ST. ALBERT'S COLLEGE (AUTONOMOUS),

ERNAKULAM

Affiliated to Mahatma Gandhi University, Kottayam, Kerala

SYLLABUS FOR POSTGRADUATE PROGRAMME

MASTER OF VOCATIONAL STUDIES IN LOGISTICS AND SUPPLY MANAGEMENT

UNDER CREDIT SEMESTER SYSTEM

(WITH EFFECT FROM 2020 ADMISSION)

Syllabus of M.Voc. Renewable Energy

Proposed by the Board of Studies on 30th June 2020

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Approved by the Academic Council on 2nd July 2020

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Preface

Education plays an important role in the overall development of a human being as well as the nation. It is the unique investment in the present and for the future. Every country develops its own system of education to express and promote its unique socio-cultural identity besides meeting the challenges of time to leverage the existing potential opportunities. Government of India, taking note of the requirement for skill development among students developed National Vocational Education Qualification Framework (NVEQF) which was later assimilated into National Skills Qualifications Framework (NSQF). UGC launched scheme of undergraduate level and post graduate programme to expand the scope of vocational education.

In 2020, St. Albert's College (Autonomous) Ernakulam has introduced the M. Voc. Renewable Energy Management programme. The present M.Voc. Renewable Energy Management programme is a credit based semester system with 4 semesters. The certification levels will lead to Post Graduate Diploma/M. Voc. Degree and will be offered under the aegis of the University. The M.Voc. programme shall include (a) General Courses (General Components) and (b) Core Courses (Skill Components). All students are to complete One Mini Project, One On-job training (OJT) and One Major Project. The major project can be done individually or as a group of students. The programme would generate interest for self employment or start ups among the pupils. M. Voc. Renewable Energy Management programme covers the major areas of Renewable Energy resources and their potential for sustainable development.

Program Outcomes

- Critical Thinking: Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational, and personal) from different perspectives.
- Problem Solving: Solve problems from the Disciplines of concern using the Knowledge, skills and attitude acquired from humanities / science / mathematics / Social Sciences etc.
- Individual and Team Work: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
- Environment and Sustainability: Understand the issues of environmental contexts and sustainable development.

Program Specific Outcomes

- Understand the progress of various renewable energy sectors and to imbibe knowledge in similar areas with the aid of mathematical, computational and interactive skills.
- Establish a competence in analysis, design, development and operation of energy systems: bio energy, heat energy, geothermal energy, wind power, ocean energy, chemical energy and also in photovoltaic systems, hydrogen production storage and fuel cells.
- Accomplish individual and technical skills including leadership, project management, on job training and communication to work as a professional, or to pursue a career in research.
- To inculcate among the student's systematic knowledge and skill about assessing the current energy scenarios and policies, energy efficiency, energy auditing, energy management and conservation techniques.

Regulations

1. SHORT TITLE

1.1. These regulations shall be called SACA Regulations (2020) governing Master of Vocational Programmes under Credit Semester System (SACA-PG-CSS-M. Voc. 2020).

1.2. These Regulations shall come into force from the Academic Year 2020-2021 onwards.

2. SCOPE

2.1. The regulations provided herein shall apply to Master of Vocational Programmes conducted in the Institution, with effect from the academic year 2020-2021.

3. DEFINITIONS

3.1. 'Academic Council' means the Committee constituted by the Governing body under this regulation to monitor the running of the post graduate programmes under the Credit Semester System (SACA-PG-CSS-M.Voc. 2020).

3.2. 'Academic Week' is a unit of five working days in which distribution of work is organized from day one to day five, with a minimum of five contact hours of one hour duration on each day. A sequence of minimum of 18 such academic weeks constitutes a semester.

3.3. 'Audit Course' is a course for which no credits are awarded.

3.4. 'CE' means Continuous Evaluation (Internal Evaluation).

3.5. 'Comprehensive viva-voice' means the oral examinations conducted by the appointed examiners and shall cover all courses of study undergone by a student for the programme.

3.6. NSQF means National Skills Qualifications Framework.

3.7. 'Vocational Course' (Skill Enhancement Course) means a course that enables the students to enhance their practical skills and ability to pursue a vocation in their subject of specialization.

3.8. 'General components' means a course that provides a general awareness about the discipline.

3.9. 'Skill components' means a course in the subject of specialization

within a vocational degree programme.

3.10. 'OJT' means On-the-job training.

3.11. 'Course' means a course segment of subject matter to be covered in a semester. Each course is to be designed variously under lectures/ tutorials/ laboratory or fieldwork/ seminar/ internship/ project/ practical training/ assignments/OJT/ viva-voice etc., to meet effective teaching and learning needs.

3.12. 'Course Code' means a unique alphanumeric code assigned to each course of a programme.

3.13. 'Course Credit' on credit of a course is defined as a minimum of 1 hour lecture /minimum of two hours lab field work per week with a minimum of 15 weeks in a Semester. The course will be considered as completed only by conducting the final examination.

3.14. 'Course Teacher' means the teacher of the institution in charge of the course offered in the programme.

3.15. 'Credit (Cr)' of a course is a numerical value which depicts the measure of the weekly unit of work assigned for that course in a semester

3.16. 'Credit point (CP)' of a course is the value obtained by multiplying the Grade Point (GP) by the credit (Cr) of the course CP = GP x Cr.

3.17. 'Cumulative Grade point average (CGPA)' is the value obtained by dividing the sum of credit points of all the courses taken by the students for the entire programme by the total number of credits and shall be rounded off to two decimal places. CGPA determines the overall performance of a student at the end of the programme. (CGPA = total CGPA obtained /Total credits of the programme)

3.18. 'Department' means any teaching Department in the Institution offering a programme of study approved as per the Act/ statutes of the University.

3.19. 'Department Council' means the body of all teachers of a Department in a college.

3.20. 'Dissertation' means a long document on a particular subject in connection with the project/research/ field work etc.

3.21. 'Duration of a Programme' means the period of time required for the conduct of the programme. The duration of the post-graduation programme shall be 4 semesters spread over two academic years.

3.22. 'ESE' means End Semester Evaluation (External Evaluation).

3.23. 'Evaluation 'is the process by which the knowledge acquired by the student is quantified as per the criteria detail in these regulations.

3.24. 'External Examiner 'is the teacher appointed from other colleges for the valuation of courses of study undergone by the students in a college. The external examiner shall be appointed by the College.

3.25. 'Exam Coordinator 'is a teacher nominated by the Department Council to coordinate the continuous evaluation and other academic activities undertaken in the Department of the college.

3.26. 'Grace Grade Points' means grade points awarded to course(s), in recognition of the students' meritorious achievement in NSS/Sports/Arts and cultural activities etc.

3.27. 'Grade point (GP) letter grade is assigned a 'Grade point' (GP) which is an integer indicating the numerical equivalent of the board level of performance of a student in a course.

3.28. 'Grade Point Average (GP)'is an index of the performance of student in a course. It is obtained by dividing the sum of the weighted grade points obtained in the course by the sum of the weights of the course. (GPA= ∑WGP/∑W).

3.29. 'Improvement course' is a course registered by a student for improving his/ her performance in that particular course.

3.30. 'Internal Examiner' is a teacher nominated by the department concerned to conduct internal evaluation.

3.31. 'Letter Grade' or 'Grade' for a course is a letter symbol (A^+, A, B^+, B, C, C^+, D) which indicates the broad level of performance of a student for a course.

3.32. 'SACA-PG-CSS M. Voc. 2020' means St. Albert's College Autonomous Regulations Governing Post Graduate Programmes under Credit Semester System, 2020.

3.33. 'Parent Department' means the Department which offers a particular post graduate programme.

3.34. 'Plagiarism' is the unreferenced use of other authors'' material in dissertations and assignments and is a serious academic offence.

3.35. 'Programme' means the entire course of study and examinations.

3.36. 'Project/Mini Project/OJT/Internship' is a skill course in a programme. It means a regular project work with stated credits on

which the student undergoes a project under the supervision of a teacher in the parent department/ any appropriate research center / industry in order to submit a dissertation on the project work as specified. It allows students to work more autonomously to construct their own learning and culminate in a realistic, student-generated product for findings.

3.37. 'Repeat course' is a course that is repeated by the student for having failed in that course in an earlier registration.

3.38. 'Semester' means a term consisting of a minimum of 90 working days, inclusive of examinations, distributed over a minimum of 18 weeks of 5 working days each.

3.39. 'Seminar' means a lecture given by the student on a selected topic and is expected to train the student in self-study, collection of relevant matter from various resources, editing, document writing and presentation.

3.40. 'Semester Grade Point Average'(SGPA) is the value of trained by dividing the sum of credit points CP obtained by a student in the various courses taken in a semester by the total number of credits for the course in that semester. The SGPA shall be rounded off to two decimal places. SGPA determines the overall performance of a student at the end of the semester (SGPA= Total CP obtained in the semester /Total Credits for the semester).

3.41. 'Tutorial' means a class to provide an opportunity to interact with students at their individual level to identify the strength and weakness of individual students.

3.42. 'University' means Mahatma Gandhi University, Kottayam, Kerala.

3.43. 'College' means St. Albert's College (Autonomous), Ernakulam, Kerala.

3.44. 'Weight' is a numeric measure assigned to the assessment units of various components of a course of study.

3.45. 'Weighted Grade Point' (WGP) is the grade point multiplied by weight. (WPG = GP x W).

3.46. 'Weighted Grade Point Average (WGPA)' is an index of the performance of a student in a course. It is obtained by dividing the sum of the weighted grade points by the sum of the weights. WGPA shall be obtained for CE (Continuous Evaluation) and ESE (End Semester

Evaluation) separately and then the combined WGPA shall be obtained for each course.

3.47. Words and expressions used and not defined in this regulation but defined in the Mahatma Gandhi University Act and Statutes that you shall have the meaning assigned to them in the Act and Statute.

ACADEMIC COUNCIL: COMPOSITON OF ACADEMIC COUNCIL

1. The Principal (Chairman)
2. All Heads of the Departments
3. Four teachers of the college representing different categories of teaching staff by rotation on the basis of seniority of service in the college.
4. Not less than four experts/academicians from outside the college representing areas such as Industry, Commerce, Law, Education, Medicine, Engineering, Sciences etc., to be nominated by the Governing Body.
5. Three nominees of the university not less than Professors.
6. A faculty member nominated by the Principal (Member Secretary).

PROGRAMME STRUCTURE

3.48. The medium of instruction shall be English except for programmes under Faculty of Language and Literature.

3.49. Student shall be admitted to post graduate programmes under various faculties. The programme shall include two types of courses, Skill and General courses. There shall be a project with the dissertation and comprehensive viva-voce as core courses for all programmes. The programme shall also include assignments/seminars/practical/OJT/ mini project/project/field study etc.

3.50. Project work

3.50.1. Project work shall be completed in accordance with the guidelines given in the curriculum and shall be carried out under the supervision of a teacher of the department concerned. A candidate may, however, in certain cases be permitted to work on the project in an Industrial/Research Organization on the recommendation of the supervising teacher.

3.50.2. There shall be internal assessment and external assessment for the

project work.

3.50.3. The project work shall be evaluated based on the presentation of the project work done by the student, the dissertation submitted and the Viva-voce on the project.

3.50.4. The external evaluation of the project work shall be conducted by an external examiner from different college and an internal examiner from the college concerned.

3.50.5. The final Grade of the project (External) shall be calculated by taking the average of the Weighted Grade Points given by an external examiner and the internal examiner.

3.51. Assignments: Every student should submit at least one assignment as an internal component for each course.

3.52. Seminar Lecture: Each student shall deliver one seminar lecture as an internal component for every course with a weightage of two. The seminar lecture is expected to train the student is self-study, collection of relevant matter from the various resources, editing, document writing, and presentation.

