent properties – Mechanical, physical and chemical – Uniqueness in these properties compared to bulk and microscopic materials.

Outcome 1	**The students will be able to understand nanoscale materials.**	K2

Unit – II

Objective 2	**To know more information about various synthesis methods such as physical, chemical and biological.**

Synthesis of Nanomaterials **(15 Hrs)**

Preparation methods: Physical methods –Arc discharge – RF/DC magnetron sputtering – Inert gas condensation – Electrospinning – Laser ablation – Spray pyrolysis. Chemical Methods – Hydrothermal method – Precipitation method – Solvothermal method – Sol gel method – Electrochemical deposition and Microwave irradiation method. Biological Methods – Phytosynthesis – Physcosynthesis – Mycosynthesis.

Outcome 2	**The students will be able to synthesize nanostructure materials via physical, chemical and biological methods.**.	K6

Unit – III

Objective 3	**To learn more knowledge about nanocomposite properties and applications.**

Nanocomposites **(15 Hrs)**

Introduction – Metal-Metal oxide nanocomposites – Metal oxide-Polymer nanocomposites – CNT-Metal oxide nanocomposites – Preparation, Chemical structure, Properties and Applications of nanocomposite materials.

Outcome 3	**The students will distinguish the advantages of nanocomposite materials and analyze the applications of nanocomposite materials.**	K4

Unit – IV

Objective 4	**To study the design factor for biomaterials, classification of biomaterials, bioplastics, magnetic materials and classification.**

Biomaterials and Magnetic Materials **(14 Hrs)**

Biomaterials: Historical development of biomaterials – Design factors for biomaterials – Implant materials – Biomaterials classifications – Bioinert – Bioactive and bioresorbable biomaterials – Biopolymers – Synthetic biodegradable polymer – Bioplastics.

Magnetic materials: Origin of magnetism in materials – Classification of magnetic materials – Magnetic moment – Magnetic hysteresis – Magnetostriction – Curie transition – Neel temperature – Giant and Colossal magneto resistance – Super paramagnetism – Magnetic phenomena at nanoscale.

Outcome 4	**The students will gain noteworthy knowledge about the types and characteristics of biomaterials**.	K2

Unit – V

Objective 5	**To understand the various application of nanomaterials.**

Applications of Nanomaterials **(14 Hrs)**

Water purification – Dye sensitized solar cells – Perovskite solar cells. Electrochemical analysis – Batteries, Supercapacitors, Hybrid capacitors, Electrical devices, Magnetic devices. Biological applications – Tissue engineering – Cancer detection – Biosensors – Medical implants and Self-cleaning.

Outcome 5	**The students will develop nanomaterials for various energy and environmental applications.**	K6

Suggested Readings:

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

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

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

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

Wautelet, Michel. (2009). *Nanotechnologies*. IET.

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

Kannan M. Krishnan. (2016). *Fundamentals and Application of Magnetic Materials*, Oxford University Press Publishers.

Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen & Jack E. Lemons. (2012), *Biomaterials Science: An Introduction to Materials in Medicine*, Edition 3, Academic Press Publishers.

Online Resources:

https://onlinelibrary.wiley.com/doi/book/10.1002/9783527683772 - Nanomaterials and Nanocomposites: Zero- to Three-Dimensional Materials and Their Composites

https://link.springer.com/book/10.1007/978-981-19-1384-6 - Nanomaterials for Advanced Technologies

https://libguides.utdallas.edu/nanotechnology-nanoscience-nanomaterials-guide/sources/books

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***

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

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	3	2	2	1	1	1	2	1	2	2
CO2	3	3	2	2	2	-	3	2	2	1
CO3	2	2	2	2	2	-	2	2	1	1
CO4	1	1	1	1	1	1	2	2	2	1
CO5	2	2	2	1	2	1	2	3	1	2
W.Avg.	2.2	2.0	1.8	1.4	1.6	0.6	2.2	2.0	1.6	1.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	**PSO**				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	3	3	1	2	1
CO2	2	2	2	1	2
CO3	2	2	2	2	2
CO4	2	2	2	2	2
CO5	1	2	1	1	1
W.Avg.	2	2.2	1.6	1.6	1.6

S –Strong (3), M-Medium (2), L- Low (1)

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)

DSE	Course Code: **540504**	**Nuclear Energy**	**T**	Credits: 4	Hours : **4**

Unit-I

Objective 1	**To understand the nuclear reactions, nuclear reactors, heat transfer techniques and reactor shielding.**	

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 – Particle and electromagnetic radiation – Radioactivity and radiation.

Outcome 1	**The students will understand nuclear reactions, nuclear reactors, heat transfer techniques and reactor shielding.**	K2

Unit-II

Objective 2	**To educate the nuclear fuel cycle, uranium production, purification, and nuclear fuels like zirconium, thorium and beryllium.**	

Reactor Materials **(15 Hrs)**

Nuclear fuel cycles – Characteristics of nuclear fuels – Types of reactors – Uranium – Production and purification of uranium – Conversion to UF_4 and UF_6 – Other fuels like Zirconium – Thorium – Beryllium – Steam generator – Creating electricity – Cooling – Shielding.

Outcome 2	**The students gain noteworthy knowledge about the nuclear fuel cycle, uranium production and purification, and nuclear fuels like zirconium, thorium and beryllium**.	K2

Unit-III

Objective 3	**To understand nuclear fuel cycles, spent fuel characteristics, role of solvent extraction in reprocessing and solvent extraction equipment.**	

Reprocessing **(14 Hrs)**

Nuclear fuel cycles – Spent fuel characteristics – Role of solvent extraction in Reprocessing – Controlling fission rate – Stress developed in the reactor vessel wall – Erosion/Corrosion effects.

Outcome 3	**The students will be able to acquire more information about nuclear fuel cycles, spent fuel characteristics, the role of solvent extraction in reprocessing and solvent extraction equipment.**	K2

Unit – IV

Objective 4	**To learn fuel element dissolution, precipitation process, ion exchange, redox, purex, refining, isotopes and principles of isotope separation.**	

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.

Outcome 4	**The students gain more knowledge about fuel element dissolution, precipitation process, isotopes and principles of isotope separation.**	K2

Unit – V

Objective 5	**To understand more information about nuclear wastes, safety control, pollution control and abatement, the international convention on safety aspects and radiation hazards prevention.**	

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 – Purpose of BWR reactor coolant system – Purpose of control of water quality – Control parameters – Sources of reactor impurities – Impurity removal.

Outcome 5	**The students will analyze the challenges of handling nuclear waste.**	K4

Suggested Readings:

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

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

Nicholas Tsoulfanidis. (2012). *Nuclear Energy; Selected Entries from the Encyclopedia of Sustainability Science and Technology*. Springer Science and Business Media.

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

Raymond L. Murray, Keith E. Holbert. (2014). *Nuclear Energy: An Introduction to the Concepts, system, and Application of Nuclear Processess, Edition 7*. Elsevier Publishers.

Twidell, J., & Weir, T. (2015). *Renewable energy resources*. Routledge.

Online resources:

https://onlinelibrary.wiley.com/doi/book/10.1002/9781118043493 Nuclear Energy Encyclopedia: Science, Technology, and Applications

https://link.springer.com/book/10.1007/978-3-030-72670-6 - Nuclear Power Explained

https://www.sciencedirect.com/book/9780124166547/nuclear-energy - Nuclear Energy An Introduction to the Concepts, Systems, and Applications of Nuclear Processes

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***

Name of the Course Teacher: Dr. S. Natarajan

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	1	-	1	-	2	2	1	2
CO2	2	1	1	-	1	-	2	2	1	1
CO3	1	2	2	2	2	1	1	1	-	2
CO4	1	2	2	2	1	1	2	1	2	1
CO5	1	2	2	1	2	1	1	2	1	2
W.Avg.	1.4	1.8	1.6	1.0	1.4	0.6	1.6	1.6	1.0	1.6

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	2	2	1	1	1
CO2	1	1	2	1	2
CO3	1	1	2	2	1
CO4	2	1	1	2	1
CO5	1	2	2	1	1
W.Avg.	1.4	1.4	1.6	1.4	1.2