3.53. Test Papers (Internal): Student shall undergo at least two class tests as an internal component for each course with a weightage of one each. The best two shall be taken for awarding the grade for class tests.

3.54. No course shall have more than 5 credits unless otherwise specified.

3.55. Comprehensive Viva-Voce: Comprehensive Viva-voce conducted at the end of fourth semester of the programme and its evaluation shall be conducted by the examiners of the project evaluation.

3.55.1. Comprehensive Viva-Voce cover questions from all courses in the programme.

3.55.2. There shall be an internal and external assessment or only an external assessment for the comprehensive Viva-voce as specified in the syllabus.

Attendance

3.56. The minimum requirement of aggregate attendance during a semester for operating at the end-semester examination shall be 75%. Condonation of shortage of attendance for students having a minimum of 65% attendance, (up to a maximum of 10 days) in a semester subject to a maximum of two times during the whole Period of the programme

may be granted by the College.

3.57. If a student represents his/her institution, University, State or Nation in Sports or Cultural or any other officially sponsored activities such as College Union/University Union etc. he/she shall be eligible to claim the attendance for the actual number of days participated subject to a maximum of 10 days in a semester based on the specific recommendations of the teacher concerned, class tutor, Head of the Department forwarded through the Dean Students Affairs subjected to the approval of the Principal. For exceptional achievements/situations, the Principal may recommend for the award of additional attendance to the Governing Body.

3.58. Those who could not register for the examination of a particular semester due to shortage of attendance will not be able to repeat the semester and will be removed from the rolls.

4. Registration/Duration

4.1. A student shall be permitted to register for the programme at the time of admission.

4.2. A student who has registered for the programme shall complete the programme within a period of four years from the date of commencement of the programme.

5. Admission

5.1. The admission to all regular PG programme shall be through the Centralized Allotment Process of the College.

5.2. If there is an entrance examination specified for the admission for a particular programme, it will be as per the directions of the office of the CoE of the college.

5.3. The eligibility criteria for admission to M. Voc programmes shall be published by the College in the prospectus.

6. Admission Requirements

6.1. Candidates for admission to the first semester of the M. Voc programme shall be required to have passed an appropriate Degree Examination of any recognized university/institutions. Other eligibility requirements for specific programmes will be published in the prospectus.

6.2. Students admitted under this programme are governed by the Regulations of the College.

7. PROMOTION

7.1. A student who registers for a particular semester examination shall be promoted to the next semester.

8. EXAMINATIONS

8.1. There shall be an examination conducted by St. Albert's College, (Autonomous) at the end of each semester.

8.2. Practical Examination shall be conducted by the College at the end of each semester. The number of examiners for the Practical Examination shall be prescribed by the Board of Studies of the programme.

8.3. End Semester Examinations: The examinations shall normally be conducted at the end of each semester.

8.4. There shall be one End-semester examination of 3 hours duration for each lecture based courses.

8.5. A question paper may contain short answer type/annotation, short essay type questions problem and long essay type questions. Different types of questions shall have different weightages.

9. EVALUATION AND GRADING

9.1. Evaluation: The evaluation scheme for each course shall contain two parts; (a) End Semester Evaluation (ESE) (External Evaluation) and (b) Continuous Evaluation (CE) (Internal Evaluation). The ratio of weightage between internal and external is 1:3 (unless for the courses, it is otherwise specified by the BoS). Both End Semester Evaluation (ESE) and Continuous Evaluation (CE) shall be carried out using direct grading system.

9.2. Direct grading: The direct grading for CE (Internal) and ESE (External Evaluation) shall be based on 6 letter grades (A+, A, B, C, D and E) with numerical values of 5, 4, 3, 2, 1 and 0 respectively.

9.3. Grade Point Average GPA: internal and external components are separately graded and the combined grade point with weightage 1 for internal and 3 for external shall be applied to calculate the Grade Point Average (GPA) of each course. Letter grade shall be assigned to each course based on the categorization provided.

9.4. Internal evaluation for regular programme: The internal evaluation shall be based on a predetermined transparent system involving periodic written tests, assignments, seminars, lab skills, records, Viva-voce etc.

9.5. Components of internal (CE) and external evaluation (ESE): Grades shall be given to the evaluation of

theory/practical/project/OJT/comprehensive Viva-voce and all internal evaluations based on the Direct Grading System.

Proper guidelines shall be prepared by the BOS for evaluating the assignment, seminar, practical, project and the comprehensive viva-voce within the framework of the regulation.

9.6. There shall be no separate minimum grade point for internal evaluation.

9.7. The model of the components and its weightages of continuous evaluation (CE) and End Semester Evaluation (ESE) are Shown in below:

a) For theory (CE)(Internal)

	Components	Weightage
i.	Assignment	2
ii.	Seminar	4
iii.	Best Two Test papers	4(2 each)
Total		10

(Grades of best two test papers shall be considered. For test papers all questions shall be set in such a way that the answers can be awarded A+, A, B, C, D, E grade.)

b) For the theory (ESE) (External)

Evaluation is based on the pattern of questions specified 12.15.5

c) For Practical (CE) (Internal)

Components	Weightage
Written/Lab test	2
Lab involvement and Record	1
Viva	2
Total	5

(The components and the weightage of the components of the practical (Internal) can be modified by the concerned BOS without changing the total weightage 5.)

d) For Practical (ESE) (External)

Components	Weightage
Written / Lab test	7
Lab involvement and Record	3
Viva	5
Total	15

[The components and the weightage of the practical (External) can be modified by the concerned BOS without changing the total weightage 15.]

e) For Project / Mini Project (CE) (Internal)

Components	Weightage
Relevance of the topic and analysis	2
Subject knowledge	2
Report	1
Total	5

(The Components and the weightage of the components of the project (Internal) can be modified by the concerned BOS without changing the total weightage 5.)

f) For Project / Mini Project / (ESE) (External)

Components	Weightage
Relevance of the topic and analysis	3
Project content and presentation	7
Project viva	5
Total	15

(The Components and the weightage of the components of the project (External) can be modified by the concerned BOS without changing the total weightage 15.)

g) Comprehensive viva-voce (CE)(internal)

Components	Weightage
Conceptual understanding of the programme	5
Total	5

(Weightage of the components of the comprehensive viva-voce (internal) shall not be modified.)

h) Comprehensive viva-voce (CE)(External)

Components	Weightage
Comprehensive viva- voce (all courses from first semester to fourth semester)	15
Total	15

(Weightage of the components of the comprehensive viva-voce (external) shall not be modified unless specified by the respective BoS for a particular course.)

i) For Internship / OJT (ISE) (Internal)

Components	Weightage
Relevance of the topic and analysis	2
Punctuality	1
Subject Knowledge	2
Total	5

[The components and the weightage of the practical (Internal) can be modified by the concerned BOS without changing the total weightage 5.]

j) For Internship / OJT (ESE) (External)

Components	Weightage
Report	3
Presentation	7
Viva	5
Total	15

[The components and the weightage of the practical (External) can be modified by the concerned BOS without changing the total weightage 15.]

9.8. All grade point averages shall be rounded to two decimal points.

9.9. To ensure transparency of the evaluation process, the internal assessment grade awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of the external examination.

9.10. There shall not be any chance for improvement for internal grade.

9.11. The course teacher and the Exam coordinator shall maintain the academic details of each student registered for the course and a copy should be kept in the department for verification for at least five years after the student completes the programme.

9.12. External evaluation: The external examination in theory courses is to be conducted by the College at the end of the semester. The answers should be in English expect those for the Faculty of Languages. The

evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. The external evaluation shall be done immediately after the examination.

9.13. Photocopies of the answer scripts of the external examination shall be made available to the students on request as per the rules prevailing in the College.

9.14. The question paper should be strictly on the basis of model question papers set and the directions prescribed by the BOS/Governing Body of the college for each programme.

9.15. Pattern of questions

9.15.1. Questions shall be set to access the knowledge acquired, standard application of Knowledge, application of knowledge in new situations, critical evaluation of knowledge and the ability to synthesize knowledge. Due weightages shall be given to each module based on content/ teaching hours allotted to each module.

9.15.2. The question setter shall ensure that questions covering all outcomes are met.

9.15.3. A question paper shall be a judicious mix of short answer type, short essay type/ problem solving type and long essay type questions.

9.15.4. The questions shall be prepared in such a way that the answers can be awarded A+, A, B, C, D, E grades.

9.15.5. Weight: Different types of questions shall be given different weights to quantify their range as follows:

Sl.No.	Type of Questions	Weight	Number of questions to be answered
1.	Short Answer type questions	1	8 out of 10
2	Short essay/ problem solving type questions	2	6 out of 8
3.	Long Essay type questions	5	2 out of 4

9.16. Pattern of questions for practical: the pattern of questions for external evaluation of practical shall be prescribed by the Board of

Studies.

9.17. **Direct grading System:** Direct Grading System based on a 6-point scale is used to evaluate the Internal and External examinations taken by the students for various courses of study.

Grade	Grade Points
A+	5
A	4
B	3
C	2
D	1
E	0

9.18. Performance Grading

Students are graded based on their performance (GPA/SGPA/CGPA) at the examination on a 7-point scale as detailed below. *(7-point scale needed clarification)*

Range	Grade	Indicator
4.50 to 5.00	A+	Outstanding
4.00 to 4.49	A	Excellent
3.50 to 3.99	B+	Very good
3.00 to 3.49	B	Good (Average)
2.50 to 2.99	C+	Fair
2.00 to 2.49	C	Marginal(pass)
up to 1.99	D	Deficient (Fail)

9.19. No separate minimum is required for internal evaluation for a pass, but a minimum C grade is required for a pass in an external evaluation. However, a minimum C grade is required for pass in a course.

9.20. A student who fails to secure a minimum grade for a pass in a course will be permitted to write the examination along with the next batch.

9.21. **Improvement of course:** The candidates who wish to improve the grade/ grade point of the external examination of a course/ courses

he/she has passed can do the same by appearing in the external examination of the semester concerned along with the immediate junior batch. This facility is restricted to first and second semesters of the program.

9.22. Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) calculations. The SGPA is the ratio of the sum of the credit points of all courses taken by a student in the semester to the total credit for that semester. After the successful completion of a semester, Semester Grade Point Average (SGPA) of a student in that semester is calculated using the formula given below.

Semester Grade Point Average –SGPA (S_j) = $\sum(C_i \times G_i) / \sum C_i$

(SGPA = Total credit Points awarded in all semesters / Total credits of the semester)

Where 'S_j' is the j^{th} semester, 'G_i' is the grade point scored by the student in the i^{th} course 'C_i' is the credit of i^{th} course.

9.23. Cumulative Grade Point Average (CGPA) of a programme is calculated using the formula:-

Cumulative Grade Point Average (CGPA) =$\sum(C_i x S_i) / \sum C_i$

(CGPA = Total credit Points awarded in a semester / Total credits of the programme)

Where 'C_i' is the credits for the i^{th} semester 'S_i' is the SGPA for the i^{th} semester. The SGPA and CGPA shall be rounded off to 2 decimal points.

For the successful completion of semester, a student shall pass all courses and score a minimum SGPA of 2.0 . However, a student is permitted to move to the next semester irrespective of her/ his SGPA.

10. GRADE CARD

10.1. The College under its seal shall issue to the students, a consolidated grade card on completion of the programme, which shall contain the following information.

a) Name of College
b) Name of the University
c) Title of the PG Program
d) Name of the Semesters
e) Name and Register Number of the student

f) Code, Title, Credits and Max GPA (Internal, External & Total) of each course (theory & Practical), project, viva etc., in each semester.
g) Internal, external and total grade, Grade Point (G), Letter Grade and Credit point (P) in each course opted in the semester.
h) The total credits and total credit points in each semester
i) Semester Grade Point Average (SGPA) and corresponding Grade in each semester
j) Cumulative Grade Point Average (CGPA), Grade for the entire Program.
k) Separate Grade card will be issued at the request of candidates and based on College Guidelines issued from time to time.
l) Details of description of evaluation process-Grade and Grade Point as well as indicators, calculation methodology of SGPA and CGPA as well as conversion scale shall be shown on the reverse side of the grade card.

11. AWARD OF DEGREE

The successful completion of all the courses with 'C' grade within the stipulated period shall be the minimum requirement for the award of the degree.

12. MONITORING COMMITTEE

There shall be a Monitoring Committee constructed by the Principal to monitor the internal evaluation conducted by departments.

13. POSITION CERTIFICATE

The College shall publish the list of top 3 candidates for each programme after the publication of the programme results. Position certificate shall be issued to candidates on their request.

Candidates shall be ranked in the order of merit based on the CGPA secured by them. Grace grade points awarded to the students shall not be counted for fixing that rank/position. Position certificates shall be signed by the Controller of Examinations.

14. GRIEVANCE REDRESSAL COMMITTEE

In order to address the grievance of students a three-level Grievance Redressal mechanism is envisaged. A student can approach the upper level only if grievance is not addressed at the lower level.

14.1. **Class Level**: The cell is chaired by the class tutor and the course teacher or a teacher nominated by the Head of the Department.

14.2. **Department level**: The College shall form a Grievance Redressal

Committee in each department comprising of the course teacher and one senior teacher as members and the Head of the Department as Chairperson. The committee shall address all grievances relating to the internal assessment grade of the students.

14.3. **College level:** A committee with the Principal as Chairman, Dept. Coordinator, HOD of concerned Department and a senior teacher nominated by the Executive Committee as members.

15. TRANSITORY PROVISION

Notwithstanding anything contained in these regulations, the Governing Body shall, for a period of two years from the date of coming into force of these regulations, have the power to provide by order that these regulations shall be applied to any programme with such modifications as may be necessary.

16. CREDITS ALLOTTED FOR PROGRAM AND COURSES

16.1. Total credit for each program shall be 120.

16.2. Semester-wise total credit can vary from 28 to 32.

16.3. The minimum credit of a course is 2 and maximum credit is 10.

17. COURSE CODE: The course codes assigned for all courses (skill courses and general courses) shall be unique.

18. MODELS OF DISTRIBUTION OF COURSES, COURSE CODES, TYPE OF THE COURSE, CREDITS, AND TEACHING HOURS FOR A PROGRAM ARE GIVEN IN THE FOLLOWING TABLE.

Example **Programs with the practical-Total Credits 120-** scheme of the syllabus

Semester	Course Code	Course name	Type of the course	Teaching Hours Per Week	Credit	Total Credits
I	Course.code1	Name1	General	3	4	30
	Course.code2	Name2	General	3	4	
	Course.code3	Name3	General	3	4	
	Course.code4	Name4	Skill	4	5	
	Course.code5	Name5	Skill	4	5	
	Practical Course.code 6	Name6	Skill	4	4	
	Practical Course.code7	Name7	Skill	4	4	
II	Course.code8	Name8	General	3	4	30
	Course.code9	Name9	General	3	4	
	Course.code10	Name10	General	3	4	
	Course.code11	Name11	Skill	4	5	
	Course.code12	Name12	Skill	4	5	
	Practical / Mini Project Course.code13	Name13	Skill	4	4	
	Practical-Course.code14	Name14	Skill	4	4	
III	Course.code15	Name15	Gener	3	4	30

			al			
	Course.code16	Name16	General	3	4	
	Course.code17	Name17	General	3	4	
	Course.code18	Name18	Skill	4	5	
	Course.code19	Name19	Skill	4	5	
	Practical / OJT Course.code20	Name20	Skill	4	4	
	Practical Course.code21	Name21	Skill	4	4	
IV	Course.code22	Name22	General	3	4	30
	Course.code23	Name23	General	3	4	
	Course.code24	Name24	General	3	4	
	Course.code25	Name25	Skill	4	5	
	Project-Course.code26	Name26	Skill	5	5	
	Practical-Course.code27	Name27	Skill	5	4	
	Comprehensive viva- voce -Course.code28	Name28	Skill	2	4	
	Total					120

Semester	Course code	Course name	Type of the course	TeachingHours per week	Credit	Total Credits
I	Course.code 1	Name 1	General	4	4	30
	Course.code 2	Name 2	General	4	4	
	Course.code 3	Name 3	General	4	4	
	Course.code 4	Name 4	Skill	5	5	
	Course.code 5	Name 5	Skill	5	5	
	Course.code 6	Name 6	Skill	4	4	
	Course.code 7	Name 7	Skill	4	4	
II	Course.code 8	Name 8	General	4	4	30
	Course.code 9	Name 9	General	4	4	
	Course.code 10	Name 10	General	4	4	
	Course.code 11	Name 11	Skill	3	4	
	Course.code 12	Name 12	Skill	3	4	
	Course.code 13	Name 13	Skill	3	4	

	Internship Course.code 14	Name 14	Skill	4	6	
III	Course.code 15	Name 15	General	4	4	30
	Course.code 16	Name 16	General	4	4	
	Course.code 17	Name 17	General	4	4	
	Course.code 18	Name 18	Skill	5	5	
	Course.code 19	Name 19	Skill	5	5	
	Course.code 20	Name 20	Skill	4	4	
	Course.code 21	Name 21	Skill	4	4	
IV	Course.code 22	Name 22	General	4	4	30
	Course.code 23	Name 23	General	4	4	
	Course.code 24	Name 24	General	4	4	
	Course.code 25	Name 25	Skill	4	4	
	Course.code 26	Name 26	Skill	4	4	
	Project-Course.code 27	Name 27	Skill	5	10	
	Total					120

Appendix

1. Evaluation first stage-Both internal and external (to be done by the teacher)

Grade	Grade Points
A+	5
A	4
B	3
C	2
D	1
E	0

The final Grade range for courses SGPA and CGPA

Range	Grade	Indicator
4.50 to 5.00	A+	Outstanding
4.00 to 4.49	A	Excellent
3.50 to 3.99	B+	Very good
3.00 to 3.49	B	Good
2.50 to 2.99	C+	Fair
2.00 to 2.49	C	Marginal
Up to 1.99	D	Deficient (Fail)

Theory -External – ESE

Maximum weight for external evaluation is 30. Therefore, Maximum Weighted Grade Point (WGP) is 150

Type of Question	Qn. No's	Grade Awarded	Grade point	Weights	Weighted Grade Point
Short Answer	1	A+	5	1	5
	2	-	-	-	-
	3	A	4	1	4
	4	C	2	1	2
	5	A	4	1	4
	6	A	4	1	4
	7	B	3	1	3
	8	A	4	1	4
	9	B	3	1	3
	10	-	-	-	
Short Essay	11	B	3	2	6
	12	A+	5	2	10
	13	A	4	2	8
	14	A+	5	2	10
	15	-	-	-	-
	16	-	-	-	-
	17	A	4	2	8
	18	B	3	2	6
Long Essay	20	A+	5	5	25
	21	-	-	-	-
	22	-	-	-	-
	23	B	3	5	15
			TOTAL	30	117

Calculation: Overall Grade of the theory paper = Sum of Weighted Grade Points /Total weight 117/30 = 3.90 = Grade B

Theory- Internal-CE

Maximum weight for internal evaluation is 10. Therefore, Maximum weight Grade Point (WGP) is 50.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W *GP	Overall Grade of the course
Assignment	2	A	4	8	WGP/Total weight = 48/10 =4.8
Seminar	4	A+	5	20	
Test paper 1	2	A+	5	10	
Test paper 2	2	A+	5	10	
Total	10			48	A+

Practical-External-ESE

Maximum weight for external evaluation is 5. Therefore Maximum Weighted Grade Point (WPG) is 75.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Written/Lab	7	A	4	28	
Test					WGP/Total
Lab					Weight
Involvement & Record	3	A+	5	15	= 58 / 15 = 3.86
Viva	5	B	3	15	
Total	15			58	B

Practical-Internal-CE

Maximum weight for internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Written/ Lab test	2	A	4	8	WGP/Total weight =17/5=3.40
Lab involvement & record	1	A+	5	5	
Viva	2	C	2	4	
Total	5			17	B

Project-External-ESE

Maximum weight for external evaluation is 15. Therefore, Maximum weighted Grade Point (WGP) is 75.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Relevance of the topic & Analysis	2	C	2	4	WGP/Total weight = 59/15= 3.93
Project content & presentation	8	A+	5	40	
Project viva- voce	5	B	3	15	
Total	15			59	B

Project-Internal-CE

Maximum weight for Internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W *GP	Overall Grade of the course
Relevance of the topic & Analysis	2	B	3	6	WGP/Total weight = 21/5 = 4.2
Subject Knowledge	2	A+	5	10	
Report	1	A+	5	5	
Total	5			21	A

Comprehensive viva-voce-External-ESE

Maximum weight for External evaluation is 15. Therefore, maximum Weighted Grade Point (WGP) 75.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Comprehensive viva-voce	15	A	4	60	WGP/Total weight = 60 / 15 = 4
Total	15			60	A

Comprehensive viva-Internal-CE

Maximum Weight for Internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W *GP	Overall Grade of the course
Conceptual understanding of the programme	5	A+	5	25	WGP/Total weight = 25/ 5 = 5
Total	5			25	A+

Internship/OJT-External-ESE

Maximum weight for external evaluation is 15. Therefore, Maximum weighted Grade Point (WGP) is 75.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W*GP	Overall Grade of the course
Report	3	C	2	6	WGP/Total weight = 46/15= 3.07
Presentation	7	A+	5	25	
Viva	5	B	3	15	
Total	15			46	B

Internship/OJT -Internal-CE

Maximum weight for Internal evaluation is 5. Therefore, Maximum Weighted Grade Point (WGP) is 25.