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)</td></tr>
<tr><td>DSE</td><td>Course Code: 540505</td><td>Climate Change</td><td>T</td><td>Credits: 4</td><td>Hours : 4</td></tr>
<tr><td colspan="6">Unit – I</td></tr>
<tr><td>Objective 1</td><td colspan="5">To understand the important contemporary topics in the field of energy and climate change.</td></tr>
<tr><td colspan="6">Introduction (14 Hrs)
Energy and Climate Change: Global consensus, GHGs emission and energy activities – Montreal protocol, evidence and predictions and impacts – Clean energy technologies – Energy economy, risk and opportunities – Measures to reduce GHGs – Role of renewable energy – Evidence of economic impacts of climate change and economics of stabilizing greenhouse gases.</td></tr>
<tr><td>Outcome 1</td><td colspan="4">The students will be able to know important contemporary topics in the field of energy and climate change.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – II</td></tr>
<tr><td>Objective 2</td><td colspan="5">To learn about the overview of climate change policies.</td></tr>
<tr><td colspan="6">Legal and Policies to Climate Changes (14 Hrs)
Climate change act – Kyoto Protocol and CDM – Governments policies for mitigation and adaptation – National action plan on climate change – Nationally Appropriate Mitigation Actions (NAMA) – Intended Nationally Determined Contributions (INDCs).</td></tr>
<tr><td>Outcome 2</td><td colspan="4">The students gain more knowledge about the overview of climate change policies.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – III</td></tr>
<tr><td>Objective 3</td><td colspan="5">To understand the carbon dioxide emission due to energy conversion and alternative resources on reduction of CO_2 emission.</td></tr>
<tr><td colspan="6">Carbon dioxide (CO_2) Emissions (15 Hrs)
Carbon dioxide (CO_2) emissions due to energy conversion – combustion physics – case studies and comparison of (i) different technologies and (ii) different resources used for energy conversion – Role of technology up gradation and alternative resources on reduction of CO_2 emission – Methodology for CO_2 assessment – UNFCCC baseline methodologies for different conversion process – Estimation of emission from fossil fuel combustion – Case studies.</td></tr>
<tr><td>Outcome 3</td><td colspan="4">The students will be able to compare the causes and control measures of CO_2 emission</td><td>K4</td></tr>
<tr><td colspan="6">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="5">To acquire advanced knowledge about carbon credit and carbon trading mechanisms.</td></tr>
<tr><td colspan="6">Carbon Credit (14 Hrs)
Concept – Commerce of carbon market, Environmental transformation fund – Technology perspective: Strategies for technology innovation and transformation – Future prospect/limitation of carbon trading mechanism.</td></tr>
<tr><td>Outcome 4</td><td colspan="4">The students gain noteworthy knowledge about carbon credit and carbon trading mechanisms.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="5">To understand the methodologies for carbon footprint.</td></tr>
<tr><td colspan="6">Carbon footprint (15 Hrs)
Methodology for CO_2 assessment/Carbon footprint: 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>Outcome 5</td><td colspan="4">The students will analyze the impact of carbon footprint.</td><td>K4</td></tr>
</table>

Suggested Readings:

Basile, A., & Nunes, S. P. (Eds.). (2011). *Advanced membrane science and technology for sustainable energy and environmental applications*. Wood head.

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.

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

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

Online Resources:

https://cup.columbia.edu/book/climate-change/9780231172837

https://www.cambridge.org/highereducation/books/introduction-to-modern-climat change/AD26BD3227322A87F72BEEA655AB1CF7#overview

https://krishi.icar.gov.in/jspui/bitstream/

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***

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

Course Outcome (CO) Vs Programme Outcomes (PO)ss

CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	2	1	-	1	1	2	2	1	-
CO2	1	1	1	-	1	2	2	2	1	1
CO3	1	2	2	1	2	1	1	1	-	-
CO4	1	2	1	1	1	1	2	1	1	-
CO5	1	2	2	1	2	2	1	2	1	1
W.Avg.	1.2	1.8	1.4	0.6	1.4	1.4	1.6	1.6	0.8	0.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	**PSO**				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	2	1	1	1
CO2	1	2	2	1	2
CO3	1	1	2	2	2
CO4	1	1	1	2	2
CO5	2	2	2	2	2
W.Avg.	1.4	1.6	1.6	1.6	1.8

S –Strong (3), M-Medium (2), L- Low (1)

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)					
DSE	Course Code: **540506**	**Energy Audit and Management**	**T**	Credits: **4**	Hours : **4**

Unit – I

Objective 1	**To provide more knowledge about energy audit and energy management.**	
General Aspects (14 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.		
Outcome 1	**The students will be able to know more information about energy audit, general principles of energy management, energy management skills and energy management strategy.**	K2

Unit – II

Objective 2	**To understand methodology and approach, maximizing system efficiency, optimizing the input energy requirements, fuel and energy substitution.**	
Energy Audit (14 Hrs) 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.		
Outcome 2	The students will be able to understand methodology and approach, maximizing system efficiency, optimizing the input energy requirements, fuel and energy substitution.	K2

Unit – III

Objective 3	**To create awareness about methodologies of energy management and understand the importance of implementing energy-saving measures.**	
Energy Policy Planning and Implementation (15 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.		
Outcome 3	**The students will be able to analyze importance of energy management.**	K4

Unit – IV

Objective 4	**To educate first law of efficiency, second law of efficiency, materials and energy balance diagram, energy balance sheet and management information system.**	
Energy Balance & MIS (15 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).		
Outcome 4	**The students will be able to apply laws of efficiency.**	K3

Unit – V

Objective 5	**To know about instruments for energy audit and monitoring energy, energy savings, types and accuracy.**	
Energy Audit Instruments (14 Hrs) Instruments for audit and monitoring energy and Energy savings – Types and accuracy.		
Outcome 5	**The students will be able to know about instruments for energy audit and monitoring energy, energy savings, types and accuracy.**	K2

Suggested Readings:

Anil Kumar, Om Prakash, Prashant Singh Chauhan, & Samsher. (2020). *Energy Management: Conservation and Audits*. CRC Press Publishers.

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

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.

Monsef Krarti. (2020). *Energy Audit of Building System: An Engineering Approach, Third Edition*. CRC Press Publishers.

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

Online Resources:

https://www.beeindia.gov.in/sites/default/files/1Ch3.pdf

https://www.routledge.com/Energy-Audit-and-Management-Concept-Methodologies-Procedures-and-Case/Kumar-Ganesan/p/book/9781032067797

https://link.springer.com/book/10.1007/978-3-658-33167-2

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***

Name of the Course Teacher: Dr. A. Nithya, Dr. S. Natarajan

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	2	-	-	-	1	2	1	1
CO2	1	2	2	-	1	1	-	-	1	2
CO3	1	1	2	1	2	1	2	-	2	2
CO4	2	2	2	2	1	2	2	2	2	1
CO5	2	2	1	2	-	1	1	2	2	2
W.Avg.	1.6	1.8	1.8	1.0	0.8	1.0	1.2	1.2	1.6	1.6

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	1	1	-	1
CO2	1	2	2	-	1
CO3	2	2	2	2	2
CO4	2	2	2	1	1
CO5	1	1	1	1	1
W.Avg.	1.4	1.6	1.6	0.8	1.2

S –Strong (3), M-Medium (2), L- Low (1)

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)

DSE	Course Code: **540507**	**Research Methodology**	**T**	Credits: **4**	Hours : **4**

Unit – I

Objective 1	**To study primary sources and secondary sources, abstract indexes, web resources databases.**	

Survey of Literature **(14 Hrs)**

Primary sources – Journals, Papers, reviews, communications, notes, patents, Journals of different fields of Energy. Secondary Sources – Titles, importance of categorization and their importance, Abbreviations of names. Abstracts – Types, Survey of abstract indexes (substance index, author index, general technique index, collective and comprehensive indices), Beiestein compounds and tables of information. Web resources – E-Journal – Journal access – TOC alerts – Hot articles – Citation index – Impact Factor – H-Index – E-Consortium – UGC infonet – E-Books – Search Engines: Scirus, Google Scholar, Chem Industry, Wiki – Databases: Chem Spider, Science Direct, SciFinder, Web of Science, Scopus, USPTO.

Outcome 1	**The students will be able to study primary sources and secondary sources, abstract indexes, web resources and databases.**	K1

Unit – II

Objective 2	**To learn about the preparation and publication of manuscripts.**	

Paper and Thesis Writing **(15 Hrs)**

Introduction to technical writing – Types of report – Title and abstract – Writing dissertation and thesis – Report of research work, laboratory observation – Records – Preparation of manuscript and poster – Writing review article and book reviews – Preparing research proposals for grants – Ethics in scientific publication – Formats for some national and international journals.

Outcome 2	**The students will be able to write manuscripts, dissertation, and posters.**	K6

Unit – III

Objective 3	**To study good laboratory practices, safe working procedures and protective environment, safe storage and disposal of chemicals in the laboratory.**	

Good Laboratory Practices and Safety **(15 Hrs)**

Definition – Principles – Good Laboratory Practices (GLP) – Application. Stepwise implementation of GLP and Compliance monitoring. Safe working procedure and Protective environment – Protective apparel – Emergency procedure and first aid – Laboratory ventilation – Safe storage and use of hazardous chemicals – Procedure for working with substance that pose hazards – Flammable or explosive hazards – Procedure for working with gases at pressures above or below atmospheric – Safe storage and disposal of waste chemicals – Recovery, recycling and reuse of laboratory chemicals – Procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste – Disposal of chemicals in the sanitary sewer system – Incineration and transportation of hazardous chemicals.

Outcome 3	**The students will apply the best laboratory practices and protective environment.**	K3

Unit – IV

Objective 4	**To study the tools and techniques for research related to reference management, and detection of plagiarism.**	

Tools for Research **(14 Hrs)**

Use of tools/Techniques for Research: Methods to search required information effectively – Reference management software like Zotero/Mendeley/Endnote – software for paper formatting like LaTeX/MS Office – Structure drawing using Origin/ChemDraw/Chemsketch – Software for detection of plagiarism.

Outcome 4	**The students will be able to utilize the tools and techniques for reference management and detection of plagiarism.**	K3

Unit – V		
Objective 5	**To study statistical analysis, precision and accuracy, Gaussian distribution, t and F-test, correlation and regression analysis.**	

Statistical Analysis of Data **(14 Hrs)**

Various types of errors – Precision and accuracy – Significant figures, various statistical tests on the accuracy of results, positive and negative deviation from accurate results – Gaussian distribution – Normal distribution of random errors, mean value, variance and standard deviation – Reliability interval – Deviations from the Gaussian law of error distribution – t-tests comparison of the mean with the expected value – Comparison of the results of two different methods – Comparison of the precision of two methods by F-test – Gross errors and elimination of outlying results – Graphical methods.