Components	Weight (W)	Grade Awarded	Grade Point (GP)	WGP= W *GP	Overall Grade of the course
Relevance of the topic & Analysis	2	B	3	6	WGP/Total weight = 21/5 = 4.2
Punctuality	1	A+	5	5	
Subject Knowledge	2	A+	5	10	
Total	5			21	A

Evaluation- Second stage (to be done by the College)

Consolidation of the Grade (GPA) of a Course PC-1

The End Semester Evaluation valuation (ESE) (External evaluation) grade awarded for the course PC -1 is A and its Continuous Evaluation (CE) (Internal Evaluation) grade is A. The consolidated grade for the course PC -1 is as follows:

Evaluation	Weight	Grade awarded	Grade Points awarded	Weighted Grade Point
External	3	A	4.20	12.6
Internal	1	A	4.40	4.40
Total	4			17
Grade of a course.	GPA of the course =Total weighted Grade Points/Total weight 17/4 =4.25 = Grade A			

Evaluation- Third stage (to be done by the College)

Semester Grade Point Average (SGPA)

Course code	Title of the course	Credits (C)	Grade Awarded	Grade Points (G)	Credit Points (CP=C X G)
01	PC-1	4	A	4.25	17.00
02	-----	4	A	4.00	16.00
03	-----	4	B+	3.80	15.20
04	-----	5	A	4.40	22.00
05	-----	5	A	4.00	20.00
06	-----	4	B+	3.70	14.80
07	-----	4	A	4.25	17.00
TOTAL		30			122
SGPA	Total credit points/Total credits = 122/30 = 4.07 = Grade A				

Evaluation- Fourth Stage (to be done by the College)

Cumulative Grade Point Average (CGPA)

If a candidate is awarded three A+ grades in semester 1 (SGPA of semester 1), semester 2 (SGPA of semester 2) and semester 4 (SGPA of semester 4) and a B grade in semester 3 (SGPA of semester 3). Then the CGPA is calculated as follows:

Semester	Credit of the Semesters	Grade Awarded	Grade point (SGPA)	Credit points
I	30	A+	4.50	135
II	30	A+	4.60	138
III	30	B	3.00	90
IV	30	A+	4.50	135
TOTAL	120			498

CGPA= Total credit points awarded / Total credit of all semesters = 498 / 120
= 4.15 (Which is in between 4.00 and 4.49 in 7-point scale). Therefore, the overall Grade awarded in the program is A

Programme Design

SEMESTER 1

No.	Course code	Course Title	Hours/Week	Credits
1	PRE1CMT0120	Applied Mathematics	3	4
2	PRE1CMT0220	Research Methodology	3	4
3	PRE1CMT0320	Geothermal Resources & Geothermal Power generating systems	3	4
4	PRE1CRT0120	Fundamentals of Renewable Energy Technology	4	5
5	PRE1CRT0220	Advanced Solar Thermal Technology - I	4	5
6	PRE1CRP0120	Practical –I : Photovoltaic Lab	4	4
7	PRE1CRP0220	Practical –II : Wind Energy Lab	4	4

Total Credit: 30 Skill: 18 General: 12

SEMESTER 2

No.	Course Code	Course Title	Course Category	Hours/Week	Credits
1	PRE2CMT0120	Energy And Environment	General Component	3	4
2	PRE2CMT0220	Materials Science For Solar Applications	General Component	3	4
3	PRE2CMT0320	Ocean Energy And Tidal Energy	General Component	3	4
4	PRE2CRT0120	Advanced Solar Thermal Technology – II	Skill Component	4	5
5	PRE2CRT0220	Solar Photovoltaic Technology	Skill Component	4	5
6	PRE2CRP0120	Practical-III	Skill Component	4	4
7	PRE2MPR0120	Mini Project	Skill Component	4	4

Total Credit: 30 General: 12 Skill: 18

SEMESTER 3

No	Course Code	Course Title	Course Category	Hours per week	Credits
1	PRE3CMT0120	Energy Storage And Distribution	General Component	3	4
2	PRE3CMT0220	Hydro Power & Biomass Energy Systems	General Component	3	4
3	PRE3CMT0320	Wind Power – Technology and Systems	General Component	3	4
4	PRE3CRT0120	Energy Efficient Buildings And System	Skill Component	4	5
5	PRE3CRT0220	Energy Scenarios & Policies	Skill Component	4	5
6	PRE3OJT0120	On Job Training	Skill Component	4	4
7	PRE3CRP0120	Practical-IV : Solar Thermal Lab	Skill Component	4	4

Total Credit: 30 General: 12 Skill: 18

SEMESTER 4

No.	Course Code	Course Title	Course Category	Hours/Week	Credits
1	PRE4CMT0120	Hydrogen production, storage and Fuel Cells	General Component	3	4
2	PRE4CMT0220	Cogeneration and Waste Heat Recovery System	General Component	3	4
3	PRE4CMT0320	Inverter Design with Applications	General Component	3	4
4	PRE4CRT0120	Energy Auditing	Skill Component	4	5
5	PRE4CRP0120	Practical-V : Solar PV Design using PVsyst	Skill Component	4	5
6	PRE4PRO0120	Project Presentation & Viva	Skill Component	5	5
7	PRE4CVI0120	Course Viva	Skill Component	2	4

Total Credit: 30 General: 12 Skill: 18

Detailed Syllabus: Semester I

Applied Mathematics (PRE1CMT0120)

60 Hours 4 credits

Course Outcomes

- Examine different types and properties of vector valued functions
- Determine the derivative and integrals of vector valued functions
- Apply different vector integral theorems to evaluate line and flux integrals
- Deduce the solutions of ordinary differential equations using different methods
- Calculate the Laplace transform of different functions

Module I: Calculus of vector functions (15 Hours)

Vector valued function of single variable, derivative of vector function and geometrical interpretation, motion along a curve-velocity, speed and acceleration. Concept of scalar and vector fields , Gradient and its properties, directional derivative , divergence and curl, Line integrals of vector fields, work as line integral, Conservative vector fields , independence of path and potential function(results without proof).

Module II: Vector integral theorems (15Hours)

Green's theorem (for simply connected domains, without proof) and applications to evaluating line integrals and finding areas. Surface integrals over surfaces of the form z = g(x, y), y = g(x, z) or x = g(y, z) , Flux integrals over surfaces of the form z = g(x, y), y = g(x, z) or x = g(y, z), divergence theorem (without proof) and its applications to finding flux integrals, Stokes' theorem (without proof) and its applications to finding line integrals of vector fields and work done.

Module III: Ordinary differential equations (15 Hours)

Homogenous linear differential equation of second order, superposition principle, general solution, homogenous linear ODEs with constant coefficients-general solution. Solution of Euler-Cauchy equations (second order only).Existence and uniqueness (without proof). Non homogenous linear ODEs-general solution, solution by the method of undetermined coefficients, methods of variation of parameters. Solution of higher order equations-

homogeneous and non-homogeneous with constant coefficient using method of undetermined coefficient.

Module IV: Laplace transforms (15 Hours)

Laplace Transform and its inverse ,Existence theorem (without proof) , linearity, Laplace transform of basic functions, first shifting theorem, Laplace transform of derivatives and integrals, solution of differential equations using Laplace transform, Unit step function, Second shifting theorems. Dirac delta function and its Laplace transform, Solution of ordinary differential equation involving unit step function and Dirac delta functions. Convolution theorem (without proof) and its application to finding inverse Laplace transform of products of functions.

References

- Mathematical Physics by B. D. Gupta
- Mathematical methods in Physical science by Mary and boas.
- Vector analysis by Spiegel and Murrey
- Mathematical methods for Physicists by Arfken and Weber

Research Methodology (PRE1CMT0220)

60 Hours 4 credits

Course Outcomes

- Describe the various kinds of research, objectives of doing research, research process, research designs and sampling.
- Discuss different methodologies and techniques used in research work.
- Illustrate different methods for Research Design, Research Publication procedure & Presentation.
- Explain ethical standards, policies and illustrate how to apply principles of basic ethics theory in decision making process in the field of research
- Prepare a project proposal.

Module I: General introduction and Research problem Formulation (15 Hours)

History of Science & Technology: Importance of research, role of research, aims& objectives, research process, phases of research. Review of Research Literature: Purpose and use of literature review, locating relevant information, use of library & electronic databases, preparation & presentation of literature review, research article reviews, theoretical models and frame work. Identification of gaps in research, formulation of research problem, definition of research objectives

Module II: Research Design (15 Hours)

Qualitative Methods: Types of hypothesis and characterization. Quantitative Methods: Statistical methods for testing and evaluation. Characterization of experiments: Accuracy, reliability, reproducibility, sensitivity, Documentation of on-going research.

Module III: Research Publication & Presentation (15 Hours)

Thesis, Research paper, Review Article & Technical Reports: Organization of thesis and reports, formatting issues, citation methods, references, effective oral presentation of research. Quality indices of research publication: impact factor, immediacy factor, H- index and other citation indices.

Module IV: Research Ethics and Morals (15 Hours)

Issues related to plagiarism, collaborative models and ethics, acknowledgements. Intellectual Property Rights: copy rights, copy left: patents, Industrial designs, Trademarks.

References

- Research Methodology, Methods & Techniques, Viswa Prakashan, 2nd Edition, 2009 C.R. Kothari
- Research Methods- A Process of Inquiry, Pearson Publications, 7th Edition, 2009 Graziano, A.M.. Raulin, M.L
- How to Write a Thesis, Tata McGraw Hill, 2nd Edition, 2010 Murray, R.
- Writing For Academic Journals, McGraw Hill International, 2009 Murray, R.
- Writing for Publication, Henson, 2005.\ K.T., Allyn &Bacon
- What is this thing called Science, Queensland University Press, 1999 Chalmers, A.F
- Methods &Techniques of Social Research, Himalaya publications, 2009 Bhandarkar & Wilkinson,
- Doing your Research project, Open University Press, Berkshire, 4thEdition, 2005 Bell J
- A Handbook of Academic Writing, Tata McGraw Hill International, Murray, R. and Moore, S

Geothermal Resources & Geothermal Power Generating Systems (PRE1CMT0320)

60 Hours 4 credits

Course Outcomes

- Understand the structure of the earth & estimate its geothermal power
- Compare the conceptual layout and the expected performance of single-flash versus double-flash geothermal steam power cycles.
- Identify the most hazardous aspects and challenges for geothermal resource utilization.
- Evaluate various Prime Movers for Geothermal Energy Conversion.
- Understand the applications of Geothermal Energy along with its advantages and disadvantages

Module I INTRODUCTION (15 Hours)

Thermal structure of earth-Heat flow and temperature distribution-heat and storage-Heat conduction, radiation and convection –Geo thermal gradient Thermal conductivity-Potential Sites Estimations of Geothermal Power-Nature of Geothermal Sites-Basic geo thermal power plant

Module II: RESOURCES & POWER PLANTS (15 Hours)

Hydro geothermal-Dry steam fields-Wet steam fields-Hot water fields-Geo pressure resources-Hot dry rocks-Magma resources-Volcanoes- Prospects of geothermal energy in India -Total flow power unit, Geothermal Power Plants (Dry Steam Units, Single-Flashing Units, Dual Flashing Units, Several Flashing Processes: A Useful Theoretical, Binary Units, Hybrid Geothermal-Fossil Power Units).

Module III: HOT SPRINGS (15 Hours)

Hot spring system structure-Warm spring-Flow rates-High flow hot springs Therapeutic uses Infections-Hot springs around the world- Effects of Impurities in the Geothermal Fluid, Cooling Systems, Geothermal District Heating: An Example of Exergy Savings and Environmental Benefit, Environmental Effects, Merits and demerits of geothermal energy-Applications of geothermal energy.

Module IV Prime Movers for Geothermal Energy Conversion (15 Hours)

Impulse Reaction Machines, Positive Displacement Machines, Impulse Machines. Applications for Geothermal Energy, Advantages & Disadvantages

References

- Harsh K. Gupta, Sukanta Roy, Elsevier, "Geothermal Energy: An Alternative Resource for the 21st Century, first edition, 2006
- G.D. Rai "Non Conventional Energy Sources" Khanna Publishers, New Delhi, Ist edition, 2010.
- Ronald Dipippo, Elsevier Geothermal Power Plants Principles, Applications and Case Studies, 2nd edition, 2007

Fundamental Of Renewable Energy Technology (PRE1CRT0120)

75 hours 5 credits

Course Outcomes

- Summarize about the need of different renewable energy resources and to relate about the historical and latest developments and importance.
- Analyse about the potential of solar energy and wind energy and to discuss about its various applications.
- Discuss about the energy obtained from Biomass, biogas and geothermal energy resources.
- Associate the energy derived from other forms of energy sources and to interpret the recent trends in renewable energy.
- Understand the concept of OTEC,Hydrogen energy,Chemical energy.

Module I: Fundamentals of Energy- Science & Technology (15 Hours)

Introduction to Energy Science, Energy Science and other Sciences, Energy, Man and Environment, Review of various forms of Energy, Energy Chains or Energy Routes. Classification of Energy Resources, Commercial Energy Source-Coal, Oil, Petrol, Diesel, Natural gas and other sources, Advantages & Disadvantages of Commercial Energy sources. World future energy demand, Alternate Energy Resources-Non Commercial Energy resources, Importance of Non-conventional Energy sources, Advantages & Disadvantages of Non-conventional Energy sources.