Correlation and regression Analysis: Correlation parameters – Correlation coefficient – adjusted r^2 – Interpolation and extrapolation of Data.

Outcome 5	**The students will be able to study various statistical analysis tools and techniques including t and F-test, correlation and regression analysis.**	K2

Suggested Readings:

Anderson, J. (1970) *Thesis and Assignment Writing.* Wilely.

Chemical safty matters-IUPAC-IPCS, Cambridge University, Press, 1992.

Cochran,W.L., (1967). *Statistical Methods*. Oxford and IBH Publication, New Delhi.

Coghill, A.M., and Gardson, L.R., (2006). *The ACS style guide- effective communication of scientific information, 3rd Ed.* oxford university press.

Handbook Good Laboratory Practice Quality practices for regulated Non clinical research and development.

J.March (2007). *Advanced organic chemistry, reaction, mechanism and structure 6th Ed.* Wilely interscience.

Willa,Y., Garnar, Meureen,S., Barge and James P. *Good Laboratory Practice Standard: Application for field and laboratory studies* ACS Professional Reference Book.

Online Resources:

https://mfs.mkcl.org/images/ebook/Fundamental%20of%20Research%20Methodology%20and%20Statistics%20by%20Yogesh%20Kumar%20Singh.pdf

https://study.sagepub.com/kumar4e

https://india.oup.com/product/research-methodology-9780199453788

K1-Remember	*K2-Understand*	*K3-Apply*	*K4-Analyze*	*K5-Evaluate*	*K6-Create*

Name of the Course Teacher: Dr. A. Nithya

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	-	1	-	2	1	3	-	2	-
CO2	1	2	2	1	2	2	3	1	2	3
CO3	1	2	1	-	1	1	1	1	1	1
CO4	1	1	1	2	2	2	2	1	1	2
CO5	1	2	1	2	1	-	1	-	2	2
W.Avg.	1.2	1.4	1.2	1.0	1.6	1.2	2.0	0.6	1.6	1.6

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	1	2	-	2	2
CO2	2	2	3	3	2
CO3	2	2	2	1	2
CO4	1	2	2	2	2
CO5	2	2	1	2	2
W.Avg.	1.6	2	1.6	2	2

S –Strong (3), M-Medium (2), L- Low (1)

NON-MAJOR ELECTIVE COURSES (for Other Departments)

NME	Course Code: 540701	**Basic Concepts in Energy Sciences**	**T**	Credits: **2**	Hours : **3**

Unit – I

Objective 1	**To understand energy resources, conventional and non-conventional energy resources, and energy needs.**	

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.

Outcome 1	**The students will be able to understand and analyze, conventional and non-conventional energy resources, and the importance of energy.**	K4

Unit – II

Objective 2	**To be knowledgeable on solar energy conversion, solar concentrators and other applications, solar photovoltaic, fabrication and types of solar cells.**	

Solar Energy **(11 Hrs)**

Solar radiation: Measurements and prediction – Flat plate collectors – Solar concentrators – Solar thermal energy conversions systems. Solar Photovoltaic: Principle of photovoltaic conversion of solar energy.

Outcome 2	**The students will gain more information about the types and fabrication of solar cells and apply this knowledge to develop solar cells.**	K6

Unit – III

Objective 3	**To acquire about wind energy conversion, wind farms in India, advantages and disadvantages of wind energy conversions.**	

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.

Outcome 3	**The students will acquire more information about wind energy conversion. Analyze the merits and demerits of wind energy.**	K4

Unit – IV

Objective 4	**To know about the origins, uses of biomass energy, sources and characteristics of biofuels like biodiesel, bioethanol and biogas.**	

Bioenergy **(11 Hrs)**

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

Outcome 4	**The students will understand the feasibility of energy recovery from biomass and biofuels. Apply this knowledge to prepare biodiesel.**	K6

Unit – V

Objective 5	**To understand geothermal energy, applications of geothermal energy, tidal power plant and limitations of tidal power generation.**	

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 – Materials selection for geothermal power plants.

Outcome 5	**The students will analyze the applications, advantages and challenges of tidal and geothermal energy.**	K4

Suggested Readings:

Bhatia, S.C. (2014). *Advanced renewable energy systems,* Part –II, WPI Publishers.

Boyle, G. (2012). *Renewable Energy: Power for a sustainable future*. Oxford.

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. Twidell, J., & Weir, T. (2015). *Renewable energy resources*. Routledge.
Online Resources: https://global.oup.com/academic/product/energy-science-9780198854401?cc=in&lang=en& https://bookboon.com/en/energy-environment-ebooks https://www.openaccessgovernment.org/category/ebooks/energy-ebooks/

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***
Name of the Course Teacher: Dr. S. Karuppuchamy, Dr. C. Karthikeyan					

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	PO									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	2	2	1	-	1	1	1	2	1	-
CO2	3	3	2	3	3	-	3	3	2	3
CO3	2	1	1	1	2	1	1	1	1	1
CO4	2	2	2	2	2	1	2	2	2	2
CO5	1	1	1	-	1	-	-	1	1	1
W.Avg.	2.0	1.8	1.4	1.2	1.8	0.6	1.4	1.8	1.4	1.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	PSO				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	1	-	1	-
CO2	3	2	2	3	2
CO3	1	1	1	1	1
CO4	2	2	2	2	2
CO5	1	-	1	1	-
W.Avg.	1.8	1.2	1.2	1.6	1

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">NON-MAJOR ELECTIVE COURSES (for Other Departments)</td></tr>
<tr><td>NME</td><td>Course Code:</td><td>Renewable Energy and Energy Storage Systems</td><td>T</td><td>Credits: 2</td><td>Hours : 3</td></tr>
</table>

<table>
<tr><td colspan="3">Unit-I</td></tr>
<tr><td>Objective 1</td><td colspan="2">To understand world energy use, energy scenario in global and India, and applications of energy resources.</td></tr>
<tr><td colspan="3">Introduction (10 Hrs)
World energy use – Conventional and Non-conventional energy resources – Environmental aspects of energy utilization – Renewable energy scenario in Global and India – Potentials – Achievements – Applications.</td></tr>
<tr><td>Outcome 1</td><td>The students will understand world energy utilization, and analyze energy consumption in global and India scenarios.</td><td>K4</td></tr>
<tr><td colspan="3">Unit-II</td></tr>
<tr><td>Objective 2</td><td colspan="2">To acquire energy storage and comparative analysis.</td></tr>
<tr><td colspan="3">Energy Storage (11 Hrs)
Introduction – Storage of mechanical energy – Electrical energy – Chemical energy – Thermal energy – Electrochemical energy Basics – Working – Advantages and disadvantages – Comparative analysis.</td></tr>
<tr><td>Outcome 2</td><td>The students gain more information about energy storage and comparative analysis.</td><td>K2</td></tr>
<tr><td colspan="3">Unit-III</td></tr>
<tr><td>Objective 3</td><td colspan="2">To know about energy storage systems, batteries and supercapacitors.</td></tr>
<tr><td colspan="3">Energy Storage System (11 Hrs)
Introduction – Electrochemical cell – Batteries – Types of batteries – Working Principle – Advantages and disadvantages. Supercapacitor – Principle – Mechanism – Electrodes – Electrolyte – Applications.</td></tr>
<tr><td>Outcome 3</td><td>The students will be able to analyze energy storage systems such as batteries and supercapacitor.</td><td>K4</td></tr>
<tr><td colspan="3">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="2">To learn more information about energy conversion systems, photovoltaics and fuel cells.</td></tr>
<tr><td colspan="3">Energy Conversion System (11 Hrs)
Photovoltaics – Basic principles of Photovoltaics – Types of photovoltaics – Fabrication methods – Applications.
Fuel Cells – Working principles of fuel cells – Design – Types of fuel cells – Applications.</td></tr>
<tr><td>Outcome 4</td><td>The students will analyze the technology behind the photovoltaics and fuel cells.</td><td>K4</td></tr>
<tr><td colspan="3">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="2">To understand more knowledge about hybrid energy systems and their applications.</td></tr>
<tr><td colspan="3">Hybrid Energy Systems (11 Hrs)
Concept of hybrid energy systems– Battery/Supercapacitor hybrid systems – Fuel cell/Battery systems. Applications: Hybrid electric vehicles for transportations.</td></tr>
<tr><td>Outcome 5</td><td>The students will be able to know more knowledge about hybrid energy systems and their real-time applications.</td><td>K2</td></tr>
<tr><td colspan="3">Suggested Readings:
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.</td></tr>
</table>

Online resources: https://www.cambridge.org/highereducation/books/100-clean-renewable-energy-and-storage-for-everything/26E962411A4A4E1402479C5AEE680B08#overview https://pubs.aip.org/books/monograph/40/chapter-abstract/20688593/Energy-Storage-Systems-for-Renewable-Energy?redirectedFrom=fulltext https://www.ebooks.com/en-in/series/renewable-energy-sources-&-energy-storage/					
K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***
Name of the Course Teacher: Dr. S. Karuppuchamy, Dr. A. Nithya					