Module II: Solar Energy (20 Hours)

The Sun as a source of Energy, Measurement of Solar Radiation, Solar Collectors, Solar Water heaters, Solar heating & Cooling systems, Other solar Applications, Basics of Solar Photovoltaic.

Wind Energy – Nature of winds, Wind turbine siting, Applications of Wind power, Types of Turbines –HAWT, VAWT. Upwind & Downwind turbines, Types of Rotors, Advantages & Disadvantages.

Module III: Energy from biomass & biogas, Geothermal Energy (20 Hours)

Usable forms of biomass, their composition and fuel properties, Biomass Conversion Technologies, Factors affecting biogas production, Types of biogas plants, Biofuel – properties, advantages & Disadvantages, Application.

Geothermal Energy –Types of Geothermal resources, Advantages & Disadvantages, Application of Geothermal Energy, Environmental Consideration, Exploration & Development of Geothermal resources, Geothermal Energy in India

Module IV: Tidal, OTEC, Hydrogen Energy & Chemical Energy Sources , Recent trends in Renewable Energy (20 Hours)

Tidal Energy – Components of Tidal Power plants, Site requirements, Advantages & Disadvantages of Wave Energy, Prospects of Tidal Energy in India. OTEC- Methods of OTEC Power Generation, Heat Exchangers, Biofouling and Site selection criteria. Hydrogen Energy – Hydrogen Production, Transportation and Storage. Fuel cells & Batteries – Types, Advantages, Disadvantages, Applications.

Recent trends in Renewable Energy – Energy Storage, Microgrids & AI, Energy Block chain and IoT, Grid parity. Energy Automation – use of Robots, automation and IoT in Renewable Energy generation

References

- Energy Technology, Non conventional, Renewable & Conventional, Third Edition, Khanna Publishers, p.1144. ISBN NO. 81-7409-040-1
- S. Rao and B.B. Parulekar. (2012)
- Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525 G.N.Tiwari. (2013)

Advanced Solar Thermal Technology I (PRE1CRT0220)

75 hours 5 credits

Course Outcomes

- Analysis of heat exchangers and evaluation of thermal stratification in storage tanks.
- Distinguish between various solar air heaters and analyze their steady state and transient conditions.
- Explain the concept of solar drying and deduce the energy balance equations for different types of solar dryers.
- Evaluate the characteristics parameters of solar concentrators and compare the thermal analysis of various types of solar concentrators.
- Understanding different tracking methods used.

Module I: Solar Water Heating System (15 Hours)

IIntroduction, Heat Exchanger, Choice of Fluid, Analysis of Heat Exchanger, Heat Exchanger Factor, Natural Convection Heat Exchanger), Heat Collection in a Storage Tank (Heat Collection with Stratified Storage Tank, Heat Collection with Well-mixed Storage Tank, Effect of Heat Load, Problems.

Module II: Solar Air Heaters (20 Hours)

Introduction, Description and Classification (Non-porous Type, Porous Type), Conventional Heater (Thermal Analysis), Double Exposure Heaters, Air Heater with Flow above the Absorber (Steady State Analysis, Transient Analysis), Air Heater with Flow on Both Sides of the Absorber, Two Pass Solar Air Heater, Comparison with Experimental Results, Heater with Finned Absorber, Heater with Vee-corrugated Absorber, Reverse Absorber Heater (Working Principle, Energy Balance, Performance Study), Air Heaters with Porous Absorbers (Matrix Air Heaters, Materials for Matrix Absorber, Overlapped Glass Plate Air Heaters, Air Heater With Honeycomb Absorber).

Module III: Solar Crop Drying (20 Hours)

Introduction, Working Principle (Open Sun Drying (OSD), Direct Solar Drying (DSD), Indirect Solar Drying (ISO)), Thermal Modelling of Open Sun

Drying (OSD) (Introduction Computational Procedure for Convective Heat Transfer, Prediction of Crop Temperature and Moisture Evaporation, Analysis for Steady State Condition, Experimental Setup for Open Sun Drying (OSD), Methodology and Input Parameters for Computation, Results and Discussion), Thermal Analysis of Cabinet Dryer, Energy Balance for Reverse Absorber Cabinet Dryer (RACD) (Thin Layer Drying, Deep Bed Grain Drying), Energy Balance for Indirect Solar Drying (ISO) System.

Module IV: Solar Concentrators (20 Hours)

Introduction, Characteristic Parameters, (Aperture Area, Acceptance Angle, Absorber Area, Geometric Concentration Ratio, Local Concentration Ratio or Brightness Concentration Ratio, Intercept Factor, Optical Efficiency, Thermal Efficiency, Concentration Ratio), Classification, Types of Concentrators (Tracking Concentrators, Non-tracking Concentrators), Geometrical Optics in Concentrators (Ray Tracing in a Reflecting Surface, Ray Tracing in a Refracting Surface), Theoretical Solar Image, Thermal Analysis (Cylindrical Parabolic Concentrator, Dimensional Concentrator, Hemispherical Bowl Mirror, V-trough), Tracking Methods (Three Dimensional Concentrators, Two Dimensional Concentrators) Materials for Concentrators (Reflecting and Refracting Surfaces, Receiver Cover and Surface Coatings, Working Fluids, Insulation)

References

- Solar Energy: Fundamentals and Applications; H. P. Garg & J. Prakash; 2000; Tata McGraw-Hill.

Practical –I : Solar Photovoltaic Lab (PRE1CRP0120)

60 Hours 4 credits

Course Outcomes

- Examine the I-V and P-V characteristics of PV module with varying insulation and temperature level.
- Examine the effect of shading and effect of variation in tilt angle on PV module output power.
- Determine the maximum power point and fill factor of a solar photovoltaic Module.
- Analysis the working of solar photovoltaic water pumping system and solar PV based street lighting system.
- Analyse the charging and discharging characteristics of batteries.

1. Illuminated IV & PV characteristics of a solar cell- calculation of Voc, Isc, FF, efficiency
2. Study the variation of Voc & Isc with change in light intensity & shading of modules.
3. Study the variation of Voc & Isc with change in tilt angle
4. IV and PV characteristics of a solar cell at different temperatures
5. IV and PV characteristics of series combination of solar cells at different radiation intensities
6. IV and PV characteristics of parallel combination of solar cells at different radiation intensities.
7. Demonstrate working diode as bypass and blocking diode.
8. Work out power flow calculation of stand alone PV system of DC load with battery
9. Work out power flow calculation of stand alone PV system of AC load with battery
10. To draw the charging & discharging characteristics of batteries
11. Find the MPP manually by varying the resistive load across the PV panel

Skill Component: Practical –II : Wind Energy Lab (PRE1CRP0220)

60 hours 4 credits

Course Outcomes

- Develop aptitude & proficiency in grid interconnection requirements for wind farms.
- Discuss the ability of integrating power electronics device with Renewable Energy Sources.
- Explain different Wind Power Control methods.
- Examine various application of wind power.
- Determine power at different branches of WTES with DC load only.

1. Evaluate the efficiency of a charge controller with battery only and battery as well as turbine.
2. To evaluate the Coefficient Of Performance using Generated power and Wind power
3. Analyse the turbine current and turbine voltage for different wind speed and plot a curve between turbine power and wind speed.
4. Evaluate the cut- in speed of wind turbine experimentally.
5. Evaluate the wind speed using anemometer by adjusting variable frequency drive of artificial wind generation unit.
6. Evaluate the Tip Speed Ratio at different wind speeds and plot a graph between TSR and COP.
7. Draw the power curve of turbine with respect to the rotational speed of rotor at fix wind speeds
8. Demonstrate power analysis at turbine output
9. Demonstrate power analysis at different branches of wind turbine energy system with AC load only.
10. Demonstrate power analysis at different branches of wind turbine energy system with DC load only.

Detailed Syllabus: Semester II

Energy and Environment (PRE2CMT0120)

60 hours 4 credits

Course Outcomes

- Understand the Energy use pattern in different parts of the world and its impact on the environment.
- Analyse the conventional and renewable energy technologies and their application.
- Design of bio-fuel production units.
- Evaluate the environmental impact of energy production and the relationship between energy production, consumption and climate change.
- Understand the relationship between energy, environment and economic level of development.

Module I: Energy resources and their exploitation (15 Hours)

Sun as source of energy - nature of its radiation, Conventional energy sources: coal, oil, and nature gas, non-conventional energy sources: hydroelectric power, tidal, wind, geothermal energy, solar collectors, Photovoltaic, solar ponds, nuclear-fission and fusion, magneto-hydrodynamic power (MHD), Energy use pattern in different parts of the world and its impact on the environment. CO2 emission in atmosphere.

Module II: Bio catalysis and nonconventional energy (15 Hours)

Biocatalysts, green chemistry in industries, fuel cell and electric vehicles, solar energy and hydrogen production, energy from alternate sources; Solar photovoltaic technology. Biofuel production (bio-ethanol and biodiesel), Biomass, prevention/minimization of hazardous/toxic products. Agricultural related practices and food processing, Production of biodegradable materials, concept of green building, and pollution free engineering processes.

Module III: Energy Use (15 Hours)

Relationship among energy, environment and economical level of development. Resources of energy and energy use pattern in different parts of the world. Indian energy scenario and its impact on the environment.

Module IV: Energy Conservation and Energy Economics (15 Hours)

Energy efficiency at national level, improving energy efficiency, energy analysis, concept of energy (theoretical treatment), capital recovery factor, annual cost, economic analysis of wind electric generation and thermal power systems.

References

- Energy Security and Environmental Sustainability - Surya Narain Yadav
- Energy and Environment: Technological Challenges for the Future - Y.H. Mori and K. Ohnishi Non-conventional Energy Sources - G.D. Rai
- Energy Explained: v. 1&2: Conventional Energy and Alternative - Vikram Janardhan and Bob Fesmire
- Non-Conventional Energy System - S.K. Agarwal
- An Introduction to Environmental Energy Resources – Manjunatha

Materials Science For Solar Applications (PRE2CMT0220)

60 Hours 4 Credits

Course outcomes

- Explain the fundamental science and engineering principles relevant to materials that include the relationships between nano/microstructure, characterization, properties, processing, and performance of materials.
- Discuss the various properties of materials and the effect of the environment on the same.
- Explain the principles of material testing and characterization to apply them for various engineering applications.
- Identify the design considerations and properties of materials used for solar thermal applications.
- Analyse the working of different solar equipments.

Module I Fundamental Principles Of Materials Science (15 Hours)

Electronic and atomic structures, atomic bonding in solids, crystal structure, microstructure, solidification, alloys. Mechanical and electrical behavior of ceramics. Description of optical and thermal materials of concrete and composite materials. Intrinsic and extrinsic semi-conductors, super conductivity and applications.

Module II Properties Of Materials (15 Hours)

Mechanical, photonic, thermal electrical and magnetic properties of metals, alloys, semiconductors, polymers, glass, nano materials and magnetic materials. Environmental effects - corrosion, erosion, wind loads, thermal stress and weathering properties of solar materials.

Module III Testing Of Materials (15 Hours)

Concepts of stress and strain, Hooke's law, tension, compression and shear. Stress-strain diagram and thermal stresses. Elasticity in metals and polymers, plastic deformation, yield stress, shear strength, strengthening mechanisms, effect of temperature, fracture behaviour of various materials, failure analysis, solid solutions and phase diagrams.

Module IV Materials For Solar Thermal Systems (15 Hours)

Design and development of heat transfer systems - Domestic community and commercial solar thermal applications. Design considerations of solar

collectors, special coatings, reflectors, lenses, receivers, tracking and non-tracking concentrator, thermal energy storage, heat exchangers, solar chimney, solar steam generators, solar ponds and solar still, solar dryer and furnace.