Course Outcome (CO) Vs Programme Outcomes (PO)

CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	1	2	-	-	-	1	-	2	-	-
CO2	-	1	-	**1**	1	-	-	1	-	-
CO3	2	2	2	2	2	1	3	1	2	3
CO4	3	2	2	2	2	-	2	1	2	2
CO5	1	-	2	-	2	1	2	2	2	2
W.Avg.	1.4	1.4	1.2	1.0	1.4	0.6	1.4	1.4	1.2	1.4

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	**PSO**				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	-	-	1	-	-
CO2	-	1	1	-	1
CO3	3	2	2	2	2
CO4	2	2	2	2	2
CO5	2	2	2	2	2
W.Avg.	1.4	1.4	1.6	1.2	1.4

S –Strong (3), M-Medium (2), L- Low (1)

<table>
<tr><td colspan="6">NON-MAJOR ELECTIVE COURSES (for Other Departments)</td></tr>
<tr><td>NME</td><td>Course Code:</td><td>Energy Conversion and Conservation Techniques</td><td>T</td><td>Credits: 2</td><td>Hours : 3</td></tr>
<tr><td colspan="6">Unit-I</td></tr>
<tr><td>Objective 1</td><td colspan="5">To understand more information about solar and wind energy conversion.</td></tr>
<tr><td colspan="6">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>Outcome 1</td><td colspan="4">The students will understand the energy conversion from solar and wind.</td><td>K2</td></tr>
<tr><td colspan="6">Unit-II</td></tr>
<tr><td>Objective 2</td><td colspan="5">To acquire wave energy conversion and pneumatic converters.</td></tr>
<tr><td colspan="6">Conversion of Wave Energy (11 Hrs)
Pneumatic converters – Oscillating wave converter – Conversation of water flows – Elevated water – Conversation heat.</td></tr>
<tr><td>Outcome 2</td><td colspan="4">The students will be able to gain more information about wave energy conversion and pneumatic converters.</td><td>K1</td></tr>
<tr><td colspan="6">Unit-III</td></tr>
<tr><td>Objective 3</td><td colspan="5">To understand the conversion of fuel and biological materials, Fuel production from biomass, generation of liquid biofuels and another conversion process.</td></tr>
<tr><td colspan="6">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>Outcome 3</td><td colspan="4">The students will be able to understand the fuel conversion techniques.</td><td>K2</td></tr>
<tr><td colspan="6">Unit – IV</td></tr>
<tr><td>Objective 4</td><td colspan="5">To understand energy conservation, conventional technique, reversible and irreversible cycles, Carnot, Stirling and Rankine cycle.</td></tr>
<tr><td colspan="6">Basics of Energy Conservation (11 Hrs)
Energy Conservation – Conventional Technique – Reversible and Irreversible cycles – Carnot – Stirling and Rankine cycle.</td></tr>
<tr><td>Outcome 4</td><td colspan="4">The students gain more knowledge about energy conservation process</td><td>K4</td></tr>
<tr><td colspan="6">Unit – V</td></tr>
<tr><td>Objective 5</td><td colspan="5">To acquire principles and methods of energy conversion and control</td></tr>
<tr><td colspan="6">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>Outcome 5</td><td colspan="4">The students will be able to analyze the science behind the energy conversion techniques</td><td>K4</td></tr>
<tr><td colspan="6">Suggested Readings:
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.
Quaschning, V. V. (2019). Renewable energy and climate change. Wiley.
Sorensen, B. (2015). Renewable energy: Physics, engineering, environmental impacts, economics & planning. Elsevier.

Stephen W. Fardo, Dale R. Patrick, Ray E. Richardson & Brian W. Fardo. (2020), Energy Conservation Guidebook, Third Edition. CRC Press Publishers.</td></tr>
</table>

Hossam A. Gabbar. (2018). *Energy Conservation in Residential, Commercial, and Industrial Facilities*. John Wiley & Sons. Clive Beggs. (2010). *Energy Management, Supply and Conservation: Edition 2*. Routledge Publishers.
Online resources: https://link.springer.com/book/10.1007/978-3-030-56164-2 - Energy Production, Conversion, Storage, Conservation, and Coupling https://www.cambridge.org/core/books/abs/mechanical-universe/energy-conservation-and conversion/F8615611A0C4E7C843C3EEEF90767C1C https://www.sciencedirect.com/journal/energy-conversion-and-management

K1-Remember	***K2-Understand***	***K3-Apply***	***K4-Analyze***	***K5-Evaluate***	***K6-Create***

Name of the Course Teacher: Dr. S. Karuppuchamy, Dr. S. Natarajan.