Reference

- Ramamrutam .S, "Strength of Materials", 16thedition, Danpat Rai Publications, 2010.
- Callister .W.D, "Materials Science and Engineering", 6 th edition, Wiley India, 2009.
- Sheckel ford J., F. Muralidham M.K., "Introduction to Materials Science for Engineers", 6thedition, Pearson, 2007.
- Raghavan .V, "Materials Science and Engineering", Prentice-Hall India, 2007.
- Askeland .D.R, "Science and Engineering of Materials", 4thedition, Thomson, 2003.
- Bala subramaniam .R, "Callister's Materials Science and Engineering", Wiley India, 2007.

Ocean Energy and Tidal Energy (PRE2CMT0320)

60 Hours 4 Credits

Course outcomes

- Understand various ocean energy resources like ocean wave, tidal and thermal energy.
- Analysis of Off-shore and On-shore energy conversion technologies.
- Describe about the energy and power in ocean waves.
- Explain the principles that underlie the ability of tidal power to deliver usable energy.
- Discuss the economic aspects about tidal energy conversion plant, tidal energy resources in India.

Module I Ocean Energy Technologies (10 Hours)

Introduction to Energy form oceans, Ocean energy Resources, Off shore and On-shore ocean energy conversion technology, Advantage and limitations of ocean energy conversion technology, The guide lines for ocean energy conversion plant, Ocean energy routes, High voltage direct current power transmission from Off shore ocean energy conversion plant to land based load centres.

Module II Ocean Thermal Energy Conversion (15 Hours)

Introduction, Principle of OTEC, Ocean surface temperature, Deep water temperature, Efficiencies of OTEC plants and their influence on plants size, Open cycle, Limitation of Open cycle OTEC system, Historical review of Open cycle OTEC plants, India's first oceans thermal energy conversion, Modified Open cycle OTEC plants, Cogeneration of electricity and fresh water from Open cycle OTEC, Closed cycle OTEC.

Module III Ocean Wave Energy Conversion (20 Hours)

Introduction, Ocean waves, Parameters of a progressive wave, Equation of a progressive wave, Energy and power in ocean waves, Summary of Equation Motion of water particles in the waves, Wave data collection, Routes of energy conversion of wave energy, Wave machines, Dolphin-buoy type of ocean wave energy converter, Oscillating float-air pump type wave machine Three-raft energy converter, Nodding duck Oscillating cam wave machine.

Module IV Tidal Energy Conversion (15 Hours)

Introduction tidal Current, High and Low Tides, Tidal Energy conversion, Tidal power, Average theoretical Power per tide (rise and fall), Summary of Expressions Tidal Work or Energy Conversion, Ocean tidal energy conversion schemes, Terms and definitions, Single basin tidal schemes, Double basin scheme and multi basin scheme, Details about plant and equipment, Economic aspects about tidal energy conversion plant, Tidal power plant in the world, Tidal energy resources in India

Reference

- Energy Technology-Nonconventional, Renewable & Conventional S. Rao and Dr. B. B. Parulekar, Khanna Publishers, ISBN No. 81-7409-040-1
- Solar Energy Utilization G. D. Rai, Khanna Publishers, ISBN-81-7409-073-8
- Non-Conventional Energy Sources G. D. Rai, Khanna Publishers, ISBN No. 81-7409-0738
- Nonconventional energy sources Domkundwar, Dhanpat rai & Co.

Advanced Solar Thermal Technology II (PRE2CRT0120)

75 Hours 5 Credits

Course outcomes

- Understand the Principle of working of Solar Energy Collecting Devices.
- Analyse about Solar Distillation procedure and construction of solar stills along with its performance analysis.
- Illustrate the concept of a solar house and various thermal cooling concepts.
- Examine the working of various types of power plant that works on solar thermal power.
- Discuss the different parameters that affect the performance of solar house.

Module I Principle of Solar Energy Collecting Devices (20 Hours)

Principle of Active system, Passive system, Operating principle of Collectors - Flat Plate Collectors-Non Tracking collectors, Tracking Collectors-Focusing (Concentrating)-Tilted Collectors- Solar Pond Collectors-Photo-Optical Collectors-Photovoltaic (PV) Cells-Fuel Cells-Energy Storages-Hydrogen Storage and Transport-Solar Energy Home- Solar Energy and Desalination Plants –Solar cooling, Future Expectations.

Module II Solar Distillation (20 Hours)

Determination of Distillate Output, Passive Solar Stills (Conventional Solar Still, Basin Construction, Thermal Analysis of Conventional Solar Still, Approximate Solution For Tw), Effect of Various Parameters (Effect of Ambient Temperature, Effect of Wind Velocity, Effect of Solar Radiation and Loss Coefficient, Effect of Double-glass Cover and Cover Inclination, of Salt Concentration on Output, Effect of Thermal Capacity on Output, Effect of Charcoal Pieces on the Performance of a Still, Effect of the Formation of Algae and Mineral Layers on Water and Basin Liner Surface on the Performance of a Still)

Module III Solar House (20 Hours)

Introduction (Physical Parameters, Physiological Parameters, Intermediate Parameters), Solar air Temperature and Heat Flux (For Bare Surface, For Wetted Surface, Blackened/Glazed Surface), Thermal Gain (Direct Gain,

Indirect Gain, Isolated Gain), Various Thermal Cooling Concepts (Evaporative Cooling, Infiltration/Ventilation, Wind Tower, air Tunnel Earth, Air Vent, Shading, Rock Bed Regenerative Cooler, Radiative Cooling, Heating and Cooling), Time Constant, Approximate Methods, Solar-load Ratio Method, Problems.

Module IV Solar Thermal Power Plants (15 Hours)

Principles, Solar tower power stations, Parabolic trough power plants, Dish/Stirling systems, Solar updraft tower power plant, Solar pond power plants, Solar Chimney Power plant, Some Case Studies.

Reference

- D.Y. Goswami, F.Kreith and J.F. Kreider. (2003) Principles of Solar Engineering, 2nd Edition, Taylor & Francis, p.694.
- J.Twidell & T. Weir. (2010). Renewable Energy Resources, Second edition, Taylor & Francis, p.601.
- Duffie and Beckman. ((2013). Solar Engineering of Thermal Process, Fourth edition, Wiley Publications, p.910.
- G.N.Tiwari. (2013) Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525.

Solar Photovoltaic Technology (PRE2CRT0220)

75 Hours 5 Credits

Course outcomes

- Explain how a solar cell converts sunlight into electric power and to discuss about various applications of solar PV system.
- Examine the various processes in the growth of silicon crystals and to study about different types of solar cells.
- Analyze the concepts of energy bands in materials and to study about the different parameters relating to a solar cell.
- Discuss about the various application of solar cells.
- Understand photovoltaic technology in detail.

Module I Solar Cell and Applications (20 Hours)

Introduction to solar cells, what are solar cells, How solar cells work, Electronic structure of semiconductors-the solar cell-power losses solar cells-Temperature and irradiation effects. Application of solar PV system - Introduction, Rural electrification-domestic supply, Health care system, Lighting, Battery charging. Water pumping- water pumping technology – sizing and cost, Professional applications- telecommunications and remote monitoring. Electric power generation in SPACE- Satellite PV system- PV generator. Grid connected system- PV power station- PV in buildings

Module II Silicon & Thin-film Solar cell (20 Hours)

Introduction, From sand to pure silicon, Growth of silicon crystals, typical solar cell fabrication process, Module fabrication. Introduction, Amorphous silicon cells, Thin polycrystalline silicon on low-cost substrates, Copper indium telluride's cells, cadmium telluride cells, DSSC, Organic Solar cells, Integrally interconnected Modules, Concentrating Solar Cells, Tandem Cells, Quantum Dots, Cell Applications, Neutrino Voltaic Technology – MSW effect, properties & reactions, stackable & scalable NV modules.

Module III Photovoltaic Technology (20 Hours)

Introduction, Crystal Structure, Cell Physics, Energy Bands, More about Electrons and Their Energy, Electrons and Holes, Direct and Indirect Band-Gap Materials, Doping, Transport, Generation and Recombination, p–n Junction, Solar Cell Equations, Characterization, Efficiency- Temperature-Light, Type

and Purity of Material, Parasitic Resistances, Current Research, Concentrating Solar Cells, Tandem Cells, Quantum Dots.

Module IV Solar Cell Applications (15 Hours)

Cell Applications, Utility Power Generation, Space Systems, Solar-Powered Products. Photovoltaic Power Generation: Principles, Technical description, Economic and environmental analysis, Some Case Studies.

Reference

- Solar Photovoltaics: Fundamental, Technologies and Applications; C.S. Solanki; 2011; Prentice Hall of India.
- Solar Energy: Fundamentals and Applications; H. P. Garg & J. Prakash; 2000; Tata McGraw-Hill.
- Handbook of Photovoltaic Science and Engineering; Antonio Luque, Steven Hegedus; 2003; John Wiley and Sons.

Practical –I: Solar Thermal Energy Storage Lab (PRE2CRP0120)

60 Hours 4 Credits

Course outcomes

- Experimental study of latent heat thermal energy storage system with multiple PCMs in series combination.
- Evaluation of heat transfer during charging and discharging of PCM
- Experimental study of a latent heat thermal energy storage system with different types of insulation (PUF, Rockwool and Glass-wool) having Paraffin wax and Organic mixtures in cascading.
- Evaluation of overall system thermal efficiency
- Experimental study of paraffin based PCM with different HTF during charging

1. Charging period analysis of system containing PCM –I (Organic Fatty Acid) at different HTF flow rate.
2. Discharging period analysis of system containing PCM –I (Organic Fatty Acid) at different HTF flow rate.
3. Charging period analysis of system containing PCM –II (Paraffin Wax) at different HTF flow rate.
4. Discharging period analysis of system containing PCM –II (Paraffin Wax) at different HTF flow rate.
5. Charging period analysis of system containing PCM –I (Organic Fatty Acid) and PCM II in cascading by varying mass flow rate.
6. Discharging period analysis of system containing PCM –I (Organic Fatty Acid) and PCM II in cascading by varying mass flow rate.
7. Experiment on PCM-1 (paraffin based) with different HTF temperature during charging
8. Experiment on PCM-2 (fatty acid based) at different HTF temperature during charging
9. Experiment on PCM-1 and PCM-2 in series combination (cascading system) at different HTF temperature during charging.
10. Evaluation of heat transfer during charging and discharging of PCM

11. Evaluation of system thermal efficiency during charging storing and discharging the PCM
12. Evaluation of overall system thermal efficiency

Detailed Syllabus: Semester III

Energy Storage and Distribution (PRE3CMT0120)

60 Hours Credits 4

Course outcomes

- Describe about different types of Energy storage and distribution.
- Analysis of Different types of Mechanical, Electrical & Hydrogen energy storage.
- Discuss about various means of hydrogen storage systems.
- Interpret about Thermal & Biological Energy Storages.
- Analysis of the energy distribution through gas pipelines, electricity transmission, batch transport, heat, and chemical heat pipe.

Module I Introduction to Energy Storages and Distribution (15 Hours)

Introduction and overview of Energy storages, Types of storages -Mechanical, Electrical, Chemical, Electromagnetic, Thermal, Biological. Introduction to distribution system. Comparison of ES Technologies.

Module II Mechanical and Electrical Energy Storage (15 Hours)

Introduction, Pumped hydroelectric storage, compressed air storage, energy storage via flywheels. Introduction electrical Energy storages- Types of batteries, lead acid battery storages, Merit and demerits of mechanical and electrical energy storages.

Module III Hydrogen Energy Storages (15 Hours)

Introduction to Hydrogen energy systems, Hydrogen storage- Physical and chemical properties- general storage methods, compressed storage- composite cylinders-Glass micro sphere storage-Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage. Overview of hydrogen utilization.

Module IV Thermal, Biological Energy Storages & Distribution of Energy (15 Hours)

Introduction to thermal energy storages- latent heat storages-sensible heat storages. Biological storages. Distribution of Energy- Introduction, Gas pipelines, Electricity transmission, batch transport, heat, chemical heat pipe.

Reference

- Principles of Solar Engineering, 2nd Edition, Taylor & Francis, p.694. (2003) D.Y. Goswami, F.Kreith and J.F. Kreider
- Renewable Energy Resources, Second edition, Taylor & Francis, p.601(2010) J.Twidell & T. Weir.
- Solar Engineering of Thermal Process, Fourth edition, Wiley Publications, p.910. (2013) Duffie and Beckman
- Solar Energy- Fundamentals, Design, Modelling and Applications, Revised edition 2013, Narosa Publishing house Pvt.Ltd, p.525, (2013) G.N.Tiwari

Hydro Power & Biomass Energy (PRE3CMT0220)

60 Hours Credits 4

Course outcomes

- Describe the hydropower sector and its components.
- Observe the characteristics and working principles of various components of hydro power plants and new innovations in the field.
- Describe biomass, its biochemical conversion & Biodiesel.
- Examine the knowledge of waste to energy conversion technology.
- Examine the economic factors of hydropower sector and waste to energy conversion technology

Module I Hydro Power Plants (15 Hours)

Introduction to Hydropower, Classification of Hydropower Plants, Small Hydropower Systems: Overview of micro, mini and small hydro systems, Status of Hydropower Worldwide, Advantages and Disadvantages of Hydropower, Selection of site for hydroelectric plant, Hydrological cycle, Essential elements of a hydroelectric power plant, Site selection Consideration, Economics & Environmental issues.

Module II Components of Hydropower Plants & New Innovations (15 Hours)

Components of hydropower plants, Hydraulic Turbines: Types and Operational Aspects, Theory of Hydro turbines; Operational Aspects of Turbines, Efficiency and selection of turbines, Types of generators, synchronous and induction, transformers, protection & control, transmission and distribution system. Dam and Spillway, Surge Chambers, Penstock, Tailrace

New Innovations in hydro power: Hydro generators with current controlled rotors, Variable speed hydro power generation, Fish friendly hydropower technologies – Fish passages, Fish friendly turbine design. Control technologies to mitigate flow instabilities- passive, active and magneto-rheological control techniques. Digitalization of hydropower operation, Novel Concepts in hydro electric energy storage, Floating solar power plants.

Module III Biomass as a Fuel, Biodiesel (15 Hours)

Overview of biomass as energy source, Production of biomass, Photosynthesis, efficiency of C3 & C4 plants on biomass production, Classification of biomass. Physicochemical characteristics of biomass as fuel, Thermal characteristics of biomass as fuel, Biomass conversion routes:

biochemical, chemical and thermo-chemical. Biodiesel – the mechanism of trans-esterification, fuel characteristics of biodiesel, technical aspects of biodiesel engine utilization, Alcohol production from biomass- types of materials of alcohol production-process description, utilization

Module IV Biochemical Conversion Of Biomass For Energy Production & Waste to Energy Conversion Technology (15 Hours)

Anaerobic digestion, biogas production mechanism, Types of digesters, installation, operation and maintenance of biogas plants, Biogas plants manure-utilization and manure values, Biogas utilization and storage, Biogas for motive power generation etc.

Preconditions for WtE, Characteristics of municipal waste, Legal framework & Environmental impacts, WtE diagram, site selection consideration, Types of waste- Processing methods – Thermal & Non thermal methods. Financial & Institutional aspects of WtE plants.

Reference

- Johnson GL. *Wind Energy Systems,* (Electronic Edition), Prentice Hall Inc, 2006
- Mathew S. *Wind Energy: Fundamentals, Resource Analysis and Economics*. Springer, 2006
- Burton T. Sharpe D. Jenkins N. Bossanyi E. *Wind Energy Handbook*. John Wiley, 2001
- Jha AR. *Wind Turbine Technology*, CRC Press, Taylor & Francis, 2011
- Jain P. *Wind Energy Engineering*. McGraw-Hill 2011
- Nag P K. *Power Plant Engineering*, 3rd Edition, Tata McGraw Hill, 2008.
- Mukunda HS. Understanding Clean Energy and fuels from biomass. Wiley-India Pvt. Ltd, 2011
- Pandey A. Hand book of plant based biofuel. CRC Press, Taylor & Francis, 2008
- Mital KM. Biogas Systems, Principle and Applications. New Age International Ltd. 1996
- Rai GD. Nonconventional energy sources. Khanna Publication, 2001
- Ravindranath NH. Hall DO. Biomass, Energy and Environment, A developing country perspective from India. Oxford University Press, 1995

Wind Power –Technology and Systems (PRE3CMT0320)

60 Hours 4 Credits

Course outcomes

- Analyse the important of wind energy and its impact on environment
- Discuss the design & applications of wind energy systems & applications
- Describe the economic factors of wind energy.
- Discuss about wind measurement & factors affecting the same.
- Analysis of the characteristics of wind energy

Module I Wind energy and Environment (15 Hours)

Environmental benefits of wind energy, Life cycle analysis -Net energy analysis, Life cycle emission, Environmental problems of wind energy -Avian issues, Noise emission, Visual impact.

Module II Wind Energy Design And Applications (15 Hours)

Characteristics of wind: Nature of atmospheric winds; wind resource characteristics and assessment, anemometry, wind statistics; speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography Aerodynamics of blade and rotor, Wind turbine design,Control Mechanisms: Wind turbine dynamics, Wind farm: design, Planning.

Module III Economics of wind energy (15 Hours)

Factors influencing the wind energy economics (Site specific factors, Machine parameters, Energy market, Incentives and exemptions, The 'present worth' approach, Cost of wind energy; Initial investment, Operation and maintenance costs, Present value of annual costs), Benefits of wind energy, Yardsticks of economic merit (Net present value, Benefit cost ratio, Pay back period, Internal rate of return), Tax deduction due to investment depreciation

Module IV Wind Measurement & Instrumentation (15 Hours)

Wind Data Presentation -Power Law Index, Betz Constant, Terrain value -Wind data Characterization Mean Wind Speed Wind Speed Distribution : Diurnal Pattern, Depression & Anti-Cyclones and Annual Pattern -Wind Turbulence

Characteristics-Short-term fluctuations & Long-term fluctuations- Wind Direction Distribution -Wind Shear.

Reference

- Wind Energy: Fundamentals, Resource Analysis and Economics; Mathew Sathyajith; 2006; Springer
- Johnson GL. Wind Energy Systems, (Electronic Edition), Prentice Hall Inc,2006
- Burton T. Sharpe D. Jenkins N. Bossanyi E. Wind Energy Handbook. John Wiley,2001
- Jha AR. Wind Turbine Technology, CRC Press, Taylor & Francis,2011
- Jain P. Wind Energy Engineering. McGraw-Hill, 2011

Energy Efficient Buildings and Systems (PRE3CRT0120)

75 Hours Credits 5

Course Outcome

- Analyse the process the energy transfer happening in buildings.
- Discuss the general principle of passive heating and cooling in buildings.
- Describe about day lighting and electrical lighting & design strategies in buildings.
- Discuss about heat control and ventilation of buildings.
- Describe the features of green building and its environmental benefits.

Module I Energy Transfer In Buildings (15 Hours)

Concepts of energy efficient buildings and energy efficient HVAC systems Calculation of heating and cooling loads of the building. Building's energy balance accounting for solar energy gain – Heat losses - Internal heat sources. Study of climate and its influence in building design for energy requirement. Low energy and zero energy buildings.

Module II Passive Solar Heating And Cooling (20 Hours)

General principles of passive solar heating – Key design elements - Direct solar heat gain trombe walls, water walls, convective air loops, concepts and case studies. General principles of passive cooling, ventilation, predicting ventilation in buildings, window ventilation calculations. Reradiation – Evaporative cooling, mass effect, thermal insulation, load control, air filtration, odor removal and heat recovery in large buildings.

Module III Day lighting And Electrical Lighting (20 Hours)

Materials, components and details - Insulation – Optical materials – Radiant barriers. Glazing materials – Day lighting – Sources and concepts – Building design Strategies – Case studies – Electric lighting, light distribution, electric lighting control for day lighted buildings and illumination requirement – Components of daylight factor – Recommended daylight factors and day lighting analysis.

Module IV Heat Control And Ventilation, Green Buildings (20 Hours)

Requirements – Heat transmission through building sections – Thermal performance of building sections – Orientation of buildings – Building

characteristics for various climates – Thermal design of buildings influence of design parameters – Mechanical controls. Ventilation – Requirements – Minimum standards for ventilation – Ventilation Design – Energy conservation in ventilating systems – Design for natural ventilation.

Green building features - Green materials, integrated ecological design, sustainable site and landscaping enhancing ecosystems, indoor environment quality, microclimate, day lighting, High-performance green buildings - Economics, managing initial costs and environment benefits.

Reference

- Means .R.S, "Green Building: Project Planning and Cost Estimating", Kingston, 2006.
- Kibert .C.J. "Sustainable Construction: Green Building Design", 2nd edition, Wiley, 2007.
- Boecker .J, "Integrative Design Guide to Green Building", Wiley, 2009.
- Eicker .U, "Low Energy Cooling for Sustainable Buildings", Wiley, 2009.
- Gevorkian .P, "Alternative Energy Systems in Building Design", McGraw-Hill, 2010.
- Majumdar .M, "Energy – Efficient Buildings in India", Tata Energy Research Institute, Ministry of Non Conventional Energy Sources, 2002.

Energy Scenarios & Policies (PRE3CRT0220)

75 Hours 5 Credits

Course outcomes

- Develop awareness on the importance of energy and its conservation and its impact on society.
- Describe about Global & Indian Energy Scenario
- Discuss on the present status and future of nuclear and renewable energy
- Develop knowledge about Indian Energy Policies.
- Describe the global energy policies, initiatives of international organizations and the importance of sustainable development.

Module I ENERGY CONSERVATION (15 Hours)

Energy Conservation Act-2001 and its features - Electricity Act – 2003 and its features - Framework of Central Electricity Authority (CEA), Central & States Electricity Regulatory Commissions (CERC & ERCs)-Role of MoP (Ministry of Power)-BEE (Bureau of Energy Efficiency).

Module II ENERGY SCENARIO – INDIAN & GLOBAL (20 Hours)

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

Role of energy in economic development and social transformation - Energy and GDP - GNP and its dynamics - Energy sources, overall Energy demand and availability - Energy consumption in various sectors and its changing pattern - Depletion of energy sources and impact economics on international relations.

Module III INDIAN ENERGY POLICY (20 Hours)

Global Energy Issues-National & State Level Energy Issues-National & State Energy Policy-Industrial Energy Policy- Energy Security-Energy Vision-Energy Pricing and Impact of Global Variations-Energy Productivity (National & Sector wise productivity).

Module IV GLOBAL ENERGY POLICY (20 Hours)

International Energy Polices of G-8 Countries - G-20 Countries - OPEC Countries - EU Countries - International Energy Treaties (Rio, Montreal and Kyoto) - INDO-US Nuclear Deal- Future Energy Options-Sustainable Development-Energy Crisis-Role of International Energy Agency.