Course Outcome (CO) Vs Programme Outcomes (PO)

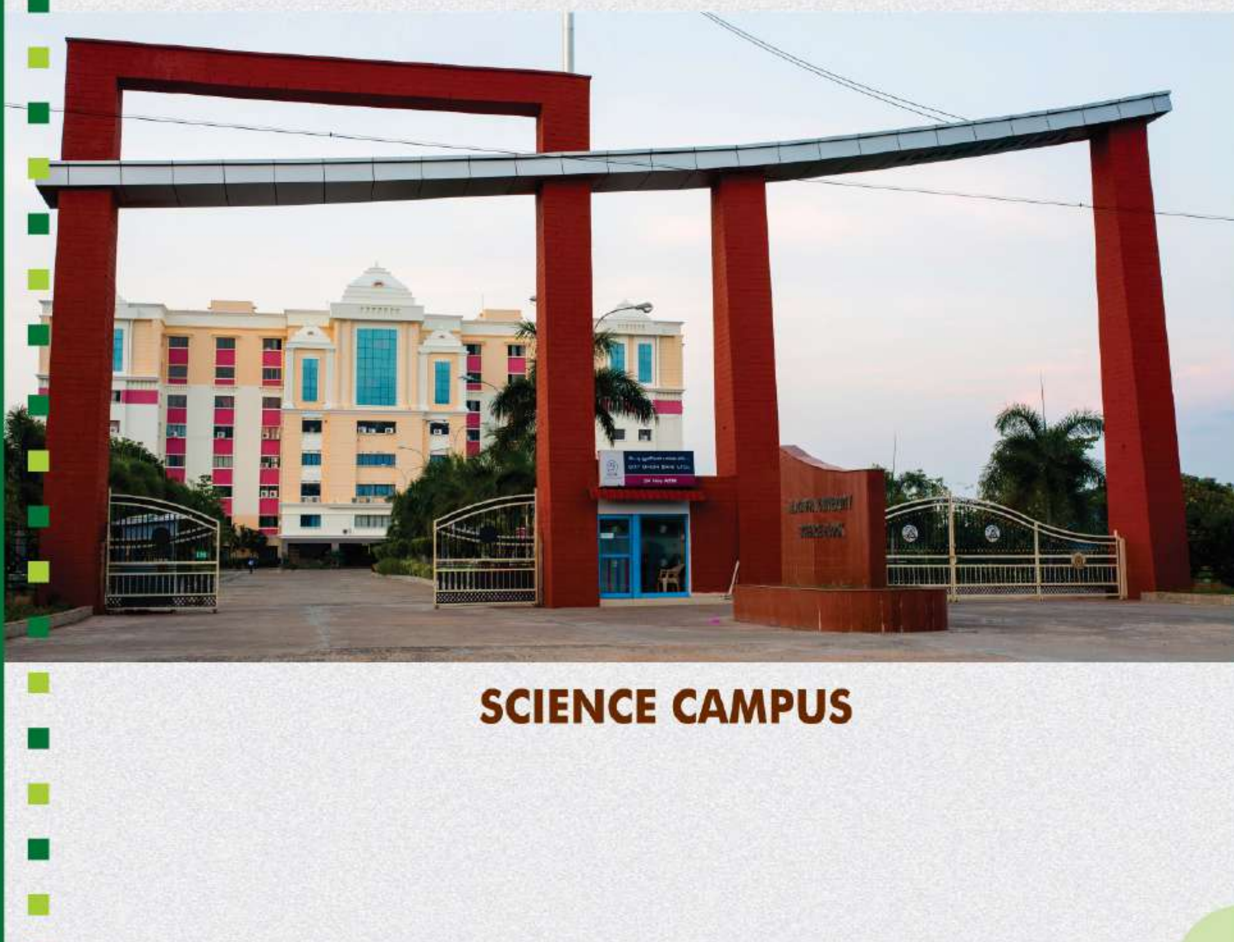
CO	**PO**									
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	1	2	1	1	2	1	2	2	2	2
CO2	1	1	1	1	-	-	-	-	-	-
CO3	1	-	1	1	1	-	1	1	1	1
CO4	2	2	2	2	2	1	-	1	1	1
CO5	1	2	2	2	2	-	-	1	1	2
W.Avg.	1.2	1.4	1.4	1.4	1.4	0.4	0.6	1	1	1.2

S –Strong (3), M-Medium (2), L- Low (1)

Course Outcome (CO) Vs Programme Specific Outcomes (PSO)

CO	**PSO**				
	PSO1	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	2	-	1	1	-
CO2	-	-	1	1	1
CO3	2	1	1	1	2
CO4	2	1	2	2	2
CO5	2	1	2	2	2
W.Avg.	1.6	0.6	1.4	1.4	1.4

S –Strong (3), M-Medium (2), L- Low (1)



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