Reference

- Mohan Munasinghe, Peter Meier. Energy Policy analysis and Modelling: Cambridge University Press1993
- J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams: Energy for a Sustainable World, Wiley Eastern, 1990.
- P. Meier and M. Munasinghe: Energy Policy Analysis & Modeling, Cambridge University Press, 1993
- World Energy Resources: Charles E. Brown, Springer 2002.
- Resources, Charles E. Brown, 'International Energy Outlook' - EIA annual Publication
- Principles of Energy Conversion: A.W. Culp (McGraw Hill International edition) BEE Reference book: no. 1/2/3/4
- S Rao, Energy Technology, Khanna Publishers

Solar Thermal Lab (PRE3CRP0120)

60 Hours 4 Credits

Course outcomes

- Obtain a basic understanding of how to measure and calculate different parameters that will allow to solve solar thermal energy design problems.
- Understand and be able to use the terminology associated with solar thermal energy to create a professional report.
- Apply the above to solar thermal systems from an engineering perspective.
- Analysis of the working of solar thermal system under various physical conditions.
- Develop the skills for experimental design, analysis and numerical calculations of solar thermal system.

1. Evaluation of different parameters (UL, FR and η) in thermosyphonic mode of flow with fixed input parameters
2. Evaluation of different parameters (UL, FR and η) in thermosyphonic mode of flow at different radiation level
3. Evaluation of different parameters (UL, FR and η) in thermosyphonic mode of flow at different inlet water temperature
4. Evaluation of different parameters (UL, FR and η) in thermosyphonic mode of flow with different wind speed
5. Evaluation of different parameters (UL, FR and η) in forced mode of flow with fixed input parameters
6. Evaluation of different parameters (UL, FR and η) and drawing of different curves in forced mode of flow with different flow rate
7. Evaluation of different parameters (UL, FR and η) in forced mode of flow at different radiation level
8. Evaluation of different parameters (UL, FR and η) in forced mode of flow at different inlet water temperature
9. Evaluation of different parameters (UL, FR and η) in forced mode of flow at different wind speed

10. Evaluation of different parameters (UL, FR and η) in forced mode of flow at different incident angle
11. Evaluation of different parameters (UL, FR and η) in thermosyphonic mode of flow at different tilt angle

Detailed Syllabus: Semester IV

Hydrogen Production & Storage, Fuel Cells & Batteries (PRE4CMT0120)

60 Hours 4 Credits

Course outcomes

- Discuss about Hydrogen energy and its production.
- Discuss about hydrogen storage, transport and its various applications.
- Describe the basic concept about fuel cells and its applications.
- Illustrate the various batteries employed for solar energy systems.
- Discuss the factors for selecting battery.

Module I Hydrogen Energy (15 Hours)

Hydrogen energy: Introduction, hydrogen production – electrolysis, thermochemical methods, Westinghouse Electro-chemical thermal sulphur cycle. Fossil fuel methods. Hydrogen storage, Utilization of hydrogen gas.

Module II Hydrogen Storage, Transport and Applications (15 Hours)

Hydrogen storage options – compressed gas –liquid hydrogen – Hydride – chemical Storage – comparisons. Hydrogen Transport systems. Applications of Hydrogen.

Module III Fuel Cells & Applications (15 Hours)

Introduction – fuel cells – design and principles of operation of a fuel cell – classification of fuel cells. Conversion efficiency of fuel cells. Types of fuel cells – Alkaline Fuel Cell, Phosphoric Acid Fuel Cell, Solid Oxide Fuel Cell, Molten Carbonate Fuel Cell, Direct Methanol Fuel Cell, Proton-exchange Membrane Fuel Cell. Applications, Large scale power generation; Power plant for vehicles; Domestic power; Fuel cells in space. Fuel cell economics; Future trends in fuel cells.

Module IV Batteries for Solar Energy Systems (15 Hours)

Deep cycle Batteries : Types of Batteries – Flooded Lead acid, AGM batteries, Gel batteries, Lithium ion batteries. Factors to be considered while choosing a Solar Battery, Battery Management systems for solar Energy Applications.

Reference

- Fuel Cell and Their Applications; Kordesch, K and G.Simader; 1996; First Edition; Wiley-VCH, Germany.
- Hydrogen and Fuel Cells: Emerging Technologies and Applications; Bent Sorensen; 2005; Illustrated Edition Elsevier Academic Press, UK.
- Hydrogen Energy: Challenges and Prospects; David Anthony James Rand and Ronald Dell; 2008; The Royal Society of Chemistry, UK.

Cogeneration And Waste Heat Recovery System (PRE4CMT0220)

60 Hours 4 Credits

Course outcomes

- Discuss the basic concepts of cogeneration systems
- Analyse different cogeneration technologies, applications & their environmental considerations.
- Describe Waste heat recovery systems
- Apply the knowledge of cogeneration and waste heat recovery systems for its economical frame work
- Discussion on regulatory and financial framework for cogeneration

Module I Basic Concepts Of Cogeneration (15 Hours)

Introduction - Principles of thermodynamics – Cycles - Topping - Bottoming – combined cycle - Organic Rankine cycles – Performance indices of cogeneration systems – Waste heat recovery – Sources and types – Concept of tri-generation.

Module II Cogeneration Technologies, Applications And Environmental Considerations (15 Hours)

Configuration and thermodynamic performance – Cogeneration systems based on steam turbine, gas turbine, combined cycle and IC engine. Advanced cogeneration systems - Fuel cell and Stirling engines. Applications of cogeneration in utility sector – Industrial sector – Building sector – Rural sector – Impacts of cogeneration plants – Fuel, electricity and environment. Environmental consideration – Mitigation of harmful emissions from energy production, conservation and utilization technologies. Control of air, water and ground pollution.

Module III Waste Heat Recovery Systems (15 Hours)

Selection criteria for waste heat recovery systems – Recuperators, regenerators, economizers, plate heat exchangers, thermic fluid heaters. Waste heat boilers - Classification, location, service conditions, design considerations - Fluidized bed heat exchangers - Heat pipe exchangers - Heat pumps – Sorption systems.

Module IV Economic Analysis (15 Hours)

Economic concepts - Measures of economic performance – Procedure for economic analysis – Investment cost – Procedure for optimized system selection and design – Load curves - Sensitivity analysis – Regulatory and financial frame work for cogeneration and waste heat recovery systems.

References

- Khartchenko N.V., "Green power: Eco – Friendly Energy Engineering". Tech book, New Delhi, 2004.
- Boyce .M.P., "Cogeneration and Combined Cycle Plants", ASME press, 2nd edition., 2010.
- Wayce Turner, Steve Doty., "Energy Management Handbook", Fairmont Press, 7th edition, 2009.
- Charles H.Butler., "Cogeneration", McGraw Hill Book Co., 1984. 5. Horlock J.H, "Cogeneration - Heat and Power, Thermodynamics and Economics", Oxford, 1987.

Inverter Design with Applications (PRE4CMT0320)

60 Hours 4 Credits

Course outcomes

- Analyse the power circuits related to DC-DC converter systems.
- Associate the principle of operation, design and DC Chopper circuits and their applications.
- Identify basic requirements for Inverter based design application.
- Analyse about different types of inverters, principle and operation.
- Discuss on voltage control of inverter.

Module I DC- DC switch mode converters (15 Hours)

DC- DC converter systems- control of DC-DC converters. Buck converters- continuous and discontinuous modes. Boost converters- continuous and discontinuous modes. Buck Boost converters continuous and discontinuous modes. Cuk converters continuous and discontinuous modes. DC-DC converter comparison

Module II Choppers (15 Hours)

Classification of DC chopper circuits- analysis of type A chopper and type B chopper- voltage, current and load commutation of choppers- step up chopper- pulse width modulated A.C. Choppers- Circuit topologies and Harmonic elimination methods.

Module III Introduction to Inverters (15 Hours)

Introduction to Inverters - Single-Phase Inverters, Three-Phase Inverters, Multilevel Inverters, Line-Commutated Inverters, Characteristics- output voltage and waveform control- bridge inverters – single phase and three phase versions- MOSFET, IGBT inverters

Module IV Inverters and types (15 Hours)

Modified Mc Murray Inverter, Different Modes of Operation of a Modified Mc Murray Half-Bridge Inverter, Voltage Control of Inverters, Control of Input Dc Voltage, External Control of AC Output Voltage, Internal Control of Inverters, Pulse-Width Modulated Inverters, Current Source Inverter.

References

- "Inverters" Michael Giesselmann, Texas Tech University
- R. E. Tarter, Principles of Solid-State Power Conversion, Howard W. Sams & Co., Indianapolis, IN, 1985, 68–76.
- Ned Mohan, Undeland and Robbin, "Power Electronics: converters, Application and design" John Wiley and sons.Inc, Newyork, 1995.
- Rashid M.H., "Power Electronics Circuits, Devices and Applications ", Prentice Hall India, New Delhi, 1995.

Energy Auditing (PRE4CRT0120)

75 Hours 5 Credits

Course outcomes

- Develop an insight about the basics of electricity and electrical load management .
- Discuss about energy conservation and energy audit .
- Explain performance test and reference standards of boilers and furnaces.
- Analyze energy policies, energy and environment, energy conservation and energy planning.
- Discuss on challenges and constraints of energy policy

Module I Basics of Energy And Electricity System (15 Hours)

Basics of Energy - Electricity basics, DC & AC currents, Electricity billing, Electrical load management and maximum demand control, Power factor improvement and its benefit, Selection and location of capacitors, Performance assessment of PF capacitors, Distribution and transformer losses.

Module II Energy Audit and Energy Action Planning (20 Hours)

Energy Audit: Types And Methodology, Ten Steps Methodology for Detailed Energy Audit, Phase I -Pre Audit Phase Activities, Phase II- Detailed Energy Audit Activities, Identification of Energy Conservation Opportunities, Energy Audit Instruments.

Energy Action Planning: Energy policy purpose, perspective, Contents, Formulation, Ratification, Organizing - location of energy management, Top management support, Managerial function, Roles and responsibilities of energy manager.

Module III Energy Performance Assessment of Boilers & Furnaces (20 Hours)

Performance Terms and Definitions, Scope, Reference Standards, The Direct Method Testing-The Indirect Method Testing-Example: Boiler Efficiency Calculation, Factors Affecting Boiler Performance, Data Collection Format for Boiler Performance Assessment, Boiler Terminology.

Industrial Heating Furnaces, Purpose of the Performance Test, Performance Terms and Definitions, Reference Standards, Furnace Efficiency Testing Method, Data Collection Format for Furnace Performance Assessment, Useful Data.

Module IV Energy Policies in India (20 Hours)

Need of Energy Policy, Energy Planning Tools – ENPEP, MARKAL, LEAP, MAED. Policy framework for promotion of renewable in India – FIP, FIIA, Industrial Policy, Policies for small scale Industries, Challenges and Constraints.

Reference

- Energy Performance Assessment for Equipment and utility systems, Bureau of energy efficiency.
- General Aspect of Energy Management and Energy Audit, Bureau of energy efficiency.

Practical I: Solar PV Design Using PVsyst (PRE4CRP0120)

60 Hours 4 Credits

Course outcomes

- Illustrate about basic solar PV systems by applying the experimental methods, examine system and inverter sizing and the site analysis of Solar PV systems.
- Evaluate the role of direct observation in shading, ageing of solar panels and also the model management.
- Analyze the solar PV system by bifacial model and evaluate isolated pumping systems with the aid of new instruments and employ the system cost evaluation.
- Analyse of PV module and model management.
- Analyse the pricing strategy, advanced financial analysis and profitability analysis.

1. Design of a basic solar PV system (Grid connected & Stand alone)
2. System sizing & inverter sizing
3. Solar site Analysis & Energy yield estimation under varying conditions
4. Shading Analysis
5. Effect of ageing on solar panel output
6. PV modules & Model Management
7. Bifacial model for tracking single axis systems
8. System Cost Evaluation – Pricing strategy, Advanced financial analysis & Profitability analysis
9. Isolated Pumping systems